# Composition Gradients in Forest Canopy and Groundlayer Vegetation within a White River Floodplain Forest

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## Introduction

While much research has been done to describe upland forests in Indiana, much less has been done with floodplain forest in the state. Two published papers are all that apparently exist. Lee (1945) reported on the floodplain vegetation of the White River, while Lindsey, *et al.* (1961), described floodplain vegetation along the banks of the Tippecanoe and Wabash Rivers (5,6).

The site described in this paper was discovered as a result of a natural areas inventory for Marion County performed by the Division of Nature Preserves of the Indiana Department of Natural Resources (Bacone 1980) (1). The site was also described in a natural areas survey for the west fork of White River conducted for the Indiana Department of Natural Resources performed by Hollett, (1980) (4).

## Study Area

The study site is located in northern Marion County in the N½, NE¼, Sec. 16, T 17N, R4E (Figure 1). The site is composed of two sections. The larger section is floodplain forest of approximately 15 to 20 acres. It is bounded on the west side by the White River, the east side by an upland transition slope, and partially on the north side by a power line and natural gas pipeline right-of-way which follows the Hamilton-Marion County line. The floodplain becomes narrower at the south end of the tract and finally becomes a slope at the river bank. The entire top of the slope along the east side of the floodplain is the site of apartment complexes and has been partially backfilled.

The floodplain section of the site shows a good diverity of tree species. A narrow band at the river bank is frequently flooded and is dominated by small-to-medium silver maple. Farther back from the river bank, the site is better drained with other tree species becoming important. While silver maple is still presnt, large cottonwood, hackberry, and sycamore increase in importance. Such tree species as box-elder, paw paw, and American elm are represented in the smaller size classes. Floodplain depressions of medium width which occur at intervals contain black ash, swamp white oak, sycamore and other very wet site species. The herb layer contains such wet site species as Canada nettle, and touch-me-not.

The upland forest area, while small in extent provides an abrupt contrast to the floodplain forest. The area is dominated by large sugar maple, beech, and red oak with some white oak. Flowering dogwood, ironwood, and other species are represented in the smaller size classes. Such species as bloodroot and hepatica are present in the herbaceous understory.

## Methods

For sampling trees, two parallel transects were laid out which started at the river

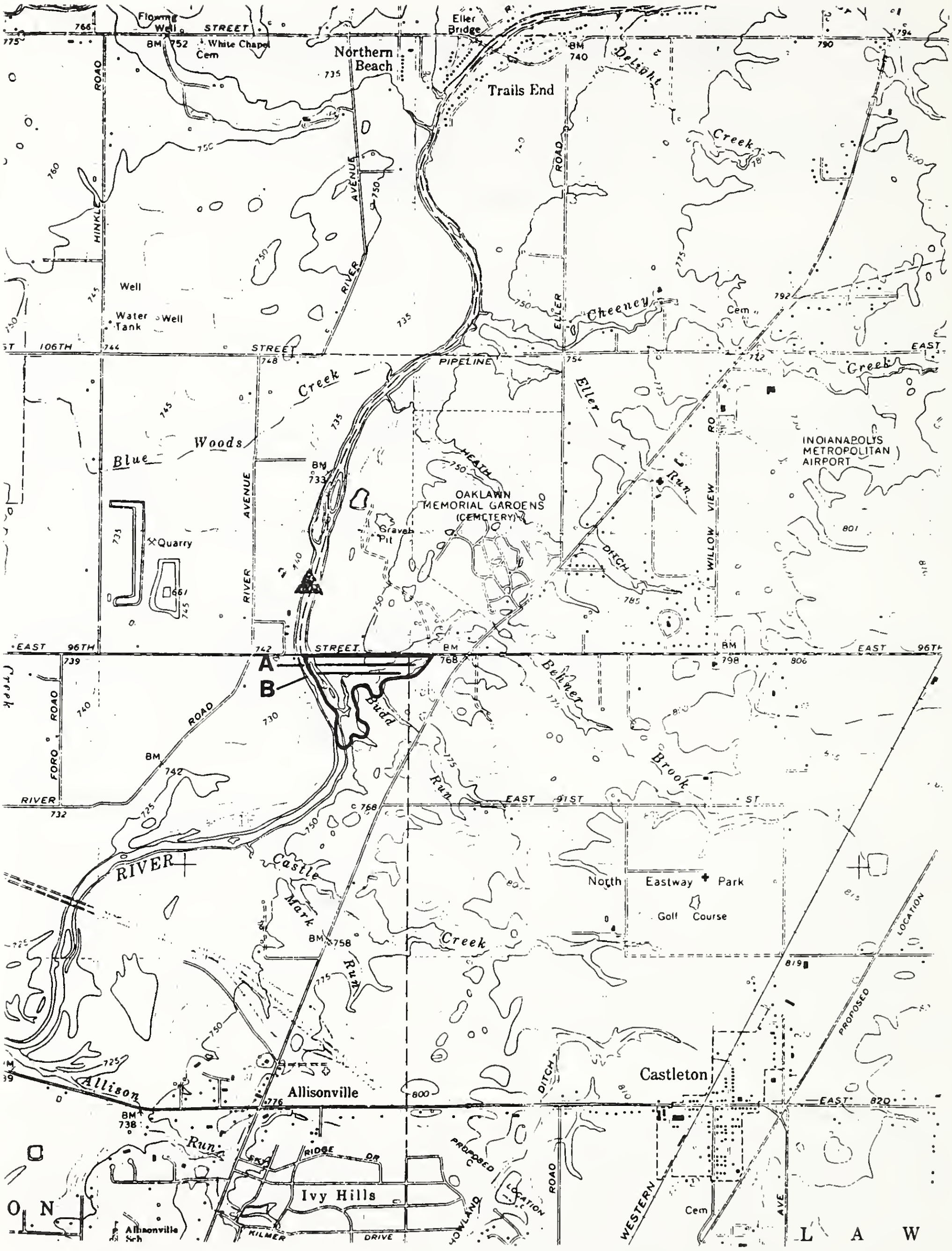


FIGURE 1. *Study site location of Bud Run Floodplain Forest, Marion County, Indiana, showing transect locations. Fishers 7 1/2-minute quandrangle. Contour interval 5 feet.*

bank and ran eastward before ending on the upland part of the site (Figure 1). The transects were then subdivided into 25-meter lengths by use of a 50-meter tape. The species and dbh of each tree over 10 cm (4 inches) diameter within a 5-meter perpendicular distance on either side of the tape was recorded separately for each 25-meter sub-section. A 2.5-meter telescoping pole was used to measure the 5-meter distance from the tape.

Sampling of shrubs was performed by recording the number of individuals less than 1 meter tall of each species within 2.5 meters of one side of the tape along a 10 meter length for each 25-meter sub-section.

The groundlayer was sampled by recording the number of individuals and estimated ground cover for each species in square meter plots. These plots were located at the end of each 25-meter section and were set up with portable plot frames. Three samplings were conducted during the growing season in May, August, and October.

## Results

Species composition varied along floodplain gradients for each of the herbaceous, shrub and canopy tree strata. Distance from the river, internal and surface drainage patterns, location of surface debris, and presence or absence of canopy openings were the prominent factors controlling microsite differences.

### *Groundlayer Composition*

The groundlayer included all herbaceous individuals plus woody plants less than 0.5 m tall. The sixty-nine species or species groups which contributed to the groundlayer vegetation are arranged in a gradient or continuum sequence in Table 1. Included were two species of mosses and *Selaginela*, eight grass and sedge species, six species of shrubs, four tree species and 49 broadleafed herbs.

TABLE 1. *Changes in herbaceous composition along transects from the White River across the floodplain into the upland forest. Values are average importance percentages derived from averaging relative density and estimated relative cover for both transects combined.*

| | Distance in Meters from White River | | | | | | | Average Percent |
|---|---|---|---|---|---|---|---|---|
| Species | 50 | 100 | 150 | 200 | 250 | 300 | 350 | Importance |
| Carex laxiflora Lam. | 0.20 | — | — | — | — | — | — | 0.03 |
| Ambrosia trifida L. | 0.21 | — | — | — | — | — | — | 0.03 |
| Campanula americana L. | 0.47 | — | — | — | — | — | — | 0.07 |
| Cinna arundinacea L. | 3.14 | — | — | — | — | — | — | 0.45 |
| Lysimachia nummularia L. | 4.84 | — | — | — | — | — | — | 0.69 |
| Menispermum canadense L. | 0.22 | 0.72 | — | — | — | — | — | 0.13 |
| Unidentified moss spp. | 0.89 | 0.19 | — | 0.18 | — | — | — | 0.18 |
| Eupatorium rugosum Houtt. | 1.21 | 0.31 | — | 0.98 | — | — | — | 0.36 |
| Elymus virginicus L. | 8.20 | 11.58 | 11.63 | 1.30 | — | — | — | 4.67 |
| Polygonatum biflorum (Walt.) | 0.58 | 0.70 | 3.89 | 1.05 | 1.08 | — | — | 1.04 |
| Rudbeckia laciniata L. | 11.15 | 0.89 | 4.61 | 3.62 | 9.40 | — | — | 4.24 |
| Chaerophyllum procumbens (L.) Crantz | 1.65 | — | 0.41 | 0.77 | 0.23 | 0.15 | — | 0.46 |
| Cryptotaenia canadensis (L.) DC. | 1.64 | 0.88 | — | 0.67 | — | 1.31 | — | 0.64 |
| Geum canadense Jacq. | 1.55 | — | 0.14 | — | 2.52 | 1.82 | — | 0.86 |
| Parthenocissus quinquefolia (L.) Planch. | 1.07 | 6.58 | 0.95 | — | 0.56 | 4.15 | — | 1.90 |
| Viola papilionacea Pursh. | 5.16 | 1.66 | 2.28 | — | 13.33 | 1.36 | — | 3.40 |
| Pilea pumila (L.) Gray | 0.36 | — | 15.84 | 3.99 | 1.25 | 15.12 | — | 5.22 |
| Solidago sp. | 2.74 | 2.68 | 0.25 | 0.42 | 0.63 | 0.27 | — | 1.00 |
| Urtica dioica L. | 5.09 | 3.90 | 4.15 | 4.46 | 8.76 | 1.66 | — | 4.00 |
| Impatiens pallida Nutt. | 8.36 | 21.25 | 10.87 | 12.82 | 10.69 | 6.85 | — | 10.08 |
| Laportea canadensis (L.) Wedd. | 9.01 | 11.58 | 11.66 | 16.08 | 20.41 | 17.56 | — | 12.33 |
| Viola sp. | 0.14 | — | — | 2.85 | 1.92 | — | 0.18 | 0.73 |
| Polygonum sp. | 4.09 | 0.22 | .023 | 1.99 | — | — | 0.31 | 0.98 |
| Aster sp. | 2.09 | — | 0.24 | 4.24 | 0.96 | 0.27 | 0.37 | 1.11 |
| Rhus radicans L. | 3.72 | 0.20 | — | — | — | 1.17 | 3.12 | 1.17 |
| Viola canadensis L. | 17.08 | 8.97 | 11.68 | 2.07 | 5.62 | — | 0.80 | 6.60 |
| Smilax hispida Muhl. | 0.85 | 0.21 | 4.52 | 0.68 | 0.32 | 0.45 | 0.99 | 1.15 |
| Osmorhiza longistylus (Torr.) DC. | 1.53 | 3.60 | 1.05 | 1.53 | 0.44 | 0.31 | 1.43 | 1.21 |

TABLE 1.—Continued

| Species | Distance in Meters from White River | | | | | | | Average Percent Importance |
|---|---|---|---|---|---|---|---|---|
| | 50 | 100 | 150 | 200 | 250 | 300 | 350 | |
| Sanicula canadensis L. | 0.78 | 8.94 | 0.63 | 7.56 | 1.85 | 10.34 | 3.12 | 4.75 |
| Galium aparine L. | 1.25 | 1.40 | 7.37 | 15.41 | 2.60 | 5.31 | 4.94 | 5.47 |
| Asarum canadense L. | — | 11.99 | 2.57 | — | 0.22 | 8.82 | 24.80 | 6.91 |
| Boehmeria cylindrica (L.) Sw. | — | 0.31 | — | — | — | 0.51 | — | 0.12 |
| Sambucus canadensis L. | — | — | 0.36 | — | — | — | — | 0.05 |
| Glechoma hederacea L. | — | — | 0.37 | — | — | — | — | 0.05 |
| Polygonum virginianum L. | — | — | 0.39 | — | — | — | — | 0.06 |
| Isopyrum biternatum (Raf.) T. & G. | — | — | 0.22 | 0.39 | — | — | — | 0.09 |
| Tradescantia virginiana L. | — | — | 0.72 | — | — | — | 0.37 | 0.16 |
| Verbesina alternifolia (L.) Britt. | — | — | 0.42 | 0.76 | — | — | — | 0.17 |
| Euonymus obovatus Nutt. | — | — | 0.18 | 0.24 | — | 0.33 | 0.53 | 0.18 |
| Ipomoea pandurata (L.) G.F.W. Meyer | — | — | 0.17 | 1.96 | 0.69 | — | — | 0.40 |
| Ranunculus septentrionalis Poir. | — | — | 0.14 | 0.58 | 1.60 | 1.12 | — | 0.49 |
| Anemonella thalictroides (L.) Spach. | — | — | 2.16 | — | — | — | 0.25 | 0.71 |
| Thalictrum revolutum DC. | — | — | — | 0.29 | — | — | — | 0.04 |
| Camassia scilloides (Raf.) Cory. | — | — | — | 11.99 | — | — | — | 1.71 |
| Hydrophyllum macrophyllum Nutt. | — | — | — | 1.28 | 11.13 | 10.10 | 24.93 | 6.76 |
| Carex hirtifolia Mackenzie. | — | — | — | — | 0.22 | — | — | 0.03 |
| Prunella vulgaris L. | — | — | — | — | 0.25 | — | — | 0.04 |
| Arisaema dracontium (L.) Schott. | — | — | — | — | 0.30 | — | — | 0.04 |
| Carex jamesii Schw. | — | — | — | — | 0.43 | — | — | 0.06 |
| Selaginella apoda (L.) Spring. | — | — | — | — | 0.69 | — | — | 0.10 |
| Carex grisea Wahl. | — | — | — | — | 0.30 | 0.40 | — | 0.10 |
| Asimina triloba (L.) Dunal. | — | — | — | — | 0.46 | 1.09 | — | 0.22 |
| Phlox divaricata L. | — | — | — | — | — | 0.20 | — | 0.03 |
| Cornus florida L. | — | — | — | — | — | 0.28 | — | 0.04 |
| Carex sp. | — | — | — | — | — | 0.65 | — | 0.09 |
| Cercis canadensis L. | — | — | — | — | — | 0.97 | — | 0.14 |
| Silene stellata (L.) Ait. | — | — | — | — | — | 1.01 | — | 0.14 |
| Sanguinaria canadensis L. | — | — | — | — | — | 1.17 | 0.42 | 0.23 |
| Geranium maculatum L. | — | — | — | — | — | 1.66 | 9.75 | 1.63 |
| Arisaema triphyllum (L.) Schott. | — | — | — | — | — | — | 0.30 | 0.04 |
| Acer saccharum Marsh. | — | — | — | — | — | — | 0.32 | 0.05 |
| Aristolochia serpentaria L. | — | — | — | — | — | — | 0.38 | 0.05 |
| Panicum sp. | — | — | — | — | — | — | 1.17 | 0.17 |
| Trillium recurvatum Beck. | — | — | — | — | — | — | 2.10 | 0.30 |
| Hepatica acutiloba DC. | — | — | — | — | — | — | 3.85 | 0.55 |
| Smilacina racemosa (L.) Desf. | — | — | — | — | — | — | 3.93 | 0.56 |
| Viburnum prunifolium L. | — | — | — | — | — | — | 4.48 | 0.64 |
| Stellaria sp. | — | — | — | — | — | — | 6.66 | 0.95 |
| Undetermined spp. | 0.91 | 1.09 | — | — | 0.55 | 4.01 | 0.23 | 0.97 |

Overall, *Laportea canadensis* and *Impatiens pallida* were the dominant species with an average combined importance value of 22.4% (Table 1). Important subdominants include *Viola canadensis, Galium aparine, Pilea pumila, Sanicula canadensis, Elymus virginicus, Rudbeckia laciniata* and *Urtica dioica* with a combined average importance of 35.0%. Collectively, these nine most important species comprise 57.4% of the groundlayer community. The ten woody species were spotty in distribution and had a combined importance of only 5.5%, with *Parthenocissus quinquefolia, Rhus radicans* and *Smilax hispida* contributing 4.1%. This illustrates the paucity of woody seedlings on frequently-flooded landscapes.

Several species had locally high importances due to large colonies falling into one or two sample plats. Examples include *Lysimachia nummularia* near the river edge, *Viola papilionacea* near the river edge and in a back water depression below the upland, and *Camassia scilloides* near the middle of the floodplain.

The groundlayer vegetation shifts sharply in composition from the floodplain to the upland sites (Table 1). Large colonies of *Hydrophyllum macrophyllum* and *Asarum canadensis* dominate the upland community at a combined importance of 49.75%. Subdominant species are *Geranium maculatum, Stellaria* sp., *Galium aparine, Viburnum prunifolium, Smilacina racemosa* and *Hepatica acutiloba* collectively total 33.6% importance. All of these species are typical of upland forests of the midwest. Floodplain species were absent from the upland, or present at very low importance.

*Shrub Layer Composition*

Although 21 woody species were encountered in the combined plots of both transects, densities were very low in the floodplain community. Only 45 individuals were distributed among only 8 species (Table 2). In contrast the upland slope community contained 208 individuals representing 18 species, almost half of which were *Acer saccharum* seedlings.

TABLE 2. *Changes in densities of woody species within the shrub stratum (>0.5<3m. tall) from the White River across the floodplain into the upland forest.*

| | Distance in Meters from White River | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | 50 | 100 | 150 | 200 | 250 | 300 | 350 | Total |
| Smilax hispida Muhl. | 1 | — | 10 | — | — | 2 | 2 | 15 |
| Celtis occidentalis L. | 1 | 3 | — | — | — | 5 | 3 | 12 |
| Aesculus glabra Willd. | 1 | 8 | — | — | — | — | — | 9 |
| Parthenocissus quinquefolia L. Planch. | 1 | — | — | 2 | — | — | — | 3 |
| Fraxinus quadrangulata Michx. | — | 4 | — | — | — | — | — | 4 |
| Lindera benzoin L. Blume. | — | — | 5 | 5 | — | 2 | 14 | 26 |
| Asimina triloba (L.) Dunae. | — | — | — | 1 | 1 | 22 | — | 24 |
| Acer negundo L. | — | — | — | 2 | — | 6 | — | 8 |
| Crataegus sp. L. | — | — | — | — | — | 1 | — | 1 |
| Euonymus obovatus Nutt. | — | — | — | — | — | 1 | — | 1 |
| Platanus occidentalis L. | — | — | — | — | — | 1 | — | 1 |
| Viburnum prunifolium L. | — | — | — | — | — | — | 13 | 13 |
| Staphylea trifoliata L. | — | — | — | — | — | — | 12 | 12 |
| Ulmus rubra Muhl. | — | — | — | — | — | — | 11 | 11 |
| Ostrya virginiana (Mill.) K. Koch. | — | — | — | — | — | — | 5 | 5 |
| Cornus sp. L. | — | — | — | — | — | — | 2 | 2 |
| Carya ovata Mill. | — | — | — | — | — | — | 1 | 1 |
| Cornus florida L. | — | — | — | — | — | — | 1 | 1 |
| Juglans nigha L. | — | — | — | — | — | — | 1 | 1 |
| Quercus muhlenbergii Engelm. | — | — | — | — | — | — | 1 | 1 |
| Total | 4 | 15 | 15 | 10 | 1 | 56 | 152 | 253 |

Only four species of true shrubs and vines were encountered, with the balance tree seedlings. Of these, only *Lindera benzoin* and *Smilax hispida* contained more than three individuals. *Fraxinus quadrangulata* was the only species not expected to occur in floodplain habitats.

*Canopy Tree Composition*

Twenty-six species contributed to the tree stratum (Table 3), but four of these were large-sized shrubs or lianas. Size-class distributions for individuals over 5 cm

TABLE 3. *Size-class distribution of tree species above 5 centimeters (2 inches) dbh. Data are combined values for both transects across the floodplain from the White River into the upland forest.*

| | Size Class in Centimeters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | 5-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-80 | 80-100 | 100-120 | 120 | Total Stems |
| Acer negundo L. | 45 | 26 | 10 | 8 | 8 | — | — | — | — | 93 |
| Celtis occidentalis L. | 34 | 22 | 13 | 8 | 5 | 2 | 2 | — | — | 86 |
| Aesculus glabra Willd. | 26 | 8 | 2 | 2 | 6 | — | — | — | — | 44 |
| Acer saccharum Marsh. | 12 | 8 | 2 | 1 | 3 | — | — | — | — | 26 |
| Acer saccharinum L. | 14 | — | 4 | 1 | 2 | 1 | 1 | 1 | — | 24 |
| Ulmus americana L. | 7 | 3 | 3 | 2 | 1 | — | — | — | — | 16 |
| Fraxinus nigra Marsh. | — | 3 | 3 | 3 | 2 | — | — | — | — | 11 |
| Platanus occidentalis L. | 1 | — | — | — | — | 2 | 2 | 1 | 2 | 8 |
| Fagus grandifolia Ehrh. | 1 | 1 | — | 1 | 2 | 1 | 1 | — | — | 7 |
| Carpinus caroliniana Walt. | 5 | 2 | — | — | — | — | — | — | — | 7 |
| Fraxinus americana L. | — | 1 | 1 | 1 | 2 | — | — | — | — | 5 |
| Juglans nigra L. | — | 2 | 1 | 2 | — | — | — | — | — | 5 |
| Other species | 19 | 3 | 2 | — | 1 | 2 | — | — | — | 27 |
| Total | 164 | 79 | 41 | 29 | 28 | 8 | 6 | 2 | 2 | 359 |

[1]Other species in descending order: Asimina triloba (L.) Dunal.; Fraxinus pennsylvanica Marsh.; Ostrya virginiana (Mill.) K. Koch; Quercus bicolor Willd.; Cercis canadensis L.; Parthenocissus quinquefolia L.; Q. marcrocarpa Michx.; Ulmus rubra Muhl.; Vitis sp. L.; Cornus florida L.; Populus deltoides Bartr.; Q. alba L.; Rhus radicans L.; Staphylea trifoliata L.

(2 inches) dbh are listed by species in Table 3. By density, *Acer negundo* and *Celtis occidentalis* predominate with a combined total of 49.9% of the stems. By size-class, 45.7% of the stems are under 10 cm (4 inches) dbh, with *A. negundo, C. occidentalis* and *Aesculus glabra* the major contributors.

Large individuals of several species were present, including two *Platanus occidentalis* at 122-cm (48.0 inches) dbh and one at 105 cm (41.1 inches). Several larger stems of sycamore occurred outside the plots. *Acer saccharinum* reached 103 cm (40.6 inches); *C. occidentalis* 90 cm (35.4 inches); the largest *A. glabra* was 59.0 (23.2 inches) with five others over 40 cm; and *A. negundo* 49 cm (18.9 inches). A lone beech on the floodplain was 89 cm (35.0 inches), perhaps signifying establishment two centuries or more ago when flooding levels, frequencies and durations were much different than those occurring today. One *Parthenocissus quinquefolia* growing on a large hackberry tree was taped at 15.9 cm (6.2 inches) dbh.

Figure 2 illustrates continuum-type changes in basal area contributions for the 16 most prevalent tree species. *Acer saccharinum, Aesculus* and *Celtis* dominate the stand near the river bank; with a more mixed community of *Celtis, A. negundo, Platanus, Juglans, Ulmus* and *Fraxinus* occurring near the middle of the floodplain. Back-water depressions near the upland slope contained a preponderance of *Fraxinus nigra, Quercus bicolor* and *Populus deltoides*. The mesophytic upland community was dominated by *Fagus, Acer saccharum*, and *Q. alba*, with *Carpinus* and *Ostrya* in the understory.

*Juglans, Ulmus* and *A. negundo* were the widest amplitude species, each ranging across most of the transect lengths, but at low basal area contributions (Figure 2). Large pulses of basal area frequently result from one or two very large trees at a given location. The presence of *Fagus* on the floodplain represents the single large tree mentioned above. Nomenclature follows Gleason and Cronquest (1963) (3).

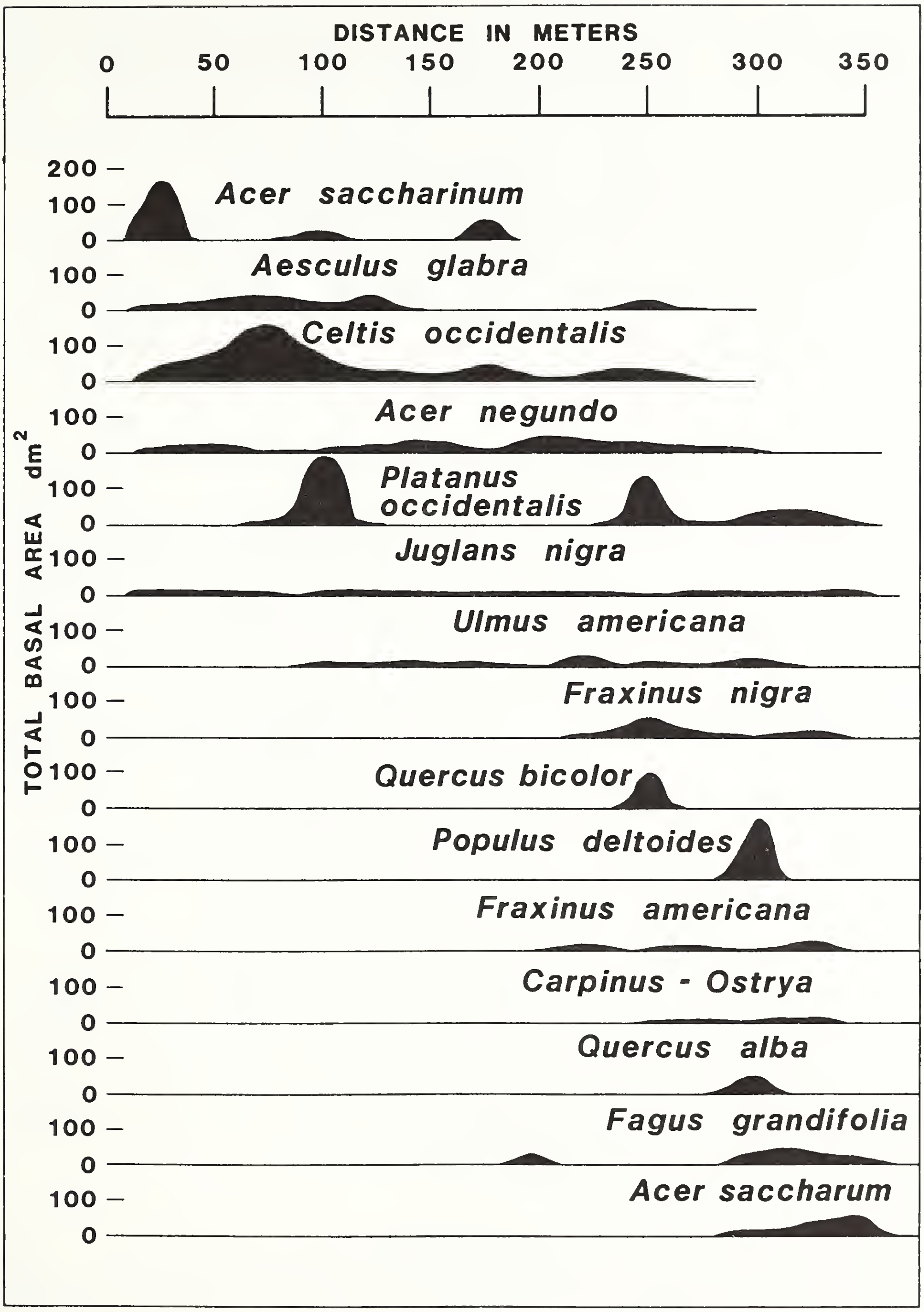


FIGURE 2. *Changes in absolute basal area values for canopy tree species along transects from the White River to the upland. Values are additive for the two transects and expressed in square decimeters.*

## Discussion

Although floodplains provide relatively uniform ecological conditions over considerable geographic distance, variations in topography, soils and drainage create a mosaic of microhabitats within a given stand (Petty and Jackson, 1966) (7). Such variability permits floodplain forest communities to assume a more fixed character than would usually be typical for an upland site with similar variations in relief. Dominance of canopy trees shifts markedly (Figure 2) in response to distance from the river, presence of depressions or low ridges and differences in soil texture. As demonstrated by Lindsey, *et al.* (1961), they are particularly well-suited for continuum analysis in response to flooding tolerance of tree species (6).

Figure 2 is a graphical representation of continuum shifts in canopy composition typical of old-growth floodplain stands. Groundlayer species have similar changes in composition and dominance along floodplain gradients (Table 2), although the relatively greater number of species causes more blurring of differences than occurs for trees. Densities are too low within the shrub layer to demonstrate much zonation within the floodplain proper, but changes are pronounced between floodplain and upland (Table 2).

Lee's (1945) study of 20 floodplain stands throughout much of the length of the White River revealed nine tree species to be major contributors to canopy cover for all stands studied (5). Seven of the nine species were common to this study. *Salix nigra* was conspicuously absent from the stand. Lee's (1945) stand near the Hamilton-Marion County line is remarkably similar to our stand in that the six most prevalent species in each study are identical, and in almost the same order of importance (5). In both cases *Aesculus glabra* assumed greater importance than usually occurs in floodplain forests.

Both Crankshaw (1964) and Qadir (1964) listed forest composition by soil types for presettlement Indiana (2,8). Their stand tables for Eel and Genesee silt loam soils list more mesophytic species at higher importance of American beech and sugar maple in presettlement floodplain forests (beech averaged 24.8% importance for the two soil types in the two studies; sugar maple averaged 9.2%). We found a single large beech and no sugar maple. White oak and tulip tree (*Liriodendron tulipifera*) were both present on presettlement floodplains, but absent today. Ohio buckeye averaged 5.5% in presettlement floodplains; almost identical to our value of 6.2%.

Undoubtedly the frequency, duration and heights of floods have been increased due to clearing the watershed for agricultural and other purposes. Silt coatings of floodplain soils during high water may also retard seedling establishment for mesophytic species. With increased pressures on watersheds of Midwestern streams, the few remaining high quality floodplain forests such as the one described here take on increased value as reference ecosystems. Our hope is that this study will improve the chances for preservation of this fine old-growth stand.

## Acknowledgment

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