

## FOREST VEGETATION OF THE KOKIWANEE NATURE PRESERVE, WABASH COUNTY, INDIANA

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**ABSTRACT.** Forest vegetation of the Kokiwanee Nature Preserve, located in east-central Wabash County, Indiana, was studied. Contemporary upland forests are dominated by *Acer saccharum*, with the exception of *Quercus*-dominated submesic forests at the top of the Salamonie River bluff. Forest composition and structure are related to disturbance history, with *ca.* 60-year old forests, established after agricultural abandonment, occupying much of the area. Remnant forests, with a significant degree of past disturbance due to partial cutting or to clearing of adjacent land, occur in a former woodlot and in small stream valleys. The least disturbed forest occurs on the bluff face, and is dominated by *Acer saccharum*, *Fraxinus americana*, *Tilia americana*, *Juglans nigra* and *Celtis occidentalis*. Composition and structure indicated that the bluff forest has many old-growth characteristics. Examination of original land-survey records for the Kokiwanee area showed that in presettlement days the river corridor differed in forest composition from the uplands. The Kokiwanee bluff forest is compositionally similar to other old-growth forests in northeastern Indiana.

**Keywords:** Forest vegetation, Wabash County, land use history

Lindsey et al.'s (1965) classic study of presettlement vegetation of Indiana grouped the upland forests of northeastern Indiana into two main types, namely beech-maple (*Acer saccharum* Marshall/*Fagus grandifolia* Ehrh.) and oak-hickory (*Quercus* spp./*Carya* spp.). Although relatively few studies have described old-growth forest vegetation in this region, they indicate that the picture can be more complex, with some stands not fitting the usual perception of these forest types. For instance, Ginn Woods in Delaware County is dominated by *A. saccharum*, but has relatively little *F. grandifolia* (Badger et al. 1999).

This paper describes forest vegetation at the Kokiwanee Nature Preserve, which is adjacent to the Salamonie River in eastern Wabash County, Indiana. Although the majority of the site was farmed as recently as the 1940s, remnant vegetation persisted on the river bluff. The remnant forests have many old-growth characteristics, and their composition is rather different from either beech-maple or oak-hickory forests. The bluff forests are dominated by *A. saccharum*, accompanied by *Tilia americana* L., *Fraxinus americana* L. and *Juglans nigra* L. Remnant forests with a

significant degree of disturbance also occur in a former woodlot and in small stream valleys. These forests are dominated by the late-successional species *A. saccharum*, and have some large trees, but historical aerial photos and current composition indicated a history of disturbance. Finally, much of the site is occupied by successional forests that were about 60 years old at the time of this study. Composition of these forests was heterogeneous.

### METHODS

**Study area.**—The Kokiwanee Nature Preserve is owned by ACRES Land Trust Inc., and consists of 56 ha (139 acres). It is located at latitude N 40.816°, longitude W 85.684°, T27N, R7E Section 1, in Lagro Township, Wabash County, Indiana. The preserve is on the Bluffton Till Plain section of the Central Till Plain natural region (Homoya et al. 1985). It is adjacent to Salamonie Reservoir (owned by the United States Army Corps of Engineers) and Salamonie State Forest (owned by the Indiana Department of Natural Resources).

Bedrock at Kokiwanee consists of lower and middle Silurian limestone, dolomite, siltstone and shale (Fleming 2005). The terrain is mostly gently rolling, with the exception of the bluff that runs along the Salamonie River. Elevation ranges from 207–247 m (680–810 feet) above

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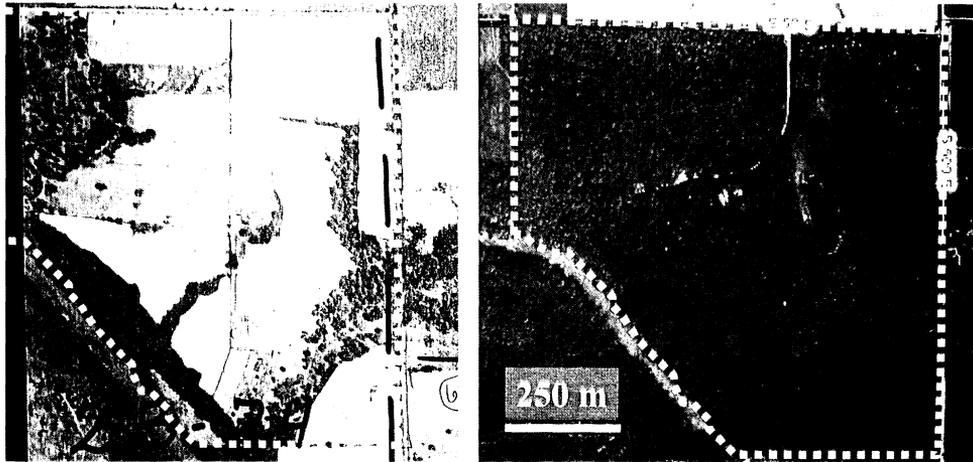


Figure 1.—Aerial photos of the Kokiwanee Nature Preserve in 1941 (left) and 2005 (right). 1941 photo from Wabash County Surveyor's office; 2005 photo from Beacon Local Government GIS for the Web (2008).

sea level. The bluff is southwest-facing and rises 20 m (~60 feet) above the river (USGS Lagro 7½ minute topographic map).

Kokiwanee upland soils are mostly alfisols that were formed in glacial deposits, with alluvial inceptosols along the river. Most soils belong to the Glynwood-Morley group, with small areas of Hennepin and Genesee loam. Rocky, better-drained soils occur on the bluff above the Salamonie River (Ruesch 1983).

Original land survey data for Wabash County show that mesic forests were dominated by *F. grandifolia*, *A. saccharum*, *Aesculus glabra* Willd. and *Prunus serotina* Ehrh. Xeric forests were dominated by *Quercus alba* L., and hydric forests by *Ulmus americana* L. and *Fraxinus* spp. (Hicks & Keller 1996; nomenclature and authorities follow USDA, NRCS 2008). Lagro Township was heavily forested in the late 1800s. *Quercus alba*, *Q. macrocarpa* Michx., *Fraxinus* spp., *Ulmus* species, *Carya* spp., *F. grandifolia*, *A. saccharum*, *T. americana*, *J. nigra*, *Liriodendron tulipifera* L. were described as abundant at that time (Anonymous 1884).

The Kokiwanee area has had a long history of human utilization. In the 1830s J. Leonard Wines owned about ¾ of a mile, including grain mills, on both sides of the Salamonie River in Lagro Township, Sections 1 and 12 (Anonymous 1884). It is unknown when agricultural activity began on what is now the Kokiwanee property.

In 1945 the Kokomo Kiwanis purchased the land for the Girl Scouts, hence the name

Kokiwanee. According to the Kokiwanee development plan (unpubl., from files of ACRES Land Trust), there were 24 ha (60 acres) of woodland at that time. The Girl Scouts operated a camp on the property from 1945 to 1996. The camp used parts of the property intensively, with the remainder left relatively undisturbed. Pine (*Pinus strobus* L. and *P. sylvestris* L.) plantations were created by the Girl Scouts shortly after they took ownership. In 2003, ACRES Land Trust Inc. purchased Kokiwanee from the Tribal Trails Girl Scout Council. Also, a pond was constructed in the mid-1960s.

**Aerial photos.**—Historical aerial photos were obtained from the Wabash County Surveyor's office. These photos showed most of the Kokiwanee property in 1941 and the entire area in 1951.

**Current vegetation.**—Forest composition was determined by sampling plots of 1000 m<sup>2</sup>. Plots were spread throughout the property to incorporate the main habitats, including the bluff, roadside, small streams, young forest and floodplain. (Pine plantations were excluded.) All trees ≥ 5 cm in diameter at breast height (dbh) were recorded by species and size, except as noted below. The number of fallen trunks > 30 cm dbh was recorded for each plot. Frequency of understory plants was determined in 25 quadrats of 1 m<sup>2</sup> within each plot (detailed understory data are not included in this report).

Some tree species that could not be distinguished reliably in the field are combined in the

Table 1.—Tree species composition (% of basal area) of 1000 m<sup>2</sup> plots at Kokiwanee Nature Preserve, Wabash County, Indiana. Aspect is measured in degrees from north.

| Plot number                    | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     | 12     | 13     | 14     | 15     | 16     |
|--------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Forested in 1941               | yes    | yes    | yes    | yes    | yes    | no     | yes    | yes    | yes    | yes    | no     | yes    | yes    | no     | no     | no     |
| Topography                     | upland | upland | upland | stream | bluff  | upland | bluff  | bench  | bluff  | bluff  | bench  | bluff  | stream | upland | upland | upland |
| Slope/aspect                   | 5/190  | 5/250  | 2/40   | varied | 35/220 | (flat) | 40/210 | (flat) | 27/235 | 25/230 | (flat) | 30/245 | 12/220 | (flat) | (flat) | (flat) |
| <i>Acer negundo</i>            |        |        |        |        |        |        |        | 6.7    |        |        |        | 15.2   |        |        |        |        |
| <i>Acer rubrum</i>             |        |        |        |        |        | 0.5    |        |        |        |        |        |        |        |        |        |        |
| <i>Acer saccharum</i>          | 34.4   | 27.4   | 2.8    | 31.4   | 29.2   | 7.5    | 30.9   | 22.6   | 20.9   | 22.5   | 1.4    | 35.1   | 28.5   | 37.6   | 37.1   | 40.3   |
| <i>Aesculus glabra</i>         |        | 0.2    | 1.8    |        |        |        | 2.0    | 5.7    | 4.1    | 2.8    | 0.6    | 0.5    | 0.1    |        |        |        |
| <i>Asimina triloba</i>         |        |        |        |        |        |        |        |        |        |        | 0.2    |        |        |        |        |        |
| <i>Carpinus caroliniana</i>    |        |        |        | 0.3    |        |        | 0.3    |        |        |        |        | 0.8    | 0.8    |        |        |        |
| <i>Carya cordiformis</i>       | 12.7   |        | 2.1    | 2.0    |        |        |        |        | 15.2   | 1.6    | 0.2    |        |        | 0.8    |        |        |
| <i>Carya ovata</i>             | 4.0    |        |        |        |        | 84.7   |        |        | 0.4    |        |        | 2.5    | 3.4    |        |        |        |
| <i>Celtis occidentalis</i>     | 1.8    |        | 2.1    |        |        |        | 2.8    | 3.5    | 25.0   | 2.6    |        | 1.1    |        |        |        |        |
| <i>Cercis canadensis</i>       |        |        |        |        |        |        |        |        |        |        | 2.7    | 0.1    |        |        |        |        |
| <i>Fagus grandifolia</i>       |        |        |        | 7.2    |        |        |        |        |        |        |        |        |        |        |        |        |
| <i>Fraxinus americana</i>      | 3.3    | 4.2    | 31.2   |        | 3.6    |        | 9.6    | 23.9   | 13.4   | 10.3   | 0.2    | 22.3   | 34.7   | 15.1   | 6.9    | 14.5   |
| <i>Fraxinus nigra</i>          |        |        |        |        |        |        |        |        |        |        |        | 10.9   |        |        |        |        |
| <i>Fraxinus quadrangulata</i>  |        |        |        |        |        |        | 0.6    |        | 0.1    | 5.3    | 0.4    | 0.1    |        |        |        |        |
| <i>Gleditsia triacanthos</i>   | 3.8    |        |        |        |        |        |        |        |        |        | 46.6   |        |        |        |        |        |
| <i>Hamamelis virginiana</i>    |        |        |        |        |        |        |        |        |        |        |        | 0.1    |        |        |        |        |
| <i>Juglans nigra</i>           |        |        | 7.5    |        |        |        | 7.5    |        | 1.8    | 22.5   | 1.9    | 6.6    | 9.8    |        |        |        |
| <i>Juniperus virginiana</i>    |        |        |        |        | 19.6   |        |        |        |        |        |        |        |        |        |        |        |
| <i>Liriodendron tulipifera</i> | 15.3   | 37.2   | 12.5   | 48.1   |        |        | 6.3    |        |        |        |        |        |        |        | 24.0   | 5.8    |
| <i>Ostrya virginiana</i>       |        |        |        | 0.7    |        |        |        |        |        | 0.1    |        | 0.1    | 0.1    |        |        |        |
| <i>Pinus strobus</i>           |        |        |        |        | 0.5    |        |        |        |        |        |        |        |        |        |        | 15.3   |
| <i>Pinus sylvestris</i>        |        |        |        |        |        |        |        |        |        |        |        |        |        | 15.8   |        |        |
| <i>Platanus occidentalis</i>   |        | 6.8    |        | 5.9    |        |        |        |        |        | 1.5    | 3.9    | 18.8   |        |        |        | 2.3    |
| <i>Populus grandidentata</i>   |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        | 12.8   |
| <i>Prunus serotina</i>         | 8.5    | 4.4    | 14.1   | 3.5    |        | 0.5    |        |        |        |        | 0.4    |        |        | 26.3   |        | 2.1    |
| <i>Quercus alba</i>            |        |        |        |        | 25.3   |        |        |        |        |        |        |        |        |        |        |        |
| <i>Quercus rubra</i>           |        | 12.5   |        | 0.1    |        |        |        |        |        |        |        |        |        |        |        |        |
| <i>Quercus muhlenbergii</i>    |        |        |        |        | 5.0    |        |        |        | 0.7    | 4.4    |        | 0.6    | 20.3   |        |        |        |
| <i>Quercus velutina</i>        |        |        | 2.1    |        | 14.5   |        |        |        |        |        |        |        |        |        |        |        |
| <i>Robinia pseudoacacia</i>    |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        | 36.3   |
| <i>Tilia americana</i>         |        | 0.2    | 12.5   | 0.4    | 0.7    |        | 39.9   | 33.4   | 11.4   | 19.9   |        |        | 0.1    |        |        |        |

Table 1.—Continued.

| Plot number                    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   |
|--------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <i>Ulmus americana</i>         | 15.9 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <i>Ulmus rubra</i>             |      | 6.5  | 11.4 | 0.6  | 1.5  | 6.7  | 34.5 | 4.3  | 7.0  | 6.6  | 26.2 | 0.3  | 2.0  | 4.5  | 1.4  | 0.6  |
| <i>Viburnum prunifolium</i>    |      |      |      |      |      |      |      |      |      |      |      | 0.1  |      |      |      |      |
| <i>Vitis riparia</i>           | 0.2  | 0.7  | 0.2  |      |      |      |      |      |      |      |      |      |      |      | 0.2  |      |
| Basal area, m <sup>2</sup> /ha | 28.9 | 26.1 | 28.8 | 30.2 | 23.5 | 24.1 | 34.5 | 30.8 | 33.8 | 40.5 | 21.1 | 32.6 | 31.4 | 31.6 | 25.2 | 37.1 |
| Trees per ha                   | 780  | 410  | 640  | 420  | 700  | 470  | 580  | 740  | 700  | 540  | 680  | 580  | 430  | 1160 | 860  | 1160 |
| Tree species                   | 10   | 10   | 12   | 11   | 9    | 5    | 10   | 7    | 11   | 12   | 13   | 16   | 10   | 6    | 8    | 7    |
| Understory species             | 36   | 45   | 34   | 45   | 58   | 43   | 38   | 38   | 54   | 37   | 43   | 50   | 39   | 40   | 30   | 27   |

data summaries. Leaves and fruits of *Fraxinus americana* and *F. pensylvanica* Marshall often were not accessible. Consequently, *F. americana* will refer to both species. *Acer saccharum* and *A. nigrum* Michx. f. are not genetically distinct (Skepner & Krane 1998), and many specimens at Kokiwanee were morphologically intermediate. Therefore, *A. saccharum* includes both of these taxa.

Non-metric multidimensional scaling (NMDS) ordination analyses were performed by the program PCORD, using the Bray-Curtis distance measure, a stability criterion of 0.00001, 400 iterations, and the slow and thorough search method (McCune & Mefford 1999). Input data were percent basal area for Kokiwanee samples. For data from the literature, percent basal area was used if available; if not, percent importance values were used.

**Presettlement vegetation.**—Data on presettlement forests were obtained from the General Land Office (GLO) surveys of 1828–1834. Tree composition of the Salamonie River gorge area was compared to that of adjacent uplands.

RESULTS

**Land use history.**—The 1941 aerial photo showed that the property was mostly used for agriculture (Fig. 1). About 21 ha (37% of the area), including the river bluff, stream valleys, and western edge of the property, was wooded. The forest in the western section appeared to have been thinned and to include several narrow dirt roads, and was probably used as a woodlot. The forests on the river bluff and stream valleys showed little sign of disturbance in 1941, although part of the bench in the adjacent flood plain was cleared. The 1951 photo (not shown) showed a similar landscape, but indicated that succession was proceeding in formerly deforested areas.

**Current forest composition.**—Current forest vegetation at Kokiwanee was dominated by *A. saccharum*; this species made up 26% of total basal area in all sample plots and ranked first or second in proportion of basal area in 13 of 16 plots (Table 1). *Fraxinus americana*, *L. tulipifera*, *J. nigra* and *T. americana* were also well represented, each of these species comprising about 10% of total basal area.

Successional forests, approximately 60 years old at the time of sampling, covered much of the area (Plots 6, 11, 14–16 in Table 1). They were rather varied in species composition. The



upland stands (Plots 14–16) were dominated by *A. saccharum* and *F. americana*. Plots 14 and 15 contained significant amounts of planted *Pinus sylvestris* and *P. strobus*. Plot 6 was strongly dominated by *Carya ovata* (Miller) K. Koch. The disturbed flood plain plot (Plot 11) was dominated by *Gleditsia triacanthos* L., *Acer negundo* L. and *U. americana*.

Successional stands had average basal area of  $27.8 \pm 6.4 \text{ m}^2/\text{ha}$  and mean density of  $870 \pm 300$  stems  $> 5 \text{ cm dbh}$  per ha (mean  $\pm$  standard deviation;  $n = 5$ ). The species richness of successional stands was  $8 \pm 3$  tree species and  $37 \pm 8$  understory species ( $n = 5$ ).

On the top of the southwest-facing bluff where the soil is thin, the subxeric forest was dominated by *Quercus* species, *A. saccharum* and *Juniperus virginiana* L. (Plot 5, Table 1). Some planted pines also occurred in this area. This sample had the highest understory diversity.

Mesic forests in the former woodlot area (Plots 1–3, Table 1) showed structure that was consistent with the disturbance history revealed by the aerial photos. The old woodlot had some large trees, including the largest seen at Kokiwanee (*A. saccharum* and *F. grandifolia*, both  $> 1 \text{ m dbh}$ ; not included in study plots). However, areas of smaller trees intervened between the large individuals. These samples had a mean basal area of  $27.9 \pm 1.6 \text{ m}^2/\text{ha}$  and a mean density of  $610 \pm 190$  stems  $> 5 \text{ cm dbh}$  per ha ( $n = 3$ ). Species richness averaged  $11 \pm 1$  tree species and  $38 \pm 6$  understory species ( $n = 3$ ).

Forests associated with small streams (Plots 4 and 13, Table 1) also contained some large trees, consistent with their being forested in 1941. *Liriodendron tulipifera* was dominant in one stream plot, *F. americana* in the other, with significant amounts of *A. saccharum* in both.

The least-disturbed forests at Kokiwanee occurred on the face of the Salamonie River bluff and the adjacent floodplain bench (Plots 7, 8, 9, 10, and 12 in Table 1) with dominant trees being *A. saccharum*, *F. americana*, *T. americana*, *J. nigra* and *Celtis occidentalis* L. These plots had a mean basal area of  $34.4 \pm 3.6 \text{ m}^2/\text{ha}$  and a mean density of  $630 \pm 90$  stems  $> 5 \text{ cm dbh}$  per ha ( $n = 5$ ). Species richness of these stands averaged  $11 \pm 3$  tree species and  $43 \pm 8$  understory species ( $n = 5$ ).

Based on ordination analysis (see below), and on the disturbance history indicated by the aerial photos, Plots 7, 8, 9, 10 and 12 were

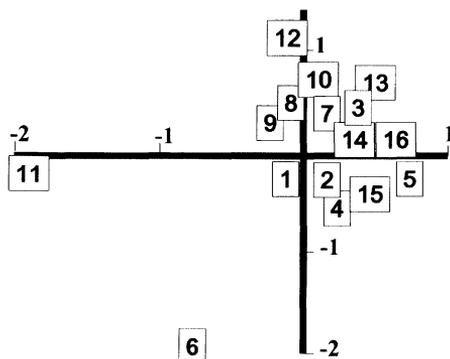


Figure 2.—NMDS ordination comparing composition of forest samples at Kokiwanee Nature Preserve. Plot numbers correspond to those in Table 1. Some data points have been slightly displaced to improve legibility.

combined into a composite sample (Table 2). The size structure of the composite sample showed an exponential decline in density with diameter over the range 5–70 cm dbh (Regression:  $\log [\text{trees per ha}] = 2.274 - 0.222 [\text{dbh, cm}]$ ;  $r = 0.94$ ,  $P = 0.001$ ). In the composite, *A. saccharum*, *T. americana*, *C. occidentalis* and *A. glabra* were well-represented in the smaller size categories, and appeared to be reproducing well. *Juglans nigra* and *F. americana*, in contrast, were represented mostly by larger individuals.

**Ordination of Kokiwanee samples.**—A significant two-dimensional ordination resulted from NMDS (Fig. 2). Plots with large amounts of *L. tulipifera* (2, 4 and 15) were placed close to each other in the ordination. Undisturbed plots on the bluff and adjacent flood plain bench (Plots 7, 8, 9, 10 and 12) were also clumped. Samples in locations that were deforested in 1941 (Plots 6, 11, 14, 15, 16) were located throughout most of the ordination space, indicating disparity in species composition.

**Comparison to presettlement and old-growth forests.**—Ordination was used to compare species composition of the Kokiwanee composite sample to upland, presettlement forests in northern Indiana and to contemporary old-growth (see Fig. 3 legend for site names and literature citations). All old-growth sites were located in the Central Till Plain natural region of Indiana (Homoya et al. 1985).

NMDS resulted in a significant 3-dimensional ordination (Fig. 3). The ordination recovered the moisture gradient in the presettlement

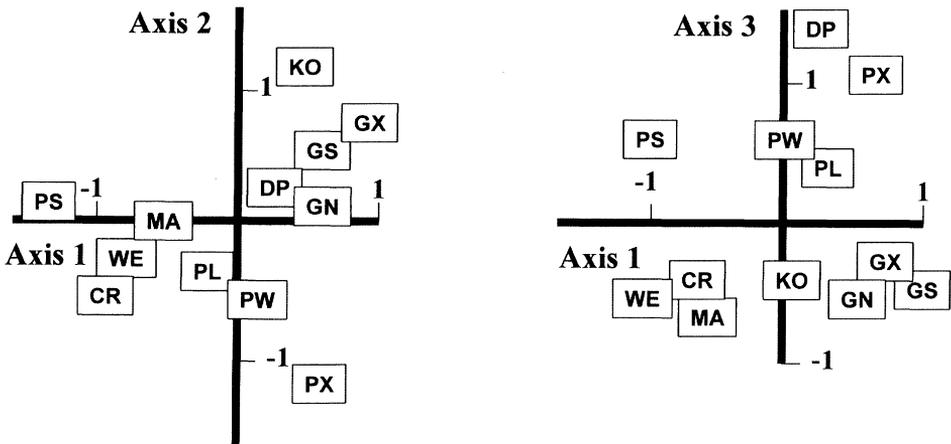


Figure 3.—NMDS ordination comparing composition of mature forest at Kokiwanee Nature Preserve (KO) to old-growth forests and pre-settlement forests in northeastern Indiana. CR = Crosby Woods (Lindsey et al. 1969), DP = Davis-Purdue Research Forest, 1976 sample (Parker et al. 1985), GN = Ginn Woods, northern section; GS = Ginn Woods, southern section, GX = Ginn Woods, Nixon section (Badger et al. 1998), MA = Manlove Woods (Lindsey et al. 1969), WE = Weaver Woods (Lindsey et al. 1969). PS = presettlement, somewhat poorly drained soils; PL = presettlement, slowly draining soils; PW = presettlement, well-drained soils; PX = presettlement, excessively well drained soils (Lindsey 1961). Some data points have been slightly displaced to improve legibility.

data set. Overall, Kokiwanee was most similar to Ginn Woods (Fig. 3). Contemporary old-growth stands with significant amounts of *F. grandifolia* (Crosby Woods, Manlove Woods, and Weaver Woods) form a tight cluster that is separated from the Kokiwanee-Ginn Woods group.

**Presettlement vegetation.**—GLO survey records indicated that the area adjacent to the Salamonie River had different forest vegetation than the nearby uplands. Upland forests were strongly dominated by *F. grandifolia*, which comprised 55% of the 47 trees sampled in this area. *Aesculus glabra* was second in abundance, making up 15% of the sample. A further eight species, each with < 10% of trees in the sample, occurred in the uplands. In contrast, forests in the river corridor were much more diverse. *Quercus alba* was most abundant in this area (15% of 53 trees in sample), followed by *F. grandifolia* (13%), *A. glabra* (11%) and *Ulmus* species (11%). Eleven further species, each with abundance < 10%, made up the rest of the river corridor sample.

## DISCUSSION

Kokiwanee forests form a mosaic influenced by disturbance history and variation in environmental factors. Most of the younger (*ca.* 60

years old) forests are dominated by *A. saccharum*, accompanied by various mid- and early-successional species (*L. tulipifera*, *P. serotina*, *Robinia pseudoacacia* L. and *G. triacanthos*). Composition of these secondary forests is quite variable, and may be related to fortuitous events at the time of abandonment, such as the proximity of seed trees.

Remnant forests with some degree of disturbance are found in the small stream valleys and former woodlot. Disturbance of the woodlot is indicated by historic aerial photos showing canopy opening. In the gully-like stream valleys, which are sometimes as narrow as 15 m, clearing of the adjacent uplands may have allowed more light to penetrate into the streamside forests. The abundance of *L. tulipifera* and *Platanus occidentalis* L., which are relatively shade-intolerant (Hewitt 1998), is also consistent with significant amounts of disturbance.

Old-growth forests are comparatively rare in Indiana, especially in the northern part of the state (Parker 1989), and therefore are of conservation significance. Are the Kokiwanee bluff forests old-growth? Runkle (1996) described structural criteria that could be used to identify old-growth forests in the Central Hardwoods region. The composite sample from

Table 3.—Characteristics of old-growth mesic deciduous forests of the Midwest (Runkle 1996) in relation to features of the Kokiwanee bluff composite sample.

| Old-growth characteristics  | Kokiwanee composite                                     |
|---|---|
| High species richness (>20 canopy trees, > 20 herbaceous species) | 16 tree, 72 herb species                                |
| Uneven-aged structure   | Exponential decline in density with increasing diameter |
| >7 trees >75 cm dbh per ha  | No  |
| Large commercially valuable trees                                 | Yes, <i>Juglans nigra</i> and <i>Acer saccharum</i>     |
| Trees >200 years old  | ?   |
| ~250 trees (>10 cm dbh) per ha                                    | 368 trees per ha  |
| BA >25 m <sup>2</sup> /ha   | 33 m <sup>2</sup> /ha                                   |
| >10 snags (>10 cm dbh) per ha, >19 logs (>30 cm dbh) per ha       | ? snags, 20 logs per ha                                 |
| Tree-falls 0.6–1% of area   | ?   |
| Old-growth plants and animals                                     | $C_{av} = 4.42$ for entire preserve (see text)          |
| Undisturbed soils   | Steep slope; no evidence of plowing                     |
| Little or no human disturbance                                    | No documented disturbance since at least 1941           |

the bluff face meets many, though not all of these criteria (Table 3). Relatively high tree density and low maximum size may be due to the steep slope and southwest aspect of the Kokiwanee bluff. As well as Runkle's criteria, the size structure of the composite is typical of old-growth forests (Schmelz & Lindsey 1965).

Floristic quality analysis is used to assess the degree to which the plant species of a site are characteristic of habitats with low impact of disturbance by humans (Rothrock & Homoya 2005). This technique assigns index of conservatism values, on a 0–10 scale, to plant taxa. High average values indicate taxa typical of undisturbed native vegetation. In previous research the average index, known as  $C_{av}$ , for the entire Kokiwanee preserve was estimated to be  $4.42 \pm 2.38$  for 382 native species (Hicks & Michaelis 2006). Since this calculation includes roadsides and old fields,  $C_{av}$  for the bluff area would doubtless be somewhat higher. According to Rothrock & Homoya (2005), for "the best natural woodland sites in the Central Till Plain  $C_{av}$  (native species) plateau in the low 4 range." Consequently, species composition indicates relatively low disturbance.

The bluff-face forest differs from Lindsey's (1961) characterization of the presettlement forests of southern Wabash County as beech-maple. However, GLO survey data indicated that, while the uplands in the area were dominated by beech, the river corridor had much more varied forests in presettlement times. Ordination analysis indicates that the bluff forests are similar to old-growth forest at

Ginn Woods (Badger et al. 1998). The similarities appear to lie in dominance by *A. saccharum* and high importance of *T. americana*, the latter being second in abundance in two sections of Ginn Woods. Also, *F. grandifolia*, *L. tulipifera*, *Quercus rubra* L. and *Q. alba*, which are common to dominant in most regional forests, are absent or uncommon at both Kokiwanee and two sections of Ginn. In conclusion, the composition of the bluff-face forest at Kokiwanee is not inconsistent with old-growth status.

With regard to the U.S. National Vegetation Classification system, the Kokiwanee bluff forest appears to be most similar to the *Acer saccharum* - *Tilia americana* / *Ostrya virginiana* - *Carpinus caroliniana* Forest (NatureServe 2008). The description of this community type indicates that "stands occur on flat to steep slopes on loamy soils derived from glacial till ... soils are well-drained, fertile, and deep," and that "*Acer saccharum* and *Tilia americana* are the most prevalent tree species" (NatureServe 2008), which fits the location and composition of the Kokiwanee bluff sample. Understory species listed as typical of this association are common in the Kokiwanee sample (pers. obs.). One variation from this type is that the subcanopy trees *Ostrya virginiana* (Mill.) K. Koch and *Carpinus caroliniana* (Walter) are uncommon in the Kokiwanee sample, in which *A. glabra* is abundant in the understory.

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