RIPARIAN FOREST COMMUNITIES OF THE LOWER KASKASKIA RIVER BOTTOMS

Susan P. Romano, James J. Zaczek, Karl W.J. Williard, Sara Baer, Andrew D. Carver, and Jean C. Mangun[1]

ABSTRACT.—Hydrologic alterations due to dam construction may have altered the floodplain ecology of the Lower Kaskaskia River. Seven forest communities within the study site were identified. Floodplain communities include *Acer negundo-Celtis occidentalis-Acer saccharinum, Acer saccharinum-Acer negundo, and Celtis occidentalis-Ulmus americana. Quercus* and *Carya* species were found in both floodplain and upland areas. *Quercus stellata* flats and *Acer saccharum* occupied upland portions of the study site. This community similarity analysis provides a basis for further research on the effects of flood duration, timing, and depth on the current and historical riparian forest community.

Apparent changes in forest vegetation within the Kaskaskia River floodplain present questions about the effects of flood duration and flood depths on the health of the associated riparian forest. A dam was constructed on the Lower Kaskaskia River in 1967 near Carlyle, Illinois for flood control and river navigation. Extensive hydrologic changes are evident when comparing historic and current river gauge data (fig. 1). Landowners and resource managers are concerned about forest composition, tree growth, and regeneration that may be altered by regulated flooding patterns.

Hydrologic alterations within watersheds can be a result of changes in climate, groundwater use, changes in vegetation patterns, and flow diversions. Hydrologic modifications by dams such as high flow, low flow, and flooding duration are distinct for a particular dam, and should not be generalized (Williams and Wolman 1984). Annual maximum discharge for the Carlyle Dam has changed radically from the pre-dam discharge. Rain events produced highly variable water discharge before the dam was constructed, compared to a much less variable and significantly reduced annual maximum discharge following construction (fig. 1).

Altered floodplain hydrology can influence changes in forest communities in several ways. Tolerance to flooding is dependent upon tree species, tree size (seedling, sapling, or mature tree), and period of inundation (Kozlowski 1984). Flood tolerance for many tree species throughout the United States is summarized in Whitlow and Harris (1979). Tree survival may depend on the vigor of the tree before flooding, timing, and depth of flooding. Floodplain forest vegetation changes can occur in response to increased xeric conditions due to the altered hydrologic regime (Walters and others 1980). Silt deposition from floodwaters can increase the elevation of the floodplain and improve soil drainage resulting in dryer conditions (O'Neil and others 1975). Plant succession in some areas may be modified so that earlier plant community types may be replaced by less flood tolerant species (Brinson and others 1981). Seed distribution from flood dispersal mechanisms change with the altered flooding patterns (Middleton 1995), and flood stabilization reduces seedling establishment for some riparian forest species (Fenner and others 1985, Scott and others 1995). Biotic or abiotic, these factors are directly related to the presence, absence, timing, and duration of flooding.

Thirty-four years have passed since the construction of the Carlyle Dam. This provides an opportunity to study the effects of hydrologic alterations on this particular riparian forest community. Under the assumption that certain environmental conditions produce similar forest

[1] Research Associate (SPR), Assistant Professor (JJZ), Assistant Professor and Principal Investigator (KWJW), Adjunct Professor (SB), Assistant Professor (ADC), and Associate Professor (JCM), Forestry Department, Southern Illinois University-Carbondale, Carbondale, IL 62901-4411. JJZ is corresponding author: to contact, call (618) 453-3341 or e-mail at zaczek@siu.edu.

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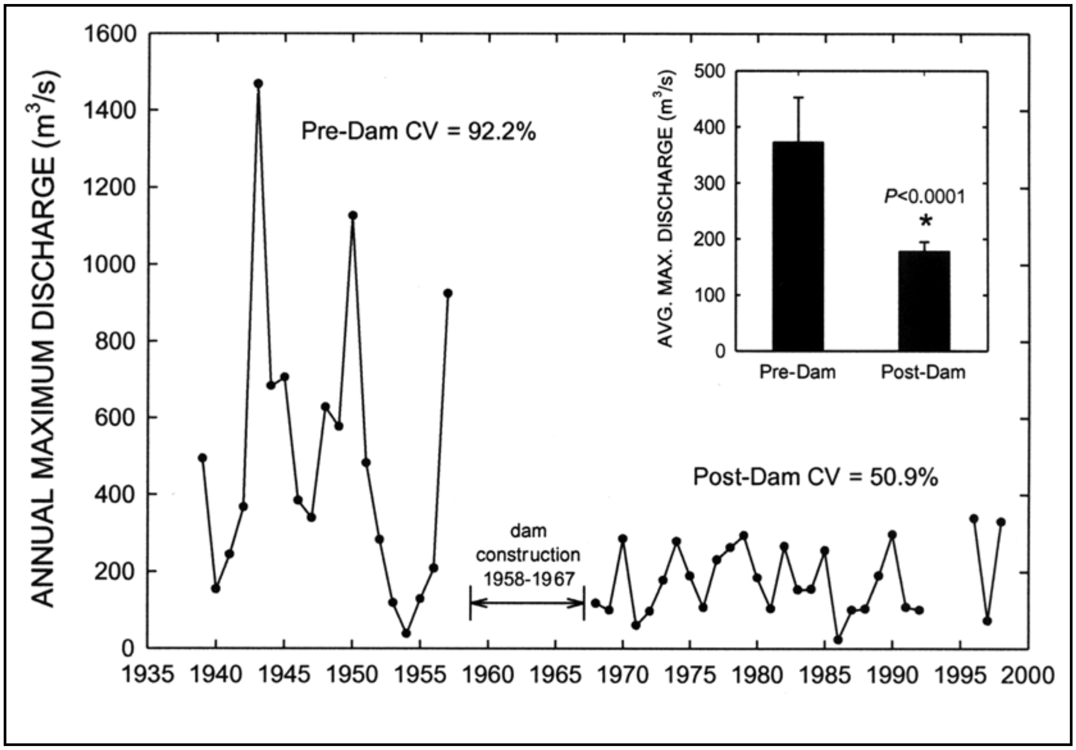

Figure 1.—*Annual maximum discharge from a USGS gauging station on the Kaskaskia River located 94 m downstream of Carlyle Lake Dam.*

communities, cluster analysis was applied as an exploratory analysis technique to detect groupings of similar forest plot data. Conditions that may impact forest communities include elevation, periods of inundation, and timber harvesting. Similarity groupings are identified as a forest community type and described. The objective of this paper is to provide community descriptions of current forest vegetation in the lower Kaskaskia River Basin.

METHODS

Study Site

The Kaskaskia River is a tributary of the Mississippi River; its source in east-central Illinois, flowing south-west and entering the Mississippi River south of St. Louis, Missouri. The Lower Kaskaskia River is the focus of this study, located 40 miles east of St. Louis. This portion of the Kaskaskia is surrounded by the largest contiguous expanse of forest in Illinois (Evans and others 1995). The forests of this area are of the Oak-Hickory Forest region, Northern Division, Prairie Peninsula Section. Within this region are low floodplains dominated by *Acer saccharinum* (silver maple), *Ulmus americana* (American elm), and *Populus deltoides* (cottonwood) (see table 1 for authorities). *Quercus palustris* (pin oak) is found in groupings or as isolated trees within wet areas (Braun 1950).

The study site is located at Venedy, Illinois, along the Kaskaskia River 20 miles south of the Carlyle Dam and about 4 miles south of the Venedy Station, United States Geological Survey (USGS) river gauge station. Elevation of the 80 acre Venedy site ranges from approximately 118.35 to 122.9 m mean sea level. The forest community consists principally of *Acer saccharinum* in the primary floodplain, *Quercus* and *Carya* species in the secondary floodplain, and *Q. stellata* (post oak) in the higher elevations of the study area. This site was selected because of its proximity to a gauge station with current and historical data, range in elevation, and a cooperative landowner.

Plots were randomly selected by applying the RAND function in EXCEL to the length and width of the sample area to obtain plot coordinates. If plots overlapped in the field, a random number and direction were chosen to offset the location. Plots were measured between July 10, 2001 and August 20, 2001 within the 80-acre study site. Forty circular overstory plots, each 0.04 hectares, were marked with steel fence posts. Plot locations were identified using a Global Positioning System. Tree species were

Table 1.—*Tree density and basal area for harvested and non-harvested areas of the Lower Kaskaskia River near Venedy, Illinois, USA*

Species	**Non-harvested area**		**Harvested area**	
	Tree density trees/ha	**Basal area m²/ha**	**Tree density trees/ha**	**Basal area m²/ha**
Acer negundo L.	1400	57.57	2400	77.01
Acer saccharum Marsh.	375	12.69		
Acer saccharinum L.	1825	145.00	925	47.09
Betula nigra L.	25	1.48		
Carya illinoiensis (Wangenh.) K. Koch	100	7.49	25	4.34
Carya laciniosa (Michx. f.) Loud.	25	5.31	25	6.20
Carya ovata (Mill.) K. Koch	800	37.66	225	7.07
Carya texana Buckl.	50	1.74		
Carya tomentosa (Nutt.)	425	32.95	75	8.32
Celtis occidentalis L.	1575	70.24	1150	57.07
Cercis canadensis L.	25	0.19	75	0.76
Cornus florida L.	25	0.23		
Crataegus sp.	25	0.26		
Diospyrus virginiana L.	50	1.58	50	2.88
Fraxinus americana L.	400	37.90	100	18.23
Fraxinus pennsylvanica Marsh.	150	16.70	150	5.71
Gleditsia triacanthos L.	50	7.35	75	0.78
Maclura pomifera (Raf.) Schneid.			25	0.41
Platanus occidentalis L.			25	0.38
Prunus serotina Ehrh.	125	1.36		
Quercus alba L.	425	23.83	50	7.28
Quercus bicolor Willd.	300	25.16	25	0.53
Quercus imbricaria Michx.	100	11.46		
Quercus macrocarpa Michx.	25	2.07	75	3.80
Quercus palustris Muenchh.	225	34.57	25	0.44
Quercus rubra L.	550	55.80		
Quercus stellata Wangenh.	750	91.71		
Quercus velutina Lam.	375	43.54		
Salix nigra Marsh.	25	2.67		
Ulmus americana L.	375	12.69	700	21.34
Ulmus rubra Muhl.	50	3.91	125	2.42

identified according to Mohlenbrock (1986). Diameter at breast height (dbh) was measured to the nearest 0.1 cm for all trees greater than 9 cm. Latitude and longitude determined through the GPS were combined with the USGS Digital Elevation Model (DEM) to provide plot elevation data.

Data Analysis

COMPAH (combinatorial, polythetic, agglomerative, hierarchial) was implemented to separate community groups based on basal area and species. COMPAH is a cluster analysis program that groups samples into dominance types (Boesch 1977, Fralish and others 1993). COMPAH first determines the resemblance, or similarity, of each of the plots sampled. The Bray-Curtis similarity coefficient, used in this analysis, is one of the most extensively used similarity coefficients in ecology (Boesch 1977, Gaugh 1982). Group averaging was also applied to the data, and is a common clustering method used in ecology. This method is “the mean of all resemblances between members of one group to members of another” (Boesch 1977). Group averaging further distinguishes the plots based on the patterns of resemblance, and determines the community groups (Boesch 1977).

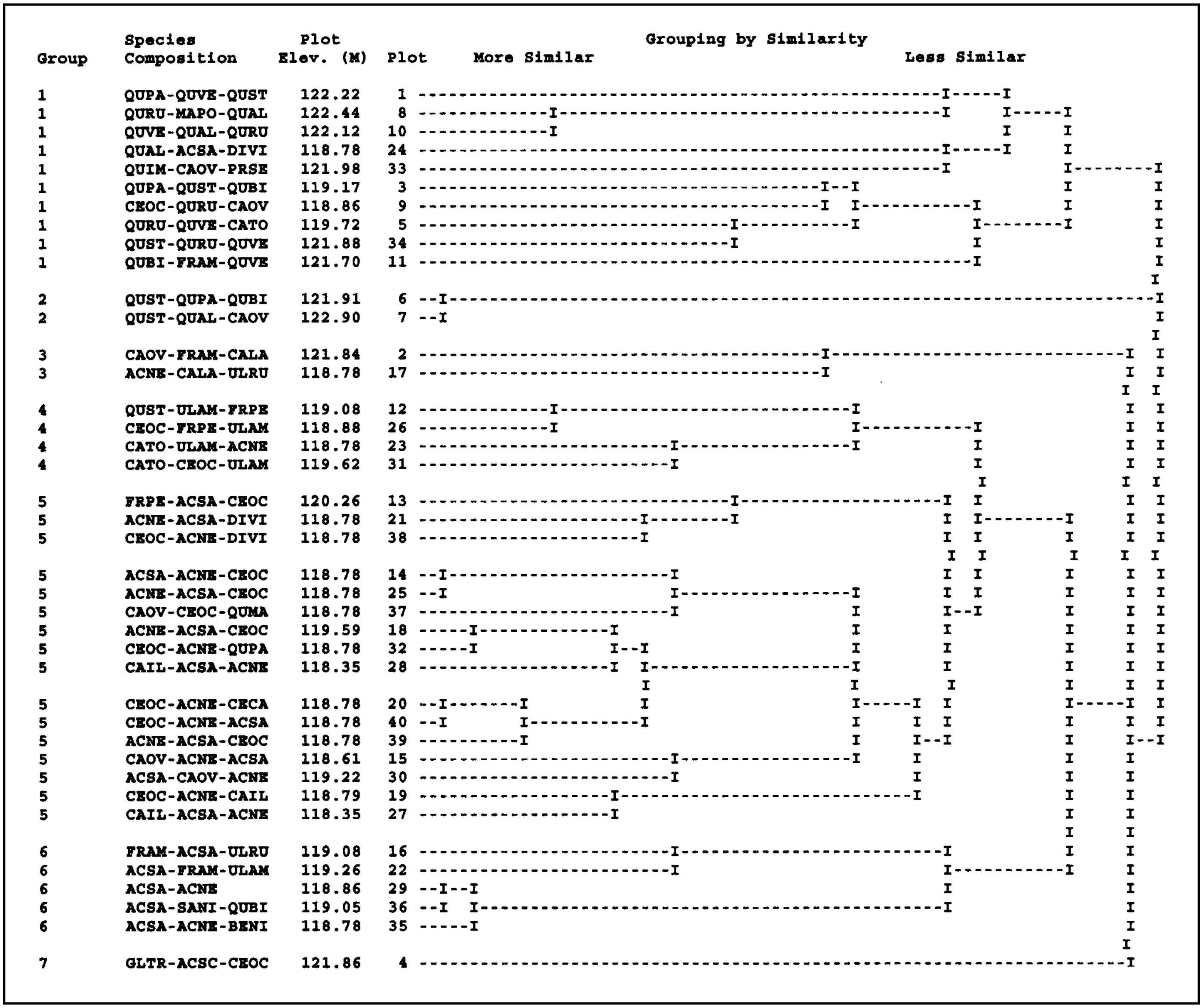

Figure 2.—*Forest community groups generated from COMPAH analysis of species and basal area for each plot within the watershed of the Lower Kaskaskia River near Venedy, Illinois. Species are indicated by genus-species code based on first two letters, respectively.*

RESULTS

COMPAH grouped overstory tree species and basal area data into 7 forest communities based on similarity (fig. 2). Groups 5, 6, and 4 contain primarily floodplain forest species. Group 1 spans both floodplain and hilltop, dominated by *Quercus* species. Group 3 also contained upland and floodplain species, but with *Carya laciniosa* in common, and Groups 2 and 7 are upland forest communities.

The primary floodplain forest community was *Acer negundo-Celtis occidentalis-Acer saccharinum* (Group 5). Within this grouping, *Acer negundo* occurred often (14/16 plots), and at higher basal area relative to other species. *Celtis occidentalis* occurred (14/16 plots) similar to *A. negundo*, but generally at lower basal area. *Acer saccharinum* also occurred very frequently (13/16 plots), also at generally lower basal area than *A. negundo*. This forest community occupies the broad, primary floodplain across the lower elevations ranging from 118.35-120.26 m.

Group 6 is another floodplain community. Basal area of *A. saccharinum* was greater in this group than Group 5, and *A. negundo* generally was present at a lower basal area in Group 6 than in Group 5. Both *Acer* species occurred in all five plots in the grouping. *Acer negundo* occurred at basal areas ranging from 0.5 to 3.9 m^2/ha, with high densities ranging from 150 to

600 stems/ha. The span of elevation for this group was 118.78-119.26 m.

Group 4 characterized by the presence of *Celtis occidentalis* and *Ulmus americana*, found in all plots. This group is distinctive in that it lacks the *A. saccharinum* component found in Groups 5 and 6. The elevation span for this group is 118.78-119.62 m. Group 1 is dominated by a variety of *Quercus* species, and spans an elevation from 118.78-122.44 m. *Quercus bicolor, Q. alba*, and *Q. rubra* were oak species of the low and moderate elevation plots, while *Q. velutina, Q. alba*, and *Q. stellata* are present at higher elevations.

The strictly upland forest community groups were Group 2 and Group 7. The remaining Group 3, represented a small sampling of *Carya* sp., and may not be related to elevation. Group 2 is a *Quercus stellata* community, and Group 7 as one plot containing *Acer saccharum* Marsh. Group 3, was neither upland nor lowland, with a *Carya laciniosa* influence.

Forest overstory species of the above communities have specific flood tolerances, indicated by their presence at various elevations in this floodplain. Figure 3 illustrates the distribution of individual species along the elevation gradient, based on presence-absence data. Soft maples were specific to low lying areas: *Acer negundo* was limited to a range of 118.35–119.59 m, and *Acer saccharinum*, 118.35–120.26 m. Some species were broadly dispersed across a range of floodplain elevations and into upland elevations. *Fraxinus pennsylvanica, Ulmus rubra, Celtis occidentalis*, and *U. americana* were generally present at the lower elevations and were often a component within the predominately *A. saccharinum* and *A. negundo* elevations, but were not limited to the lower elevations.

Oak and hickory dominated higher elevations with *Quercus bicolor*, *Carya laciniosa, C. tomentosa, Fraxinus americana, Quercus palustris, Q. alba, Q. rubra* L., and *Q. stellata* (fig. 3). A narrow elevation distribution was apparent for the flood intolerant *Q. velutina,* distributed at 119.72–122.44 m. *C. ovata* was the most ubiquitous species, present at elevations that supported soft maples, and also present in the high elevation *Q. stellata* community.

Forest management is another factor that may influence species composition. Table 1 separates data from an area harvested about 20 years ago from the data collected in an area that was not harvested. The area harvested was primary floodplain, located adjacent to the Kaskaskia River. Similar floodplain species were present in the harvested area, with the inclusion of *Platanus occidentalis* and *Maclura pomifera*, and the exclusion of *Betula nigra.*

DISCUSSION

Flooding patterns and the tolerance of species to flooding influence the establishment and survival of forest communities. Floodplain plant community structure is a result of the effects of flooding over time, set back to an earlier successional state by extreme floods, and accelerated when flooding is reduced (Junk and others 1989). Factors other than flooding are also involved. Robertson and others (1978) indicated that soil characteristics and topographic form are also very important factors in floodplain forest community patterns. Silt deposition and seed dispersal mechanisms also influence the composition of floodplain forest communities (O'Neil and others 1975, Walters and others 1980, Middleton 1995).

Flood tolerance of species may explain some of the similarity within community groupings. The largest primary floodplain community of the study site is composed of flood tolerant species. The *Acer saccharinum-Acer negundo-Celtis occidentalis* community group was common across the primary floodplain of the study area. Flood tolerance may have a large influence on these composition patterns. Mature *A. saccharinum* can survive flood conditions for long periods, up to 149 days in one study (Bell and Johnson 1974), and for 3 years in another study (Yeager 1949). *Acer negundo* was also tolerant to 149 days of flooding, and *Celtis occidentalis* survived 109 days of flooding (Bell and Johnson 1974).

The *Acer saccharinum-Acer negundo* community (Group 6) is an interesting similarity grouping. Silver maple is a very flood tolerant species, and large diameter trees more tolerant of flooding than trees of smaller diameter. This may result in an even-age floodplain forest structure of large diameter *A. saccharinum* (Oldenburg 1980). The lack of diversity in these plots could also be an artifact of successional state, current flood patterns, or soil characteristics.

Ulmus americana has a wider range of tolerance for conditions found in the floodplain than any other floodplain forest species (Hosner and Minkler 1960). It is considered to be somewhat

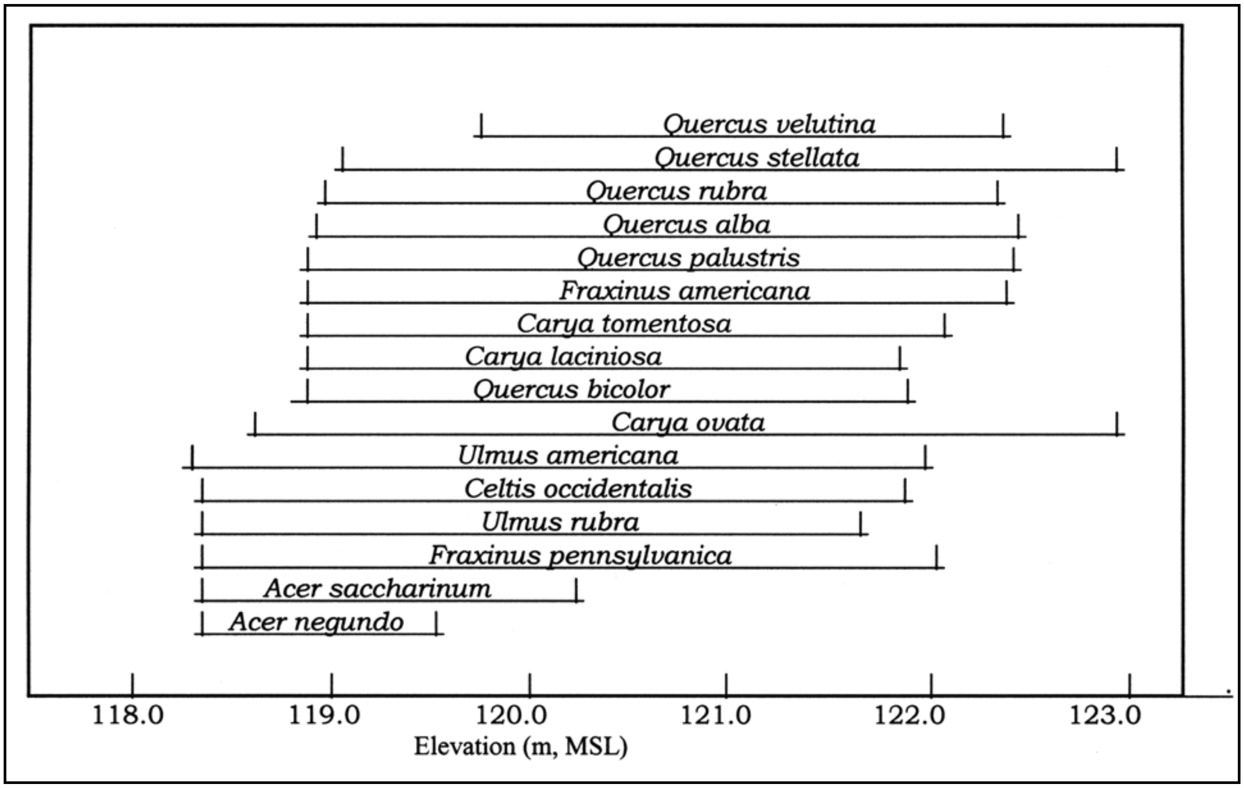

Figure 3.—*Species distribution across the elevation gradient present in the watershed of the Lower Kaskaskia River near Venedy, Illinois.*

flood tolerant by Bell and Johnson (1974). This unique combination of a wider tolerance range, and slightly less flood tolerance relative to other floodplain species may contribute to the presence of *U. americana* in the *Celtis occidentalis-Ulmus americana* community.

The *Carya* sp. group is a small similarity grouping of only two plots. Hickory was found across all but the lowest floodplain areas. Further data collection at other sites will determine if this grouping, although quite different from other community groups, is prevalent among the floodplain forest of this site.

Upland forest communities contained species that were intolerant to moderately tolerant of flooding. The *Q. stellata* flat is seasonally wet and dry, on a perched water table (Taft and others 1995). Only one plot contained *A. saccharum*, an upland species.

Quercus species were present on the slopes above the floodplain and throughout the floodplain below. More tolerant *Quercus* species were found in the floodplain. The *Quercus* similarity grouping contained all *Quercus* species across the range of plot elevations. This indicates a dispersal of oak without a particular community or elevation relationship. Resource managers are concerned about the perceived lack of oak regeneration in the floodplain. Our results indicate that several species of oak are still present as overstory trees in the floodplain. These include *Q. stellata*, *Q. rubra*, *Q. alba*, *Q. palustris*, and *Q. bicolor*. Midstory and seedling strata will be analyzed for regeneration of oak in the floodplain, and at higher elevations within the site. Further investigations will determine if the floodplain forest is succeeding to an *A. saccharinum* forest community without an oak component in the lower strata.

Harvesting may be another factor to consider. The similarity analysis (fig. 2) indicated that the harvested floodplain plots within the study site were similar to the unharvested areas. Harvested plots were numbers 24, 26, 21, 25, 28, 40, 39, 27, and 22. The summary of species, basal area, and density in table 1 indicated that although there were differences in basal area and density, the same species were present in the harvested area as were in the old growth floodplain, with only a few exceptions. This similarity indicates that species tolerance to flooding may have a greater impact than harvesting in determining species composition of riparian forest communities, making succession concepts questionable.

CONCLUSION

This study provides community descriptions that demonstrate some relationships among elevation, hydrology, and forest tree species in this Illinois bottomland forest. Further research will incorporate data from two additional Lower Kaskaskia River floodplain sites. This data will include species and basal area of the overstory and mid-story strata, soil factors, and inundation periods. Specifically, *Quercus* species correlations to these factors will be investigated. Historical growth and inundation relationships will be determined through dendrochronology techniques. This community analysis is the first step in our efforts to define the past, present, and future community patterns within the modified floodplain of the Lower Kaskaskia River.

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