AN ECOLOGICAL INVESTIGATION OF THE OAKWOOD BOTTOMS GREENTREE RESERVOIR IN ILLINOIS

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The vegetation of the Oakwood Bottoms Greentree Reservoir, Jackson County, Illinois, which is under the management of the U.S. Forest Service, was examined using the quadrat method. A total of 27 stands were sampled on this bottomland area, and the data obtained was used to delineate community types. The following communities were recognized: shagbark hickory, pin oak, black willow, pin oak - cherrybark oak, and pin oak - red maple. Pin oak (Quercus palustris Muenchh.) is the dominant species over most of the area, however, its successful reproduction is limited to more open stands. In stands with more than 18.4 m of basal area/ha (80 sq. ft. of basal area/acre), green ash (Fraxinus pennsylvanica Marsh.), slippery elm (Ulmus rubra Mühl.) and American elm (Ulmus americana L.) dominate in the reproductive strata. A synthetic moisture gradient was developed using selected indicator species, and success of herbaceous species and tree seedlings examined across the gradient. The presettlement vegetation was examined using the Government Land Office Records and compared with existing vegetation.

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INTRODUCTION

Greentree reservoir systems are utilized along major flyways from Maryland to Missouri, and serve the dual purposes of attracting ducks for public hunting, while still permitting management of the timber resource. Sites are located where (1) water is available for the flooding operation, (2) suitable timber mast provides an adequate food source, (3) soils are generally impervious and (4) the terrain is relatively flat. These criteria are best met in bottomland situations along the major drainage systems (Rudolph and Hunter 1964).

Bottomland oaks are the most desirable form of tree cover in the reservoirs and provide a source of food for the waterfowl. In Missouri

and Illinois, pin oak (Quercus palustris Muenchh.) is the dominant tree species, but further south dominance may be shared with cherrybark oak (Quercus falcata var. pagodaefolia Ell.), and Nuttall oak (Quercus nutallii E. J. Palmer).

The area now occupied by the Oakwood Bottoms Greentree Reservoir was intensively farmed until acquisition by the federal government, as part of the Shawnee National Forest. From 1933 to 1938 much of the Oakwood Bottoms came under federal ownership. The land since its acquisition has been left to reforest itself naturally. The "Greentree Reservoir" was constructed in 1964. The management plan is to harvest the pin oak by clearcutting at intervals of approximately 40 years. Cutting releases the pin oak reproduction and growth on the alluvial soils is rapid (McIllwain 1967).

This reservoir, managed by the U.S. Forest Service since 1964, provides a public hunting facility and commercial timber stands of pin and cherrybark oak (McIllwain 1967). The reservoir is flooded during the fall and drained before the onset of the growing season, so the two primary functions are not in conflict.

Despite wide application of this type of management program, relatively little information concerning the effect on the vegetational component is known. The purpose of this study is to give a detailed account of the vegetation of the Oakwood Bottoms Greentree Reservoir. Specific consideration is given to floristic composition, community structure, regeneration of the tree species and past vegetational patterns.[1]

Description of the Study Area

The Oakwood Bottoms is within the Shawnee National Forest, located in southwestern Jackson county, 3.2 km (2 miles) northeast of Grand Tower, Illinois. It lies in the Mississippi River floodplain between the Big Muddy River on the east and low lying hills paralleling the Mississippi on the west. The boundaries of the area, are shown in figure 1. Elevation rises approximately .37 m per km (2 ft. per mi.) from south to north and from east to west, so that the general contour of the land is described as sloping gently to the south and east (U.S. Geological Survey 1947).

Topographic features of bottomland sites have been described by (Putnam 1951). Those considered here are ridges and terraces of second bottoms. First bottoms include those portions of the present drainage

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1/ This work was originally submitted as a Masters of Arts Thesis to the Botany Department of Southern Illinois University, Carbondale. Thomson, P.M. An Ecological Investigation of the Oakwood Bottoms Greentree Reservoir in Illinois, M. A. Thesis, SIU, Carbondale.

system subjected to frequent inundation, while second bottoms were formed by previous drainage systems and are flooded only at superflood stages. The ridge-terrace system of the region was formed by alluvium deposit during the glacial epoch. Most of the alluvium was deposited as higher level floodplains, and as loess, that has been reworked and transported comparatively short distances (Weller 1926).

Jacob and Beaucoup clay loams are the principal soil types in the area. Alluvium from the Big Muddy River was the parent material for the Jacob clay loam that developed under standing water, and is found in depressions in the northern portion of the reservoir. Beaucoup clay loam is found in all areas of higher relief. Both soils have essentially the same slightly acid reaction (Univ. Ill. 1933).

The dominant tree species in the Oakwood Bottoms is pin oak. Distribution of this species is so extensive that the Bottoms are often referred to as a pin oak "flat." A well developed seedling and sapling layer is typically absent, but a dense herbaceous cover exists. In addition to the extreme tightness of the soil, slight depressions create areas in which rainwater collects, thus the area has an overall marshy appearance.

STAND NUMBERS ARE UN-CIRCLED
COMPARTMENT NUMBERS ARE CIRCLED

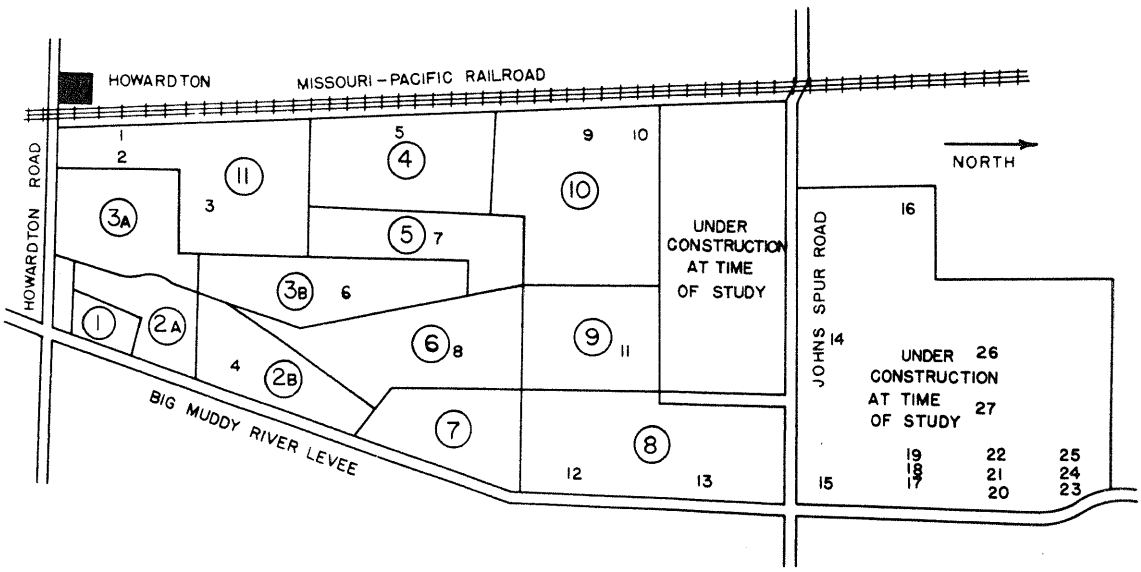

Figure 1: The location of stands within the study site. Stand numbers are not circled, compartment numbers are circled.

METHODS

The vegetational pattern prior to European settlement was determined by the application of the quarter method (Cottam and Curtis 1956, Lindsey et al. 1965) to the General Land Survey of 1806. Surveyors measured the distance from each section and quarter section point to two witness trees, and estimated the diameters of these trees. The two distances were considered to be Q1 and Q2 of the quarter method. With this information, density, dominance (basal area) and an importance value based on relative density and relative dominance were calculated for the trees.

The rate of reforestation following cessation of agriculture activities of the 1930's was determined from aerial photographs taken in 1938, 1952, and 1969. Percent forest cover of the area was calculated by placing a sheet of acetate, marked with a series of 10 dots per sq. cm (64 dots per sq. in.) in grid fashion, over the photographs. The number of dots striking tree cover expressed as a percentage represented those portions of land inhabited by trees.

The quadrat method was used to sample the existing vegetation. Twenty-seven stands were located in ten of the thirteen reservoir compartments to insure that all major community types were represented. Stand selection was based on reconnaissance of the areas using the criterion previously stated. The location of the stands in the compartments is shown in figure 1. In each stand five points were located along paced compass lines at intervals of 25 paces. A table of random digits was employed to determine the final location of the five sampling points within each stand.

At each sampling point, tree species were sampled by size class in 0.0405, 0.0101 and 0.0004 ha (1/10, 1/40, 1/100 acre) circular quadrats. Trees were considered stems with a dbh of 8.9 cm (3.5 in.) or greater and were tallied in 0.0405 ha (1/10 acre) plots. These plots were divided into 4 quadrants and the species, number of trees and their dbh in each were recorded. Woody species less than 8.9 cm (3.5 in.) dbh were recorded in five size classes. Seedlings, classes I and II, included all stems greater than 15.2 cm (6 in.) in height, but less than 1.37 m (4.5 ft.), and 0.0 to 1.2 cm (0.0 to 0.49 in.) dbh respectively; they were measured in the 0.0004 ha (1/100 acre) plots. Plots .0016 ha (1/40 acre) in area were used to sample saplings, defined by 2.5 cm (1 in.) dbh intervals ranging from 1.3 to 8.9 cm (0.5 to 3.5 in.) and assigned to size classes III, IV, and V. In each of the five categories, only number of stems by species was tallied.

Herbaceous ground-layer was examined in 10 meter-square quadrats placed in standard position within the 0.0405 ha (1/10 acre) quadrats. Presence-absence data for these species were converted to quadrat frequency values.

Importance value was calculated for tree species by summing relative frequency, density and dominance (Curtis and McIntosh 1951). A modification of the SIZESUM computer program developed at the University of Wisconsin Plant Ecology Laboratory was used for the computations in this study.

Successional patterns among tree species were evaluated using the importance value of species in various size classes. The seedling size class by definition has no dbh and is represented by a midpoint diameter (mpd) of zero. The mpd for the saplings is 5 cm (2 in.) and trees are grouped by 12.7 cm (5 in.) dbh intervals from 8.9 to 59.7 cm (3.5 to 23.5 in.). Midpoint diameters of 15.2, 27.9, 40.6 and 53.3 cm (6, 11, 16 and 21 in.) represent the respective size class groupings.

A series of indicator species was used to evaluate the environment within each stand in terms of its position along a moisture gradient. Indicator species were selected and assigned to one of three moisture categories designated as moist, wet and heavy-wet. These categories were arbitrarily assigned index values of 4, 8 and 16. Selection of the indicator species in each category was based on previous drainage schemes by Rowe (1956) and Voigt and Mohlenbrock (1964). In addition, the work of Drapalik (1959) on the physiological response to inundation of 33 species of bottomland herbs was consulted. Eleven indicator species were selected for each of the three moisture classes.

Individual stands were assigned a stand index value by multiplying the number of indicator species in each moisture category by the assigned value of the category. The products for all of the categories were summed and divided by the total number of indicator species. All values thus obtained were multiplied by 10 to eliminate fractional values. Stands were arranged from lower to higher values establishing a synthetic moisture gradient. Theoretically index values could range from 40 (moist indicators only) to 160 (heavy-wet indicators only). Actual values obtained, however, varied from 51 to 130. Species distributions were then examined by plotting quadrat frequency for herbs and importance values for tree seedlings over stand index.

RESULTS

Presettlement Vegetation

The vegetation was considerably different at presettlement times in terms of density and dominance, but floristic composition and distribution of tree species remained relatively unchanged. The surveyors were not trained botanists and their determinations were, in many cases, generic. Species of elm and hickory were listed as "elm" or "hickory" and in this study are referred to as *Ulmus* sp. or *Carya* sp. "Black oak" of their records is believed to be cherrybark oak and not (*Quercus velutina* Lam.) to which that common name presently has reference.

Presettlement distribution generally conformed to the contours of the land. Stand density increased as the elevation rose from 106.7 m (350 ft.) Mean Sea Level (MSL) at the banks of the Big Muddy, to 109.7 m (360 ft.) MSL within the reservoir. Sites above 108.2 m (355 ft.) MSL contained 11 species with an average density of 247 trees per ha (100 trees per acre). These higher elevation sites supported communities that were more complex in their composition, and dominance was shared among more tree species compared with communities on lower ground (Table 1). Cherrybark oak, the most important species, occurred most frequently in sections 17 and 20. Other important species included elm, green ash (*Fraxinus pennsylvanica* Marsh.), and hickory. Species of lesser importance included red maple (*Acer rubrum* L.), bur oak (*Quercus macrocarpa* Michx.), sugarberry (*Celtis laevigata* Willd.), pin oak, honeylocust (*Gleditsia triacanthos* L.), red mulberry (*Morus rubra* L.) and eastern cottonwood (*Populus deltoides* Marsh.).

That portion of the forest situated on lower ground contained five fewer species (6) than its counterpart at higher levels, and averaged only 123 trees per ha (50 trees per acre) or less. The leading dominants were pin oak and elm, with hickory, burr oak, ash and cherrybark oak being of only minor importance in the community. Importance values of the species varied with the site conditions as evident by the substitution of dominants on the respective sites. Pin oak, the most important species on the lower sites, was barely represented on the better drained sites. Its dominance there was assumed by cherrybark oak.

Table 1. The Importance Values of tree species in the presettlement vegetation, low density and high density areas are compared.

	Importance Value		
Species	High Density Community	Low Density Community	Average
Ulmus sp.	54.2	100.0	73.0
Quercus falcata var. *pagodaefolia*	66.5	10.9	48.0
Quercus palustris	14.1	114.5	48.0
Carya sp.	42.4	33.9	38.6
Fraxinus pennsylvanica	47.5	10.9	33.8
Quercus macrocarpa	19.3	29.8	22.6
Acer rubrum	22.1	--	13.9
Celtis laevigata	14.8	--	9.5
Gleditsia triacanthos	6.8	--	4.9
Morus rubra	6.4	--	3.9
Populus deltoides	6.0	--	3.6
Total	300.0	300.0	300.0

Vegetational Change (1939-1969)

Analysis of aerial photographs show the development pattern of the forest. The 1938 survey revealed a total cover of 31 percent. Forested areas were primarily restricted to sites that had been undesirable as farmland (Minton 1970). Timbered tracts occurred north of the Johns Spur Road, along the Big Muddy River, the eastern border of the present-day Greentree Reservoir and south of the Howardton Road.

The 1952 survey revealed the pattern of reforestation that proceeded after the cessation of agricultural activities. At this time many smaller trees were evident along the periphery of the formerly cultivated fields. Forest cover was 68 percent and treeless areas were grown over in dense brush. By the time of the 1969 survey, 87 percent of the Oakwood Bottoms was covered by trees with only portions of compartments 3b and 5 containing open areas.

The Oakwood Bottoms soil is highly productive as indicated by the rapid development of pin oak over a period of 35 years. Individuals barely visible as trees in the 1938 survey had an average dbh of 30.5 cm (12 in.) and an average height of 18.9 m (62 ft.) at the time of the present study. A site index interpolated from the work of Schnur (1937) yielded a value of 90.

Community Descriptions

Analysis of the data indicated five species associations definable as communities. Communities were defined by the dominant tree species as indicated by their importance value. The locations of these communities is related to the general features of the terrain, namely, ridges, flats, depressions and land higher in relief but not considered ridges.

Shagbark Hickory Community: Shagbark hickory (*Carya ovata* Mill.) is primarily restricted to those portions of the reservoir having better drainage. It is found on well-drained sites throughout the reservoir and occurs in nearly pure stands on a ridge in the northern portion of the reservoir. This community type is not common and accounts for a small portion of the total area. Aside from species composition, its physiognomic characters are unique. The site is the most open of the timbered tracts supporting only 21.6 trees per ha (94 trees per acre). Despite low density, the basal area value of 24 m per ha (104.6 sq. ft. per acre) is comparatively high (Table 2). Absence of water marks on the trees, coupled with numerous fire scars, attests to the dryness of the ridge. No evidence of prior cuttings was discovered in three visits to the site. The community gradually blends into pin oak "flats" on the adjacent lower ground.

Table 2. Average density, basal area and importance values for species with IV's greater than 10 in each of the five communities.

Community Type	Species	Density/ha	Basal Area m^2/ha	Importance Value* (IV 300)
Shagbark Hickory	*Carya ovata*	207.5 (84)	24.4 (106.0)	265
	Quercus falcata var. *pagodaefolia*	9.9 (4)	1.2 (5.0)	15
	Quercus palustris	4.9 (2)	.1 (0.5)	10
	Ulmus americana	4.9 (2)	.1 (0.3)	10
	Total All Species	227.2 (92)	25.8 (111.8)	300
Pin Oak	*Quercus palustris*	444.6 (180)	25.5 (111.0)	211
	Fraxinus pennsylvanica	59.3 (24)	.9 (4.0)	26
	Ulmus rubra	44.5 (18)	.5 (2.0)	20
	Total All Species	548.3 (222)	26.9 (117.0)	257
Black Willow	*Salix nigra*	375.4 (152)	8.7 (38.0)	162
	Fraxinus pennsylvanica	256.9 (104)	4.6 (20.0)	101
	Quercus palustris	74.1 (30)	.9 (4.0)	26
	Total All Species	706.4 (286)	14.2 (62.0)	289
Pin Oak - Cherrybark Oak	*Quercus palustris*	133.4 (54)	5.8 (25.0)	128
	Quercus falcata var. *pagodaefolia*	96.3 (39)	2.5 (11.0)	72
	Ulmus rubra	64.2 (26)	2.3 (10.0)	44
	Fraxinus pennsylvanica	17.3 (7)	1.2 (5.0)	10
	Ulmus americana	9.9 (4)	.1 (0.5)	10
	Total All Species	321.1 (130)	6.1 (51.5)	264
Pin Oak - Red Maple	*Quercus palustris*	133.4 (54)	15.4 (67.0)	100
	Ulmus rubra	148.2 (60)	12.9 (56.0)	101
	Acer rubrum	113.6 (46)	5.3 (23.0)	40
	Acer saccharinum	19.8 (8)	2.5 (11.0)	15
	Fraxinus pennsylvanica	14.8 (6)	.9 (4.0)	10
	Total All Species	429.8 (174)	37.0 (161.0)	266

*Importance Value is listed only for species having values of 10 or greater. For those with IV's less than 10, see Thomson (1971). Values in parenthesis are trees per acre and sq. ft. per acre.

Table 2 shows that shagbark hickory has an importance value of 265, compared with a maximum value of 300 for all species. The structural diagram for this community (Figure 2) shows that shagbark is not an important species in the understory, however, neither are most of the other members of the community. Only American elm (Ulmus americana L.) shows evidence of becoming more important in the overstory, but it is also limited.

Minor associates in the overstory are cherrybark oak and American elm. In the understory are found pin oak, honeylocust, persimmon (Diospyros virginiana L.), winged elm (Ulmus alata Michx.) and hackberry (Celtis occidentalis L.), in addition to the seedlings and saplings of shagbark, American elm, and cherrybark oak. Interestingly, no understory trees of any species surpassed size class three, 3.8 - 6.4 cm (1.5 - 2.5 in.) dbh. This condition seems to have persisted for a long time as the smallest shagbark tree had a dbh of 20.3 cm (8 in.). Cherrybark oak and American elm are represented in the understory, but like the shagbark, smaller trees are absent.

The herbaceous layer of the community contains 30 species, many of which show affinities for more mesic woods. Those species occurring in 20 percent or more of the herb quadrats, presented in order of decreasing frequency, are: Rhus radicans L., Aster ontarionis Wieg., Cinna arundinacea L., Carex tribuloides Wahlenb., Prunella vulgaris L., Galium obtusum Bigel. and Carex squarrosa L.

Woody species sampled in the seedling quadrats, other than trees, include Rhus radicans and Rubus allegheniensis Porter. Poison ivy was especially prolific in the community with an average of 3540 stems per acre with 80 individuals attaining size class two, 0.03 - 1.3 cm (0.01 - 0.5 in.) dbh. Blackberry was also abundant with 540 class one stems per acre being recorded. The dense shrub layer may be limiting tree reproduction in this community.

Pin Oak Community: The pin oak community is found on extensive level alluvial "flats". Tree growth is rapid on such sites (Minckler 1957) and stands commonly have 617 - 679 trees per ha (250 to 275 trees per acre). Basal area is frequently in excess of 23 m^2 per ha (100 sq. ft. per acre).

Pin oak, unquestionably the dominant tree species, occurs in nearly pure, even-aged stands. In the stands comprising the pin oak community, it has an importance value of 211, compared with 26 for green ash, the second leading dominant (Table 2). Growth is rapid on the heavy soils and pin oak trees often reach heights of 21.4 m (70 ft.) in 30 years (Minckler 1957). Open-grown trees, however, may attain heights of 36.6 m (120 ft.) and measure 1.2 to 1.5 m (4 - 5 ft.) in diameter. The largest pin oak in this study was 34.1 m (112 ft.) tall and had a dbh of 106.7 cm (42 in.).

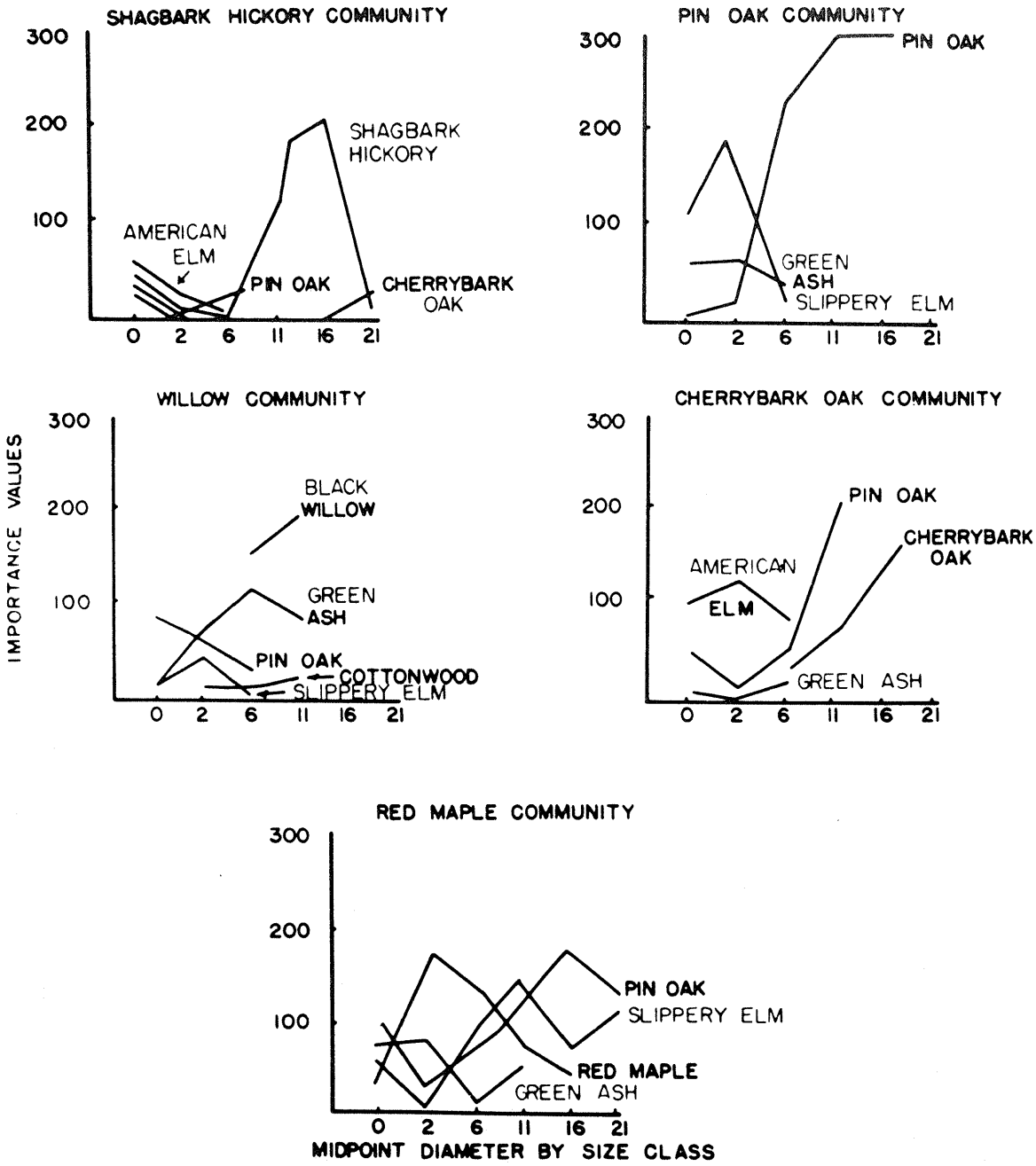

Figure 2: Structural diagrams for representative stands indicating the Importance Values of selected tree species by size class.

In the completed portions of the reservoir, pin oak is subjected to flooding during the non-growing season. Because prolonged inundation during the growing season can be fatal to the trees (Yeager 1949), the reservoir is drained at the onset of the growing season. Moreover, the additional moisture stored in the soil during flooding, and available later during the growing season, may enhance tree growth.

Although pin oak predominates in the overstory, green ash and slippery elm (Ulmus rubra Mühl.) show indications of becoming increasingly more important (Figure 2). Slippery elm trees of the Oakwood Bottoms average 15.2 to 30.5 cm (6 to 12 in.) in diameter. Slippery elm reproduction is abundant in all areas of the bottoms and particularly in the pin oak flats.

Green ash is common on alluvial soils and is rated intolerant to moderate in reaction to competition. Like the slippery elm, reproduction is profuse, but a larger proportion of the seedlings reaches tree size. In both species the number of seedlings and saplings surpasses those produced by pin oak.

In all areas of the reservoir where pin oak communities occur, a pattern of replacement similar to that suggested by figure 2 is noted. Elm and ash increase in importance value in the 5.1 and 15.2 cm (2 and 6 in.) size classes, as pin oak decreases or is absent. The site conditions of the particular stand determine which of the two will become the more successful. Relatively drier sites tend to support more elm, while wetter sites contain green ash in greater abundance.

Burr oak occurred as a minor associate in two stands. This species is considered to be intermediate in reaction to competition, and along with the other more tolerant species in these stands is becoming more important.

Important herbaceous members of the community in the spring and summer include Carex squarrosa, Carex tribuloides, Galium obtusum, Lysimachia nummularia L. and Scutellaria nervosa Pursh. in order of decreasing frequency. The ground cover is often interrupted by open spaces where pockets of water stood during the rainy season. These openings often contain an occasional individual of Alisma subcordata Raf., Cicuta maculata L., or Sagittaria latifolia Willd. The ground layer in the flats contains fewer numbers of species than the drier ridge sites.

Black Willow Community: The willow community, located in the northern portion of the reservoir, is represented in this study by single stand. Pin oak flats surround this depressed area which supports black willow (Salix nigra Marsh.), swamp cottonwood (Populus heterophylla L.), and buttonbush (Cephalanthus occidentalis L.). The willow population contributes the significant portion of the tree cover, with swamp cottonwood represented only as an occasional member of the community. Where present, buttonbush forms dense thickets, and individuals are often

included in the sapling size class IV. Other tree species contributing to the composition of this community are green ash, pin oak, and slippery elm.

Willow accounted for 152 of the 541.2 trees per ha (220 trees per acre). However, data on reproduction indicate ash, elm and pin oak are assuming more importance in the community, and willow is not replacing itself. No individuals of willow were recorded in the seedling and sapling classes (Figure 2). Although this evidence would indicate replacement by more shade tolerant species, willow still contributes 57.6 percent of the total basal area of 15.2 m^2 per ha (66.3 sq. ft. per acre).

The ground layer of this area contains a larger number of herbaceous vascular plants displaying a higher level of tolerance to inundation than those found in the other communities (Drapalik 1959; Voigt and Mohlenbrock 1964). Species include Carex tribuloides, Cicuta maculata, Glyceria septentrionalis Hitchc., Lycopus rubellus Moench., Rumex verticillatus L., and Scutellaria lateriflora L.

Pin Oak - Cherrybark Oak Community: The pin oak - cherrybark oak stands are located primarily in compartments 1, 2, and 3 (Figure 1). These sites were intensively farmed and aerial photographs taken shortly after federal acquisition revealed a tree cover of only 31 percent. Associated with cherrybark and pin oak are green ash, shagbark hickory and American elm. Occasional species include shellbark hickory (Carya laciniosa Michx.), persimmon, honeylocust, and shingle oak (Quercus imbricaria Michx.). No single species dominates in these communities as in the pin oak, black willow, and shagbark communities, but rather dominance is shared by cherrybark and pin oak, and to a lesser extent by elm and ash. Pin oak is the most important overstory species, with cherrybark oak a close second (Table 2).

The stands had a high density of trees, 548 per ha (222 per acre), and a basal area of 26.8 m^2 per ha (117 sq. ft. per acre). The structure of stand 5 (Figure 2) is typical of the pattern displayed by the cherrybark oak stands of the Greentree Reservoir. Importance values by size classes indicate that cherrybark and pin oaks dominate in the larger tree classes, 27.9 to 40.6 cm (11 to 16 in.), but their importance is diminished in the seedling and sapling classes. Elm is dominant in the seedling, sapling and small tree size classes.

Herbaceous plants associated with the pin oak - cherrybark oak community are: Rhus radican, Aster ontarionis, Impatiens biflora Meerb., Cinna arundinacea, Oxalis stricta L., Carex granualaris Muhl., Campsis radicans L., Carex hyalinolepis Steud., Carex tribuloides. As with the hickory community, sites on higher ground contain a greater number of species, particularly in the herbaceous layer.

Pin Oak - Red Maple Community: Along the eastern edge of compartment 10 the land is slightly depressed. As a consequence of this shallow depression, water pumped in for the migrating wildlife drains very slowly. Runoff from the surrounding land area also accumulates and thus, the soil is saturated from the early growing season through mid-July.

Tree density was 429.8 trees per ha (174 per acre) and basal area was the highest of all the communities, 36.9 m^2 per ha (161 sq. ft. per acre). The floristic composition differs from other stands on low ground by the presence of Drummond's red maple (*Acer rubrum* var. *drummondii* (H. & A.) Sarg.). This tree is common on moist sites, but it is not found in pure stands in this portion of its range. The pin oak - red maple community is represented by stand 10 (Figure 2). Pin oak is the dominant overstory species on this wet site, although both green ash and red maple are components of the 15.2 and 27.9 cm (6 and 11 in.) size classes. Slippery elm has the second highest importance value.

The trend on this site appears to be one of diminishing importance of pin oak, and an increase in the importance of green ash and red maple. The comparatively high importance values for red maple in the seedling and sapling classes suggest that red maple will increase in importance. Pin oak shows little success in the sapling class and will probably decrease in dominance in the future.

The most frequently encountered herbaceous plants in this community are: *Glyceria striata* Lam., *Leersia virginica* Willd., *Lysimachia nummularia*, *Saururus cernus* L., *Aster vimineus* Wieg., *Carex tribuloides* and *Carex hyalinolepsis*.

A Synthetic Moisture Gradient

To examine the distribution of plant species as it relates to soil moisture, 33 herbaceous species were selected as indicators. Selections were based upon published results of Curtis (1955), Rowe (1956), Drapalik (1959), and Voigt and Mohlenbrock (1964). Moisture categories and their indicators were defined as heavy-wet, represented by *Alisma plantago-aquatica* L., *Alisma subcordata* Raf., *Cephalanthus occidentalis*, *Eleocharis obtusa* (Willd.) Schultes, *Hibiscus lasiocarpus* Cau., *Iris fulva* Ker., *Leersia oryzoides* (L.) Sw., *Rosa palustris* Marsh., *Rumex verticillatus*, *Sagittaria latifolia* and *Saururus cernuus*; wet, represented by *Asclepias incarnata* L., *Aster vimineus*, *Boehmeria cylindrica* (L.) Sw., *Campsis radicans*, *Carex crus-corvi* Shuttlw., *Carex squarrosa*, *Glyceria septentrionalis*, *Glyceria striata*, *Lobelia cardinalis* L., *Lysimachia ciliata* L., *Sium suave* Walt.; and moist, characterized by *Apocynum cannibinum* L., *Arisaema dracontium* L., *Cinna arundinacea*, *Elymus virginicus* L., *Erigeron annus* (L.) Pers., *Impatiens biflora*, *Oxalis stricta*, *Parthenocisscus quinquefolia* (L.) Planch., *Prunella vulgaris*, *Ptilimnium costatum* (Ell.) Raf. and *Vitis cinerea* Engelms. Index values for the area south of the Johns Spur Road (Figure 1) ranged from 62 to 100 with an average of 79. Those stands north of the road ranged from 51 to 130 and averaged 86.

Arranging index numbers from lowest (moist condition) to highest (heavy wet condition) and plotting frequency for herbaceous species and importance values for tree seedlings, produced the species curves shown in figures 3 and 4. The curves were derived by averaging frequency or importance values for each species in five segments along the gradient.

Generally, the findings of this study, with regard to the moisture tolerance of the species concerned, are in agreement with those of earlier investigators (Curtis 1955; Gilbert and Curtis 1958; and Drapalik 1959). Herbaceous species having affinities for moist sites include Rhus radicans, Cinna arundinacea and Ptilimnium costatum. Poison ivy is especially successful on the moist, more open sites, but is found under all moisture conditions as shown in figure 3. Carex tribuloides, Cicuta maculata, Leersia oryzoides and Leersia virginica, are species having optimum success on very wet soils. Leersia oryzoides and Leersia virginica show similar environmental requirements for soil moisture. Impatiens biflora, a commonly encountered species in the bottoms, has highest frequency in the wet range.

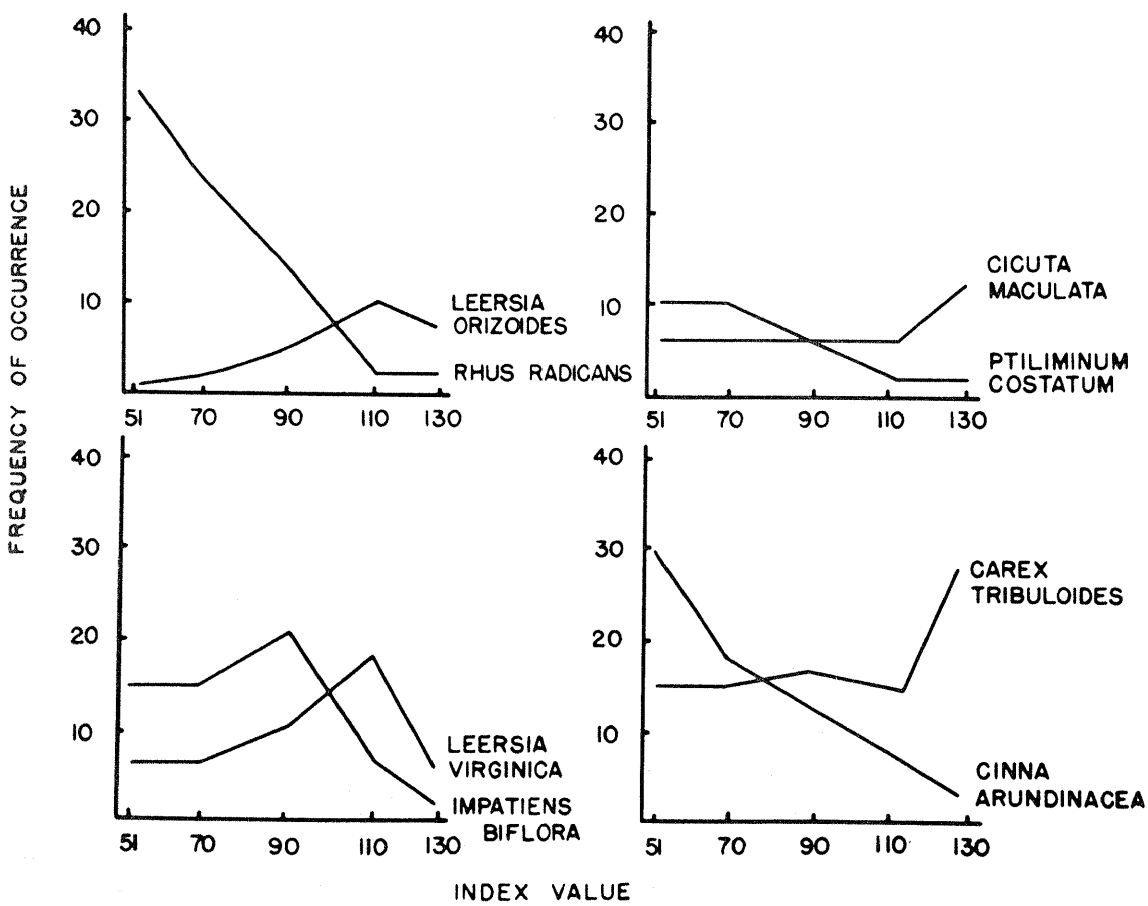

Figure 3: Tolerance curves for selected herbaceous species across the synthetic moisture gradient.

The distribution of tree species also varies with soil moisture conditions. Importance values for seedlings instead of mature trees of selected species were plotted because future forest composition is indicated by the successful establishment of seedlings. Shagbark hickory is the dominant member of stands occurring on ridges, and is important on other better-drained sites. It becomes of minor importance under wetter conditions. Cherrybark oak, also a major component of moist sites, is restricted in its distribution to these areas. Red maple is the dominant species on wet sites, and is found in great abundance in swampy areas. Green ash, slippery elm and pin oak are species which make up the largest proportion

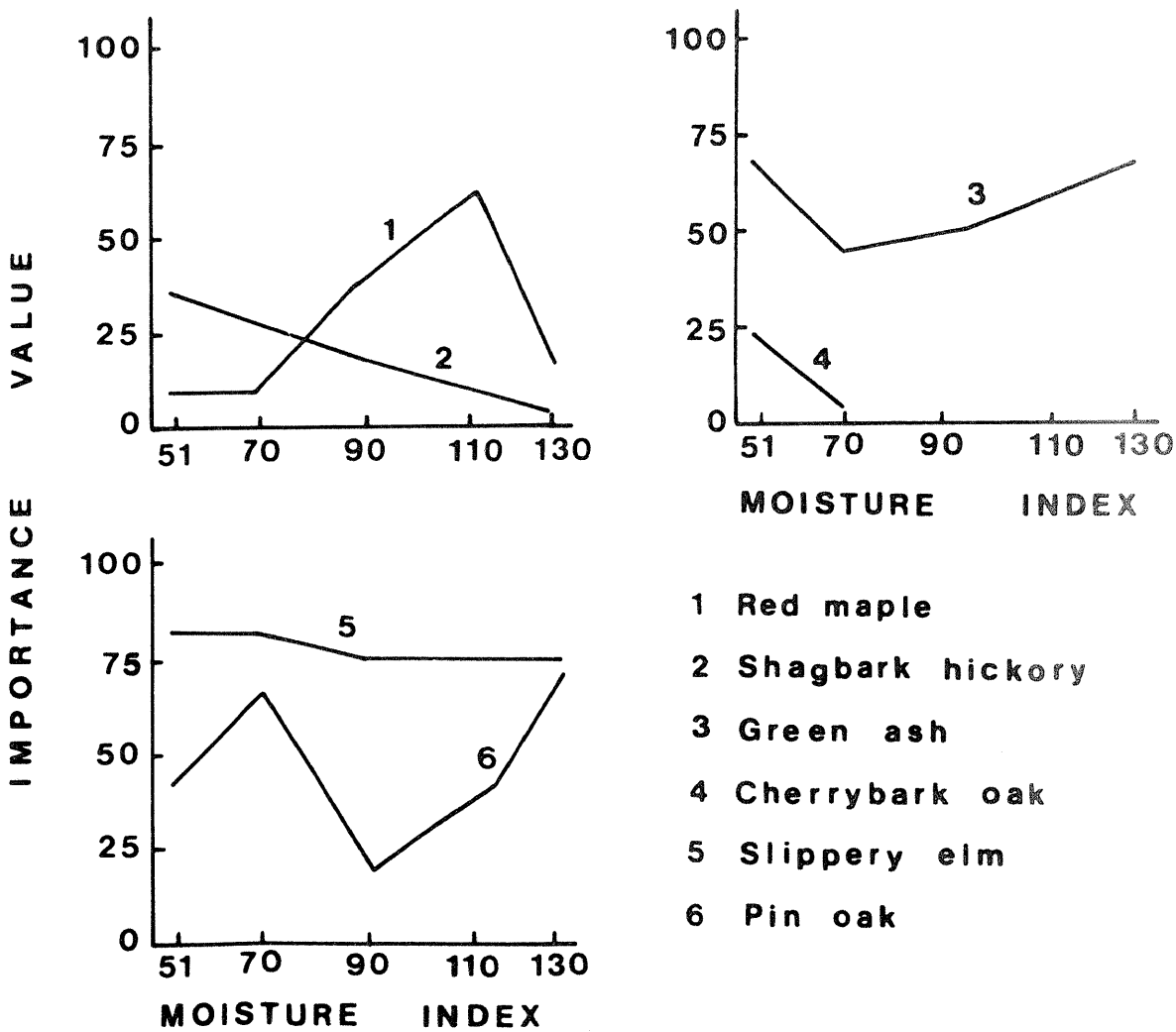

Figure 4: The success of tree seedlings across the synthetic moisture gradient.

of the composition of the Oakwood Bottoms communities. These species have a wide range of tolerance for soil moisture conditions and occur in large numbers throughout Oakwood Bottoms (Figure 4). Generally elm has higher importance values in stands having lower moisture content and ash has a higher importance value on wetter soils.

The number of species within a given area tend to increase as mois- conditions improve (Figure 5). However, on the mesic sites many of the species have relatively low frequency values. In contrast the wet and heavy-wet sites have fewer species, but relatively high frequency values are achieved by more species.

DISCUSSION

The vegetation of the Oakwood Bottoms presents a complex pattern of species associations. Generally, species distributions conform to topography and subtle topographic differences; a rise of 0.6 m (2 ft.) or less, may account for major compositional changes. Because topography determines the relative drainage capacity of the site, species distribution is also related to drainage. Soil permeability may be of considerable importance in delineating drainage patterns, but the small ridges and gentle elevational rises appear to be of greater significance.

Several authors have examined the tolerances of bottomland species to inundation (Yeager 1949; Brink 1954; Hosner 1960; and Hosner and Boyce 1962). In this study, species distributions were found to conform to a moisture gradient, and those species with similar tolerances to moisture associated together in a somewhat consistent pattern. Species displaying a narrow range of tolerance for a particular moisture regime include cherrybark oak, red maple, silver maple, shagbark hickory and American elm. Pin oak, slippery elm, and green ash are species which are less restrictive in their distribution.

While topographic factors influence species distribution, successful establishment, to a large extent, depends on light conditions at the seedling level. This phenomenon is especially pronounced in the pin oak communities. A pioneer on bottomlands, pin oak is being replaced by more shade tolerant species in all stands in which basal area exceeds 18.4 m^2 per ha (80 sq. ft. per acre).

A similar pattern is noted in the cherrybark oak stands. In this study cherrybark was a major component of those areas of better drainage that had previously been cleared for agriculture. Similarly, Fowells (1965), indicates cherrybark oak is especially common in second bottoms, if the site happens to be an abandoned field. However, in none of the stands sampled was there evidence of this species replacing itself. Cherrybark is also rated as intolerant to shading (Baker 1949). In both

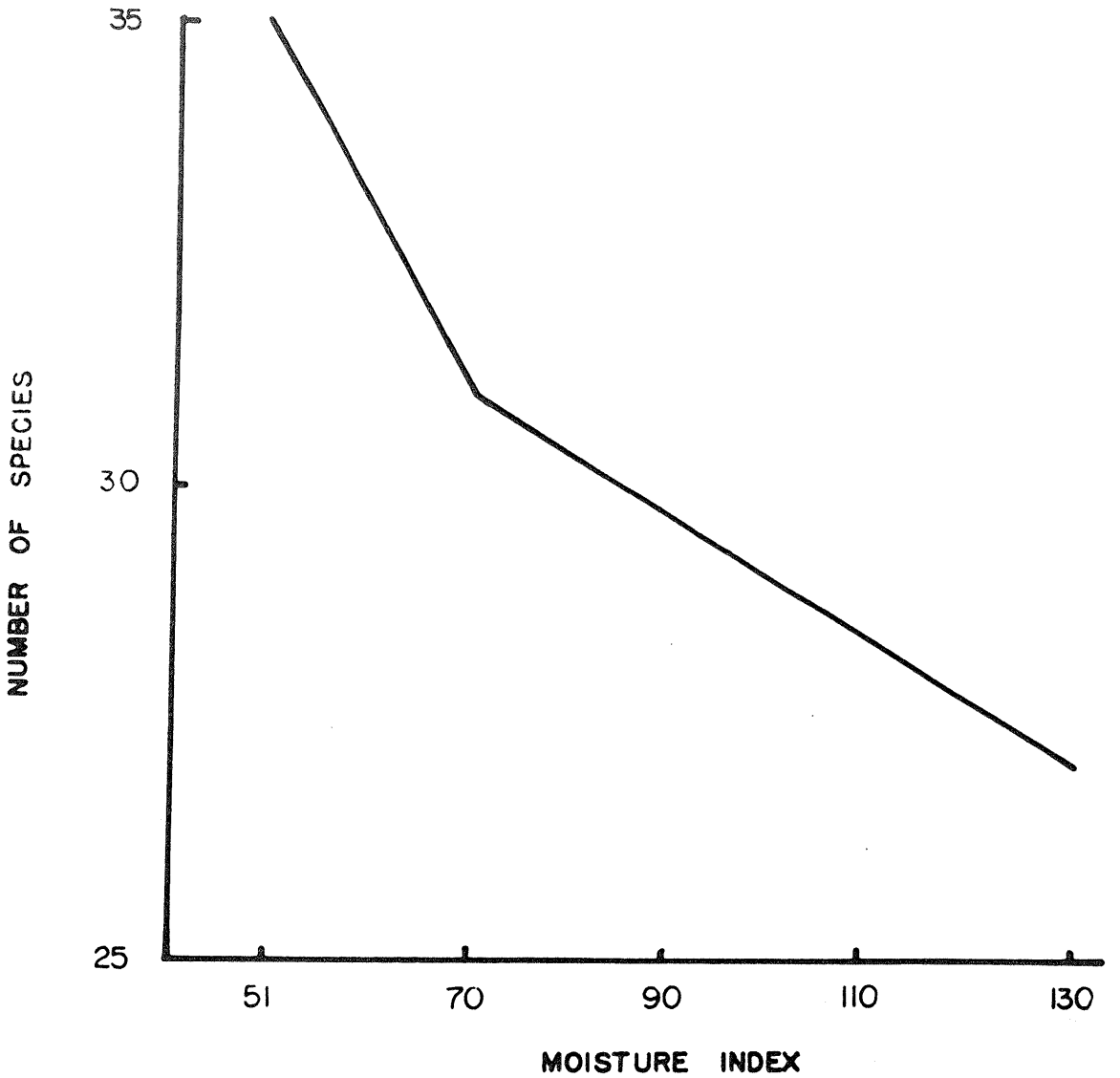

Figure 5. The diversity of herbaceous species along the synthetic moisture gradient.

communities slippery elm and green ash are increasing in importance in the seedling, sapling, and small tree size classes. In none of the stands did elm or ash surpass the 40.6 cm (16 in.) size class. The current management plan for the area calls for a system of clear cutting, on a forty year rotation, which will encourage pin and cherrybark oak reproduction, and maintain these fast growing, mast-producing species.

The willow community occupies a site somewhat lower in elevation than the surrounding pin oak communities, and prior to levee construction probably contained some overflow water most of the year. The site

on which this community occurs was mapped as a swampy area during the 1911 U.S. Geological Survey, but drained shortly thereafter. As a result of flood control, the community is being invaded by pin oak and ash, and will probably be replaced by these species. The composition of the red maple community is also being altered by encroaching pin oaks. Red maple, however, is rated as more tolerant to shade than pin oak, and for this reason, the community structure may not be greatly altered.

Even though sites may be flooded due to rainfall during the early growing season, the fall and winter months are often quite dry. In the past, these have been the months when fires most frequently occurred (Minton 1970). When pin oak is young the bark is thin and easily damaged by fire, but the bark on older trees is thicker and more fire resistant. Ground fires at this time of the year will kill trees up to saw timber size (Minckler 1957).

The shagbark hickory community is without substantial reproduction of any tree species, and yet shows no signs of recent disturbance. Past fires in the bottoms may have contributed to the even-age appearance of some stands. It is also possible that the lush growth of herbaceous plants and shrubs, supported by this drier site, reduces the success of seedlings and saplings.

The hydrology of the area has been altered by levees, and high density stands of pin oak exist where formerly more species rich communities apparently occurred. Because compartmentalization of the reservoir has impeded run-off, soils tend to be wetter and remain so for longer periods of time. Dormant season flooding has contributed to increased soil moisture, but the effect upon pin oak reproduction and survival seems to be negligible (Minckler and McDermott 1960, Minckler and James 1965). A more important factor in pin oak establishment is light intensity and competition during the seedling and sapling stages. Pin oak ranks above cottonwood and willow, but below slippery elm, green ash and hickory in shade tolerance. Overtopped trees do not compete but will quickly respond to release (Minckler 1958). Thus, the flooding operation need not be interrupted from year to year, but rather a prescribed program of clear cutting would seem to insure the maintenance of high density pin oak stands.

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