STRUCTURE OF SLOPE FORESTS ALONG THE DES MOINES RIVER IN CENTRAL IOWA PRIOR TO IMPOUNDMENT

by

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TABLE OF CONTENTS

INTRODUCTION

Land office survey records show that in Iowa prior to 1850, native deciduous forests occupied about 16 percent of the total land area. In central Iowa, these forests occurred principally along major stream systems such as the Des Moines and Raccoon Rivers. Even less of Iowa is now forested, and that which remains is becoming more and more valuable for erosion control, as a provider of recreation, as cover for wildlife, and possibly as a timber source. The encroachment upon natural areas as a result of expanding urbanization will certainly continue, and it is necessary to insure that certain of these areas are studied and preserved.

This investigation was undertaken with two principal objectives in mind: (1) to provide data relating to the composition of forested slopes in central Iowa; and (2) to initiate a study which may be used in the future to determine the effects of flooding on forest species in the area of the Saylorville Reservoir.

Species composition of forested slopes is incompletely known for central Iowa. No study was found in which the forest community has been studied quantitatively, and interrelationships between canopy species and herbaceous species have not been reported. Obtaining data showing these interrelationships has always been a problem and this study proved to be no exception. After sites were chosen, the problem arose as to which techniques best accomplished the goals. The terrain also presented problems, for it is difficult to assess cover values on a 60 percent slope.

Reservoirs currently being constructed along the Des Moines River are expected to have a profound effect on the composition of the forested slopes along the river. In order to determine the effects of flooding on species composition, it was necessary for a study to be conducted prior to flooding. A comparison of the values obtained following flooding with those obtained prior to flooding will aid in management of these areas in the future.

The Saylorville Dam and Reservoir project was authorized by Congress in the Flood Control Act of 1958. The dam site is located 213.7 miles above the mouth of the Des Moines River, near the geographic center of the state. The reservoir will function primarily as a means of flood control for the city of Des Moines, but it will also be used for recreation purposes. Work on the dam was begun in the summer of 1965 and is scheduled for completion during 1970. According to the plans, the conservation pool will cover 5,550 acres, and the flood control pool will cover a maximum of 16,250 acres. The surface of the conservation pool will be 833 feet above sea level, while the maximum surface level of the flood control pool will be 884 feet above sea level. The watershed above the dam will include 5,823 square miles (U.S. Army Corps of Engineers, 1964). Parts of Polk, Dallas, and Boone counties are included in the reservoir area.

Hopefully, the data made available by the completion of this portion of the study will be useful in long-range planning and management of the forests bordering reservoirs in Iowa.

LITERATURE REVIEW

The vegetation of central Iowa during the earliest European settlement has traditionally been described as prairie with forests along the streams. Transeau (1905) included Iowa within the prairie peninsula and noted that the number of forest species in Iowa was fewer than the number found in the eastern portion of the prairie peninsula. Braun (1947) considered central Iowa to be a transition zone in which at least two major forest associations merged, the oak-hickory forest association found principally to the south of Iowa and the maple-basswood association found primarily to the northeast of central Iowa. Kuchler (1964) indicated on his map of the potential natural vegetation of the United States that central Iowa is oak-hickory forest along the streams, and a mosaic of tall-grass prairie and oak-hickory forest on the uplands away from the stream systems. Central Iowa has a precipitation-evaporation ratio of .80, which indicates a prairie vegetation (Jenny, 1941). A value greater than 1.0 is indicative of forest vegetation, while a value less than 1.0 indicates prairie vegetation. McComb and Loomis (1944) suggested that the invasion of the prairie by forest species, which seems to be occurring at present, is caused by a climatic change toward more humid conditions.

Literature Regarding Forest Composition

The earliest records of forest species in Iowa were historical notes regarding the presence of timber species. Hewes (1950) reported that historical notes of 1856 included references to the vegetation along the Skunk River in which the following was reported:

> There was a goodly amount of timber along the river (Skunk) consisting largely of white, burr, red, and black oak, black walnut, butternut or white walnut, hard and soft maple, basswood or linden, buttonwood, honey-locust, coffeenut, hickory, elm, etc., etc.

Much of the early work relating to forest ecology in central Iowa was concerned with attempts to explain why forest species did not successfully invade the prairie. The earliest attempt was by MacBride (1895) in which he suggested fire as a factor preventing establishment of forest seedlings in prairies. Shimek (1899) suggested that prevailing winds could greatly affect the presence or absence of a forest flora on upland sites.

One of the first studies of the forest habitat in central Iowa was conducted by Becraft (1923). Later, Aikman and a number of his students studied the forests of central Iowa, placing emphasis upon classification of the community types and upon measuring the various microclimatic factors existing in the different community types which they recognized. Aikman and Gilly (1948) recognized three distinct forest communities along the Des Moines River. In order of decreasing mesophytism, these were the maple-basswood community, the oak-hickory community, and the shrub community. Aikman and Smelser (1938) stated that the maple-basswood community represents the highest stage of forest development in central Iowa.

The most extensive work relating to composition of forests along the Des Moines River was reported by Kucera (1950). An attempt was made to relate species composition to environmental factors including soil, climatic conditions, parent material, and topography. He found white oak (Quercus alba)[a] to be the dominant species on upland areas with red oak (Quercus rubra), basswood (Tilia americana), and black maple (Acer nigrum) occurring on the more mesic slopes. He pointed out, however, that the forest composition showed wide variations from stand to stand.

Literature Relating to Response of Vegetation to Flooding

Few studies have been conducted on the effects of flooding on forest species in the Midwest. Vegetative changes following flooding were reported by Peterson (1957) in Nebraska. His results were reported using photographs only, and the study was begun after the reservoir had filled with water. Consequently, little is known of the original vegetation or the initial effects of the water on the vegetation.

There have been a few studies conducted relating the effects of excess water on tree species. These have limited application to the present study because they were conducted under greenhouse conditions. The effects of complete inundation on seedlings of six bottomland species was reported by Hosner (1958). He found that all test seedlings were dead after 32 days except those of willow. A similar study in which seedlings of bottomland tree species were subjected to prolonged periods of saturated soils was conducted by McDermott (1954). No quantitative studies were found in which vegetative responses to flooding under natural

[a]Nomenclature after Fernald (c1950).

conditions have been studied.

Literature Regarding Environmental Conditions in Forest Communities

Large quantities of data on environmental conditions in Midwest forest communities have been collected. In some cases, comprehensive studies have been conducted in an attempt to show relationships between forest patterning and environmental conditions in central Iowa (Kucera, 1950; and Aikman and Smelser, 1938) and elsewhere (McIntosh, 1957; and Cranshaw et al., 1965). Other studies relating environmental conditions to vegetation in Midwest forests include those of Beals and Cope (1964), Bray (1960), Eggler (1938), and Dodge and Aikman (1932).

METHODS

Location and Description of Field Sites

The areas in this study were selected using the following criteria: (1) locations with little recent disturbance; (2) sites from different sections of the reservoir area; and (3) ease of relocation following reservoir construction.

Area I - Corydon Bridge

This area, designated CB, is located nearest the dam site, at T80N, R25W, Sect. 13, SW 1/4. This southeast-facing slope is short and very steep with an average percent slope of about 50 percent for the upper slope. The lower portion of the area consists of a small terrace and a narrow floodplain. The slope here averages about 10 percent.

Site I The upper slope consists of a poorly-developed, immature soil with evident erosion. Herbaceous vegetation on this site is sparser than on most other sites.

Site II The lower slope is not as steep as the upper site and a well-developed soil is present. The site includes the terrace and a part of the floodplain. The soil type here is likely Kato, Marshan, or Waukegan. These and other soil types were taken from Oschwald et al. (1965) based on topographic position and site observations.

Area II - Jester County Park I

This area, designated as JI, is located at T81N, R25W, Sect. 33, SW 1/4. It represents an area which has had some disturbance of unknown amount in the past. This was likely in the form of selective removal of trees. Although no stumps were evident, the scarcity of trees on the site suggested some cutting. This is an east-facing slope with an average slope of about 24 percent. The lower portion of the area is not as steep with an average of 5 percent slope.

Site III The upper slope has a very open canopy and a dense understory dominated by "disturbance species". The soil type of this site is likely Hayden, based on topographic position (Oschwald et al., 1965).

Site IV The lower slope appears to be less disturbed than the previous site, with much less sunlight reaching the herbaceous layer. Part of the area seems to be on a terrace, and this portion of the site will be permanently flooded by the reservoir. The soil types of this site include Hayden on the steeper portions with Kato, Marshan, or Waukegan on the terrace.

Area III - Jester County Park II

This area, designated JII, is located at T81N, R25W, Sect. 32, NE 1/4. This east-northeast facing slope is not as steep as any of the other areas, and a well-developed soil is present. The extreme upper slope has an average slope of 4 percent while the lower slope has a 22 percent average.

Site V The upper slope is gentle with a well-developed soil. The soil types here include Lester and Hayden, with the Lester occurring on the extreme upper portion of the area and the Hayden elsewhere.

Site VI The lower slope is much steeper than the upper slope. The canopy is quite dense. The soil is well-developed and is predominantly Hayden.

Area IV - High Bridge I

This area, designated as HBI, is located at T81N, R26W, Sect. 25, NE 1/4, NE 1/4. This north-facing slope varies from steep to very steep with an average slope of 36 percent on the lower slope and 32 percent on the upper slope. Soil development varies from poorly developed on very steep slopes to well-developed on moderate slopes. Shale outcrops in portions of the area. Very little signs of disturbance were noted.

Site VII The upper slope has a closed canopy in which little direct sunlight reaches the herbaceous layer. The soil is well-developed and is primarily Hayden. A gully runs through the middle of the site.

Site VIII The lower slope has both the steepest slope and the most gentle slope in this area. Soils vary from undeveloped to Hayden to Kato, Marshan, or Waukegan (on the extreme lower portion).

Area V - High Bridge II

This area has the same location as Area IV except that it is the NW 1/4 of the NE 1/4. It is similar to Area IV in topography, slope aspect, and soil types. The upper slope is steeper than in Area IV, with an average slope of 43 percent.

Site IX The upper slope is quite steep. The soil is well-developed except on the steeper portions of the slope. Hayden is the principal soil type.

Site X The lower slope includes the very narrow floodplain. On this site *Quercus rubra* and *Acer nigrum* are growing on the floodplain.

This unusual occurrence will give an opportunity to evaluate the ability of these two species to survive long periods of flooding. The soil types here include Hayden on the slopes and Kato, Marshan, or Waukegan on the floodplain.

Site XI The upper flat, with an average slope of 6 percent, was chosen to allow comparison of vegetation occurring on slopes with that occurring on level ground. The soil types here are Lester and Hayden.

Field Techniques

Transect study

A preliminary procedure of sampling was used which consisted of transects laid out from the top of the slope to the bottom in each of the first four areas. The location of each of the transects was marked using prominent features of the area. The upper end of the transect was marked with a stake, and the compass direction in which the transect extended was recorded. The transects were of varying lengths, depending upon the length of the slope. Quadrats (20 cm. X 50 cm.) were placed at constant intervals of six feet along the transect. The quadrat was always placed on the left side of the tape with the longest side of the quadrat at right angles to the tape. Each sample point was marked with a six-inch piece of wire to facilitate re-sampling at a later date.

At each point, species were recorded that extended any vegetative part into the area of the quadrat. The degree to which each species covered the quadrat area was recorded using the canopy-coverage method of Daubenmire (1959). Coverage classes were used:

Coverage class	Cover range (percent)	Mid-point of range
1	0.1- 5.0	2.5
2	5.1- 25.0	15.0
3	25.1- 50.0	37.5
4	50.1- 75.0	62.5
5	75.1- 95.0	85.0
6	95.1-100.0	97.5

Because density was not being recorded, it was not necessary for the stem of an individual to be anchored within the plot in order to be recorded. Daubenmire (1959) justified the use of coverage classes 1 and 6 because some rare species would be over-estimated using a coverage class of 0.0 to 25.0 percent, while other very abundant species would be under-estimated using a coverage class of 75.0 to 100.0 percent.

Random-point study

A more intensive study was conducted in which the sample points were chosen at random. I decided that this study would be most meaningful if the sites were studied by vegetation layers. It was also decided that the areas should be divided into upper and lower sites in order to determine if significant differences in composition could be noted between upper and lower slopes. Altogether, eleven sites were studied in which the canopy species, the reproduction of the canopy species, and the herbaceous vegetation were analyzed separately.

The quarter method described by Cottam and Curtis (1956) was used to sample the canopy layer vegetation. For the location of sample points, a guide-line was established using prominent features of the landscape. The study was random in the sense that features used were not within the study area and the trees which would be sampled were not subjectively chosen. Along the guide-line, sample points were taken at intervals of 13 paces. This interval was chosen because the number of individuals sampled in consecutive sample points would be reduced. In most cases, it was necessary to set up additional guide-lines at different angles across the area depending upon the size of the area. At each sample point, a point-centered cross was set up with one axis along the guide-line and the other at right angles to the guide-line. In each of the four quadrants, the tree nearest the center of the cross was recorded. The data recorded included species, distance to the tree (to the nearest one-half foot), and basal area in square inches. Basal area was determined using a specially-marked tape from which basal area in square inches could be obtained directly. For each stand, a total of 48 points was sampled, resulting in the recording of 192 individuals in each stand.

For sampling the tree reproduction layer, the quarter method was used with the height of saplings as a mean of determining dominance instead of basal area. The following height-classes were used instead of individual measurements:

Height-class	Height-range (in feet)
1	0.5- 2.0
2	2.1- 4.0
3	4.1- 6.0
4	6.1- 8.0
5	8.1-10.0
6	over 10.0

Any individual with a basal area of 12 square inches was considered a tree and those individuals with less than 12 square inches basal area were considered saplings. Again, 48 sample points were taken for each stand. The number of paces between sample points was variable, depending on the number drawn from a table of random numbers (Curtis and Cottam, 1962).

The herbaceous vegetation was sampled by the canopy-coverage method used in the preliminary transect study. Samples were taken at random, using a random numbers table. Cover of mature canopy species was omitted, as was the cover of the saplings; however, tree seedlings less than 0.5 feet were included in the cover data. For each site, 161 points were sampled. Care was taken not to range beyond the limits of the site being sampled, and border areas were not sampled.

Data Analysis

Transect study

Average cover was determined for each species using the midpoint of the ranges of the cover classes. Average cover per plot was determined by dividing the total cover for each species (in percent) by the total number of points sampled.

Correlation matrices were prepared in which the average cover of each species was compared with that of all other species. Species which tended to occur together would show positive correlations, while those which seldom or never occur together would show negative correlations. Samples were generally grouped into four's or two's in order to reduce the number of zeros. Otherwise, results would show more correlations than actually exist (Bray, 1956). Absolute values of .400 or greater were considered sufficient to suggest correlations.

Random-point study

For the analysis of the data obtained for canopy species, importance values were determined for each species in each stand. Importance values consist of the sum of the relative frequency, relative density, and relative dominance. These values are determined as follows:

$$\text{Relative frequency} = \frac{\text{No. of points of occurrence of a species}}{\text{No. of points of occurrence of all species}} \times 100$$

$$\text{Relative density} = \frac{\text{No. of individuals of each species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Basal area of each species}}{\text{Basal area of all species}} \times 100$$

For any stand the total importance value is 300. The density of trees in each stand was determined as in Curtis and McIntosh (1951).

The saplings were treated in a manner similar to the canopy layer. Importance values were determined for each species in each stand. However, a slight modification in obtaining relative dominance values was necessary. Relative dominance was determined as follows:

$$\text{Relative dominance} = \frac{\text{Total height of each species}}{\text{Total height of all species}} \times 100$$

Density of saplings was determined in the same manner as for the density of trees of the canopy layer.

For the herbaceous vegetation, frequency and average cover were calculated. Frequency was determined by dividing the number of plots of occurrence of each species by the total number of plots sampled. Average cover was determined by dividing the total cover for each species by the number of sample plots.

Presentation of Data

Transect study

The correlation-matrix data were suitable for presenting in tabular form. Species constellations often can be used to help point out the interrelationships between species in each area.

Random-point study

The concept of the continuum index developed by Curtis and McIntosh (1951) was used to present the data of all three layers of this study. It was hoped that the three layers could be related in this manner.

In order to determine the position along the continuum index which each stand occupied, each species was assigned a climax-adaptation number (see Table 12). A majority of species assigned numbers by Curtis and McIntosh (1951) in Wisconsin also occurred in central Iowa. The same numbers were used in my study. Species which were not included in their study were assigned climax-adaptation numbers based on the tolerance values used by foresters, since tolerance values are closely related to climax-adaptation numbers (Curtis and McIntosh, 1951).

The position of a stand along the continuum index was determined by multiplying the climax-adaptation number of each species in the stand by the importance value of that species. The continuum-index number of the stand was determined by summing the products of the climax-adaptation number times importance values.

The tables and graphs were presented on the basis of the vegetational continuum, in which stands with lower continuum-index numbers were at one end of the scale and those with higher continuum-index numbers at the other. In all instances, tables were presented with the stands with lower continuum-index numbers toward the left-hand side of the page.

RESULTS

Transect Study

Correlation values based on average cover per plot for species-pairs in each of the four areas are presented in Table 1, assuming .4 as the level which suggests correlation. Values with negative signs indicate situations in which the species tend not to occur together. Positive values represent tendencies for species to occur together.

In Area I (Corydon Bridge), red oak (Quercus rubra), white oak (Quercus alba), basswood (Tilia americana) and black maple (Acer nigrum) are positively correlated. Parthenocissus quinquefolia and ironwood (Ostrya virginiana) are correlated with each other but not with any of the tree species mentioned above. Relationships for Area I are summarized in Figure 1.

In Area II (Jester I), only three species-pairs show negative correlations. Also, only two tree species show correlations with as many as five other species (Acer nigrum and slippery elm, Ulmus rubra). Other species relationships for Area II are presented in Figure 2.

Many correlations at the .4 level are shown for species-pairs in Area III (Jester II). Tree species which are correlated with several other species include Ulmus rubra, Quercus alba, and Tilia americana. These and other relationships for Area III are shown in Figure 3.

Correlation values obtained for species-pairs in Area IV (High Bridge I) show that important tree species in terms of the number of correlations with other species include Acer nigrum, American elm (Ulmus americana)

Table 1. Correlation values greater than .4 (absolute value) between species in slope transects

Species	to	Species	Correlation value
		Area I (Corydon Bridge)	
Parthenocissus quinquefolia	-	Tilia americana (1)[a]	-.43
Parthenocissus quinquefolia	-	Quercus alba (1)	-.43
Parthenocissus quinquefolia	-	Carex sp.	-.42
Parthenocissus quinquefolia	-	Ulmus americana (1)	-.44
Parthenocissus quinquefolia	-	Ostrya virginiana (1)	.50
Rhus radicans	-	Celtis occidentalis (1)	.40
Tilia americana (1)	-	Quercus rubra (1)	.52
Tilia americana (1)	-	Quercus alba (1)	.84
Tilia americana (1)	-	Acer nigrum (1)	.73
Tilia americana (1)	-	Ostrya virginiana (1)	-.53
Tilia americana (1)	-	Celastrus scandens	.54
Tilia americana (1)	-	Xanthoxylum americanum	.41
Tilia americana (1)	-	Ribes spp.	-.42
Quercus rubra (1)	-	Quercus alba (1)	.63
Quercus rubra (1)	-	Carex sp.	.53
Quercus rubra (1)	-	Acer nigrum (1)	.65
Quercus rubra (1)	-	Tilia americana (s)[b]	.42
Quercus rubra (1)	-	Ribes spp.	-.41
Quercus rubra (1)	-	Populus deltoides (1)	-.47
Quercus alba (1)	-	Carex sp.	.64
Quercus alba (1)	-	Acer nigrum (1)	.92
Quercus alba (1)	-	Ostrya virginiana (1)	-.68
Quercus alba (1)	-	Celastrus scandens	.48
Quercus alba (1)	-	Xanthoxylum americanum	.49
Carex sp.	-	Acer nigrum (s)	.68
Carex sp.	-	Amelanchier sp.	.65
Carex sp.	-	Carya ovata (s)	.65
Carex sp.	-	Acer nigrum (1)	.73
Acer nigrum (s)	-	Amelanchier sp.	.90
Acer nigrum (s)	-	Carya ovata (s)	.90
Acer nigrum (s)	-	Acer nigrum (1)	.42
Acer nigrum (1)	-	Ostrya virginiana (1)	-.53
Acer nigrum (1)	-	Celastrus scandens	.57
Acer nigrum (1)	-	Xanthoxylum americanum	.50
Ulmus americana (1)	-	Pilea pumila	-.43

[a](1) - refers to mature individuals of a species.

[b](s) - refers to saplings and seedlings of a species.

Table 1. Continued

Species	to	Species	Correlation value
Thalictrum dioicum	-	Carya cordiformis (s)	.51
Celastrus scandens	-	Xanthoxylum americanum	.59
Celtis occidentalis (s)	-	Populus deltoides (l)	.56
Celtis occidentalis (s)	-	Menispermum canadense	.57
Tilia americana (s)	-	Ostrya virginiana (s)	.78
Cornus spp.	-	Carya cordiformis (s)	.70
Carex rosea	-	Celtis occidentalis (l)	.56
Carex rosea	-	Polygonatum canaliculatum	.46
Ribes spp.	-	Juglans nigra (l)	.47
Ribes spp.	-	Crataegus sp.	.45
Ribes spp.	-	Platanus occidentalis (l)	.41
Juglans nigra (l)	-	Celtis occidentalis (l)	.61
		Area II (Jester I)	
Parthenocissus quinquefolia	-	Carya cordiformis (s)	.46
Viola spp.	-	Carex rosea	.47
Carex rosea	-	Ribes spp.	-.46
Tilia americana (l)	-	Pilea pumila	.49
Tilia americana (l)	-	Carya cordiformis (s)	.41
Ulmus spp. (s)	-	Ulmus rubra (l)	-.40
Ulmus spp. (s)	-	Celtis occidentalis (s)	.41
Pilea pumila	-	Celtis occidentalis (l)	.41
Pilea pumila	-	Viola pensylvanica	.70
Pilea pumila	-	Menispermum canadense	.47
Celtis occidentalis (l)	-	Viola pensylvanica	.47
Centis occidentalis (l)	-	Ulmus rubra (l)	.46
Celtis occidentalis (l)	-	Smilax tamnoides hispida	.44
Galium aparine	-	Quercus macrocarpa	-.46
Cornus spp.	-	Smilax tamnoides hispida	.62
Cornus spp.	-	Carya ovata (l)	.41
Rhus radicans	-	Viola pensylvanica	.58
Rhus radicans	-	Ulmus rubra (l)	.42
Ulmus rubra (l)	-	Acer nigrum (s)	.48
Ulmus rubra (l)	-	Carya cordiformis (s)	.41
Acer nigrum (s)	-	Ostrya virginiana (l)	.42
Acer nigrum (s)	-	Acer nigrum (l)	.60
Acer nigrum (s)	-	Viola pensylvanica	.54
Bromus purgans	-	Gymnocladus dioica (s)	.40
Fraxinus nigra (l)	-	Morus rubra (s)	.46
Carya cordiformis (s)	-	Quercus rubra (s)	.44
Carya cordiformis (s)	-	Acer nigrum (l)	.46
Vitis riparia	-	Nepeta cataria	.55

Table 1. Continued

Species	to	Species	Correlation value
Vitis riparia	-	Hydrophyllum virginianum	.44
Quercus rubra (1)	-	Osmorhiza claytoni	.49
Campanula americana	-	Oxalis stricta	.54
Geum canadense	-	Leersia virginica	.55
Geum canadense	-	Gymnocladus dioica (s)	.47
Geum canadense	-	Amphicarpa bracteata	.55
Hydrophyllum virginianum	-	Nepeta cataria	.46
Hydrophyllum virginianum	-	Ostrya virginiana (1)	.57
Hydrophyllum virginianum	-	Acer nigrum (1)	.58
Amphicarpa bracteata	-	Gleditsia triacanthos (s)	.79
Amphicarpa bracteata	-	Leersia virginica	.48
Ostrya virginiana (1)	-	Acer nigrum (1)	.70
Gymnocladus dioica (s)	-	Leersia virginica	.48
Sanicula canadensis	-	Chenopodium album	.45
Viola pensylvanica	-	Menispermum canadense	.70
Quercus alba (1)	-	Leersia virginica	.76
		Area III (Jester II)	
Quercus alba (1)	-	Ulmus spp. (s)	.45
Quercus alba (1)	-	Viola spp.	-.57
Quercus alba (1)	-	Quercus rubra (1)	-.41
Quercus alba (1)	-	Rhus radicans	-.45
Quercus alba (1)	-	Ostrya virginiana (1)	-.43
Vitis riparia	-	Sanicula canadensis	.79
Vitis riparia	-	Ulmus rubra (1)	.43
Vitis riparia	-	Potentillia arguta	.56
Vitis riparia	-	Solidago ulmifolia	.46
Galium aparine	-	Ulmus spp. (s)	.41
Galium aparine	-	Amphicarpa bracteata	-.43
Parthenocissus quinquefolia	-	Lonicera dioica	.53
Parthenocissus quinquefolia	-	Ribes spp.	.43
Parthenocissus quinquefolia	-	Fraxinus nigra (s)	-.43
Parthenocissus quinquefolia	-	Silene stellata	.58
Parthenocissus quinquefolia	-	Celtis occidentalis (s)	.43
Parthenocissus quinquefolia	-	Morus rubra (s)	.61
Ulmus spp. (s)	-	Ribes spp.	.42
Ulmus spp. (s)	-	Carex sp.	-.46
Ulmus spp. (s)	-	Fraxinus nigra (s)	-.51
Ulmus spp. (s)	-	Amphicarpa bracteata	-.50
Carex rosea	-	Poa pratensis	.43
Carex rosea	-	Phryma leptostachya	.57
Carex rosea	-	Geum canadense	.57

Table 1. Continued

Species	to	Species	Correlation value
Carex rosea	-	Bromus purgans	.42
Carex rosea	-	Prunus virginiana	.49
Carex rosea	-	Oxalis stricta	.49
Sanicula canadensis	-	Ulmus rubra (l)	.61
Canicula canadensis	-	Potentillia arguta	.62
Ulmus rubra (l)	-	Potentillia arguta	.42
Ulmus rubra (l)	-	Smilax herbacea	.48
Ulmus rubra (l)	-	Sanguinaria canadensis	.46
Ulmus rubra (l)	-	Polygonum convolvulus	.50
Ulmus rubra (l)	-	Osmorhiza longistylis	.50
Ulmus rubra (l)	-	Hystrix patula	.50
Quercus alba (s)	-	Lonicera dioica	.48
Quercus alba (s)	-	Crataegus sp.	.49
Quercus alba (s)	-	Rubus spp.	.42
Quercus alba (s)	-	Celtis occidentalis (s)	.44
Quercus alba (s)	-	Morus rubra (s)	.41
Phryma leptostachya	-	Poa pratensis	.77
Phryma leptostachya	-	Geum canadense	.82
Phryma leptostachya	-	Prunus virginiana	.45
Phryma leptostachya	-	Oxalis stricta	.44
Bromus purgans	-	Impatiens pallida	.40
Bromus purgans	-	Fraxinus nigra (s)	.50
Bromus purgans	-	Fraxinus nigra (l)	.53
Bromus purgans	-	Cystopteris fragilis	.44
Viola spp.	-	Ostrya virginiana (s)	.47
Viola spp.	-	Campanula americana	.54
Viola spp.	-	Asarum canadense	.43
Poa pratensis	-	Smilax tamnoides hispida	.56
Poa pratensis	-	Geum canadense	.68
Poa pratensis	-	Cornus spp.	.46
Tilia americana (s)	-	Geum canadense	.47
Tilia americana (s)	-	Fraxinus pennsylvanica (l)	.46
Silene stellata	-	Morus rubra (s)	.49
Lonicera dioica	-	Celtis occidentalis (s)	.59
Lonicera dioica	-	Ribes spp.	.41
Lonicera dioica	-	Crataegus sp.	.53
Prunus virginiana	-	Ostrya virginiana (s)	.54
Prunus virginiana	-	Geum canadense	.49
Prunus virginiana	-	Carya ovata (s)	.53
Prunus virginiana	-	Carya cordiformis (s)	.46
Fraxinus pennsylvanica (s)	-	Carex sp.	.47
Fraxinus pennsylvanica (s)	-	Fraxinus nigra (s)	.44
Celtis occidentalis (s)	-	Ribes spp.	.58
Celtis occidentalis (s)	-	Crataegus sp.	.68

Table 1. Continued

Species	to	Species	Correlation value
Celtis occidentalis (s)	-	Morus rubra (s)	.45
Celtis occidentalis (s)	-	Fraxinus nigra (s)	-.44
Geum canadense	-	Oxalis stricta	.59
Ribes spp.	-	Crataegus sp.	.55
Ribes spp.	-	Fraxinus nigra (s)	-.47
Ribes spp.	-	Amphicarpa bracteata	-.56
Carya ovata (s)	-	Cornus spp.	.53
Carya ovata (s)	-	Carya cordiformis (s)	.43
Carya ovata (s)	-	Smilax tamnoides hispida	.59
Oxalis stricta	-	Rhus radicans	.40
Acer nigrum (l)	-	Amphicarpa bracteata	.54
Carya cordiformis (s)	-	Ostrya virginiana (s)	.47
Cornus spp.	-	Smilax tamnoides hispida	.87
Pilea pumila	-	Sanguinaria canadensis	.59
Hydrophyllum virginianum	-	Smilax herbacea	.84
Xanthoxylum americanum	-	Gleditsia triacanthos (s)	.55
Xanthoxylum americanum	-	Tilia americana (l)	.59
Acer nigrum (s)	-	Carex sp.	.72
Polygonatum canaliculatum	-	Ulmus americana (l)	.62
Polygonatum canaliculatum	-	Gleditsia triacanthos (s)	.41
Polygonatum canaliculatum	-	Celastrus scandens	.62
Polygonatum canaliculatum	-	Gymnocladus dioica (s)	.48
Polygonatum canaliculatum	-	Gymnocladus dioica (l)	.43
Celastrus scandens	-	Ulmus americana (l)	.68
Celastrus scandens	-	Gleditsia triacanthos (s)	.46
Ulmus americana (l)	-	Gleditsia triacanthos (s)	.84
Tilia americana (l)	-	Fraxinus nigra (l)	.77
Tilia americana (l)	-	Cystopteris fragilis	.72
Tilia americana (l)	-	Impatiens pallida	.60
Gymnocladus dioica (s)	-	Carya cordiformis (l)	.76
Gymnocladus dioica (s)	-	Gymnocladus dioica (l)	.61
Gymnocladus dioica (s)	-	Quercus rubra (l)	.41
Carex sp.	-	Amphicarpa bracteata	.46
Carex sp.	-	Rubus spp.	.41
Carex sp.	-	Asarum canadense	.41
Carex sp.	-	Ostrya virginiana (s)	.43
Impatiens pallida	-	Fraxinus nigra (l)	.69
Impatiens pallida	-	Cystopteris fragilis	.69
Carya cordiformis (l)	-	Smilax herbacea	.46
Carya cordiformis (l)	-	Gymnocladus dioica (l)	.47
Quercus rubra (l)	-	Fraxinus nigra (l)	.41
Fraxinus nigra (s)	-	Amphicarpa bracteata	.54
Fraxinus nigra (l)	-	Cystopteris fragilis	.82
Amphicarpa bracteata	-	Solidago ulmifolia	.54

Table 1. Continued

Species	to	Species	Correlation value
Ostrya virginiana (s)	-	Cystopteris fragilis	.48
Campanula americana	-	Asarum canadense	.49
		Area IV (High Bridge I)	
Asarum canadense	-	Ulmus rubra (l)	.72
Asarum canadense	-	Quercus rubra (l)	-.41
Parthenocissus quinquefolia	-	Ostrya virginiana (l)	.44
Parthenocissus quinquefolia	-	Amphicarpa bracteata	.51
Parthenocissus quinquefolia	-	Polygonatum canaliculatum	-.41
Acer nigrum (s)	-	Hepatica acutiloba	.44
Acer nigrum (s)	-	Desmodium glutinosum	.41
Acer nigrum (s)	-	Carya ovata (s)	.70
Ulmus rubra (l)	-	Quercus rubra (l)	-.54
Tilia americana (l)	-	Sanguinaria canadensis	.46
Tilia americana (l)	-	Anemonella thalictroides	.49
Tilia americana (l)	-	Hepatica acutiloba	.57
Acer nigrum (l)	-	Ostrya virginiana (l)	-.43
Acer nigrum (l)	-	Phryma leptostachya	-.41
Acer nigrum (l)	-	Rhus radicans	-.41
Acer nigrum (l)	-	Ulmus americana (l)	-.63
Acer nigrum (l)	-	Celtis occidentalis (s)	-.46
Acer nigrum (l)	-	Fraxinus nigra (l)	-.53
Hydrophyllum virginianum	-	Carex sp.	-.49
Hydrophyllum virginianum	-	Anemonella thalictroides	-.47
Hydrophyllum virginianum	-	Osmorhiza longistylis	.48
Viola spp.	-	Carex sp.	.42
Carex sp.	-	Ostrya virginiana (l)	.44
Carex sp.	-	Fraxinus pennsylvanica (s)	.47
Amphicarpa bracteata	-	Desmodium glutinosum	.62
Amphicarpa bracteata	-	Impatiens pallida	.54
Polygonatum canaliculatum	-	Anemonella thalictroides	.43
Polygonatum canaliculatum	-	Prunus virginiana	.52
Polygonatum canaliculatum	-	Uvularia grandiflora	-.47
Carex rosea	-	Sanicula canadensis	.57
Pilea pumila	-	Bromus purgans	.42
Ostrya virginiana (l)	-	Uvularia grandiflora	-.47
Celtis occidentalis (s)	-	Ulmus americana (l)	.68
Celtis occidentalis (s)	-	Phryma leptostachya	.62
Celtis occidentalis (s)	-	Rhus radicans	.51
Celtis occidentalis (s)	-	Fraxinus nigra (l)	.95

Table 1. Continued

Species	to	Species	Correlation value
Ulmus americana (l)	-	Bromus purgans	.46
Ulmus americana (l)	-	Phryma leptostachya	.60
Ulmus americana (l)	-	Sanicula canadensis	.44
Ulmus americana (l)	-	Rhus radicans	.50
Ulmus americana (l)	-	Fraxinus nigra (l)	.78
Bromus purgans	-	Phryma leptostachya	.49
Phryma leptostachya	-	Sanicula canadensis	.49
Phryma leptostachya	-	Fraxinus nigra (l)	.66
Sanicula canadensis	-	Fraxinus pennsylvanica (l)	-.41
Sanicula canadensis	-	Fraxinus nigra (l)	.41
Sanicula canadensis	-	Quercus rubra (s)	.42
Fraxinus pennsylvanica (s)	-	Hepatica acutiloba	.41
Hepatica acutiloba	-	Anemonella thalictroides	.61
Rhus radicans	-	Fraxinus nigra (l)	.52
Carya cordiformis (s)	-	Desmodium glutinosum	.40
Desmodium glutinosum	-	Impatiens pallida	.81
Fraxinus nigra (l)	-	Fraxinus nigra (s)	.89

black ash (Fraxinus nigra), and Tilia americana. These relationships are shown diagrammatically in Figure 4.

Random-Point Study

Canopy species

Importance values for all tree species on upper sites are presented in Table 2. Quercus alba and shagbark hickory (Carya ovata) show marked decreases in importance values with increases in the continuum-index number of the stands. Other species such as Quercus rubra, Tilia americana, and Acer nigrum show increases in importance values as the continuum-index number of the stand increases. The other species show no

Figure 1. Constellation based on correlation values greater than .4 for species-pairs in Area I (Corydon Bridge). Those symbols with an *s* in parentheses represent saplings and seedlings of the particular species, while those symbols with an *l* in parentheses represent mature individuals. Species symbols include: Ani, *Acer nigrum*; Aar, *Amelanchier arborea*; Cro, *Carex rosea*; Csp, *Carex* sp.; Cco, *Carya cordiformis*; Cov, *Carya ovata*; Csc, *Celastrus scandens*; Coc, *Celtis occidentalis*; Cosp, *Cornus* spp.; Crsp, *Crataegus* sp.; Jni, *Juglans nigra*; Mca, *Menispermum canadense*; Ovi, *Ostrya virginiana*; Pqu, *Parthenocissus quinquefolia*; Ppu, *Pilea pumila*; Poc, *Platanus occidentalis*; Pca, *Polygonatum canaliculatum*; Pde, *Populus deltoides*; Qal, *Quercus alba*; Qru, *Quercus rubra*; Rra, *Rhus radicans*; Risp., *Ribes* spp.; Tdi, *Thalictrum dioicum*; Tam, *Tilia americana*; Uam, *Ulmus americana*; and Xam, *Xanthoxylum americanum*

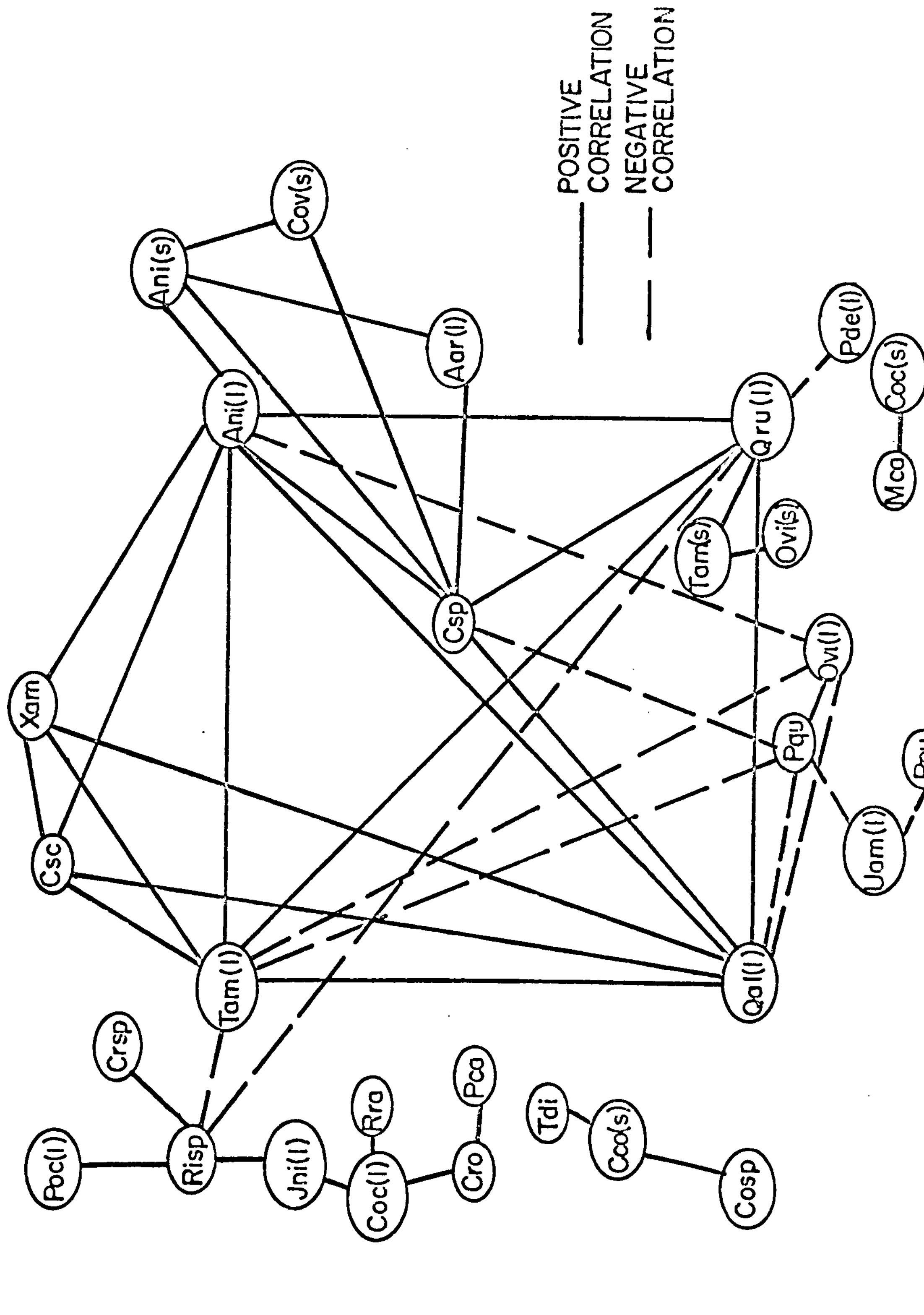

POSITIVE CORRELATION
NEGATIVE CORRELATION
Ani(s)
Cov(s)
Aar(l)
Ani(l)
Qru(l)
Pde(l)
Coc(s)
Mca
Tam(s)
Ovi(s)
Csp
Ovi(l)
Xam
Pqu
Ppu
Uam(l)
Csc
Tam(l)
Qal(l)
Crsp
Pca
Rra
Poc(l)
Risp
Jni(l)
Coc(l)
Cro
Tdi
Cosp

Figure 2. Constellation based on correlation values greater than .4 for species-pairs in Area II (Jester I). Those symbols with an *s* in parentheses represent saplings and seedlings of the particular species, while those symbols with an *l* in parentheses represent mature individuals. Species symbols include: Ani, *Acer nigrum*; Abr, *Amphicarpa bracteata*; Bpu, *Bromus purgans*; Cam, *Campanula americana*; Cro, *Carex rosea*; Cco, *Carya cordiformis*; Cov, *Carya ovata*; Coc, *Celtis occidentalis*; Cosp, *Cornus* spp.; Fni, *Fraxinus nigra*; Gap, *Galium aparine*; Gca, *Geum canadense*; Gtr, *Gleditsia triacanthos*; Gdi, *Gymnocladus dioica*; Hvi, *Hydrophyllum virginianum*; Lvi, *Leersia virginica*, Mca, *Menispermum canadense*; Mru, *Morus rubra*; Nca, *Nepeta cataria*; Ocl, *Osmorhiza claytoni*; Ovi, *Ostrya virginiana*; Ost, *Oxalis stricta*; Pqu, *Parthenocissus quinquefolia*; Ppu, *Pilea pumila*; Qal, *Quercus alba*; Qma, *Quercus macrocarpa*; Qru, *Quercus rubra*; Rra, *Rhus radicans*; Risp, *Ribes* spp.; Sth, *Smilax tamnoides hispida*; Tam, *Tilia americana*; Uru, *Ulmus rubra*; Ulsp, *Ulmus* spp; Vpe, *Viola pensylvanica*; Visp, *Viola* spp.; and Vri, *Vitis riparia*

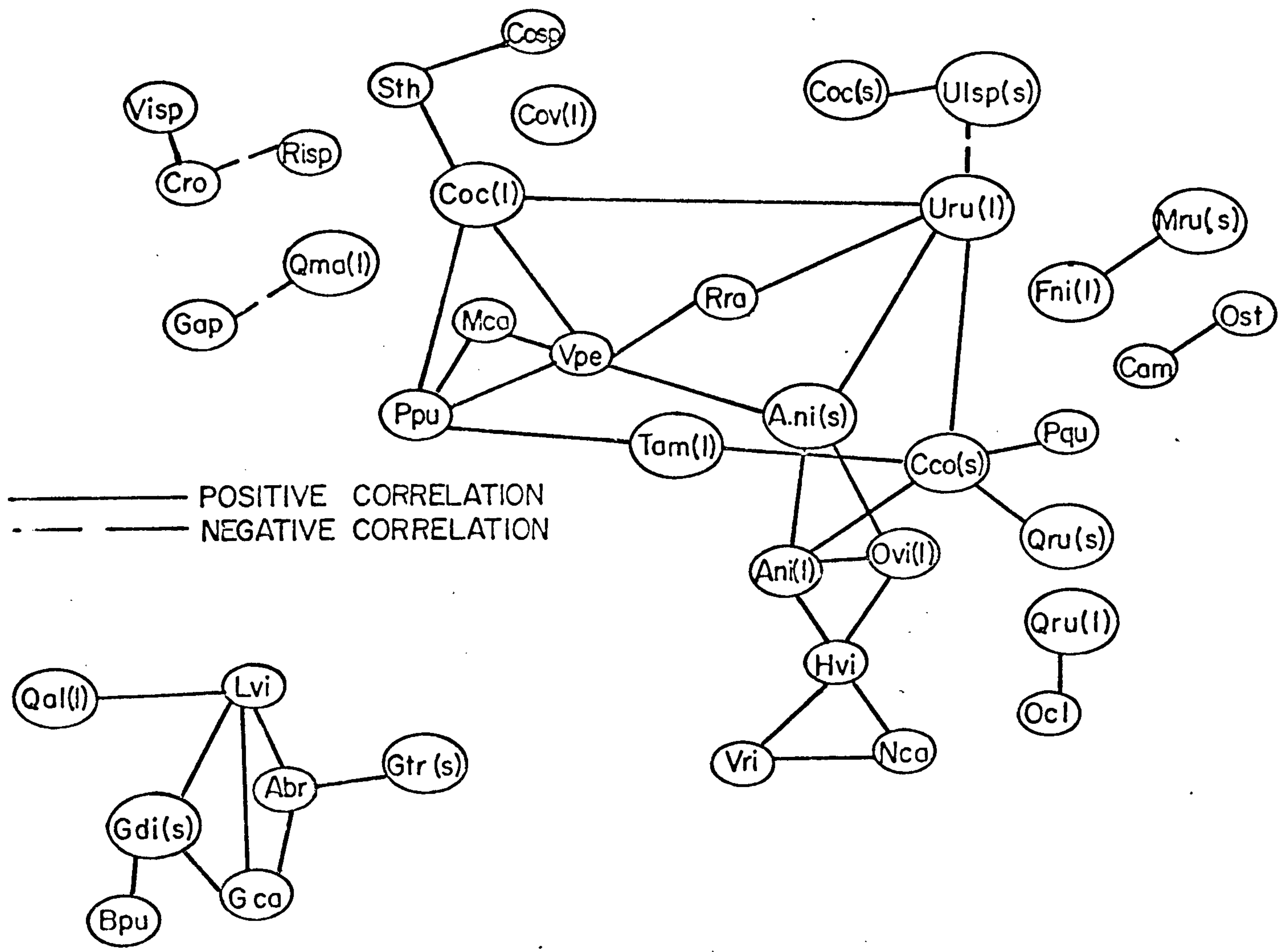

POSITIVE CORRELATION
NEGATIVE CORRELATION
Visp
Cro
Risp
Qma(l)
Gap
Sth
Cosp
Cov(l)
Coc(l)
Mca
Vpe
Ppu
Rra
Tam(l)
A.ni(s)
Coc(s)
Ulsp(s)
Uru(l)
Mru(s)
Fni(l)
Ost
Cam
Pqu
Cco(s)
Qru(s)
Ani(l)
Ovi(l)
Hvi
Vri
Nca
Qru(l)
Ocl
Qal(l)
Lvi
Abr
Gtr (s)
Gdi(s)
G ca
Bpu

Figure 3. Constellation based on correlation values greater than .4 for species-pairs in Area III (Jester II). Those symbols with an *s* in parentheses represent saplings and seedlings of the particular species, while those symbols with an *l* in parentheses represent mature individuals. Species symbols include: Ani, *Acer nigrum*; Abr, *Amphicarpa bracteata*; Bpu, *Bromus purgans*; Cam, *Campanula americana*; Cro, *Carex rosea*; Csp, *Carex* sp.; Cco, *Carya cordiformis*; Cov, *Carya ovata*; Csc, *Celastrus scandens*; Coc, *Celtis occidentalis*; Crsp, *Crataegus* sp.; Fni, *Fraxinus nigra*; Fpe, *Fraxinus pennsylvanica*; Gap, *Galium aparine*; Gdi, *Gymnocladus dioica*; Ipa, *Impatiens pallida*; Ldi, *Lonicera dioica*; Ovi, *Ostrya virginiana*; Pqu, *Parthenocissus quinquefolia*; Pca, *Polygonatum canaliculatum*; Qal, *Quercus alba*; Qru, *Quercus rubra*; Rra, *Rhus radicans*; Risp, *Ribes* spp.; Sca, *Sanguinaria canadensis*; Sst, *Silene stellata*; Tam, *Tilia americana*; Uru, *Ulmus rubra*; Ulsp, *Ulmus* spp.; Visp, *Viola* spp.; and Xam, *Xanthoxylum americanum*

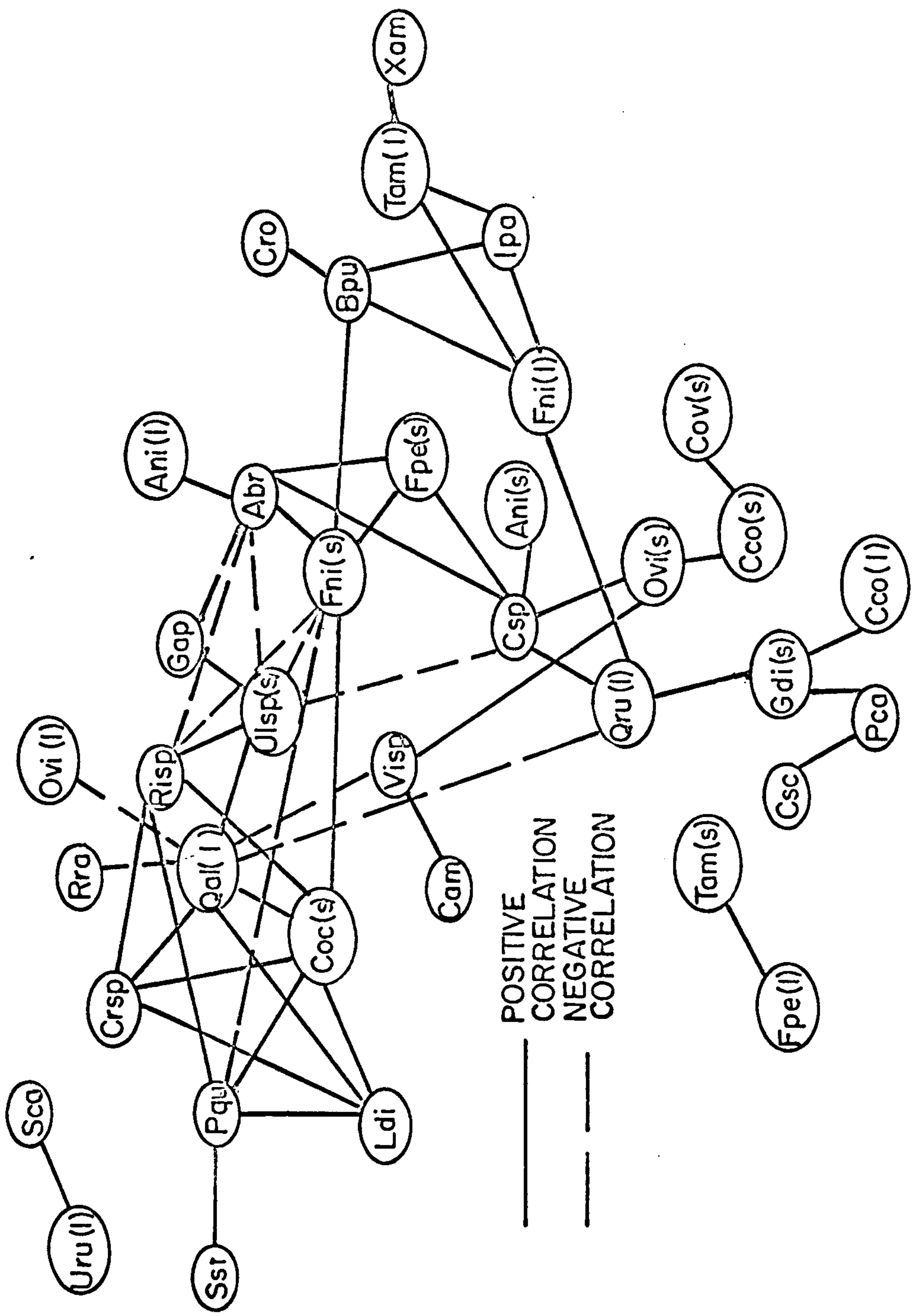
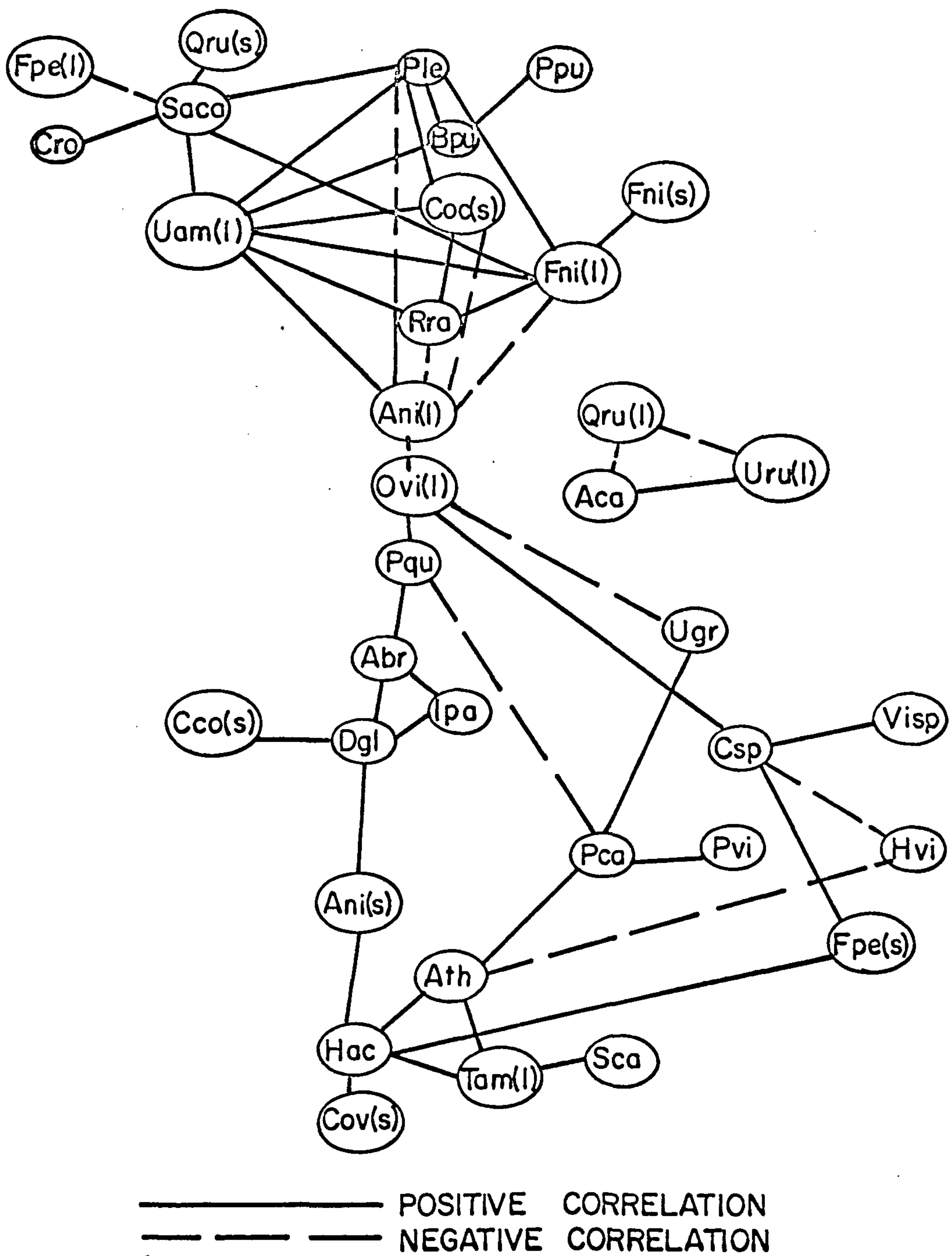

Xam
Tam(l)
Ipa
Cro
Bpu
Fni(l)
Cov(s)
Ani(l)
Fpe(s)
Abr
Ani(s)
Cco(s)
Fni(s)
Ovi(s)
Cco(l)
Csp
Gap
Usp(s)
Gdi(s)
Qru(l)
Pca
Ovi(l)
Risp
Visp
Csc
Rra
Qal(l)
Cam
Tam(s)
Coc(s)
Crsp
Fpe(l)
Sca
Pqu
Ldi
Uru(l)
Sst
POSITIVE CORRELATION
NEGATIVE CORRELATION

Figure 4. Constellation based on correlation values greater than .4 for species-pairs in Area IV (High Bridge I). Those symbols with an _s_ in parentheses represent saplings and seedlings of the particular species, while those symbols with an _l_ in parentheses represent mature individuals. Species symbols include: Ani, _Acer nigrum_; Abr, _Amphicarpa bracteata_; Ath, _Anemonella thalictroides_; Aca, _Asarum canadense_; Bpu, _Bromus purgans_; Cro, _Carex rosea_; Csp, _Carex_ sp.; Cco, _Carya cordiformis_; Cov, _Carya ovata_; Coc, _Celtis occidentalis_; Dgl, _Desmodium glutinosum_; Fni, _Fraxinus nigra_; Fpe, _Fraxinus pennsylvanica_; Hac, _Hepatica acutiloba_; Hvi, _Hydrophyllum virginianum_; Ipa, _Impatiens pallida_; Ovi, _Ostrya virginiana_; Pqu, _Parthenocissus quinquefolia_; Ple, _Phryma leptostachya_; Ppu, _Pilea pumila_; Pca, _Polygonatum canaliculatum_; Pvi, _Prunus virginiana_; Qru, _Quercus rubra_; Rra, _Rhus radicans_; Sca, _Sanguinaria canadensis_; Saca, _Sanicula canadensis_; Tam, _Tilia americana_; Uam, _Ulmus americana_; Uru, _Ulmus rubra_; Ugr, _Uvularia grandiflora_; and Visp, _Viola_ spp.


Fpe(l)
Qru(s)
Saca
Cro
Ple
Ppu
Bpu
Uam(l)
Coc(s)
Fni(s)
Fni(l)
Rra
Ani(l)
Qru(l)
Uru(l)
Aca
Ovi(l)
Pqu
Ugr
Abr
Ipa
Cco(s)
Dgl
Csp
Visp
Hvi
Pca
Pvi
Ani(s)
Fpe(s)
Ath
Hac
Tam(l)
Sca
Cov(s)
POSITIVE CORRELATION
NEGATIVE CORRELATION

definite trends in their importance values from stand to stand. These include Ulmus americana, Ulmus rubra, Ostrya virginiana, and green ash (Fraxinus pennsylvanica). Importance values for selected species are illustrated graphically in Figure 5.

Importance values for all tree species occurring on lower sites are presented in Table 3. Ulmus americana is shown to have relatively high importance values on all sites, although it shows a wide variation from stand to stand (128.9 on CB-lower to 16.0 on JII-lower). Species increasing in importance value with increases in the continuum-index number of the stands include Tilia americana, Fraxinus nigra, Quercus rubra, Acer nigrum, and Ostrya virginiana. Species showing decreases in importance values with increases in the continuum-index number of the stands include burr oak (Quercus macrocarpa), hackberry (Celtis occidentalis), Fraxinus pennsylvanica, and black walnut (Juglans nigra). Trends were not apparent in importance values of other species, some of which occurred too infrequently to be of great significance. Figure 6 represents importance values of selected tree species on lower sites.

Certain comparisons can be made on values obtained for tree species on upper and lower slopes (see Tables 2 and 3). Acer nigrum, Quercus rubra, and Tilia americana show trends toward increasing importance values with increases in continuum-index number of the stands regardless of slope position. Ulmus americana is shown to occur on all eleven sites but with variation from stand to stand in relation to continuum-index numbers. Amelanchier arborea is apparently limited to the upper sites. Species found on lower sites but not the upper include butternut (Juglans cinerea),

Table 2. Importance values for tree species on upper sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JII upper (1506)	HBII flat (1730)	JI upper (1778)	CB upper (2128)	HBI upper (2199)	HBII upper (2235)
Quercus alba	117.3	66.5	14.0	17.6	-	2.1
Carya ovata	79.1	55.7	3.8	8.1	5.5	3.9
Ulmus americana	27.6	66.3	5.0	52.7	5.8	3.7
Ulmus rubra	16.7	3.4	31.5	7.2	17.2	5.2
Ostrya virginiana	10.6	40.7	-	53.2	21.8	56.0
Juglans nigra	8.9	-	13.9	2.2	-	-
Acer nigrum	7.5	-	-	31.7	73.9	45.3
Carya cordiformis	7.4	-	9.4	4.8	12.3	3.2
Gymnocladus dioica	7.0	-	-	-	-	-
Tilia americana	6.9	6.2	32.2	20.5	49.4	60.2
Quercus rubra	4.3	25.6	25.0	86.8	62.7	94.2
Gleditsia triacanthos	2.0	4.2	4.0	-	2.3	-
Quercus macrocarpa	1.8	1.9	-	-	3.0	-
Celtis occidentalis	1.5	-	56.3	1.3	5.3	-
Fraxinus nigra	1.4	-	9.4	5.9	23.3	-
Fraxinus pennsylvanica	-	28.3	78.6	5.3	16.2	11.6
Amelanchier arborea	-	1.3	-	1.3	1.3	8.5
Prunus serotina	-	-	13.3	-	-	-
Crataegus sp.	-	-	3.5	-	-	-
Morus rubra	-	-	-	1.3	-	-

Table 3. Importance values for tree species on lower sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JI (1613)	CB (1904)	JII (2090)	HBII (2228)	HBI (2268)
Ulmus americana	60.0	128.9	16.0	54.3	57.4
Quercus macrocarpa	58.5	-	3.7	-	-
Celtis occidentalis	36.7	29.5	2.0	3.2	-
Fraxinus pennsylvanica	34.3	7.6	10.6	6.7	-
Juglans nigra	24.5	30.5	3.1	-	-
Carya cordiformis	21.2	10.8	41.5	4.4	-
Tilia americana	13.8	-	13.8	55.5	51.1
Gymnocladus dioica	10.7	-	-	-	-
Carya ovata	9.4	3.3	26.9	4.3	-
Fraxinus nigra	8.9	4.2	19.7	15.1	19.4
Quercus rubra	7.7	-	41.7	30.5	65.3
Ulmus rubra	7.6	-	14.6	12.7	5.7
Quercus alba	3.7	-	19.6	9.2	-
Acer nigrum	2.9	-	56.5	54.0	52.1
Ostrya virginiana	-	22.9	30.4	42.5	49.0
Morus rubra	-	20.4	-	-	-
Gleditsia triacanthos	-	17.1	-	-	-
Populus deltoides	-	17.0	-	6.2	-
Platanus occidentalis	-	6.2	-	-	-
Acer negundo	-	1.7	-	-	-
Juglans cinerea	-	-	1.3	-	-

Figure 5. Importance values of selected tree species on upper sites in relation to continuum-index numbers

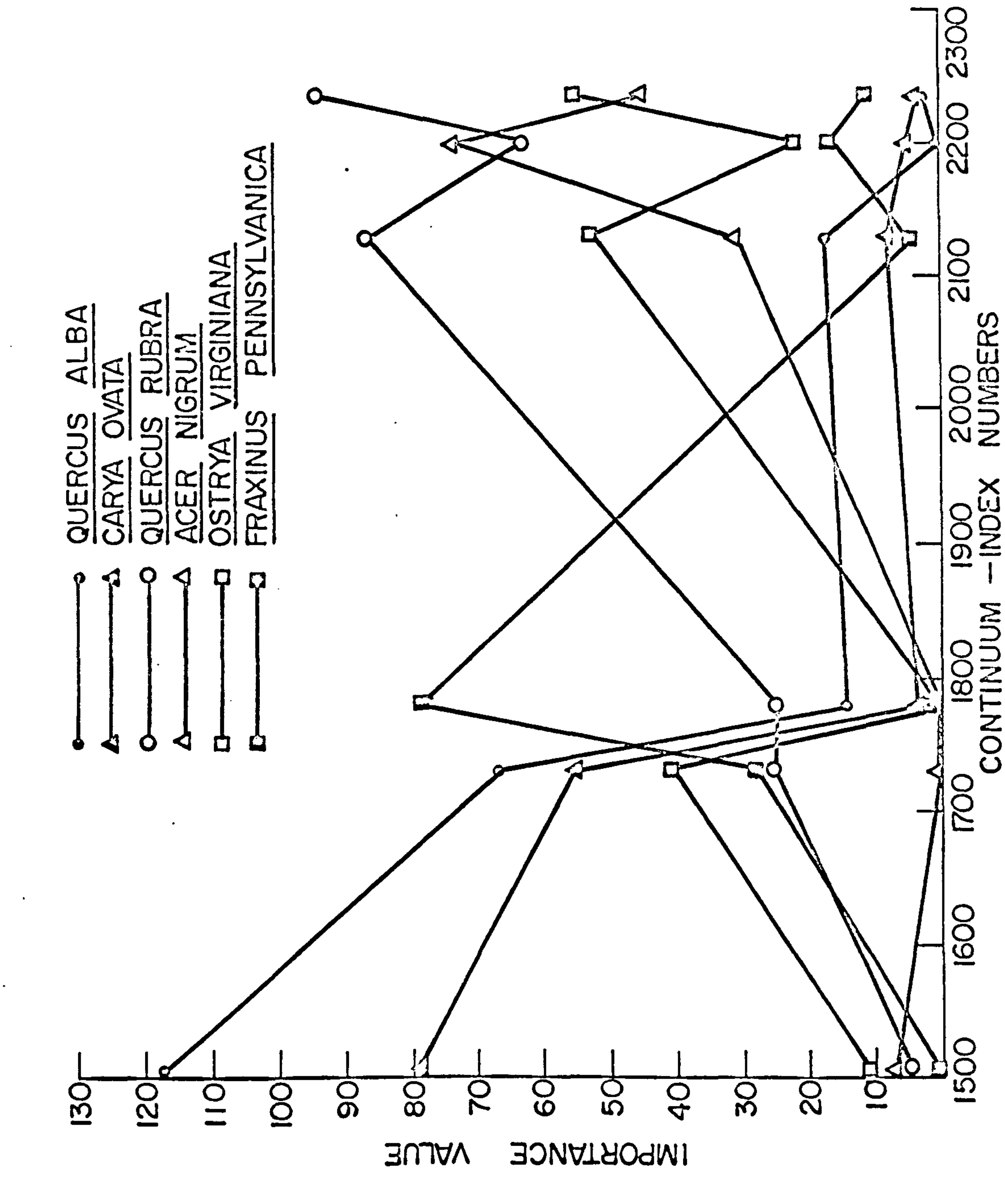

QUERCUS ALBA
CARYA OVATA
QUERCUS RUBRA
ACER NIGRUM
OSTRYA VIRGINIANA
FRAXINUS PENNSYLVANICA
IMPORTANCE VALUE
130
120
110
100
90
80
70
60
50
40
30
20
10
1500
1600
1700
1800
1900
2000
2100
2200
2300
CONTINUUM -INDEX NUMBERS

Figure 6. Importance values of selected tree species on lower sites in relation to continuum-index numbers

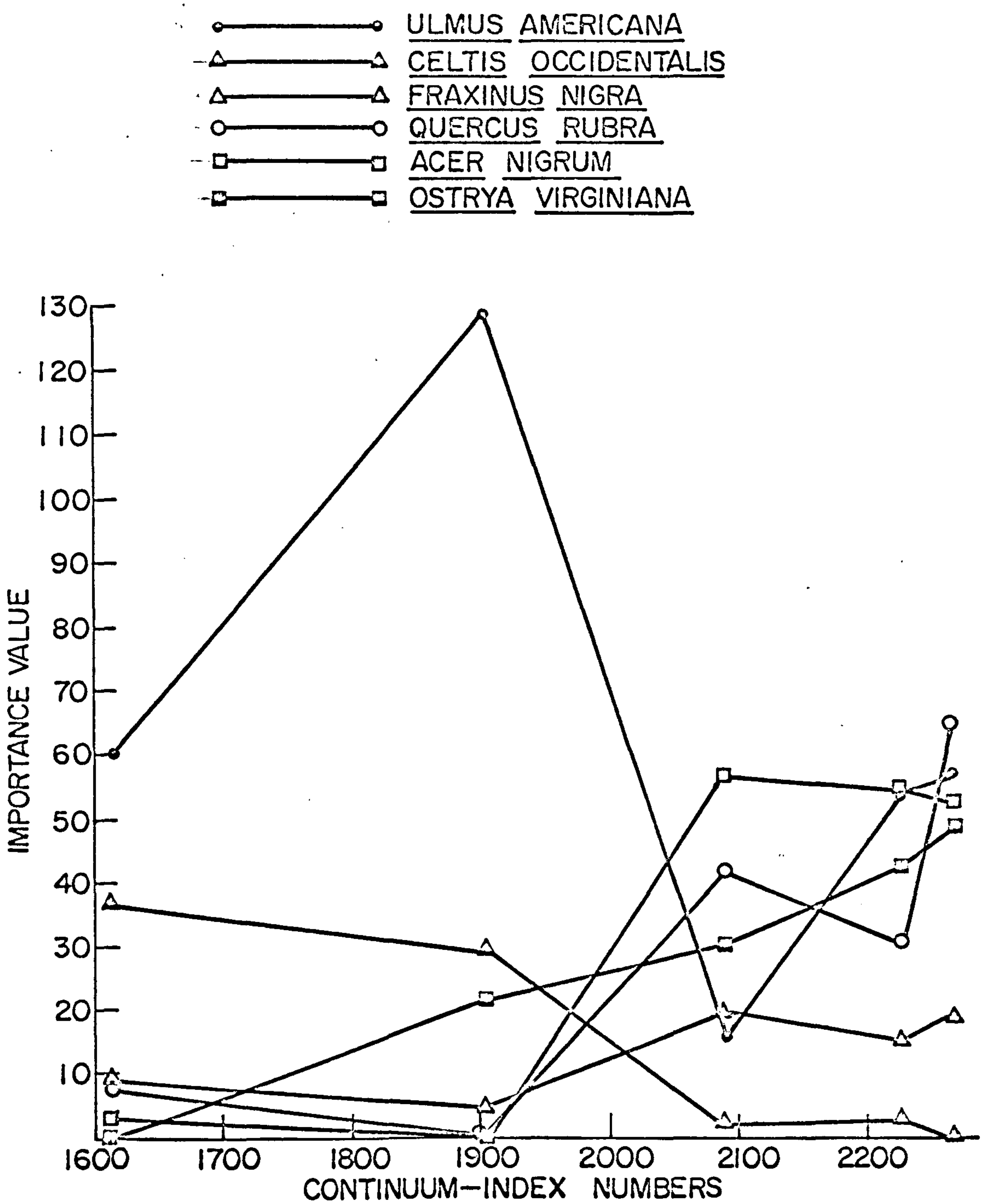

ULMUS AMERICANA
CELTIS OCCIDENTALIS
FRAXINUS NIGRA
QUERCUS RUBRA
ACER NIGRUM
OSTRYA VIRGINIANA
IMPORTANCE VALUE
130
120
110
100
90
80
70
60
50
40
30
20
10
1600
1700
1800
1900
2000
2100
2200
CONTINUUM-INDEX NUMBERS

Table 4. Average distance between trees and density per stand in relation to continuum-index number of the stands

Stand	Continuum-index number	Average distance (ft.)	Density
Jester II-upper	1506	15.66	177.6
Jester I-lower	1613	17.02	150.4
High Bridge II-upper flat	1730	13.30	246.3
Jester I-upper	1778	22.60	85.3
Corydon Bridge-lower	1904	16.64	157.4
Jester II-lower	2090	13.74	230.7
Corydon Bridge-upper	2128	15.02	193.1
High Bridge I-upper	2199	15.37	184.5
High Bridge II-lower	2228	15.71	176.5
High Bridge II-upper	2235	12.72	269.2
High Bridge I-lower	2268	14.32	212.6

eastern sycamore (Platanus occidentalis), and box-elder (Acer negundo). Quercus rubra is shown to be the dominant species on the greatest number of sites (three).

The density of trees in each stand is shown in Table 4 with stands arranged in relation to continuum-index numbers. Density tends to increase with increasing values of the index although wide fluctuations in density occur. The fluctuation becomes even more pronounced if species density is considered. Quercus alba (in Tables 2 and 3) shows an increase in importance value of 108 from a stand with an average density of 176 to a stand with a density of 177 trees per acre.

Tree reproduction and shrub species

The importance values of the tree reproduction and shrub species on upper sites are presented in Table 5. Elm (Ulmus spp.), Carya ovata, and Quercus alba decrease with increases in the continuum-index number of the stands. Importance values of saplings of Ostrya virginiana, Acer nigrum, Fraxinus pennsylvanica, Quercus rubra, and Amelanchier arborea indicate increased reproduction of these species as the continuum-index number of the stands increases. The remaining species do not show trends.

The importance values of saplings and shrubs found on lower slopes are presented in Table 6. Species showing increases in importance values with increases in the continuum-index number of the stands include Carya ovata, Fraxinus pennsylvanica, Quercus rubra, Acer nigrum, Ostrya virginiana, and Celastrus scandens. Species showing decreases in importance values with increases in the continuum-index number of the stands include Celtis occidentalis, Juglans cinerea, Juglans nigra, and

Quercus macrocarpa. The other species do not show trends.

Saplings of four species are found on all eleven sites (see Tables 5 and 6). These include Ulmus spp., Celtis occidentalis, Fraxinus pennsylvanica, and yellowbud hickory (Carya cordiformis). Species occurring on all but one site include Carya ovata, Acer nigrum, Tilia americana, and Quercus rubra. Celtis occidentalis is shown to be the leading dominant in the sapling layer on four sites (JI-upper, CB-upper, JI-lower, and CB-lower), while Acer nigrum is the dominant sapling on three sites (HBI-upper, JII-lower, and HBII-lower). Species occurring only on upper sites include Kentucky coffee-tree (Gymnocladus dioica), hazelnut (Corylus americana), Viburnum rafinesquianum var. affine, and Staphylea trifolia. Juglans cinerea, Celastrus scandens, honey locust (Gleditsia triacanthos), and box-elder (Acer negundo) are species found only on lower sites.

Figures 7 and 8 illustrate the importance values of saplings and shrub species on upper and lower sites respectively. Figure 7 shows that, on upper slopes, importance values of Acer nigrum, Quercus rubra, and Ostrya virginiana increase with increases in the continuum-index number of the stands. Quercus alba and Carya ovata saplings decrease in importance with increases in the continuum-index number of the stands. In Figure 8, Acer nigrum and Quercus rubra increase in importance values just as they did on upper sites. Celtis occidentalis shows a decrease in importance with an increase in the continuum-index number of the stands.

The relationship of mature trees to reproduction on upper sites is presented for selected species in Figure 9. Ostrya virginiana shows a

Table 5. Importance values of tree reproduction and shrubs on upper sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JII (1506)	HBII flat (1730)	JI (1778)	CB (2128)	HBI (2199)	HBII (2235)
Ulmus spp.	137.9	32.1	31.0	13.2	54.7	28.1
Carya ovata	35.5	59.4	-	11.6	22.7	25.9
Celtis occidentalis	21.6	19.6	87.8	100.5	13.2	8.1
Quercus alba	19.2	33.8	-	1.4	-	-
Ostrya virginiana	17.1	39.0	-	61.6	15.5	57.7
Acer nigrum	17.1	30.7	14.6	31.7	67.3	55.2
Tilia americana	11.6	32.7	10.0	27.6	27.0	28.0
Fraxinus pennsylvanica	10.4	30.9	6.1	12.8	49.3	33.5
Gymnocladus dioica	8.9	-	6.2	-	-	-
Crataegus sp.	8.2	-	-	-	-	-
Fraxinus nigra	4.9	-	69.2	19.0	-	16.6
Prunus virginiana	4.1	-	-	-	2.0	-
Carya cordiformis	2.2	16.0	15.5	9.2	25.7	1.6
Corylus americana	1.5	-	-	-	-	-
Quercus rubra	-	6.0	3.5	4.9	8.7	36.5
Juglans nigra	-	-	-	4.9	-	-
Morus rubra	-	-	-	1.7	-	-
Cornus spp.	-	-	-	-	9.2	1.6
Amelanchier arborea	-	-	-	-	3.0	2.2
Staphylea trifolia	-	-	-	-	2.0	-
Viburnum rafinesquianum var. affine	-	-	-	-	-	2.8
Quercus macrocarpa	-	-	-	-	-	2.2

Table 6. Importance values of tree reproduction and shrubs on lower sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JI (1613)	CB (1904)	JII (2090)	HBII (2228)	HBI (2268)
Celtis occidentalis	114.7	175.2	8.2	27.8	16.3
Fraxinus nigra	96.3	41.6	56.4	65.4	66.3
Ulmus spp.	66.5	37.1	15.1	32.2	21.5
Carya ovata	6.3	2.4	18.3	12.6	25.4
Carya cordiformis	3.8	8.3	2.1	4.7	11.8
Fraxinus pennsylvanica	3.5	2.0	40.1	3.2	20.9
Juglans cinerea	3.3	-	-	-	-
Juglans nigra	2.6	1.6	-	-	-
Quercus macrocarpa	1.6	-	-	-	-
Quercus rubra	1.6	1.6	6.7	7.2	18.3
Morus rubra	-	20.8	-	-	-
Acer nigrum	-	5.9	71.1	110.8	60.1
Gleditsia triacanthos	-	1.8	-	-	-
Tilia americana	-	1.6	16.5	12.7	2.9
Ostrya virginiana	-	-	48.9	7.2	46.0
Quercus alba	-	-	16.3	-	-
Acer negundo	-	-	1.5	-	2.5
Prunus virginiana	-	-	-	7.9	-
Celastrus scandens	-	-	-	5.7	4.5
Amelanchier arborea	-	-	-	2.5	-
Crataegus sp.	-	-	-	-	2.0
Cornus spp.	-	-	-	-	1.5

Figure 7. Importance values of tree reproduction on upper sites for selected species in relation to continuum-index numbers. *Ulmus* spp. represents reproduction of both *Ulmus americana* and *Ulmus rubra*

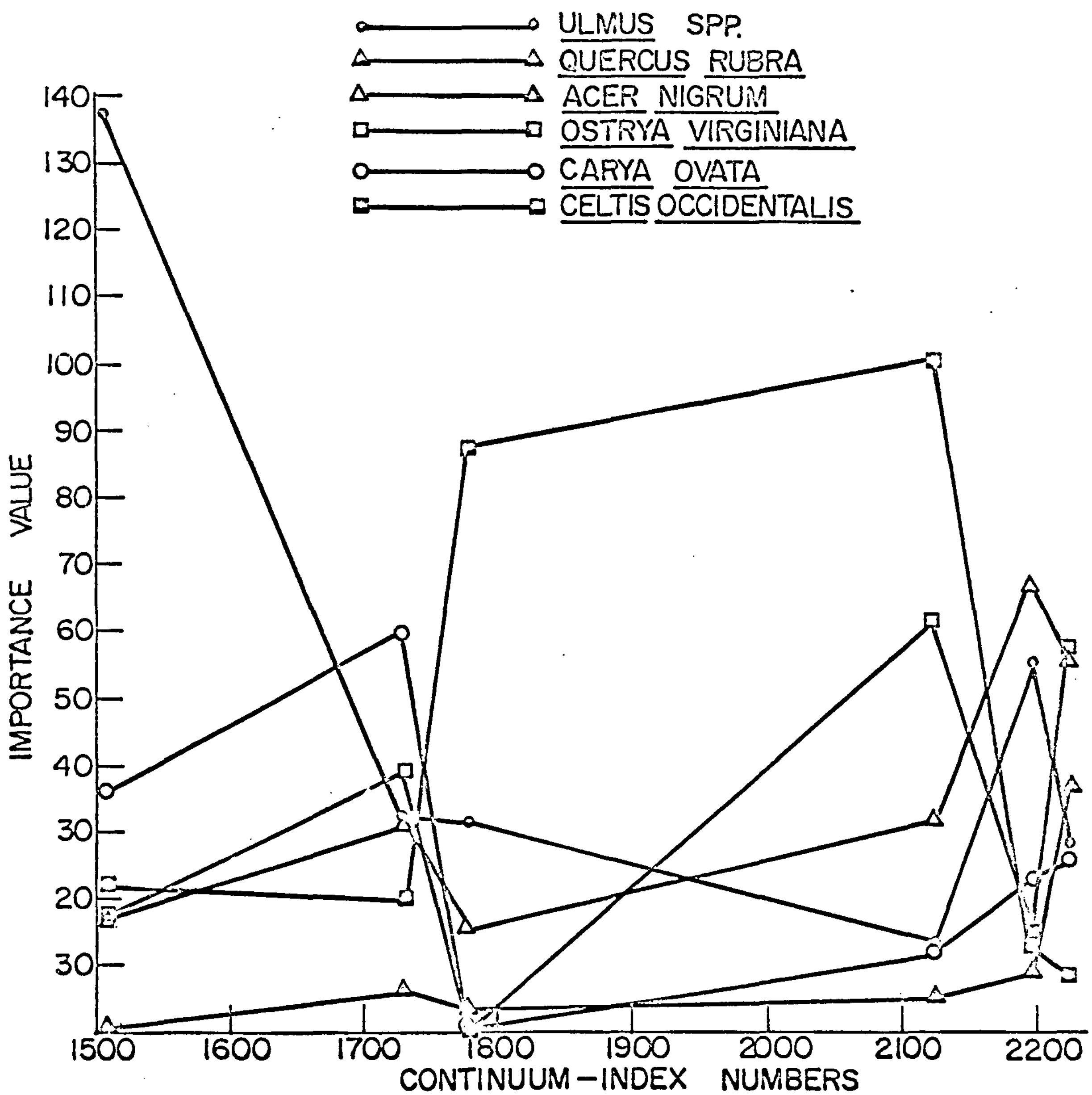

ULMUS SPP.
QUERCUS RUBRA
ACER NIGRUM
OSTRYA VIRGINIANA
CARYA OVATA
CELTIS OCCIDENTALIS
140
130
120
110
100
90
80
70
60
50
40
30
20
30
IMPORTANCE VALUE
1500
1600
1700
1800
1900
2000
2100
2200
CONTINUUM-INDEX NUMBERS

Figure 8. Importance values of tree reproduction on lower sites for selected species in relation to continuum-index numbers. *Ulmus* spp. represents reproduction of both *Ulmus americana* and *Ulmus rubra*

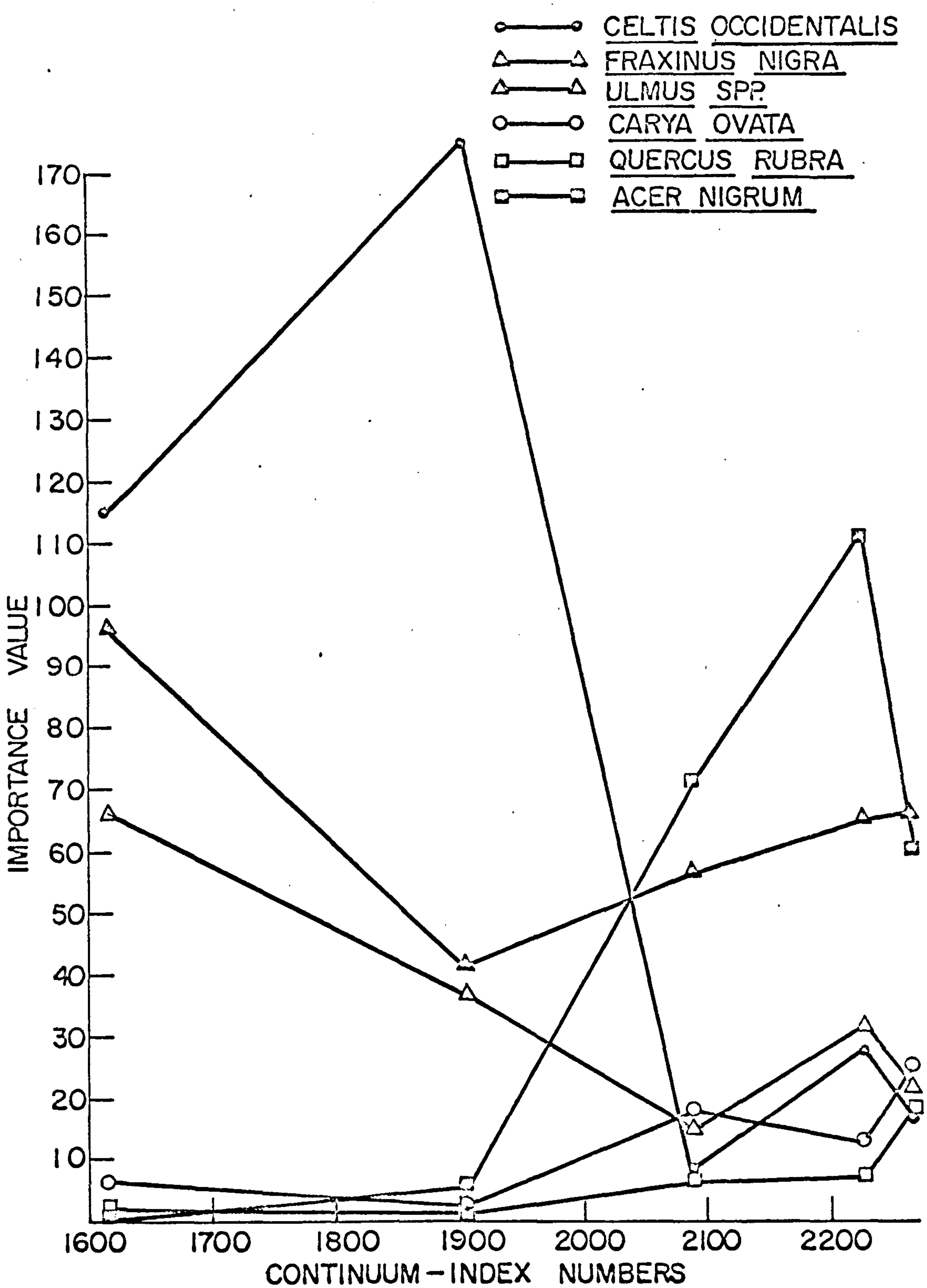
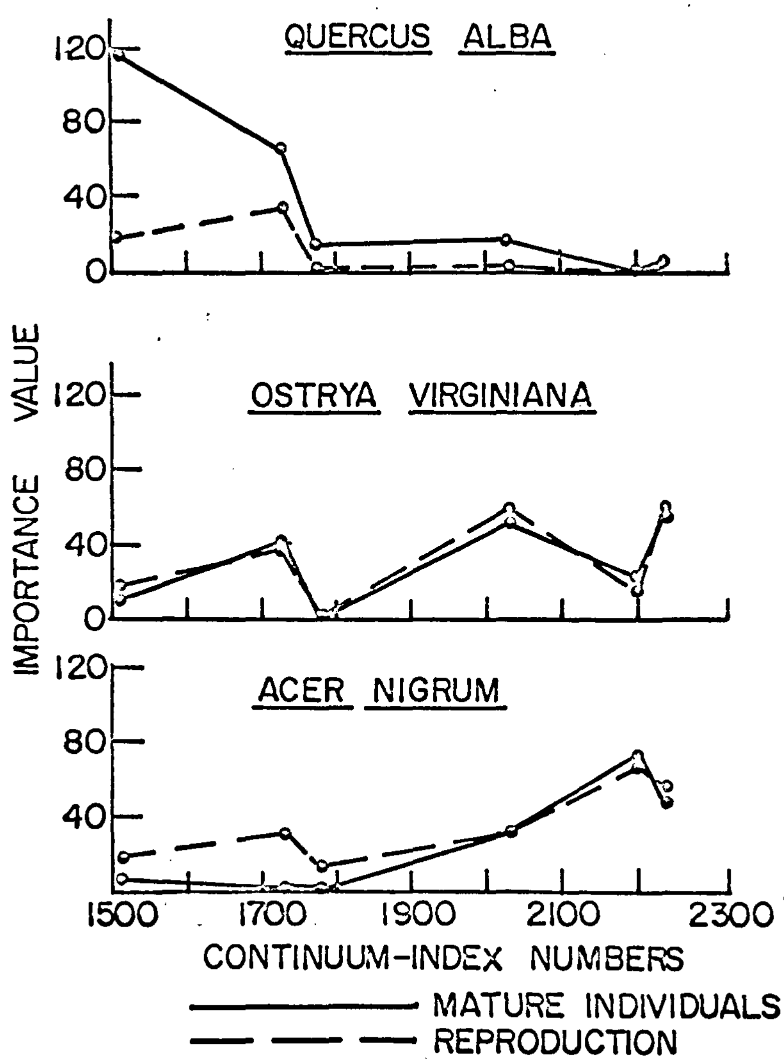

CELTIS OCCIDENTALIS
FRAXINUS NIGRA
ULMUS SPP.
CARYA OVATA
QUERCUS RUBRA
ACER NIGRUM
IMPORTANCE VALUE
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1600
1700
1800
1900
2000
2100
2200
CONTINUUM-INDEX NUMBERS

Figure 9. Comparison of importance values obtained for trees with the importance values obtained for tree reproduction of selected species on upper sites in relation to continuum-index numbers



QUERCUS ALBA
OSTRYA VIRGINIANA
ACER NIGRUM
IMPORTANCE VALUE
120
80
40
0
1500
1700
1900
2100
2300
CONTINUUM-INDEX NUMBERS
MATURE INDIVIDUALS
REPRODUCTION

close relationship between mature individuals and reproduction on all upper sites. Acer nigrum and Quercus alba show close relationships in some stands but not in others.

Herbaceous layer

Frequency values for herbaceous species found on upper sites are arranged in order of increasing continuum-index number of the stands in Table 7. Parthenocissus quinquefolia is shown to be the dominant species on all but one upper site. It shows a decrease in frequency as the continuum-index number of the stands increases. Other species showing decreases in frequency with increased continuum-index numbers include Ribes spp., Carex rosea, Lonicera dioica, Ulmus spp. seedlings, Viola spp., and Carya ovata seedlings. Species showing increases in frequency values with increases in continuum-index number of the stands include Carex sp., Amphicarpa bracteata, Acer nigrum seedlings, Impatiens pallida, Quercus rubra seedlings, Tilia americana seedlings, Hystrix patula, Anemonella thalictroides, Hepatica acutiloba, Asarum canadense, Uvularia grandiflora, and Carex albursina. Frequency values of selected species on upper sites are presented in Figure 10.

Frequency values for herbaceous species found on lower sites are presented in Table 8. Species showing decreases in frequency with increases in continuum-index number of the stands include Parthenocissus quinquefolia, Carex rosea, Geum canadense, Ulmus spp. seedlings, Cystopteris fragilis, Viola spp., Rubus spp., Celtis occidentalis seedlings, Xanthoxylum americanum, and Menispermum canadense. Species showing increases in frequency with increased continuum-index numbers include

Table 7. Frequency values for herbaceous species and tree seedlings on upper sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JII (1506)	HBII flat (1730)	JI (1778)	CB (2128)	HBI (2199)	HBII (2235)
Parthenocissus quinquefolia	94.4	88.2	95.6	86.3	81.9	29.8
Ribes spp.	59.0	28.0	56.9	42.2	13.8	9.9
Carex rosea	49.1	22.4	81.3	6.2	3.1	6.8
Lonicera dioica	43.5	-	6.9	1.9	0.6	1.2
Ulmus spp. (s)[a]	35.4	16.2	41.9	3.1	16.9	13.7
Geum canadense	21.1	1.2	42.5	6.8	-	-
Viola spp.	19.9	9.3	77.5	6.2	6.3	0.6
Quercus alba (s)	10.6	24.2	-	-	0.6	-
Eupatorium rugosum	9.9	-	-	-	-	-
Sanicula canadensis	9.3	1.2	-	5.6	13.1	2.5
Poa pratensis	8.1	-	3.8	-	-	-
Carya ovata (s)	8.1	24.8	0.6	3.1	13.1	5.0
Silene stellata	6.8	-	0.6	0.6	0.6	-
Carex sp.	6.2	28.0	1.9	7.5	23.1	31.7
Celastrus scandens	5.6	21.1	-	16.8	8.8	21.1
Prunus virginiana	5.0	0.6	1.3	-	1.3	-
Vitis riparia	5.0	-	4.4	1.9	1.3	1.2
Celtis occidentalis (s)	4.3	1.2	13.1	13.0	-	-
Rhus radicans	4.3	3.7	18.8	30.4	4.4	6.8
Tilia americana (s)	4.3	3.7	4.4	3.7	1.9	6.2
Hydrophyllum virginianum	3.1	6.8	-	0.6	8.8	0.6
Muhlenbergia sobolifera	3.1	-	-	-	-	-
Fraxinus pennsylvanica (s)	2.5	6.8	-	-	10.6	7.5
Amphicarpa bracteata	2.5	7.5	-	1.2	10.6	42.2
Plantago purshi	2.5	-	-	-	-	-
Viola pensylvanica	1.2	-	2.5	-	1.3	-
Aster sp.	1.2	-	1.9	1.9	-	6.2
Cryptotaenia canadensis	1.2	-	-	-	-	-
Acer nigrum (s)	1.2	8.1	5.0	6.2	21.3	39.1
Rosa blanda	1.2	2.5	0.6	-	-	-
Chenopodium album	1.2	-	-	-	-	-
Menispermum canadense	1.2	-	-	3.7	4.4	-
Rubus spp.	1.2	-	26.9	-	-	-
Osmorhiza claytoni	1.2	1.9	1.9	-	9.4	1.2
Morus rubra (s)	0.6	-	-	-	-	-
Bromus purgans	0.6	1.2	-	0.6	8.8	-
Campanula americana	0.6	12.4	1.3	3.1	-	8.7
Impatiens pallida	0.6	3.1	-	8.1	14.4	26.1
Crataegus sp. (s)	0.6	-	-	0.6	-	-

[a](s) - refers to seedlings.

Table 7. Continued

Species	JII (1506)	HBII flat (1730)	JI (1778)	CB (2128)	HBI (2199)	HBII (2235)
Gleditsia triacanthos (s)	0.6	-	0.6	-	-	-
Carya cordiformis (s)	0.6	-	1.3	-	6.9	0.6
Smilax tamnoides hispida	0.6	1.2	3.1	13.7	1.3	-
Smilax herbacea	0.6	-	-	-	2.5	-
Galium aparine	0.6	41.0	4.4	15.5	18.8	19.3
Ostrya virginiana (s)	0.6	31.1	-	5.0	9.4	26.7
Potentillia arguta	0.6	-	1.9	-	-	-
Polygonum convolvulus	0.6	-	-	-	-	-
Helianthus tuberosum	-	16.2	-	-	-	-
Desmodium glutinosum	-	14.3	-	-	6.9	17.4
Phryma leptostachya	-	7.5	4.4	1.2	15.6	5.0
Anemone quinquefolia	-	5.6	6.3	-	-	-
Sanguinaria canadensis	-	5.6	-	-	28.1	-
Quercus rubra (s)	-	4.3	-	1.9	11.9	13.7
Corylus americana (s)	-	3.7	-	-	-	-
Elymus villosus	-	3.1	0.6	-	-	-
Festuca obtusa	-	3.1	1.9	-	-	9.9
Hystrix patula	-	1.9	-	1.9	2.5	3.7
Panicum latifolium	-	1.9	-	-	-	9.9
Pilea pumila	-	1.2	10.6	16.0	15.0	1.2
Anemonella thalictroides	-	1.2	-	0.6	48.1	85.1
Polygonatum canaliculatum	-	0.6	-	0.6	1.3	0.6
Hepatica acutiloba	-	0.6	-	-	43.8	28.0
Adiantum pedatum	-	0.6	-	-	1.3	-
Lactuca sp.	-	0.6	-	-	-	-
Fraxinus nigra (s)	-	-	28.8	1.9	6.9	-
Xanthoxylum americanum	-	-	23.8	4.3	-	-
Nepeta cataria	-	-	1.9	-	-	-
Cornus spp.	-	-	1.3	1.9	0.6	-
Oxalis stricta	-	-	1.3	-	-	-
Cystopteris fragilis	-	-	0.6	-	3.1	-
Thalictrum dioicum	-	-	-	5.6	-	-
Osmorhiza longistylis	-	-	-	1.2	10.6	-
Amelanchier arborea	-	-	-	1.2	-	-
Arisaema triphyllum	-	-	-	0.6	-	-
Asarum canadense	-	-	-	-	21.3	14.3
Uvularia grandiflora	-	-	-	-	8.8	10.6
Carex albursina	-	-	-	-	8.8	1.9
Solidago ulmifolia	-	-	-	-	5.6	-
Staphylea trifolia	-	-	-	-	3.1	0.6
Laportea canadensis	-	-	-	-	1.9	-
Panax quinquefolius	-	-	-	-	-	2.5

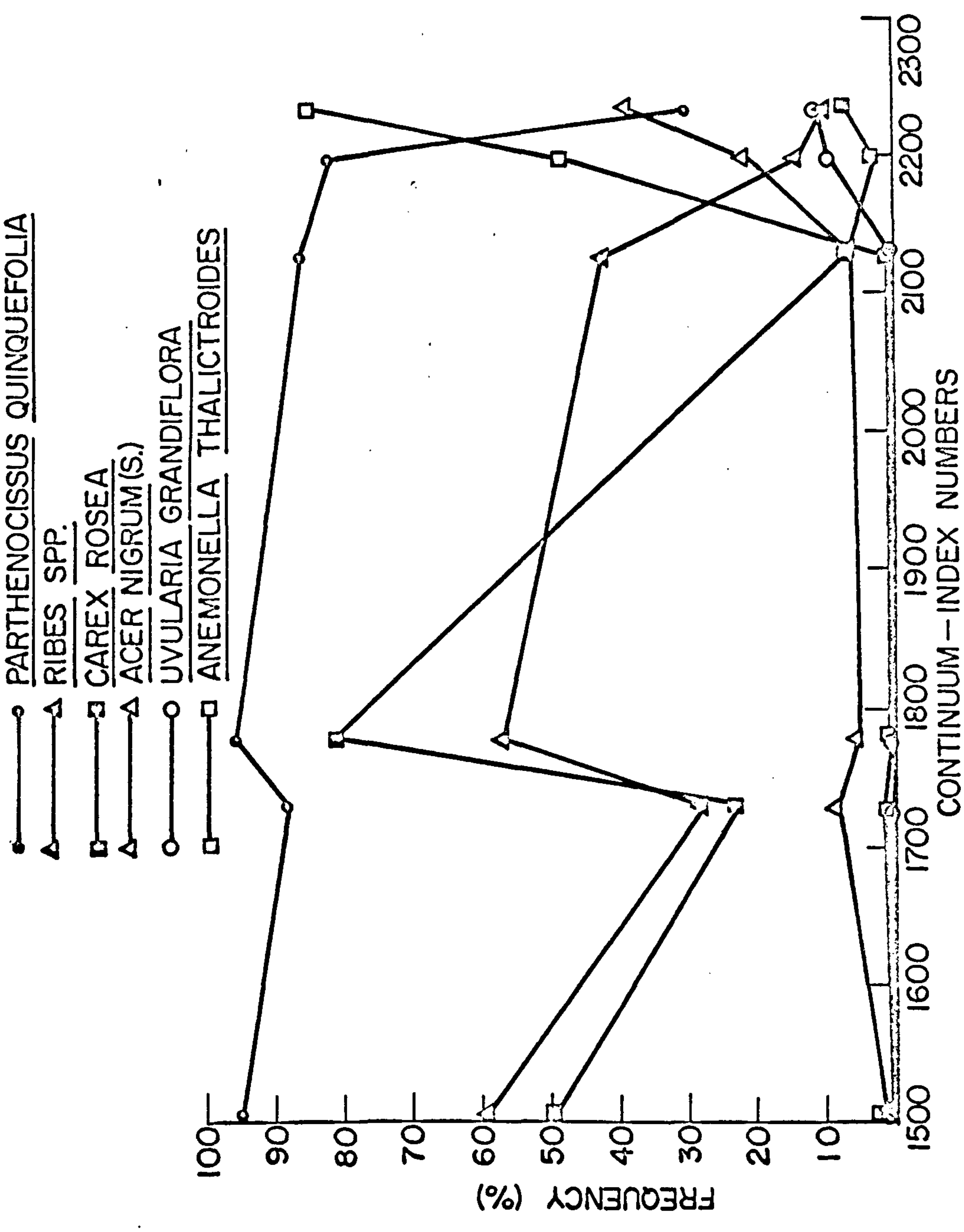
Table 8. Frequency values for herbaceous species and tree seedlings on lower sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JI (1613)	CB (1904)	JII (2090)	HBII (2228)	HBI (2268)
Parthenocissus quinquefolia	93.2	76.4	41.6	60.2	57.1
Carex rosea	85.1	44.7	32.3	5.0	28.0
Viola spp.	70.8	13.0	28.6	1.2	8.7
Geum canadense	70.2	21.1	18.0	1.9	3.1
Ribes spp.	38.5	54.0	19.9	27.3	26.7
Ulmus spp. (s)	37.9	16.8	21.7	8.7	-
Festuca obtusa	31.7	-	-	3.7	-
Pilea pumila	28.0	15.5	5.6	1.1	16.8
Xanthoxylum americanum	21.1	6.2	1.2	-	-
Amphicarpa bracteata	20.5	1.2	79.5	6.2	22.4
Nepeta cataria	19.3	-	-	-	-
Lonicera dioica	16.8	18.6	1.9	-	0.6
Hydrophyllum virginianum	16.8	2.5	6.8	-	7.5
Rhus radicans	16.1	63.4	8.7	17.4	23.0
Menispermum canadense	14.3	8.7	1.9	1.9	0.6
Cystopteris fragilis	14.3	1.2	3.1	-	-
Rubus spp.	12.4	-	0.6	-	0.6
Celtis occidentalis (s)	11.8	11.8	1.9	3.1	3.1
Viola pensylvanica	11.8	-	-	-	-
Fraxinus nigra (s)	11.2	1.2	16.8	0.6	8.1
Campanula americana	9.3	1.9	6.2	3.1	0.6
Panicum latifolium	8.7	0.6	1.2	-	-
Polygonum convolvulus	8.1	-	-	-	-
Plantago purshi	5.6	-	-	-	-
Cornus spp. (s)	5.0	1.2	-	-	-
Sanicula canadensis	5.0	19.3	6.2	28.0	40.4
Cryptotaenia canadensis	4.3	-	2.5	-	3.7
Laportea canadensis	4.3	2.5	-	1.9	6.8
Glyceria striata	4.3	0.6	-	-	-
Carex sp.	3.7	-	50.9	6.8	11.8
Phryma leptostachya	3.7	3.7	-	21.1	27.3
Elymus villosus	3.1	-	-	0.6	1.9
Osmorhiza claytoni	2.5	-	-	9.9	25.5
Lactuca sp.	2.5	-	-	-	-
Smilax tamnoides hispida	2.5	23.0	1.2	-	1.2
Vitis riparia	2.5	13.7	-	0.6	1.2
Carya ovata (s)	1.9	2.5	9.3	1.9	5.0
Gymnocladus dioica	1.9	-	-	-	-

Table 8. Continued

Species	JI (1613)	CB (1904)	JII (2090)	HBII (2228)	HBI (2268)
Podophyllum peltatum	1.2	-	-	-	-
Potentillia arguta	1.2	1.9	-	-	-
Bromus purgans	1.2	1.2	2.5	-	5.6
Smilax herbacea	0.6	-	-	-	0.6
Carya cordiformis (s)	0.6	0.6	1.2	-	-
Gleditsia triacanthos (s)	0.6	-	-	-	-
Silene stellata	0.6	0.6	5.6	-	0.6
Scrophularia lanceolata	0.6	-	-	-	-
Galium aparine	-	6.8	32.3	8.7	7.5
Polygonatum canaliculatum	-	5.0	1.2	2.5	1.2
Quercus rubra (s)	-	3.7	1.9	2.5	3.7
Celastrus scandens	-	2.5	1.9	16.8	1.2
Aster sp.	-	2.5	-	-	-
Impatiens pallida	-	1.9	31.7	9.3	8.7
Ostrya virginiana (s)	-	1.2	21.1	1.9	4.3
Thalictrum dioicum	-	1.2	0.6	-	0.6
Morus rubra (s)	-	0.6	-	-	-
Arisaema triphyllum	-	0.6	-	-	0.6
Ambrosia trifida	-	0.6	-	-	-
Sambucus canadensis	-	0.6	-	-	-
Acer nigrum (s)	-	-	38.5	24.8	5.0
Sanguinaria canadensis	-	-	18.6	0.6	16.1
Fraxinus pennsylvanica (s)	-	-	10.6	5.6	-
Quercus alba (s)	-	-	10.6	0.6	-
Melica nitens	-	-	8.7	-	-
Hystrix patula	-	-	5.6	1.9	3.1
Solidago ulmifolia	-	-	5.6	-	1.9
Tilia americana (s)	-	-	3.1	2.5	-
Hepatica acutiloba	-	-	2.5	28.6	24.8
Asarum canadense	-	-	1.2	9.9	32.2
Desmodium glutinosum	-	-	1.2	3.7	3.7
Uvularia grandiflora	-	-	0.6	15.5	24.2
Osmorhiza longistylis	-	-	0.6	-	0.6
Anemonella thalictroides	-	-	-	70.2	44.7
Carex albursina	-	-	-	13.7	6.2
Staphylea trifolia	-	-	-	2.5	0.6
Panax quinquefolius	-	-	-	1.9	2.5
Adiantum pedatum	-	-	-	1.9	1.2
Smilicina racemosa	-	-	-	-	1.2

Figure 10. **Frequency (percent) obtained for selected species on upper sites in relation to continuum-index numbers**

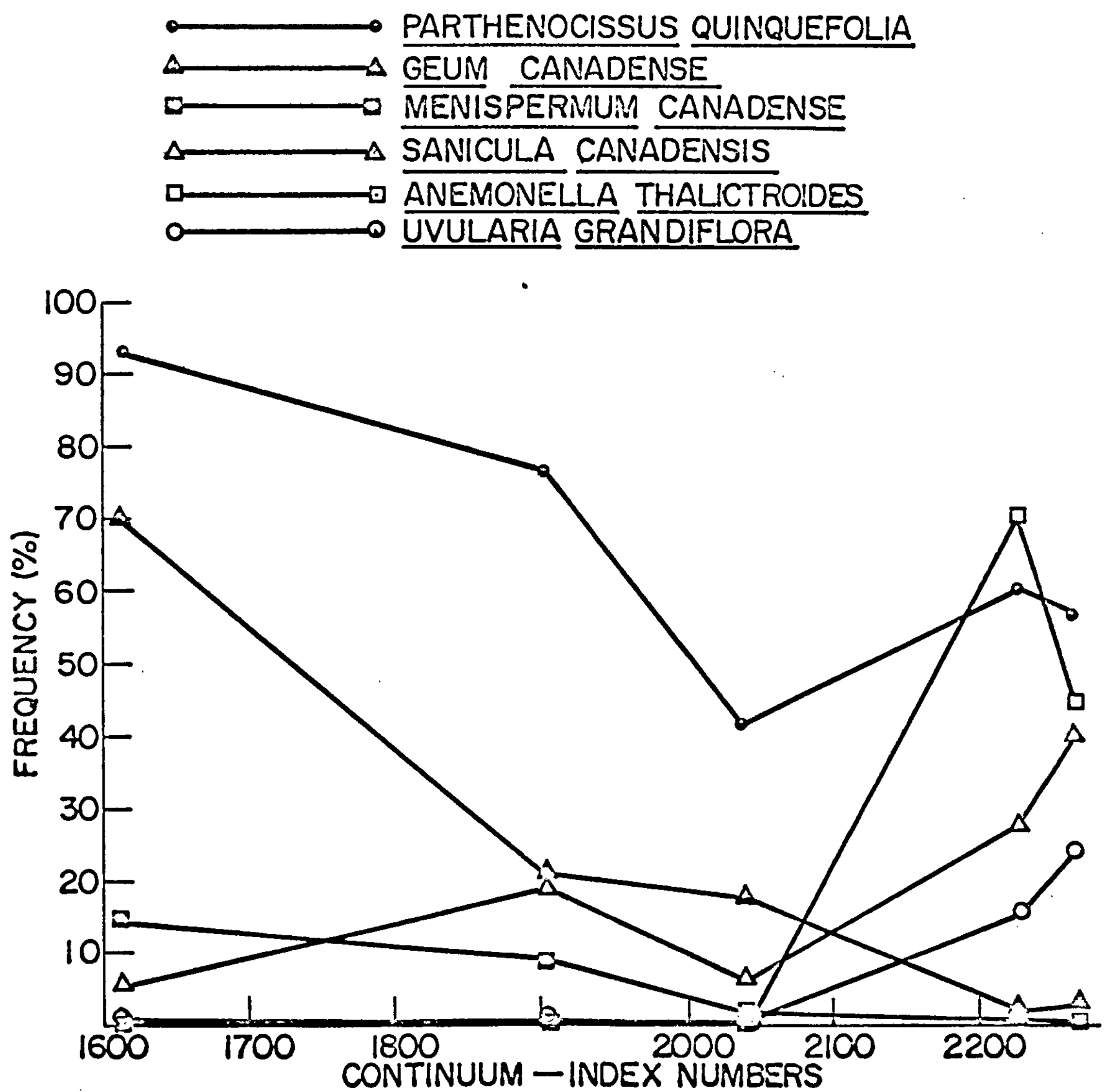

PARTHENOCISSUS QUINQUEFOLIA
RIBES SPP.
CAREX ROSEA
ACER NIGRUM(S.)
UVULARIA GRANDIFLORA
ANEMONELLA THALICTROIDES
FREQUENCY (%)
100
90
80
70
60
50
40
30
20
10
1500
1600
1700
1800
1900
2000
2100
2200
2300
CONTINUUM—INDEX NUMBERS

Sanicula canadensis, Phryma leptostachya, Osmorhiza claytoni, Sanguinaria canadensis, Hepatica acutiloba, Asarum canadense, Uvularia grandiflora, Anemonella thalictroides, and Carex albursina. Frequency values of selected species on lower sites are presented in Figure 11.

Average herbaceous cover per plot in percent for species on upper sites is presented in Table 9. Parthenocissus quinquefolia is shown to be the dominant species on all but one site, but it does show a decrease in average cover with an increase in the continuum-index numbers. Other species showing decreases in average cover include Ribes spp., Lonicera dioica, Carex rosea, Geum canadense, Quercus alba seedlings, Aster sp., Viola spp., Carya ovata seedlings, and Silene stellata. Species showing increases in average cover per plot with increases in the continuum-index number of the stands include Carex sp., Celastrus scandens, Ostrya virginiana seedlings, Amphicarpa bracteata, Acer nigrum seedlings, Impatiens pallida, Desmodium glutinosum, Quercus rubra seedlings, Hepatica acutiloba, Anemonella thalictroides, Asarum canadense, and Uvularia grandiflora. Average cover per plot is presented in Figure 12 for selected herbaceous species on upper sites.

The average cover per plot in percent for herbaceous species found on lower sites is presented in Table 10 and for selected species in Figure 13. Parthenocissus quinquefolia is the leading dominant on only one of the lower sites, but has a relatively high average cover on all sites. Species showing decreases in average cover per plot with increases in the continuum-index number of the stands include Ribes spp., Geum canadense, Celtis occidentalis seedlings, Cystopteris fragilis,

Figure 11. Frequency (percent) obtained for selected species on lower sites in relation to continuum-index numbers



PARTHENOCISSUS QUINQUEFOLIA
GEUM CANADENSE
MENISPERMUM CANADENSE
SANICULA CANADENSIS
ANEMONELLA THALICTROIDES
UVULARIA GRANDIFLORA
100
90
80
70
60
50
40
30
20
10
FREQUENCY (%)
1600
1700
1800
2000
2100
2200
CONTINUUM — INDEX NUMBERS

Table 9. Average cover per plot for herbaceous species and tree seedlings on upper sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JII (1506)	HBII flat (1730)	JI (1778)	CB (2128)	HBI (2199)	HBII (2235)
Parthenocissus quinquefolia	13.26	15.33	13.30	14.43	11.11	2.52
Ribes spp.	8.57	3.39	9.48	3.31	.73	.33
Lonicera dioica	4.00	-	.70	.05	.02	.03
Carex rosea	1.62	.64	2.34	.16	.08	.17
Ulmus spp. (s)	1.12	.40	1.36	.08	.89	.34
Geum canadense	1.07	.03	2.38	.17	-	-
Quercus alba (s)	.65	1.23	-	-	.02	-
Aster sp.	.62	-	.05	.05	-	.16
Viola spp.	.50	.33	3.66	.16	.16	.02
Carya ovata (s)	.44	1.09	.02	.08	.88	.12
Eupatorium rugosum	.40	-	-	-	-	-
Poa pratensis	.36	-	.17	-	-	-
Rhus radicans	.34	.76	1.47	6.17	.56	.85
Sanicula canadensis	.31	.03	-	.30	.63	.14
Vitis riparia	.28	-	.11	.20	.19	.11
Tilia americana (s)	.26	.17	.48	.33	.56	.23
Carex sp.	.23	.70	.05	.34	.81	.95
Silene stellata	.17	-	.02	.02	.02	-
Celastrus scandens	.14	.76	-	1.20	.30	.99
Prunus virginiana	.12	.02	.03	-	.03	-
Celtis occidentalis (s)	.11	.03	.56	.95	-	-
Osmorhiza claytoni	.11	.05	.05	-	.63	.03
Rubus spp.	.11	-	6.03	-	-	-
Ostrya virginiana (s)	.09	1.23	-	.42	.67	.92
Hydrophyllum virginianum	.08	.17	-	.02	.22	.02
Muhlenbergia sobolifera	.08	-	-	-	-	-
Amphicarpa bracteata	.06	.19	-	.25	.58	1.37
Fraxinus pennsylvanica (s)	.06	.25	-	-	.66	.26
Plantago purshi	.06	-	-	-	-	-
Viola pensylvanica	.03	-	.06	-	.03	-
Cryptotaenia canadensis	.03	-	-	-	-	-
Acer nigrum (s)	.03	.44	.20	.54	1.61	1.96
Rosa blanda	.03	.06	.02	-	-	-
Chenopodium album	.03	-	-	-	-	-
Menispermum canadense	.03	-	-	.33	.19	-
Morus rubra (s)	.02	-	-	-	-	-
Bromus purgans	.02	.03	-	.02	.30	-
Campanula americana	.02	.78	.11	.08	-	.30
Impatiens pallida	.02	.08	-	.28	.59	.73
Crataegus sp. (s)	.02	-	-	.02	-	-

Table 9. Continued

Species	JII (1506)	HBII flat (1730)	JI (1778)	CB (2128)	HBI (2199)	HBII (2235)
Gleditsia triacanthos (s)	.02	-	.02	-	-	-
Carya cordiformis (s)	.02	-	.11	-	.86	.02
Smilax tamnoides hispida	.02	.11	.30	1.18	.11	-
Smilax herbacea	.02	-	-	-	.31	-
Polygonum convolvulus	.02	-	-	-	-	-
Galium aparine	.02	1.10	.11	.39	.63	.48
Potentillia arguta	.02	-	.05	-	-	-
Helianthus tuberosum	-	1.10	-	-	-	-
Desmodium glutinosum	-	.82	-	-	.94	1.96
Sanguinaria canadensis	-	.30	-	-	1.94	-
Phryma leptostachya	-	.19	.19	.03	1.08	.20
Anemone quinquefolia	-	.14	.23	-	-	-
Hystrix patula	-	.12	-	.05	.06	.09
Quercus rubra (s)	-	.11	-	.05	.38	.50
Hepatica acutiloba	-	.09	-	-	2.70	.93
Corylus americana	-	.09	-	-	-	-
Festuca obtusa	-	.08	.05	-	-	.25
Elymus villosus	-	.08	.02	-	-	-
Panicum latifolium	-	.05	-	-	-	.02
Pilea pumila	-	.03	.66	1.23	1.06	.11
Anemonella thalictroides	-	.03	-	.02	10.06	18.57
Lactuca sp.	-	.02	-	-	-	-
Polygonatum canaliculatum	-	.02	-	.02	.11	.02
Adiantum pedatum	-	.02	-	-	.25	-
Xanthoxylum americanum	-	-	5.23	.19	-	-
Fraxinus nigra (s)	-	-	1.89	.05	.64	-
Nepeta cataria	-	-	.05	-	-	-
Cornus spp. (s)	-	-	.03	.05	.02	-
Oxalis stricta	-	-	.03	-	-	-
Cystopteris fragilis	-	-	.02	-	.08	-
Thalictrum dioicum	-	-	-	.44	-	-
Osmorhiza longistylis	-	-	-	.03	.66	-
Amelanchier arborea	-	-	-	.03	-	-
Arisaema triphyllum	-	-	-	.02	-	-
Asarum canadense	-	-	-	-	3.17	1.20
Uvularia grandiflora	-	-	-	-	.97	.73
Carex albursina	-	-	-	-	.45	.05
Staphylea trifolia (s)	-	-	-	-	.16	.02
Solidago ulmifolia	-	-	-	-	.14	-
Laportea canadensis	-	-	-	-	.13	-
Panax quinquefolius	-	-	-	-	-	.59

Table 10. Average cover per plot for herbaceous species and tree seedlings on lower sites arranged from left to right in order of increasing continuum-index number of the stands

Species	JI (1613)	CB (1904)	JII (2090)	HBII (2228)	HBI (2268)
Parthenocissus quinquefolia	11.20	7.52	2.64	6.97	5.82
Ribes spp.	7.16	4.55	1.86	3.56	3.37
Geum canadense	4.38	1.38	.84	.05	.08
Xanthoxylum americanum	4.04	.47	.11	-	-
Carex rosea	3.45	2.05	.81	.12	1.01
Viola spp.	2.47	.33	.87	.03	.22
Rubus spp.	2.33	-	.02	-	.02
Pilea pumila	2.07	1.68	.14	.42	.58
Lonicera dioica	1.93	.62	.12	-	.02
Menispermum canadense	1.21	1.06	.05	.05	.09
Ulmus spp. (s)	1.10	.50	.54	.37	-
Amphicarpa bracteata	.98	.03	10.78	.16	1.48
Festuca obtusa	.95	-	-	.09	-
Laportea canadensis	.93	.95	-	.12	1.89
Rhus radicans	.85	9.67	.95	2.00	2.38
Celtis occidentalis (s)	.61	.53	.20	.08	.08
Nepeta cataria	.56	-	-	-	-
Polygonum convolvulus	.51	-	-	-	-
Fraxinus nigra (s)	.44	.03	1.27	.02	.59
Hydrophyllum virginianum	.42	.06	.33	-	.34
Campanula americana	.39	.05	.61	.08	.02
Viola pensylvanica	.37	-	-	-	-
Cystopteris fragilis	.36	.03	.16	-	-
Cryptotaenia canadensis	.34	-	.06	-	.17
Phryma leptostachya	.25	.09	-	.99	1.23
Plantago purshi	.22	-	-	-	-
Smilax tamnoides hispida	.22	2.07	.03	-	.25
Panicum latifolium	.22	.02	.03	-	-
Sanicula canadensis	.20	.56	.61	1.32	2.52
Vitis riparia	.14	.58	-	.02	.03
Carya ovata (s)	.12	.06	.47	.05	.12
Gymnocladus dioica (s)	.12	-	-	-	-
Cornus spp. (s)	.12	.03	.05	-	-
Potentillia arguta	.11	.05	-	-	-
Glyceria striata	.11	.02	-	-	-
Carex sp.	.09	-	2.66	.17	.76
Gleditsia triacanthos (s)	.09	-	-	-	-
Smilax herbacea	.09	-	-	-	.02
Elymus villosus	.08	-	-	.02	.05

Table 10. Continued

Species	JI (1613)	CB (1904	JII (2090)	HBII (2228)	HBI (2268)
Osmorhiza claytoni	.06	-	-	.33	.87
Lactuca sp.	.06	-	-	-	-
Bromus purgans	.03	.03	.06	-	.14
Podophyllum peltatum	.03	-	-	-	-
Silene stellata	.02	.02	.14	-	.02
Carya cordiformis (s)	.02	.02	.03	-	-
Scrophularia lanceolata	.02	-	-	-	-
Polygonatum canaliculatum	-	.36	.03	.22	.03
Arisaema triphyllum	-	.23	-	-	.09
Galium aparine	-	.17	.81	.28	.26
Celastrus scandens	-	.14	-	.73	.11
Quercus rubra (s)	-	.09	.05	.14	.09
Morus rubra (s)	-	.09	-	-	-
Impatiens pallida	-	.05	1.32	.31	.37
Ostrya virginiana (s)	-	.03	.99	.05	.11
Thalictrum dioicum	-	.03	.02	-	.02
Ambrosia trifida	-	.02	-	-	-
Sambucus canadensis	-	.02	-	-	-
Acer nigrum (s)	-	-	2.72	1.01	.20
Sanguinaria canadensis	-	-	1.62	.02	1.03
Fraxinus pennsylvanica (s)	-	-	.87	.22	-
Quercus alba (s)	-	-	.58	.02	-
Tilia americana (s)	-	-	.39	.14	-
Hystrix patula	-	-	.30	.12	.08
Desmodium glutinosum	-	-	.25	.17	.40
Uvularia grandiflora	-	-	.23	.92	2.02
Melica nitens	-	-	.22	-	-
Hepatica acutiloba	-	-	.14	1.34	1.24
Solidago ulmifolia	-	-	.14	-	.05
Asarum canadense	-	-	.03	.92	4.16
Osmorhiza longistylis	-	-	.02	-	.02
Anemonella thalictroides	-	-	-	15.23	6.27
Carex albursina	-	-	-	.50	.16
Panax quinquefolius	-	-	-	.48	.14
Adiantum pedatum	-	-	-	.05	.11
Staphylea trifolia	-	-	-	.03	.09
Smilicina racemosa	-	-	-	-	.03

Figure 12. Average cover per plot (percent) for selected herbaceous species on upper sites in relation to continuum-index numbers

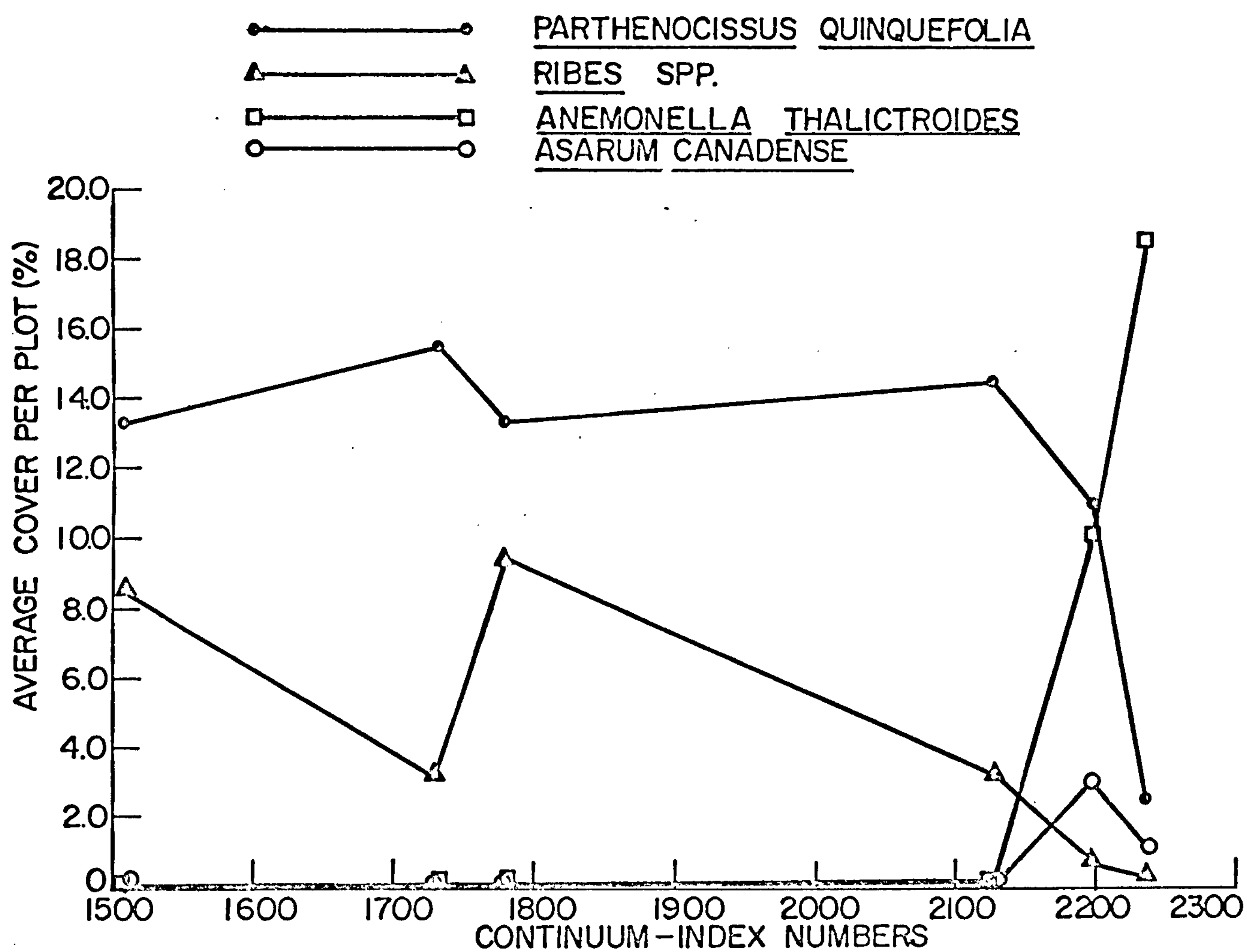
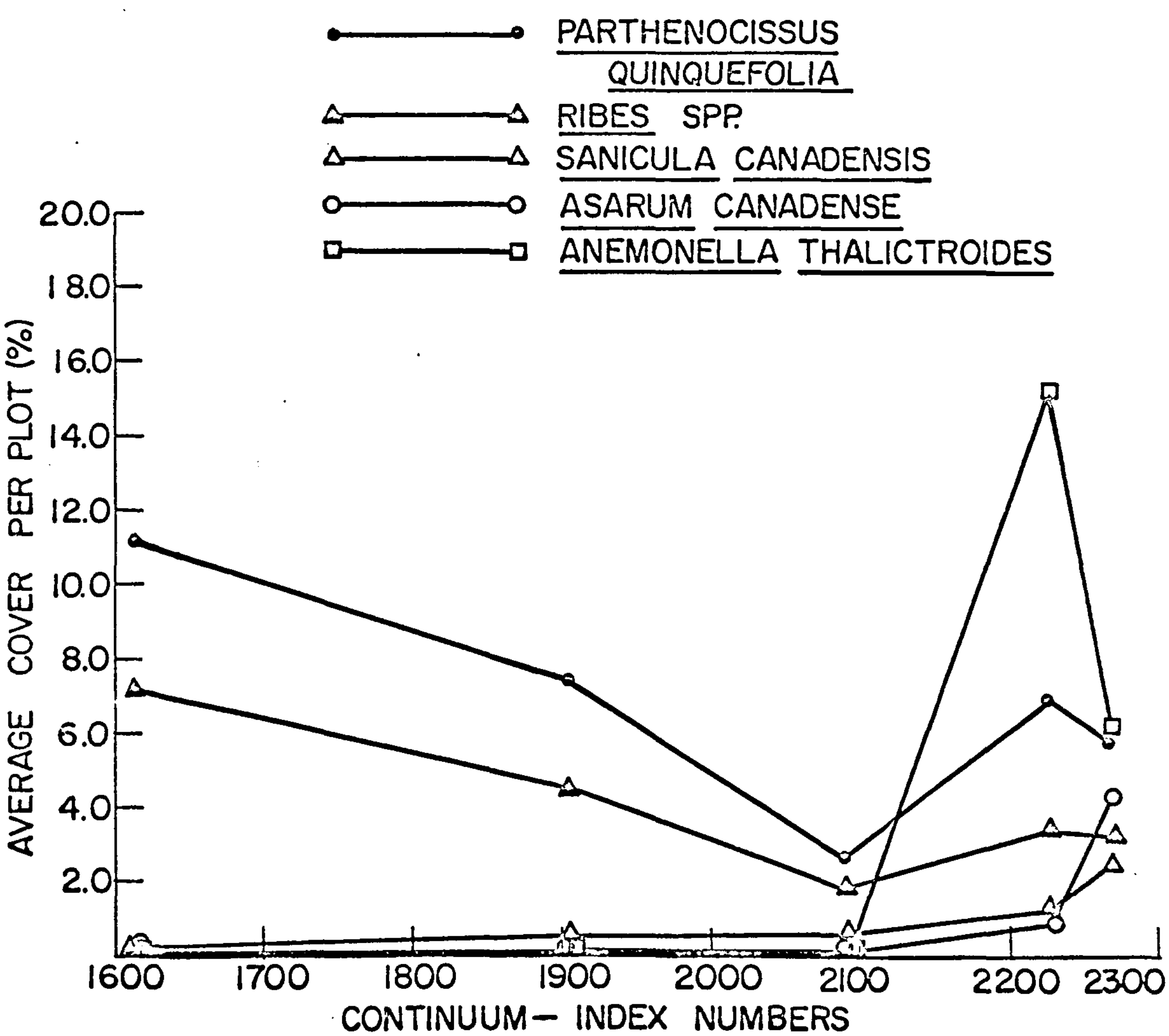

PARTHENOCISSUS QUINQUEFOLIA
RIBES SPP.
ANEMONELLA THALICTROIDES
ASARUM CANADENSE
AVERAGE COVER PER PLOT (%)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
1500
1600
1700
1800
1900
2000
2100
2200
2300
CONTINUUM-INDEX NUMBERS

Figure 13. Average cover per plot (percent) for selected herbaceous species on lower sites in relation to continuum-index numbers


PARTHENOCISSUS QUINQUEFOLIA
RIBES SPP.
SANICULA CANADENSIS
ASARUM CANADENSE
ANEMONELLA THALICTROIDES
AVERAGE COVER PER PLOT (%)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1600
1700
1800
1900
2000
2100
2200
2300
CONTINUUM— INDEX NUMBERS

Xanthoxylum americanum, *Viola* spp., *Rubus* spp., *Pilea pumila*, *Lonicera dioica*, *Menispermum canadense*, *Festuca obtusa*, and *Panicum latifolium*. Species with increased average cover per plot with increased continuum-index number of the stands include *Phryma leptostachya*, *Sanicula canadensis*, *Carex* sp., *Osmorhiza claytoni*, *Hepatica acutiloba*, *Acer nigrum* seedlings, *Asarum canadense*, *Uvularia grandiflora*, *Impatiens pallida*, *Desmodium glutinosum*, *Ostrya virginiana* seedlings, *Sanguinaria canadensis*, *Anemonella thalictroides*, and *Carex albursina*.

An alphabetical listing of species encountered in the study plots is presented in Table 11. A total of 99 species was encountered.

Table 11. List of species recorded in the study

Acer negundo L.
Acer nigrum Michx. f.
Adiantum pedatum L.
Ambrosia trifida L.
Amelanchier arborea (Michx. f.) Fern.
Amphicarpa bracteata (L.) Fern.
Anemone quinquefolia var. interior Fern.
Anemonella thalictroides (L.) Spach
Arisaema triphyllum (L.) Schott
Asarum canadense L.
Aster sp. L.

Bromus purgans L.

Campanula americana L.
Carex albursina Sheldon
Carex rosea Schkuhr
Carex sp. L.
Carya cordiformis (Wang.) K. Koch
Carya ovata (Mill.) K. Koch
Celastrus scandens L.
Celtis occidentalis L.
Chenopodium album L.
Cornus spp. L.
Corylus americana Walt.
Crataegus sp. L.
Cryptotaenia canadensis (L.) DC.
Cystopteris fragilis (L.) Bernh.

Desmodium glutinosum (Muhl.) Wood

Elymus villosus Muhl.
Erigeron strigosus Muhl.
Eupatorium rugosum Houtt.

Festuca obtusa Biehler
Fraxinus nigra Marsh.
Fraxinus pennsylvanica Marsh.

Galium aparine L.
Geum canadense Jacq.
Gleditsia triacanthos L.
Glyceria striata (Lam.) Hitchc.
Gymnocladus dioica (L.) K. Koch

Table 11. Continued

Helianthus tuberosus L.
Hepatica acutiloba DC.
Hydrophyllum virginianum L.
Hystrix patula Moench

Impatiens pallida Nutt.

Juglans cinerea L.
Juglans nigra L.

Lactuca sp. L.
Laportea canadensis (L.) Wedd.
Leersia virginica Willd.

Melica nitens Nutt.
Menispermum canadense L.
Morus rubra L.
Muhlenbergia sobolifera (Muhl.) Trin.

Nepeta cataria L.

Osmorhiza claytoni (Michx.) C. B. Clarke
Osmorhiza longistylis (Torr.) DC.
Ostrya virginiana (Mill.) K. Koch
Oxalis stricta L.

Panax quinquefolius L.
Panicum latifolium L.
Parthenocissus quinquefolia (L.) Planch.
Phryma leptostachya L.
Pilea pumila (L.) Gray
Plantago purshi R. and S.
Platanus occidentalis L.
Poa pratensis L.
Podophyllum peltatum L.
Polygonatum canaliculatum (Muhl.) Pursh
Polygonum convolvulus L.
Populus deltoides Marsh.
Potentillia arguta Pursh
Prunus serotina Ehrh.
Prunus virginiana L.

Table 11. Continued

Quercus alba L.
Quercus macrocarpa Michx.
Quercus rubra L.
Rhus radicans L.
Ribes spp. L.
Rosa blanda Ait.
Rubus spp. L.
Sambucus canadensis L.
Sanguinaria canadensis L.
Sanicula canadensis L.
Scrophularia lanceolata Pursh
Silene stellata (L.) Ait. f.
Smilax herbacea L.
Smilax tamnoides var. hispida (Muhl.) Fern.
Smilicina racemosa (L.) Desf.
Solidago ulmifolia Muhl.
Staphylea trifolia L.
Thalictrum dioicum L.
Tilia americana L.
Ulmus americana L.
Ulmus rubra Muhl.
Uvularia grandiflora Sm.
Viburnum rafinesquianum var. affine (Bush) House
Viola spp. L.
Viola pensylvanica Michx.
Vitis riparia Michx.
Xanthoxylum americanum Mill.

DISCUSSION

Transect Study

The correlation values listed in Table 1 are difficult to interpret. Samples were inadequate and were not taken at random; however, they are useful in showing some relationships. In many cases, relationships which are obvious to the investigator show up as either positive or negative correlations (Kershaw, 1966). In other cases, associations are pointed out through the correlation matrix which are not apparent from field observations.

The line transect method of sampling has certain advantages over random samples. With this method, it is possible to relocate the sample points at a later date so that recordings of the vegetation at the same points can be repeated. The systematic placing of sample points along a line yields reproduceable results with the inspection of a minimum number of plots (Daubenmire, 1959).

Because average cover per plot was recorded, it was necessary to project the quadrat area upward in order to estimate the cover of the canopy species. Some compensation for the error involved with this type of measurement was made through the use of cover-classes. Another problem arose because individuals of many species occurred so rarely that a correlation matrix produced few meaningful correlations. This was partially compensated for by lumping sample points into groups of four and using the average cover for determining correlation values.

The constellations shown in Figures 1 through 4 were constructed to help point out association tendencies of species in each of the four areas. In Figure 1, four dominant tree species were shown with positive correlations existing between each other. This was somewhat unexpected because Quercus alba is not usually found in association with Acer nigrum, Quercus rubra, and Tilia americana. The fact that Quercus alba does, in some cases, associate with Acer nigrum and other species which occur as dominants in stands toward the upper end of the continuum index supports the principle of the continuum. Also several herbaceous species such as Carex sp. and Celastrus scandens are shown to be associated with the four tree species mentioned above.

The constellation for Area II (Jester I) as shown in Figure 2 presented some problems in construction. There are several groups or pairs of species which are not correlated with the majority of the species. Also, there is a scarcity of negative correlations. Finally, no individual species is correlated with more than five species. Jester I is a disturbed area, and it is possible that the observations above represent what one would expect to find in analyzing a disturbed area using a correlation matrix.

Two distinct groupings of species separated by negative correlations are apparent in Figure 3 for Area III (Jester II). Although not as distinct, these two groupings of species can be recognized in the field. One group, centered around mature Quercus alba and Celtis occidentalis reproduction, was confined to the extreme upper slope while the other larger group was found along the middle and lower slope. There were so many correlations greater than .4 that it was necessary to exclude those species from the constellation which did not occur in as many as five lumped "plots".

Two clusters are also apparent in Figure 4. One cluster of species includes a number of lower slope-floodplain species, such as Ulmus americana and Fraxinus nigra. The other species cluster represents what would be expected to occur on upper slopes in area IV. Key species in this cluster include Tilia americana, Hepatica acutiloba, and Anemonella thalictroides, all of which show positive correlations with each other. Acer nigrum represents the sole link between the two groups, being negatively correlated with both groups.

Random-point Study

It became apparent that random plots afforded the best means of more adequately elucidating the structure of the slope forests. In addition, it became obvious that the layers of vegetation comprising these forests could not be characterized adequately by the use of cover values alone. Consequently, each layer of vegetation was sampled independently in each stand with techniques being employed to fit the limitations of each layer.

The data obtained from random-point sampling suggested that the most meaningful approach to analysis was by the use of the concept of the continuum (Curtis and McIntosh, 1951). This concept is based on the hypothesis that all species in a given stand respond to the same environmental factors but in a different manner so that species aggregations occur in a continuous fashion rather than as discrete communities.

Canopy species

A cursory examination of the importance values of the species presented in Tables 2 and 3 suggested the absence of discrete communities. No single species dominates more than three stands. Also, no stand has the same pair of leading dominants. On this basis the continuum concept seems tenable. The degree to which each species is found in a given stand is influenced by its range of environmental tolerances and unknown historical events.

Quercus alba and Carya ovata tend to occur together (see Table 2) which has led in the past to the usual description of the oak-hickory community as a discrete category (Figure 14). They do not occur as co-dominants with Acer nigrum and Quercus rubra (Figure 15) which has led to the other common community often reported for this region (Kucera, 1950). Ulmus americana and Fraxinus pennsylvanica represent species with broad environmental tolerances because their importance values vary from stand to stand. The species listed as Fraxinus pennsylvanica represents both green ash and white ash (Fraxinus americana) because of extreme difficulty in field identification of the two species, and because the two species hybridize quite readily according to Sargent (1961) and Mickel[1].

The importance values presented for Jester I (upper) in Table 2 are taken from a disturbed site. Apparently this site had been subjected to selective cutting in the past of unknown extent which may have had an important effect on the present composition of the stand (Figure 16).

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[1]Mickel, J. T. Ames, Iowa. Hybridization in Fraxinus. Private communication. 1967.

Several species occurred in only one or two stands and seemed to be insignificant in characterizing the structure of the individual stand. However, it should be pointed out that these species, including Gymnocladus dioica, Prunus serotina, and Crataegus sp. are included in the determination of the continuum-index number of the stands.

Because the areas in this study designated as lower slopes are positioned between the floodplain and the upper slope forests, it is not surprising to find in Table 3 a considerable number of species commonly found on upper slopes interspersed with species commonly found on the upper floodplain. These floodplain species include Celtis occidentalis, Fraxinus nigra, cottonwood (Populus deltoides), sycamore (Platanus occidentalis), Acer negundo, and Juglans cinerea.

In Table 3, it is apparent that Ulmus americana is the most abundant tree species on lower slopes. It is able to compete here probably due to the fact that the moisture level of the soil is higher because of the water table. With a rise in the water table of the area brought on by impoundment, one would suspect Ulmus americana to be an important species on the slopes along the reservoir. However, with Dutch elm disease becoming a greater problem (Kurtz, 1964), it is possible that Ulmus americana will be unable to fill this niche. It could well be that Fraxinus nigra might fill this niche instead of Ulmus americana because it also thrives where abundant moisture is available.

The site designated as CB-lower actually represents a floodplain-terrace stand. This site was selected because it allowed a comparison to be made of a floodplain-terrace stand with a lower slope stand. Also, the river slope in this area is so steep that it could not be divided into two sites which were large enough to provide useful information.

The major canopy species show the same trends on lower slopes as on upper slopes. Acer nigrum, Quercus rubra, Tilia americana, and Ostrya virginiana show increases in importance values with increases in the continuum-index number of the stands. Species such as Quercus alba, which show decreases in importance values with increased continuum-index numbers on upper sites, show variations in importance values on lower sites.

The data shown in Tables 2 and 3 were obtained using the quarter method (Cottam and Curtis, 1956). It was found by these authors that of all types of distance sampling, the quarter method yields results which show the least variability.

One of the major problems encountered in the analysis of the data involved the assignment of climax-adaptation numbers. This was necessary because the continuum-index number of a stand is the sum of the products of importance values and climax-adaptation numbers of all species. Curtis and McIntosh (1951) suggested that Iowa is a part of the same floristic province as southwestern Wisconsin; therefore I decided where possible to use the same climax-adaptation number which they assigned to a species (see Table 12). Some species were encountered in the present study which did not occur in the Wisconsin study. For these species, climax-adaptation numbers were assigned according to the tolerance values used by foresters (Preston, 1966). Curtis and McIntosh (1951) stated that tolerance values are closely correlated with climax-adaptation numbers.

Table 12. Climax-adaptation numbers of tree species recorded in this study[a]

Species	Climax-adaptation number
Quercus macrocarpa	1.0
Acer negundo	1.0
Populus deltoides[b]	1.5
Platanus occidentalis[b]	2.0
Crataegus sp.[b]	2.5
Fraxinus nigra[b]	3.0
Carya ovata	3.5
Prunus serotina	3.5
Gleditsia triacanthos[b]	4.0
Quercus alba	4.0
Fraxinus pennsylvanica[b]	4.0
Juglans nigra	5.0
Quercus rubra	6.0
Juglans cinerea	7.0
Ulmus americana[b]	7.0
Gymnocladus dioica	7.5
Morus rubra[b]	7.5
Amelanchier arborea[b]	8.0
Ulmus rubra	8.0
Tilia americana	8.0
Celtis occidentalis	8.0
Carya cordiformis	8.5
Ostrya virginiana	9.0
Acer nigrum	10.0

[a]Largely from Curtis and McIntosh (1951).

[b]Species for which tentative climax-adaptation numbers were assigned.

The relationship which exists between density (trees per acre) and continuum-index number of the stands is presented in Table 4. Although in the present study there is a general increase in the density with increases in the continuum-index number of the stands, one must consider other factors in order to explain stand to stand variations. Factors such as stand age, succession, and disturbance effects must be considered. Through competition, one would expect the number of trees per acre to decrease with age until an equilibrium is reached. A successional stand might have more trees per acre than a steady-state stand, depending upon the growth habit of the dominant species. Disturbance effects may work in one of two ways. First, the number of trees per acre may be lower than in undisturbed stands through selective removal of one or two species. Secondly, a disturbed stand might show high densities after a number of years in which replacement of removed trees has occurred.

Tree reproduction and shrub species

Interpretation of the data shown in Tables 5 and 6 regarding the reproductive vegetation presents some difficulty. In order to adequately interpret the values obtained, it is necessary to have more information on the response of the seedlings of each species to environmental conditions. An example of this may be noted for *Quercus rubra*. Reproduction of this species is appreciable in only one stand, although it is a dominant in several stands. It would be helpful to know the percentage of the seedlings which reach maturity. Based on the importance values of the mature individuals, the data suggest that *Quercus rubra* seedlings have a high survival rate. We must assume, however, that *Quercus rubra* is replacing itself in stands where it is now a dominant species. This may or may not be true.

Fraxinus pennsylvanica and *Fraxinus nigra* are species which have high reproductive rates. It is noted that only rarely (Tables 2 and 3) does either of these species play a dominant role in the composition of a stand. From this we may conclude that both *Fraxinus pennsylvanica* and *Fraxinus nigra* have high mortality rates in the sapling stage, or that environmental changes have occurred which now favor these two species. *Celtis occidentalis* is another example of this situation.

It may be surprising to note that *Acer nigrum* and *Ostrya* have high importance values for reproductive vegetation, even in stands which are located at the lower end of the continuum index (Figure 17). This suggests that while seed of these species are able to germinate and become established in most stands, only in those stands which have more mesic conditions can they compete favorably. A second possibility is that environmental changes over the whole area have occurred which now favor these species.

The two species of elm (*Ulmus americana* and *Ulmus rubra*) were included together for determining the importance values of the reproductive vegetation. This was done due to the impossibility of distinguishing the two species at this age. Consequently, the values obtained are much higher than would be found for either species separately. The elms are prolific seed-producers and may be found in any area of a stand where sunlight reaches the forest floor. Because elms are fast-growing species and maple is slow-growing, this may account for the presence of elms in stands where Acer nigrum is a dominant species.

The quarter method was also used in recording the data relating to the reproduction layer. It was necessary to devise a scheme for determining the dominance of the individuals. I decided that the appropriate technique for determining the dominance was the use of height classes, with greater height being used as an indicator of greater ability to compete. This has not been reported previously, although Curtis and McIntosh (1951) discussed the difficulty in adequately sampling the reproduction of the tree species.

From Tables 5 and 6 and from Figures 7 and 8 it may be noted that the reproduction of Acer nigrum shows increased importance values with increases in the continuum-index number of the stands (from 17.1 to 55.2 on upper sites and 0.0 to 60.1 on lower sites). Quercus rubra shows the same relationship (0.0 to 36.5 on upper sites and 1.6 to 18.3 on lower sites). Other species such as Quercus alba and Carya ovata show tendencies to vary in importance values of the reproduction with increases in the continuum-index number of the stands. Quercus alba on upper sites decreases from 19.4 to 0.0, and on lower sites is found in only one stand. Carya ovata shows a decrease in importance values on upper sites from 35.5 to 25.9, but on lower sites increases in importance values from 6.3 to 25.4. These trends would be expected to occur because generally, the same trends occur among mature individuals (Tables 2 and 3).

Figure 9 represents the relationship of mature trees to reproduction on upper sites. No generalizations are apparent, but relationships can be shown to exist for several species. Ostrya virginiana shows a close relationship between mature trees and reproduction on all sites. The other species, Acer nigrum and Quercus alba, show close relationships only on certain sites.

Herbaceous vegetation

The same type of pattern shown by the canopy vegetation is shown for the herbaceous species in Tables 7 and 8 and Figures 9 and 10. Parthenocissus quinquefolia decreases in frequency on both upper and lower sites (from 94.4 to 29.8 on upper sites and from 93.2 to 57.1 on lower sites). Ribes spp. show the same trends (59.0 to 9.9 on upper sites and 38.5 to 26.7 on lower sites). These trends were expected because these species thrive in areas where a considerable amount of sunlight reaches the herbaceous layer.

Anemonella thalictroides and Hepatica acutiloba show increases in frequency values with increases in the continuum-index number of the stand. Anemonella thalictroides shows an increase in frequency on upper slopes from 0.0 to 85.1 and from 0.0 to 44.7 on lower slopes (Figure 18). Hepatica acutiloba increases in frequency from 0.0 to 28.0 on upper slopes and from 0.0 to 24.8 on lower sites. This suggests that these two species are successful in competing with other species under low light conditions. It should be noted that first-year seedlings of Acer nigrum, Quercus rubra, and Tilia americana show increases in frequency values with increases in continuum-index numbers (which is also reflected in the reproduction importance values in Tables 5 and 6.)

From Tables 7 and 8, it is apparent that many species occur too infrequently to be considered as dominant species. Certain of these species may be used as indicators of certain environmental conditions and of certain positions of stands along the continuum index. For example, species such as Uvularia grandiflora, Carex albursina, and Panax quinquefolius are commonly associated with conditions in which little light reaches the top of the herbaceous layer. Because stands in which Quercus rubra, Acer nigrum, and Tilia americana occur as dominants have these conditions, we may infer that the above herbaceous species tend to occur in stands in which these trees are dominants. On the other hand, species such as Plantago purshi, Chenopodium album, Eupatorium rugosum, and Poa pratensis represent species which require more light, and one would expect to find them in stands at the lower end of the continuum index.

The upper stand in Jester I represents a disturbed area. This fact is as well illustrated with herbaceous species as with canopy species. High frequency values were obtained for Rubus spp., Ribes spp., Xanthoxylum americanum, and Viola spp. All of these species are commonly found in disturbed forests or forest edges where abundant sunlight reaches the herbaceous layer.

Average cover values are presented in Tables 9 and 10 and in Figures 12 and 13. The canopy-coverage method (Daubenmire, 1959) seemed to be the most efficient technique which could be used to sample the herbaceous layer. This method yields not only data regarding presence or absence, but also yields data regarding dominance of the species present. Lindsey (1956) reported that canopy-coverage "is the most important single parameter of a species in its community relations".

Comparing Tables 7 and 8 (frequency) with Tables 9 and 10 (average cover), it seems that both values yield about the same ranking of herbaceous species for the dominants. However, very different species rankings are noted for non-dominant species. Daubenmire (1959) has suggested that average cover per plot yields more reliable results than frequency because cover expresses the influence of each species in addition to presence or absence.

A complete species list is presented in Table 11 for species encountered in all of the samples. Some plants were identified only to genus because of the difficulty in following keys with the available material. In other cases, flowering and fruiting material were not observed.

From careful analysis of the tables and figures which have been presented, it is possible to present a composite description of slope forests along the Des Moines River. Individual stands show wide variations in species composition (both trees and herbaceous vegetation) from stand to stand and from upper to lower sites. In general, three groups of stands can be recognized. Some stands are dominated by Quercus alba, Carya ovata, and Ulmus spp. (Figure 14). These stands have a high importance value for Ulmus spp. reproduction and Celtis occidentalis reproduction. Characteristic herbaceous species include Parthenocissus quinquefolia and Ribes spp. These stands are limited to the extreme upper slope and are found on sites with an average of less than 10 percent slope.

A second recognizable grouping of stands is characterized by the dominance of Acer nigrum, Tilia americana, and Quercus rubra (see Figure

15). In these stands, reproduction of the three species mentioned above is high, especially for Quercus rubra and Acer nigrum. Many herbaceous species appear to be associated with these stands including Anemonella thalictroides, Hepatica acutiloba, Uvularia grandiflora, and Carex albursina. These species are conspicuously absent from stands where Quercus alba is a dominant canopy species. These stands are found on both upper and lower slopes usually where the slope is greater than 10 percent.

The third grouping of stands includes all stands which do not fit into either of the above categories. This category includes transition stands, disturbed stands, and successional stands. Any of a number of species may be dominant, and reproduction of canopy species in these stands is variable.

SUMMARY

1. Transects down the slopes yielded data from which correlation matrices were prepared. However, the values obtained have limited significance because sample points were not randomly selected. Constellation diagrams of species interrelationships were also presented. From these the overall relationships which existed were shown.

2. In the random-point study, the vegetation was considered at three levels - the canopy, the tree reproduction, and the herbaceous layer. Each was sampled separately on 11 sites using appropriate sampling procedure.

A. Canopy layer. Importance values were determined for each species on each site. Sites were grouped according to topographic position. On upper sites, Quercus alba and Carya ovata were shown to decrease in importance values as Acer nigrum, Quercus rubra, and Tilia americana increased in importance values. The same was shown to exist on lower sites except that Carya ovata showed some variations. Some species, such as Ulmus americana, showed variations from site to site regardless of slope position. From the data obtained from the present study, it is difficult to accept the hypothesis that discrete community types exist on slopes in central Iowa. It does allow the grouping of certain types of stands according to continuum-index numbers. For instance, stands in which Acer nigrum, Quercus rubra, or Tilia americana occur as the dominant canopy species can be grouped according to the continuum index as stands toward the upper or mesic end of the continuum.

B. Reproduction layer. Species showed variations in relation to continuum-index numbers. It appears that in many cases, reproduction is a function of effective seed dispersal and not necessarily a function of the species composition of mature individuals. Comparing reproduction to mature trees, Ostrya virginiana shows a close relationship between mature trees and reproduction, while others (Acer nigrum and Quercus alba) show close relationships only in some stands.

C. Herbaceous layer. Many species showed either a trend toward increasing or toward decreasing in frequency and average cover in relation to continuum-index numbers. Species increasing with increased continuum-index numbers included Asarum canadense, Uvularia grandiflora, Carex albursina, and Anemonella thalictroides. Species decreasing in frequency and average cover with increased continuum-index numbers included Parthenocissus quinquefolia and Ribes spp.

3. The data obtained from each layer were summarized and compared by use of the continuum index. Stands occupying a low position along the index (1500-1800) were found to have a group of associated species. Tree reproduction was variable, but herbaceous species consistently found in these stands included Ribes spp., Carex rosea, and Parthenocissus quinquefolia. Stands with higher continuum-index values (2000-2250) were usually dominated by Acer nigrum or Quercus rubra, with other associated species. Often Acer nigrum reproduction was abundant in these stands, and characteristic herbaceous species included Anemonella thalictroides,

Carex albursina, *Asarum canadense*, and *Hepatica acutiloba*.

4. Data made available by this study will be important in comparing the results obtained after flooding has occurred with composition prior to flooding. Hopefully, this comparison will lead to some predictions as to which species can be successfully grown along the periodically flooded slopes of the reservoir.

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APPENDIX

Figure 14. General view of a stand in which Quercus alba and Carya ovata are dominant species (Jester II-upper). Note the "openness" of the area and the dense understory

Figure 15. A stand dominated by Quercus rubra, the large trees to the right, and Acer nigrum, the smaller tree near the left margin (High Bridge I-upper). Understory density is sparser than in Figure 14

Figure 16. General view of a disturbed site (Jester I-upper). Note the amount of light reaching the understory level and the denseness of the understory. Fraxinus spp. and Celtis occidentalis are important components of the reproduction layer

Figure 17. Acer nigrum and Quercus rubra reproduction in openings within the disturbed site (Jester I-upper). Note the Quercus rubra sapling in the center of the photo and the Acer nigrum saplings at the left and right margins

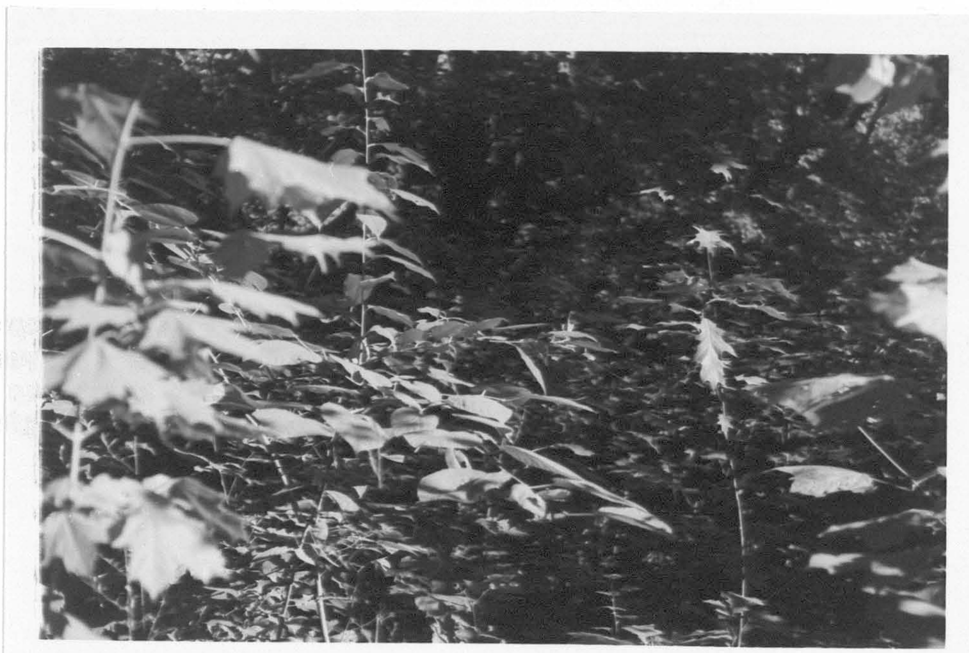

Figure 18. The herbaceous layer in a stand dominated by Acer nigrum and Quercus rubra (High Bridge I-upper). The dominant herbaceous species is Anemonella thalictroides, in the center of the photo. Note the small amount of direct sunlight reaching the herbaceous layer