COMPOSITION AND STRUCTURE OF AN OLD-GROWTH FLOODPLAIN FOREST OF THE LOWER KASKASKIA RIVER

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ABSTRACT.—Compositional and structural properties of canopy, shrub/sapling, and ground-cover strata were measured within an old-growth floodplain forest bordering the lower Kaskaskia River in southwestern Illinois. Basal area for trees was estimated at 31.8 m^2/ha, tree density was 398 trees/ha with 27 species recorded in the canopy stratum. The dominant tree species were *Acer saccharinum, A. negundo, Carya laciniosa, Ulmus rubra,* and *Quercus macrocarpa*. Presently, there appears to be insufficient recruitment to maintain *A. saccharinum* at current abundance levels in the canopy. Total sapling/shrub density, including woody vines, was estimated to be 7,440 stems/ha and 24 species were recorded. Dominant species were *Toxicodendron radicans, Campsis radicans, Ulmus rubra, Celtis occidentalis*, and *Ilex decidua*. Ground-cover vegetation was characterized by species density (species per 1/4-m^2 quadrat) of 4.88, with 81 species (in 240 quadrats), and 80.8 percent cover. Dominant species were *Laportea canadensis, Toxicodendron radicans, Ranunculus septentrionalis, Viola pratincola*, and *Galium aparine*. The floodplain is a mosaic of intergrading wet, wet-mesic, and mesic floodplain forest natural communities.

An assessment was made of the vegetation within selected portions of the Kaskaskia River Corridor (KRC) with a focus on native plant communities (Taft, unpubl. report A). The KRC is an area of privately owned lands in Clinton, Washington, and St. Clair Counties in southwestern Illinois bordering the Kaskaskia River between Carlyle, and a reservoir at Carlyle, and Fayetteville, IL (Evans and others, unpubl. report). The vegetation of the KRC is a particularly noteworthy resource because it includes some of the largest tracts of unfragmented forest remaining in Illinois, including some old and old second-growth stands of floodplain forest and flatwoods, providing habitat for area-sensitive native plant and animal species. About 343 acres of forest within the KRC are recognized as statewide-significant natural areas (i.e., remain in a state of high ecological integrity (White 1978)) including about 230 acres of flatwoods and 110 acres of floodplain forest. In addition to the sites recognized as natural areas, many other forest stands in the KRC have considerable ecological integrity and/or restoration potential.

The main goals of the vegetational survey were to identify and describe the natural plant communities present in the KRC and provide estimates on composition, abundance, and diversity patterns in an old-growth forest associated with the Kaskaskia River. A specific focus was to estimate the spatial heterogeneity of old-growth floodplain forest community types, to examine patterns of recruitment among canopy species, and to document composition, abundance, and diversity patterns among all vegetation strata in an old-growth floodplain forest complex. These data provide a representative standard for comparison with other floodplain forests in the region.

NATURAL DIVISION AND PHYSIOGRAPHIC REGION

The KRC occurs in the Southern Till Plain Natural Division (Schwegman and others 1973). The lower portion of the Kaskaskia River basin, the area including the KRC, occurs in the Mt. Vernon Hill Country physiographic division (Leighton and others 1948), a region characterized by surface deposits of the Illinoian glacial period. Elevation within the KRC ranges from a

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minimum of about 116 m above sea level at the lowest reach of the Kaskaskia River in the study area at Fayetteville, to a maximum of about 180 m above sea level at the "Pelican Pouch" glacial feature 6 km SSW of Carlyle. However, by far, most of the forest in the study area occurs between the 116 m and 125 m contour intervals. The KRC occurs within the Kaskaskia River Ecosystem Partnership Assessment Area, a 9,248 km^2 area mostly defined by the drainage basin of the Kaskaskia River. The vegetational and physiographic characteristics of that region previously have been described (Taft unpubl. report B).

METHODS

The vegetation in the KRC was examined with two methods:

1) basic floristic inventory of available habitats, and
2) quantitative vegetation sampling in representative forest habitats.

The results of quantitative sampling in a floodplain forest and, in part, adjacent flatwoods, are reported here.

Quantitative Sampling

Overstory, shrub/sapling, and ground-cover sample data were collected in a stratified-random sampling regime with nested subsamples for each vegetation stratum. In order to provide a description of the composition, abundance, and diversity patterns associated with the gradient from forest bordering the river to upland forest habitat, the vegetation was sampled across the floodplain, extending in a distance gradient perpendicular from the Kaskaskia River, until reaching upland forest habitat, in this case flatwoods. The site sampled, Jackson Slough Woods (038° 25′ 23.66″ N latitude, 089° 45′ 52.99″ W longitude), is 181-acre unit within a larger forest and is recognized by the Illinois Natural Areas Inventory as a high-quality natural area with Grades A and B floodplain forest and southern flatwoods (White 1978).

Vegetation was sampled using two parallel transects, each approximately 275 m long, oriented perpendicular to the axis of the Kaskaskia River. The locations of the transects and plots were determined randomly. Trees (woody stems ≥ 6 cm diameter-at-breast-height [dbh]) were sampled in ten 0.05-ha circular plots on each transect for a total of 20 plots. Tree basal area (derived from dbh) and tree density were recorded for all individuals of each species from each plot. Importance values (IV 200) for each species were derived by summing relative basal area and relative density. Density of shrubs and saplings (woody plants < 6 cm dbh and > 50 cm high) was determined from a 0.005-ha circular plot nested at the center of each tree plot. Importance values for shrubs and saplings were calculated by summing relative density and relative frequency.

Frequency and cover data for herbaceous species, seedlings (woody plants < 50 cm), and vines were collected from twelve 0.25-m^2 quadrats in each tree plot. Importance values for each species (IV 200) were calculated by summing relative cover and relative frequency. The ground-cover plots were located along a line transect at 1 m intervals along a randomly determined radius of the tree plot. Only plants rooted in the quadrats were recorded. Sample data collected with similar methods from flatwoods adjacent to the Jackson Slough floodplain forest in a previous study (Taft and others 1995) were used to contrast with the floodplain forest communities. In the flatwoods study, tree plots were independent (not along a transect) and for ground cover 25 quadrats were sampled across a random diameter of each tree plot. Botanical nomenclature follows Mohlenbrock (1986). Classification of natural communities follows White (1978).

Data Analysis

Relationships of diversity and abundance within and among vegetation strata were examined with correlation analysis. Stand compositional and structural stability was examined using a similarity index (Similarity = 2C/A+B, whereas C = species in common, A is species number from subcanopy, and B is species number from canopy) (Mueller-Dombois and Ellenberg 1974).

Vegetation Analysis by Ordination

Ordinations shown for this study are biplots with species and site scores plotted in the diagrams. The ecological meaning of the axes when only species-sample data (and no environmental data) are available are interpretations based on the arrangement of species in the ordinations. The axes can be interpreted as representing gradients of environmental variables and the patterns of species abundance and plot associations in the biplots thus represent the response to the environmental gradients. For some ordinations in this study, to elucidate the relationships among species of floodplain forest and adjacent flatwoods, data previously collected from the flatwoods at Jackson Slough Woods were used (Taft and others 1995).

Vegetation data for each stratum was examined by Detrended Correspondence Analysis (Gauch 1982), using CANOCO ver. 4.0 (ter Braak and Smilauer 1998) in order to characterize the species and plots associations in the floodplain forest and flatwoods habitats. Detrended Correspondence Analysis (DCA) is a multivariate ordination method for indirect gradient analysis based on a unimodal response model and is often used with vegetation data to describe communities, particularly when samples (as in this study) come from across a range of habitats (ter Braak 1995). Gradient lengths on the first DCA axis were greater than 4.9 s.d. for all strata in this study justifying use of a unimodal model rather than a linear-response model such as with Principal Components Analysis. Cluster analysis (PC-ORD ver. 2; McCune and Mefford 1995), a method used to define groups of plots based on similarities, was used for the tree sample data. DCA and cluster analysis were used together to objectively identify plant communities based on tree sample data and how these may relate to natural community classification.

RESULTS AND DISCUSSION

Quantitative Sampling of Floodplain Forest Canopy Stratum

Twenty-six species of woody plants, including trees and a few large grape vines, were identified in the canopy stratum. Based on importance values, *Acer saccharinum* (see Appendix for authority and corresponding common plant names) is the most abundant tree species followed by *A. negundo*, *Carya laciniosa*, *Ulmus rubra*, *Quercus macrocarpa*, and *Fraxinus pennsylvanica* (table 1). Total tree density was 398/ha and total basal area was 31.8 m^2/ha. Stand basal area is slightly less than an old and old second-growth floodplain forest at the northern extent of the coastal plain (34.4 m^2/ha) in southern Illinois (Robertson and others 1978), but greater than southern wet forests (22.6 m^2/ha) at their northern extent in southern Wisconsin (Curtis 1959), and considerably greater than most old growth dry upland forests, flatwoods, or savannas (e.g., Fralish and others 1991, Taft 1997).

Size-class distribution patterns indicate that *A. saccharinum* dominates the intermediate size classes (fig. 1a); however, there are few silver maples in the smaller size classes indicating that presently there is little successful recruitment to the canopy stratum. The pattern for silver maple tree density indicates trees are common in all plots except those nearest and furthest from the river. However, the average diameter of individual trees is greatest near the river. Consequently, while there are fewer trees near the river, their size (and presumably average age) is the greatest in the floodplain; average diameter declines in intermediate zones in the floodplain and increases somewhat away from the river (fig. 1b).

The pattern suggests that establishment and recruitment of silver maple may have changed over time creating a mosaic of scattered old trees near the river, relatively dense stands of smaller (and presumably younger) trees in intermediate zones, and intermediate size and density in the floodplain farthest from the river. As the sample transects ascend a few meters towards the flatwoods community (plot 9 in

Table 1.—*Characteristics of canopy tree species of the floodplain at Jackson Slough Woods in the Kaskaskia River Corridor study area. BA = basal area, IV = importance value, RD = relative density, RBA = relative basal area.*

Species	BA/ha (m-sq)	Density per ha	IV 200 (RD+RBA)
Acer saccharinum	9.269	81	49.48
Acer negundo	1.789	95	29.52
Carya laciniosa	6.201	27	26.27
Ulmus rubra	1.004	46	14.71
Quercus macrocarpa	2.943	9	11.51
Fraxinus pennsylvanica	2.534	11	10.73
Quercus stellata	2.010	12	9.33
Celtis occidentalis	1.124	21	8.81
Carya ovata	0.521	16	5.66
Platanus occidentalis	1.042	7	5.03
Ilex decidua	0.063	15	3.97
Quercus palustris	1.085	2	3.91
Cercis canadensis	0.082	14	3.78
Carya tomentosa	0.446	6	2.91
Morus rubra	0.054	10	2.68
Juglans nigra	0.477	3	2.25
Quercus velutina	0.603	1	2.15
Ulmus americana	0.360	3	1.89
Celtis laevigata	0.083	6	1.77
Vitis sp.	0.016	3	0.80
Populus deltoides	0.063	2	0.70
Sassafras albidum	0.012	2	0.54
Prunus serotina	0.008	2	0.53
Diospyros virginiana	0.005	1	0.27
Vitis aestivalis	0.004	1	0.27
Vitis cinerea	0.004	1	0.27
Quercus rubra	0.004	1	0.26
TOTALS	**31.82**	**398**	**200.00**

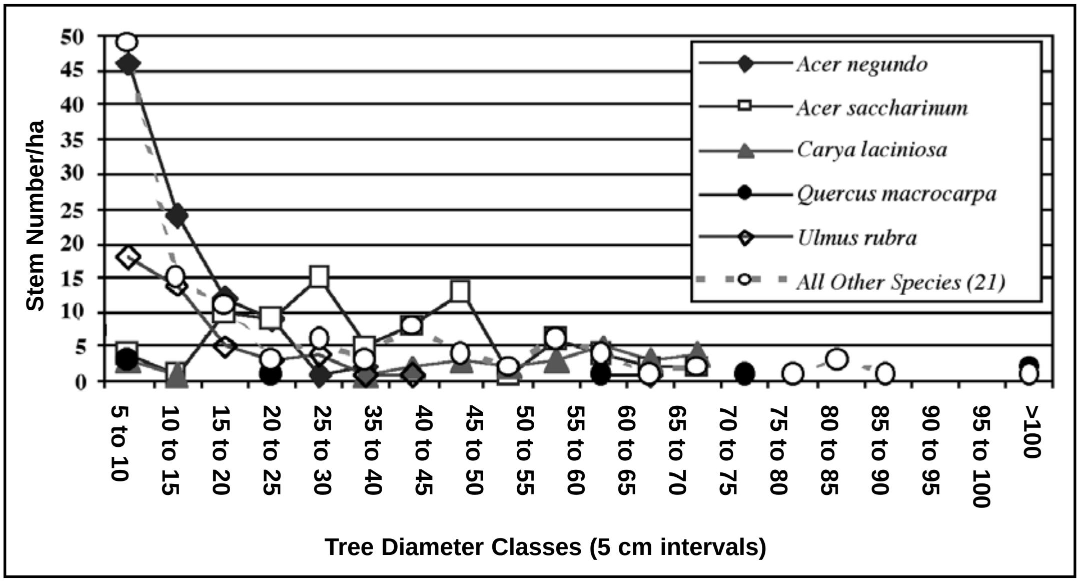

Figure 1a.—*Distribution of tree size classes among dominant floodplain forest tree species at Jackson Slough Woods.*

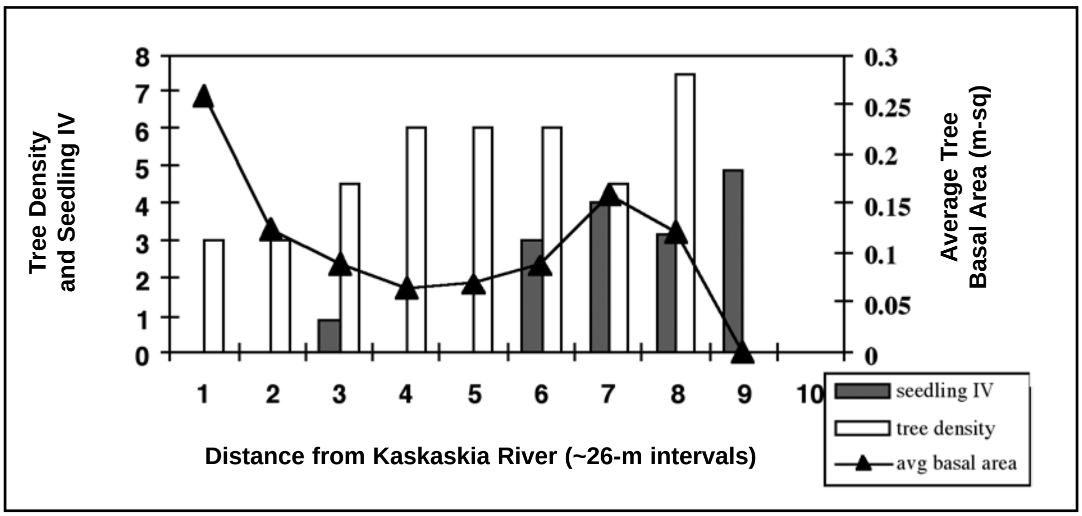

Figure 1b.—*Pattern of tree density, average diameter, and recruitment of silver maple* (Acer saccharinum) *seedling recruitment in old-growth floodplain forest habitat. The distance intervals refer to plot numbers and the data are averaged among two transects. Tree plot size was 0.05-ha; seedling IV refers to the total importance value (sum of relative freqency and percent cover).*

both transects), there are no silver maple trees although seedlings are present. These patterns may reflect variation in flooding season and duration over time due to a meandering river channel. However, hydrological changes as a result of damming the Kaskaskia River upstream at the Carlyle Reservoir may limit flood levels and duration downstream and alter the recruitment patterns for some species such as *A. saccharinum*.

Compositional changes favoring more flood and silt-tolerant tree species like *Acer saccharinum* appear to have occurred since settlement along many Illinois streams (King and Johnson 1977, Nelson and others 1994). Siltation from agricultural lands into the floodplain of the Kaskaskia River and tributaries also may have promoted similar changes in floodplain vegetation within the KRC, at least prior to construction of the Carlyle Reservoir. Floodplain forests in the KRC include some stands, young and mature ages, that are dominated by *A. saccharinum*. However, in contrast to many floodplain forests in glaciated portions of Illinois, oak and hickory species are among the dominant trees in several sites in

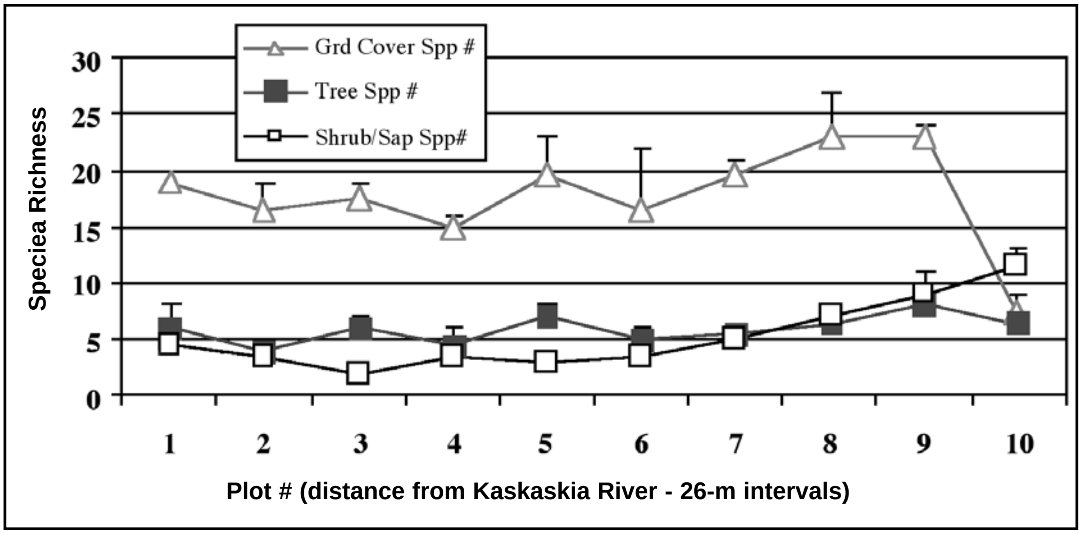

Figure 1c.—*Species richness patterns among vegetation strata along distance gradient from Kaskaskia River to transition with flatwoods upland forest habitat. Values are averages from two parallel transects. Ground-cover species richness was determined from twelve 0.25-m² quadrats per transect at each distance interval (24 plots/interval); shrub/sapling species richness is average from two 0.005-ha circular plots at each interval; tree species richness is average from two 0.05-ha circular plots at each interval. Error bars are standard error.*

the KRC. While *A. saccharinum* is the most dominant species in the sample data, based on total basal area the second and third ranking species are *Carya laciniosa* and *Quercus macrocarpa*, respectively (table 1). Neither species is abundant among individual size classes but both are present as a few trees among small and larger classes suggesting ongoing recruitment that may sustain both species (fig. 1a).

Abundance patterns for *C. laciniosa* and *Q. macrocarpa* show that they are most common in plots where *A. saccharinum* is in low abundance (fig. 2) suggesting these species occupy different habitat niches in the floodplain. At transect 1, *A. saccharinum* is most abundant near the river and becomes less common farther away while *Q. macrocarpa* and *C. laciniosa* become more dominant farther from the river. However, at transect 2, *A. saccharinum* becomes most abundant at points farther from the river while *Q. macrocarpa* and especially *C. laciniosa* are more common near the river. This suggests that the two transects capture some of the spatial variation of the floodplain where local overflow channels and ponding occur at locations distant from the river.

Detrended Correspondence Analysis (DCA) for the canopy stratum reveals clear separation along the first axis (eigenvalue of 0.898) between vegetation in the floodplain forest from the adjacent flatwoods and places plots and tree species found in the transition zone (e.g., *Prunus serotina, Q. velutina, Q. stellata,* and *Carya ovata* in plots 9 and 10 on each transect) in an intermediate position (fig. 3a). Axis II separates plots with species such as *Q. macrocarpa, Q. palustris, Carya laciniosa* from plots characterized by *Platanus occidentalis, Populus deltoides*, and *Acer saccharinum*, species often associated with greater flood frequency and duration. Based on species and plot positions in the ordinations, Axis I is interpreted as a moisture gradient and Axis II is interpreted as a flood-disturbance gradient.

Cluster analysis was used to objectively identify plant species assemblages based on the sample data and how these may relate to natural community classification. With tree data, cluster analysis identified seven groups, based on nearest floristic similarity, and these groups are indicated in the graphical depiction of the DCA (fig. 3a). A key to the species acronyms shown in the ordinations is in the Appendix. From these analyses and the interpretation that the axes in the DCA represent essentially wetness gradients, Group 1 would include plots exposed to the wettest conditions for the greatest duration among all clusters. These plots represent *wet floodplain forest*. Note that in transect 1, plots classified as *wet floodplain forest* (plot 1 and plot 3) are near the river (18 m and 70 m, respectively) while in transect 2, plots classified

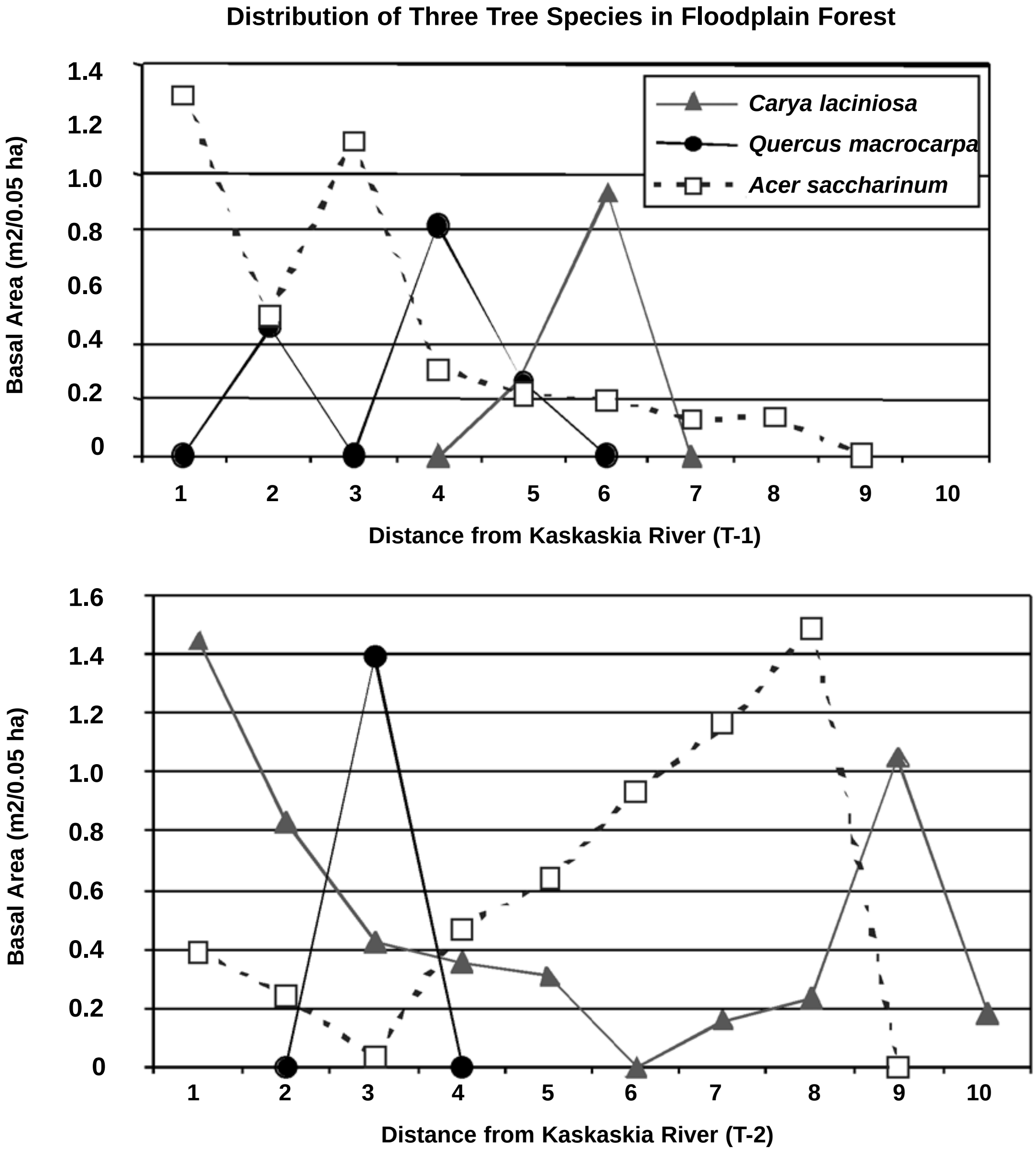

Figure 2.—*Distribution of dominance patterns (basal area m-sq/0.05 ha) for* Acer saccharinum (*Acesai),* Carya laciniosa *(Carlac), and* Quercus macrocarpa *(Quemac), the three most dominant species based on basal area in the floodplain forest samples at Jackson Slough Woods (floodplain). Distance units refer to plot numbers and represent approximately 26-m distance intervals from the Kaskaskia River. T1 refers to Transect 1 and T2 refers to Transect 2.*

as *wet floodplain forest* (plots 6, 7, and 8) occur at locations more distant from the river (147 m to 200 m). Groups 2 and 4 represent *wet-mesic floodplain forest* while Groups 3 and 7 are transitional between the floodplain and adjacent flatwoods (Groups 5 and 6) and can be classified as *mesic floodplain forest*. Richness of tree species across the floodplain and these natural communities remained relatively constant (fig. 1c).

Shrub/Sapling (Subcanopy) Stratum

Twenty-four species of woody plants, including woody vines, shrubs, and saplings, were recorded in the shrub/sapling stratum (table 2). *Toxicodendron radicans* was the most abundant species in the shrub/sapling sample followed by *Campsis radicans, Ulmus rubra, Celtis occidentalis*, and *Ilex decidua*. Stem density was estimated to be 7,440 stems/ha. Excluding the two woody vines, the estimate for saplings and shrubs (mostly saplings) is 3,240 stems/ha.

Only two stems of *Acer saccharinum*, the dominant tree in the sample area, were recorded in the sapling stratum and both were in the same plot. These results, together with data from canopy stratum, indicate that current conditions in the floodplain forest do not favor recruitment of *A. saccharinum*.

Qualitative similarity, a measure of stand stability based on species present both in the subcanopy (i.e., sapling) and canopy stratum (excluding very small species and vines), yielded an index of 72.7 percent. Quantitative similarity, using the least common importance value, yielded an index of 34.47 percent. These values vary only slightly from similarity estimates in the adjacent flatwoods community (78 percent and 21 percent, respectively for qualitative and quantitative indices). Floodplain forest canopy species absent from the subcanopy sample are *Platanus occidentalis, Quercus palustris, Ulmus americana, Populus deltoides,* and *Diospyros virginiana* (a single tree). These trees were all from the wet and wet-mesic floodplain forest zone. Other species absent from the subcanopy include *Juglans nigra, Q. stellata,* and *Q. rubra*, species limited to the transition zone near the flatwoods.

DCA of the shrub/sapling stratum reveals clear separation along the first axis (eigenvalue of 0.851) between vegetation in the flatwoods from floodplain forest (fig. 3b). As with the canopy stratum, based on species and plot positions in the ordination, Axis I is interpreted as a moisture gradient. The species associated with the left side of the first axis (wettest portion of gradient) include *Campsis radicans, Toxicodendron radicans, Fraxinus pennsylvanica, Acer negundo*, and *Ilex decidua*. These are species typically associated with wet and wet-mesic floodplain forest (e.g., plots T1-1, T1-7, T2-6, T2-7, T2-8). Species and plots on the right of Axis I include species of the flatwoods community (e.g., *Prunus serotina, Sassafras albidum, Q. velutina, Q. alba, Carya ovata*, and *Rubus allegheniensis*). Plots and species located intermediately on the first axis were primarily from the mesic floodplain forest transition zone from floodplain forest to flatwoods (e.g., *Morus rubra, Cercis canadensis, Ulmus rubra, Carya tomentosa*) but also included *Carya laciniosa* and *Quercus macrocarpa*. Richness of subcanopy (shrub/sapling) species is low throughout the floodplain but increases in the transition zone (fig. 1c).

Table 2.—*Characteristics of the shrub/sapling stratum of the floodplain forest at Jackson Slough Woods in the Kaskaskia River Corridor study area, St. Clair County, Illinois. IV = importance value, RD = relative density, RF = relative frequency*

Species	Density/ha	% Frequency	IV 200 (RD+RF)
Toxicodendron radicans	2,480	60	44.76
Campsis radicans	1,720	50	32.64
Ulmus rubra	1,060	60	25.68
Celtis occidentalis	480	60	17.88
Ilex decidua	360	40	12.46
Acer negundo	130	45	10.32
Cornus drummondii	310	25	8.93
Fraxinus pennsylvanica	250	20	7.17
Morus rubra	160	25	6.91
Carya laciniosa	80	30	6.79
Cercis canadensis	70	20	4.75
Celtis laevigata	30	15	3.26
Carya tomentosa	30	10	2.31
Euonymus atropurpureus	30	10	2.31
Quercus macrocarpa	20	10	2.17
Sassafras albidum	70	5	1.89
Prunus serotina	60	5	1.76
Acer saccharinum	20	5	1.22
Quercus bicolor	20	5	1.22
Quercus rubra	20	5	1.22
Carya ovata	10	5	1.09
Carya texana	10	5	1.09
Quercus imbricaria	10	5	1.09
Quercus velutina	10	5	1.09
TOTALS	**7,440**		**200.00**

Ground-Cover Stratum

A total of 81 species of vascular plants were recorded in the ground-cover stratum, including 69 and 52 species for transects 1 and 2, respectively. *Laportea canadensis* was the most abundant species occurring in 40 percent of the quadrats (table 3) with about 14 percent of the total IV. Other species with IV > 5.0 in descending rank order of abundance included *Toxicodendron radicans, Ranunculus septentrionalis, Viola pratincola, Galium aparine, Phlox divaricata, Pilea pumila, Campsis radicans, Carex festucacea,* and *Ulmus rubra* (seedlings). *Carex grisea*, if adding the sterile material believed to be this species (see *Carex* cf. *grisea* in table 3) to the identified material, also would rank among the most important species. *Carex* had the most species among genera in the ground-cover sample with 10. No other genus had more than 3 species (*Galium* and *Vitis*).

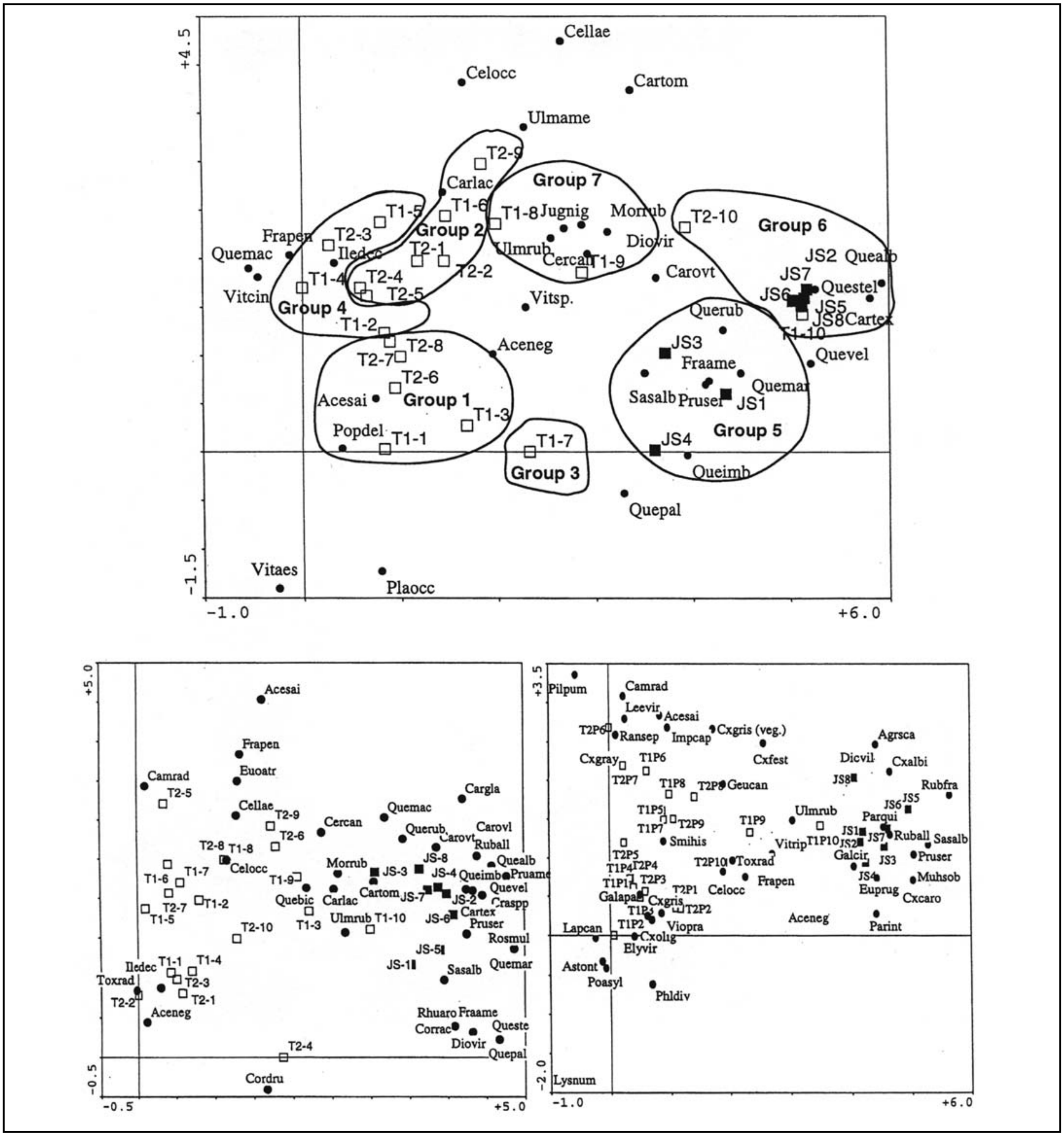

Figure 3a.—*Detrended Correspondence Analysis of canopy stratum of floodplain forest and adjacent flatwoods. Flatwoods plots (JS-1 through JS-8) are indicated by solid squares; plots from floodplain (T1 and T2, plots 1-10) are indicated by open squares. Groupings identified through cluster analysis that are most similar, based on nearest neighbor similarity, also are shown. See Appendix for a key to the species acronym codes.*

Figure 3b.—Detrended Correspondence Analysis of shrub/sapling stratum of floodplain forest and adjacent flat-woods. Flatwoods plots (JS-1 through JS-8) are indicated by solid squares; plots from floodplain (T1 and T2, plots 1-10) are indicated by open squares. See Appendix for a key to the species acronym codes.

Figure 3c.—*Detrended Correspondence Analysis of ground-cover stratum of floodplain forest and adjacent flat-woods. Flatwoods plots (JS-1 through JS-8) are indicated by solid squares; plots from floodplain (T1 and T2, plots 1-10) are indicated by open squares. See Appendix for a key to the species acronym codes.*

Seedlings of *Acer saccharinum* were relatively scarce, occurring in about 7 percent of quadrats and always with less than 5 percent cover (i.e., mostly individual seedlings). These seedlings largely were limited to a zone ranging from about 150 to 230 m from the river (fig. 1b) and were uncorrelated with density of *A. saccharinum* trees (R^2 = 0.0067). Occurrence of silver maple seedlings showed a statistically significant inverse correlation with total percent ground cover (R^2 = 0.22, df = 19, $p < 0.05$). *Acer saccharinum* is considered to be a shade intolerant species and is noted to be intolerant of competition from other ground cover species (Fowells 1965). Existing abundance patterns among strata suggest an approximately 1 percent survival from one stratum to the next.

Estimates for total seedling number of *A. saccharinum* are about 2,833/ha based on 7 percent frequency of typically single seedlings among 240 quadrats. Sapling density was estimated to be about 20/ha while only 1 and 4 stems/ha were found in the two smallest tree size classes (to 15 cm dbh). With these survival patterns, existing seedling density may be insufficient to maintain *A. saccharinum* at the present abundance in the canopy. These trends may be the result of reduced flood frequency and duration and consequently less available bare soil for successful establishment of *A. saccharinum* seedlings or recruitment of seedlings into the subcanopy or canopy stratum. Regulation of flooding in the watershed may influence long-term distribution patterns of some species among the overstory strata including the current dominant *A. saccharinum.*

Only a single non-native species, *Lysimachia nummularia*, was recorded in the sampling effort, occurring in about 3 percent of the ground cover quadrats. *Lysimachia nummularia*, a perennial herbaceous vine, is a European species occurring in wet floodplain forests throughout Illinois and the Midwest. It is not known to set fruit in Illinois and reproduces entirely through vegetative means.

Among physiognomic groups, perennial forbs dominated with 26 species and about 44 percent of the importance value, followed by woody vines with 8 species and about 19.5 percent of the IV, annual forbs with 8 species (11.5 percent of IV), perennial sedges with 10 species (10.8 percent), tree seedlings with 12 species (7.5 percent), perennial grasses with 5 species (4.2 percent), shrub seedlings with 3 species (0.5 percent), herbaceous vines with 2 species (0.5 percent), biennial forbs with 2 species (0.13 percent), and ferns with 1 species (0.04 percent) among ground cover stratum.

Table 3.—*Summary of quantitative sample data from the ground cover stratum of the floodplain forest at Jackson Sloug Woods. Only species with IV 200 > 1.0 are shown; remainder are available upon request from author. IV = importance value, RF = relative frequency, RC = relative cover.*

Species	**% Frequency**	**% Cover**	**IV 200 (RF+RC)**
Laportea canadensis	40.0	15.95	27.94
Toxicodendron radicans	46.7	11.53	23.83
Ranunculus septentrionalis	52.9	9.43	22.52
Viola pratincola	50.0	4.01	15.22
Galium aparine	37.9	3.96	12.68
Phlox divaricata	17.1	2.88	7.06
Pilea pumila	17.9	2.53	6.81
Campsis radicans	17.5	2.43	6.59
Carex festucacea	7.1	3.70	6.03
Ulmus rubra	15.4	1.86	5.46
Aster ontarionis	10.8	2.04	4.74
Carex grisea	8.8	2.32	4.66
Leersia virginica	8.3	1.96	4.14
Fraxinus pennsylvanica	15.0	0.83	4.10
Smilax hispida	14.2	0.83	3.94
Carex grayii	5.8	2.18	3.89
Carex oligocarpa	6.3	1.30	2.89
Impatiens capensis	9.2	0.37	2.34
Carex cf. grisea	5.4	0.88	2.20
Celtis occidentalis	8.8	0.19	2.03
Poa sylvestris	5.4	0.70	1.98
Lysimachia nummularia	2.9	1.02	1.86
Elymus virginicus	3.3	0.94	1.85
Parthenocissus quinquefolia	5.8	0.46	1.77
Acer saccharinum	7.1	0.15	1.64
Vitis riparia	5.8	0.19	1.44
Aster lateriflorus	3.8	0.50	1.38
Carex tribuloides	1.7	0.82	1.36
Geum canadense	4.2	0.29	1.23
TOTALS		**StDev**	
# Species/0.25 m-sq plot	**4.9**	**1.32**	
Total % cover	**79.9**	**29.40**	
Total species richness	**81.0**		

Species density (average number of species) for the 240 quadrats sampled in the floodplain averaged 4.86 (sd 1.32) per 1/4-m^2 quadrat. Species richness among the 12 quadrats sampled in each tree plot averaged 17.7 (sd 5.16). Cover of ground-layer vegetation averaged 79.9 percent (sd 29.4) among tree plots and 80.8 percent overall. Species density and richness were highly correlated (R^2 = 0.68, p = 0.0001). Species density and percent cover also showed significant correlation (R^2 = 0.26, p = 0.02); however, there was no correlation between species richness and percent cover. Patterns for species richness among canopy, subcanopy, and ground-cover strata (fig. 1c) show ground cover was the most diverse stratum throughout the floodplain. However, species richness of the ground cover declined sharply in the transition zone to flatwoods and was exceeded there by shrub/sapling species richness.

Based on sample data collected in 1989 (Taft and others 1995), ground cover in the adjacent flatwoods had lower diversity and cover compared with the floodplain forest (e.g., mean species density was 2.38, cover was 25 percent). Total ground-cover richness from 200 quadrats in the adjacent flatwoods was 71 compared to 81 species in 240 quadrats in the floodplain forest. In oak-dominated flatwoods and barrens communities there tends to be an inverse relationship between overstory tree density and ground cover diversity (Taft and others 1995, Taft and Solecki, in press), particularly at sites lacking recent fire history. There is no such relationship between over-story structure and patterns of diversity in the ground-cover stratum in the floodplain communities sampled (R^2 = 0.02, df = 19).

DCA of the ground-cover stratum reveals, similar to the other strata, clear separation along the first axis (eigenvalue of 0.862) between the ground-cover vegetation in the flatwoods from the floodplain forest (fig. 3c). Species associated with wet to wet-mesic floodplain forests (e.g., *Laportea canadensis, Campsis radicans, Pilea pumila, Ranunculus septentrionalis, Viola pratincola, Aster ontarionis, Poa sylvestris, Galium aparine, Leersia virginica, Impatiens capensis, Carex grisea, C. grayii, C. oligocarpa*) predominate the left side of the ordination so again the first axis is interpreted as representing a moisture gradient (drier to the right side). Plots located intermediately on the first axis include species with fairly broad ecological amplitude (e.g., *Carex festucacea, Toxicodendron radicans, Geum canadense, Vitis riparia, Ulmus rubra*). However, interpretation of the second axis is less clear as species associated with the “wettest” tree plots (Group 1, fig. 3a) are scattered along the length of Axis II (fig. 3c).

CONCLUSIONS

The floodplain forest is comprised of a mosaic of wet and wet-mesic floodplain forest. Mesic floodplain forest occurs in transitional areas with flatwoods. The most salient evidence for change in forest composition is among *Acer saccharinum*, which was found to be the dominant species, but for which there was little evidence of successful reproduction or recruitment. Other species of the wet to wet-mesic floodplain forest canopy that were absent from the subcanopy include *Populus deltoides, Platanus occidentalis, Ulmus americana*, and *Quercus palustris*. A total of 87 species were sampled among canopy, shrub/sapling, and ground cover strata within the floodplain forest. Only a single non-native species, moneywort (*Lysimachia nummularia*), was recorded in the vegetation sampling effort. The ground cover was the richest stratum with 81 species; perennial forbs dominated the ground cover with 26 species and 44 percent of the importance value. The canopy and shrub/sapling stratum had 26 and 24 species, respectively. There was no relationship between overstory structure and ground cover diversity patterns.

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APPENDIX

List of acronyms used in ordinations with corresponding scientific and common names.

Acronym	Scientific Name	Common Name
Aceneg	*Acer negundo* L.	box elder
Acesai	*Acer saccharinum* L.	silver maple
Agrsca	*Agrostis perennans* (Walt.) Tuckerm.	autumn bent grass
Astont	*Aster ontarionis* Wiegand	Missouri aster
Camrad	*Campsis radicans* (L.) Seem.	trumpet creeper
Cargla	*Carya glabra* (Mill.) Sweet	pignut hickory
Carlac	*Carya laciniosa* (Michx.) Loudon	kingnut hickory
Carovl	*Carya ovalis* (Wangenh.) Sarg.	false shagbark hickory
Carovt	*Carya ovata* (Mill.) K. Koch	shagbark hickory
Cartex	*Carya texana* Buckl.	Texas hickory
Cartom	*Carya tomentosa* (Poir.) Nutt.	mockernut hickory
Cellae	*Celtis laevigata* Willd.	sugarberry
Celocc	*Celtis occidentalis* L.	hackberry
Cercan	*Cercis canadensis* L.	redbud
Cordru	*Cornus drummondii* C. A. Mey	rough-leaved dogwood
Corrac	*Cornus racemosa* Lam.	grey dogwood
Craspp	*Crataegus* sp.	hawthorn
Cxalbi	*Carex artitecta* Mack.	blunt-scaled oak sedge
Cxcaro	*Carex caroliniana* Schwein.	short-scaled green sedge
Cxfest	*Carex festucacea* Schk.	fescue oval sedge
Cxgray	*Carex grayi* Carey	common bur sedge
Cxgris	*Carex grisea* Wahlenb.	wood gray sedge
Cxgris2	*Carex cf. grisea* Wahlenb.	wood gray sedge
Cxolig	*Carex oligocarpa* Schk.	few-fruited gray sedge
Dicvil	*Dichanthelium villosissimum* (Nash) Freckm.	old field panic grass
Diovir	*Diospyros virginiana* L.	persimmon
Elyvir	*Elymus virginicus* L.	Virginia wild rye
Euoatr	*Euonymus atropurpureus* Jacq.	wahoo
Euprug	*Eupatorium rugosum* Houtt.	white snakeroot
Fraame	*Fraxinus americana* L.	white ash
Frapen	*Fraxinus pennsylvanica* Marsh.	green ash
Galapa	*Galium aparine* L.	annual bedstraw
Galcir	*Galium circaezans* Michx.	wild licorice
Geucan	*Geum canadense* Jacq.	white avens
Iledec	*Ilex decidua* Walt.	swamp holly
Impcap	*Impatiens capensis* Meerb.	jewelweed
Jugnig	*Juglans nigra* L.	black walnut
Lapcan	*Laportea canadensis* (L.) Wedd.	Canada wood nettle
Leevir	*Leersia virginica* Willd.	white grass
Lysnum	*Lysimachia nummularia* L.	moneywort
Morrub	*Morus rubra* L.	red mulberry
Muhsob	*Muhlenbergia sobolifera* (Muhl.) Trin.	rock satin grass
Parint	*Parthenium integrifolium* L.	wild quinine
Parqui	*Parthenocissus quinquefolia* (L.) Planch.	Virginia creeper
Phldiv	*Phlox divaricata* L.	blue phlox
Pilpum	*Pilea pumila* (L.) Gray	clearweed
Plaocc	*Platanus occidentalis* L.	sycamore
Poasyl	*Poa sylvestris* Gray	woodland blue grass
Popdel	*Populus deltoides* Marsh.	cottonwood
Pruame	*Prunus americana* Marsh.	American plum
Pruser	*Prunus serotina* Ehrh.	black cherry
Quealb	*Quercus alba* L.	white oak
Quebic	*Quercus bicolor* Willd.	swamp white oak
Queimb	*Quercus imbricaria* Michx.	shingle oak

Acronym	Scientific Name	Common Name
Quemac	*Quercus macrocarpa* Michx.	bur oak
Quemar	*Quercus marilandica* Muenchh.	blackjack oak
Quepal	*Quercus palustris* Muenchh.	pin oak
Querub	*Quercus rubra* L.	red oak
Questel	*Quercus stellata* Wangh.	post oak
Quevel	*Quercus velutina* Lam.	black oak
Ransep	*Ranunculus septentrionalis* Poir.	swamp buttercup
Rhuaro	*Rhus aromatica* Ait.	aromatic sumac
Rosmul	*Rosa multiflora* Thunb.	multiflora rose
Ruball	*Rubus allegheniensis* Porter	black raspberry
Rubfra	*Rubus flagellaris* Willd.	creeping dewberry
Sasalb	*Sassafras albidum* (Nutt.) Nees.	sassafras
Smihis	*Smilax hispida* Muhl.	bristly catbrier
Toxrad	*Toxicodendron radicans* (L.) Kuntze	poison ivy
Ulmame	*Ulmus americana* L.	American elm
Ulmrub	*Ulmus rubra* Muhl.	slippery elm
Viopra	*Viola pratincola* Greene	common blue violet
Vitaes	*Vitis aestivalis* Michx.	summer grape
Vitcin	*Vitis cinerea* Engelm.	winter grape
Vitrip	*Vitis riparia* Michx.	riverbank grape