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Age Structure, Species Composition and Succession in a Loess Hills Woodland.

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Age Structure, Species Composition and Succession in a Loess Hills Woodland

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Abstract

Age Structure, Species Composition and Succession in a Loess Hills Woodland

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The Loess Hills of central North America is a unique geologic region that historically was dominated by prairie with scattered oak trees in an environment of frequent fires. Following European settlement, woody-plant cover expanded throughout the Loess Hills so that today, existing prairies occur as remnants surrounded by an oak-dominated woodland. Large-, intermediate-, and small-sized trees were sampled along three adjacent lowland-to-upland belt-transects in western Iowa to document more accurately the dynamics of this woody expansion. Trees were cored or cross-sectioned and dated using standard dendrochronological techniques. Results characterize the pre-1850 woody canopy as consisting of a few widely scattered oak trees on both upper and lower slopes. The rapid development of an even-aged stand of bur oak (*Quercus macrocarpa* Michx) by the 1870s and 1880s suggests release of the species perhaps from its historic suppression by fire. Other species subsequently colonizing included hackberry (*Celtis occidentalis* L.) and green ash (*Fraxinus*

pennsylvanica Marsh), both arriving principally in the 1920s and 1930s; American linden (*Tilia Americana* L.), arriving principally in the 1940s and 1950s; and ironwood (*Oystra virginiana* Mill.), arriving principally in the 1950s. Patterns of encroachment varied from uniform establishment across all elevational segments (e.g. bur oak and ironwood) to invasion from either upper slopes (e.g. green ash) or lower slopes (e.g. hackberry). The absence of small- and intermediate-sized trees suggest that bur oak will not remain a dominant species in future Loess Hills woodlands. These results quantify both our understanding of the dynamics of the Loess Hills woody-plant invasion and our knowledge of the historic plant community of the region, both important considerations as we move to better manage this unique resource.

INTRODUCTION

The Loess Hills of central North America, a unique geologic region that borders the Missouri River Valley, extends 325 kilometers from Plymouth County, Iowa, south to Holt County, Missouri (Mutel, 1989) (Fig. 1). This distinctive landform is composed of a narrow band of bluffs varying from 4-16 kilometers in width. Its western boundary rises from the Missouri River Valley floodplain to heights of 60-90 meters. The eastern boundary is not well defined, with hills gradually giving way to a rolling landscape. The Loess Hills formed from wind-blown silt (loess) deposited marginal to glaciers as they retreated from the region approximately 10,000 - 12,000 YBP. Erosion, combined with the unique properties of loess that allow it to form steep vertical slopes (50-75°) when exposed, has given the hills their present form (Bettis *et al.*, 1986).

Positioned in an area of climatic transition, the Loess Hills environment may support either woodland or prairie (Albertson and Weaver, 1945). Prior to European settlement, prairie dominated most of the Loess Hills, with woody plant cover, dominated by bur oak (*Quercus macrocarpa* Michx.), occurring in savannas of widely scattered trees (General Land Office, 1852; Loomis and McComb, 1944; Nuzzo, 1986; Bonney, 1986). Modern Loess Hills vegetation cover, however, includes fewer prairies and more woodlands (Novacek *et al.*, 1985). Nuzzo (1986) also describes a transition from oak savanna to closed oak forest in numerous areas of the Midwest such that today oak savannas occupy less than one percent of their original range. The increase in woody plant cover in the Loess Hills, presumed to be an expansion from mesic lowlands to more xeric upper slopes and hilltops, is generally attributed to either fire suppression since

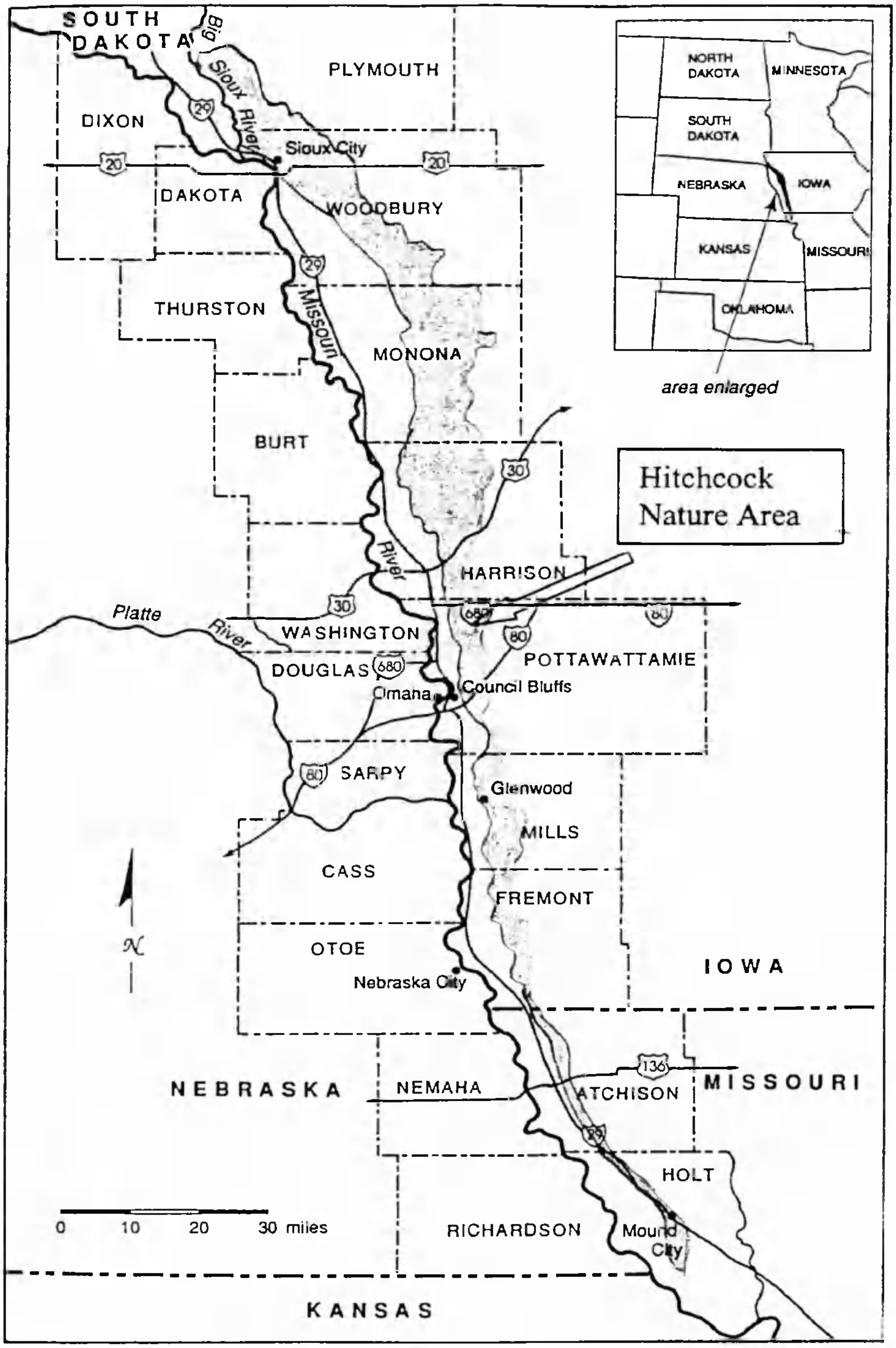


Fig. 1. The Loess Hills landform (shaded area) of Central North America and location of the Hitchcock Nature Area (Mutel, 1989).

European settlement or climate change (Novacek *et al.*, 1985). Historic fires are believed to have prevented expansion of woods plants perhaps by limiting establishment of seedlings (Novacek *et al.*, 1985; Nuzzo, 1986). Release from fire suppression would enable woody-plants to expand their range (Bragg, 1976). Climate change resulting in more mesic conditions than occurred in pre-settlement times would also favor woody plant encroachment (Novacek *et al.*, 1985), although evidence for such a cause is not available.

Novacek *et al.* (1985) identified two broad vegetation communities of the Loess Hills: eastern deciduous forest, dominated by oak (*Quercus* spp.) and hickory (*Carya* spp.), and mixed-grass prairie, dominated by little bluestem (*Andropogon scoparius* Michx.) and side oats grama (*Bouteloua curtipendula* Michx.). Effectively, the remnants of Loess Hills prairie are eastern outliers of the more western mixed-grass prairies. For example, the Loess Hills prairie contains many of the plant species that typify the mixed prairies 110 km farther west, and fewer of the species of tall-grass prairie that surround them (Novacek *et al.*, 1985). Present woody-plant cover is still largely dominated by bur oak, although regeneration of the species is poor (Bragg, 2001, pers. comm.). In addition, the present forest canopy cover is continuous rather than scattered throughout most of the wooded portion of the Loess Hills (Novacek *et al.*, 1985). Further, within the Loess Hills, prairie and woodland are not uniformly distributed since both are affected by aspect and latitude. Western and southern aspects of the Loess Hills are more xeric, having been exposed to stronger wind and more intense afternoon sun throughout the year (Shimek, 1909-cited in Novacek *et al.*, 1985). These aspects are generally dominated by prairie whereas the more mesic northern and eastern aspects are wooded (Novacek *et al.*, 1985). In addition, more prairie occurs in the northern areas of the Loess Hills than in the south where woodland cover is higher. Southern counties also support a greater diversity of trees (Species Richness = 31) than northern areas (Species Richness = 14) (Appendix Table 1). This varying distribution of woodland and prairie may be explained by various climatic and physical gradients of which 10 seem particularly noteworthy. Elevation, velocity and frequency of wind, number of sunny days and evaporation rates all increase from the southern- to northern-Loess hills locations, while precipitation, average temperature, length of growing season, average humidity, and soil moisture all decrease (Novacek *et al.*, 1985).

The woodlands of today almost certainly are seral communities of various ages (Loomis and McComb, 1944; Heineman, 1982) with differences depending both on how long ago conditions were altered to favor woody species and on subsequent management. The sequence of community succession, however, has not been well documented. In the 1940s, Loomis and McComb (1944) predicted that the Loess Hills were capable of supporting an oak-hickory association, although intermediate stages were not described. Heineman (1982) described bur oak-hackberry (*Celtis occidentalis* L.) associations on upper-slope locations in the Loess Hills of Monona County, providing data to show that these areas had been invaded since European settlement. In the absence of age-dating trees, however, the seral status described in these communities was inconclusive; Loomis and McComb (1944) used field observations and Heineman (1982) used canopy cover supplemented with data from Section-Line Surveys conducted in 1853. This study was designed to add dendrochronological analysis to our understanding of woody-plant succession in the Loess Hills. Specifically, my objective was to describe past and present woody-plant communities in the Loess Hills by dating trees of all sizes and to use these results to infer future trends for Loess Hills woody plant communities.

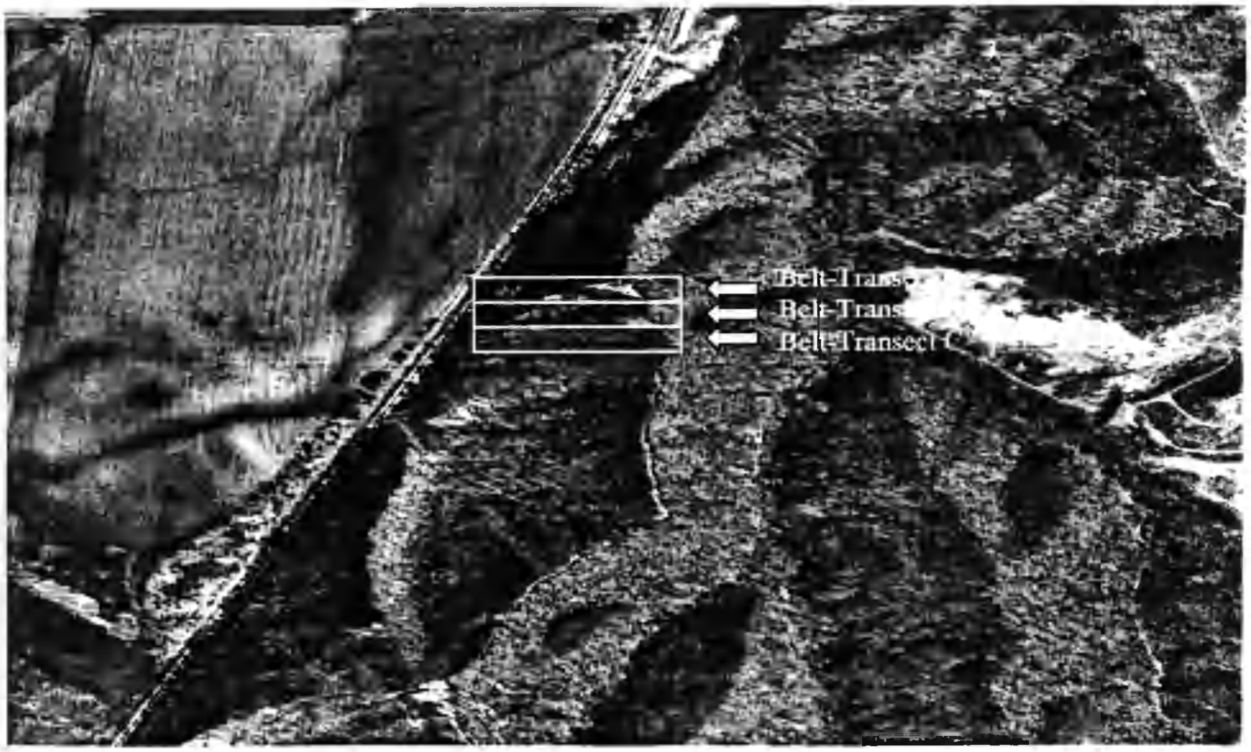
METHODS

Study area.—The study was conducted at the Hitchcock Nature Area (HNA), a 335-hectare County Park situated in the Loess Hills of northwestern Pottawattamie County, Crescent Township, Iowa (Sections 1, 2 and 11, Township 76N, Range 44W, 41N 24′, 95W 52′) (Fig.1). The area is mostly woodland with small areas of remnant prairie located principally on ridge tops. The western bluffs of the HNA adjoin Missouri River bottomland, now under cultivation. In 1852, General Land Office survey notes for Crescent Township described the "high bluffs" as either "Thin Oak barrens" or "no timber" (General Land Office, 1852). Today, however, the Township bluffs are wooded. The historic domination by prairie and present domination by woodland provided the ideal location for a study on woody-plant succession in the Iowa Loess Hills.

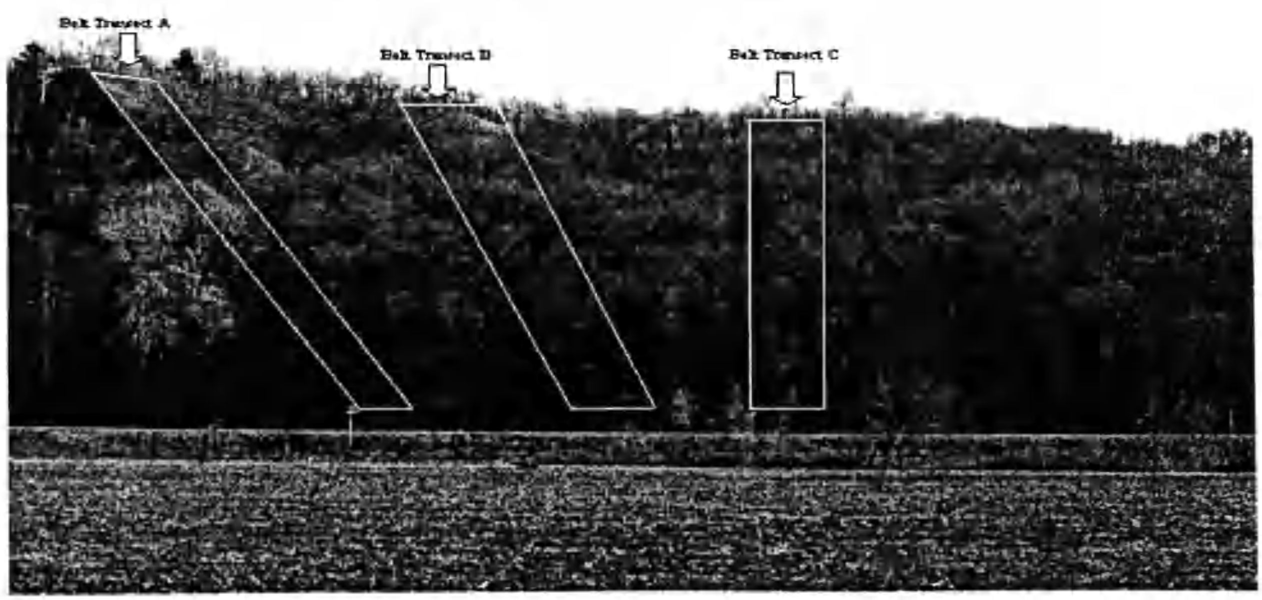
Human use on and around the HNA predated European settlement, as demonstrated by the many artifacts, including a burial site, found on the property (Anderson, 2000, pers. comm.). By 1894, European settlers were farming and grazing livestock on suitable low-lying areas (Pottawattamie Records, 2000). These early inhabitants are also likely to have felled timber in the area for firewood, building materials, and charcoal production (Pammel *et al.*, 1915; Anderson, 2000, pers. comm.). In 1968, the property was purchased by the Young Men's Christian Association (YMCA) for a youth camp and used primarily for hiking and nature study. In 1991 the land was purchased by Pottawattamie County and has since been managed by the County Conservation Board as a nature area.

The site used for this study (Fig. 2) was selected from among various possible locations within the HNA because there was little evidence of human use since the mid-1800s and because it contained some remnant, bluff-top prairies. In addition, the steepness of the slope (average 24°) (Appendix Table 2) and recollections of local residents were sufficient to suggest that the site had neither been farmed nor grazed by domestic animals. The steepness and remote location of the site, in conjunction with the absence of old tree-stumps, also made it unlikely that there has been significant timber cutting. Together, these observations suggest that most historic trees would still be represented at the site. In addition, aerial photographs from 1938, 1950 and 1999 illustrate an increase in woody-plant cover at the study site, indicating that the remnant prairies found on hilltops were historically the dominant vegetation cover for the study area.

Sampling methods.—From Fall of 1998 through the Spring of 2000, three adjacent ridges were sampled at the study site. Each ridge was sampled along a belt-transect that extended from the base of the slope to the hilltop. Transects followed the ridge-top and were bounded by the low point of each adjacent gully (Fig. 3). Each transect was divided into elevational segments by placing a stake-wire flag at 20-m intervals from the base of the slope to the hilltop. Boundaries of each elevational segment were located 10 m above and below each stake-wire flag, extending to the low-



A.



B.

Fig. 2. Distribution (A) and location (B) of Transects A-C at the Hitchcock Nature Area.

Fig. 3. View of Transect B showing ridge-top (center) and adjacent gully (left). The gully on the right is out of the picture.

point of adjacent gullies. Boundary adjustments were made at the upper-most and lower-most elevational segments to accommodate differences in transect length. Six elevational segments were identified for Transects A and B and eight elevational segments for Transect C (Figure 2; Appendix Table 2). Geomorphic differences among the transects accounted for variations in the width (5-58 m), length (130-180 m), and surface area (2695 – 6550 m^2) sampled of each transect (Appendix Table 2). Each elevational segment was separately evaluated. Sampling protocol differed for *Large-*, *Intermediate-*, and *Small-sized* trees: large–sized trees are those with a stem diameter greater than 15 cm at 1.4 m height (DBH), intermediate-sized are those with less than 15 cm stem diameter DBH but greater than 1.4 m in total height, and small-sized trees are all those less than 1.4 m in height.

For all large-sized trees at each elevational segment, species, DBH, and distance from the base of the slope were recorded. In addition, each large-sized tree was cored at the lowest possible point on the stem (usually no more than 9 cm above grade) using an increment borer with the objective of intercepting the pith. To verify stem age, at least two cores were taken from each tree sampled. Core samples were mounted and belt-sanded successively with 80-, 120-, 240-, 300- and 400-grit belts. American linden (*Tilia Americana* L.) and ironwood (*Oystra virginiana* Mill.) cores were particularly difficult to date so additional steps included sanding with 600- and 800-grit belts followed by hand sanding with 1000-grit paper. Some of these cores were also stained with Phloroglucinol, Fehling's solution or a yellow highlight marker to enhance ring boundaries. The perimeter of each elevational segment was measured and used to calculate the density of large-sized trees (Appendix Table 2).

For the intermediate- and small- size classes, I sampled the 15 trees closest to the stake-wire flag that marked the center of each elevational segment. The distance of each tree from the stake-wire flag was recorded, then each was cut at ground level, identified to species, cross-sectioned, sorted into either intermediate- or small-size classes, sanded, and aged using methods previously described. For each elevational segment, the distance from the stake-wire flag to the most distant tree was used as the radius of a circle, the area of which was used to calculate tree density by species for intermediate-and small-sized trees (Appendix Table 2).

Data analysis.—Cores and cross-sections were aged using standard dendrochronological methods (Stokes and Smiley, 1968). To retain accuracy, no extrapolations of tree age were made from large-sized trees with center-rot or from cores taken above the base of the tree. However, for samples where the pith was not intercepted, age was adjusted by comparing ring widths of trees similar in age and size and adding years to compensate for missing center rings. No more than eight years were added to any sample. Since intermediate- and small-sized trees were cross-sectioned at ground level, they always included the pith and age counts were considered to be accurate.

Past communities.—Past woody-plant communities of the study area were reconstructed using large- and intermediate-size tree data. The accuracy of this extrapolation may be affected by the loss of evidence of some of the historic trees, although the absence of stumps and large downed trees suggests that conclusions from available trees are a reasonable approximation of past conditions. In order to demonstrate a progression of tree species that might approximate seral stages, trees in the large-size class were divided into four 50-year age categories: $\leq$1850, 1851-1900, 1901-1950, 1951-2000. Graphs of the number of individuals in each age category at each elevational segment were used to visualize both the historic distribution and the change in species composition at 50-year intervals. Trees in the younger, intermediate-size class were arranged similarly except that 25-year intervals were used: $\leq$1950, 1951-1975, 1976-2000.

Present communities.—Present woody-plant communities of the study site were described using two parameters: dominance and density. Dominance is the sum of cross-sectional stem area at DBH for each species for each unit of surface area converted to cm^2 of stem area / 100 m^2 of surface area. Density is the number of individuals of each species for each unit of surface area converted to number of individuals / 100 m^2 surface area (after Cottam and Curtis, 1956). Small-sized trees were evaluated only for density since they were not tall enough to reach the height established for DBH.

Future communities. —Future woody-plant communities were inferred by examining intermediate- and small-size tree data. Dominance and density of intermediate-sized trees, along with density of the small-sized trees, were used to describe possible species compositions of future woody plant communities.

RESULTS

Thirteen trees species and two shrubs, smooth sumac (*Rhus glabra* L.) and roughleaf dogwood (*Cornus drummondii* Meyer) were evaluated in this study (Appendix Tables 3-8). Of these, the principal species, defined as those with more than two individuals in the large-size class, were American linden, bur oak, green ash (*Fraxinus pennsylvanica* Marsh), hackberry, ironwood and elm species (including red elm [*Ulmus rubra* Muhl.] and American elm [*Ulmus americana* L.]). Cross-dating between species and individuals was easily accomplished since consistently narrow rings were found for the years 1910, 1918, 1956, 1977, 1988, and 1989. Except for 1932 and 1935, ring widths for the 1930s, a period of drought in the Midwest, were also narrow. The relatively wider ring widths for 1932 and 1935 were used as marker-rings for cross-dating in cores with particularly tight ring structures. In four tree samples, age data could not be determined due to poor cross-dating and unclear ring boundaries. Three of these were large-sized ironwood trees from Transect C (Two at Elevational Segment 4, and one at Elevational Segment 5). The fourth tree was a small-size elm from Transect B (Elevational Segment 4). None of these trees was included in tables depicting age data (Table 1; Appendix Table 6), although the three ironwoods were included in dominance and density tables (Table 2; Appendix Table 7), and the one elm was included in small-sized tree density (Table 2; Appendix Table 8). The pith was intercepted in 27% of large-sized trees sampled (Appendix Table 2-3). Pith-dates were used to approximate tree age since most samples were within nine cm of the soil surface. In 12 % of all large-sized trees sampled (31 of 262), center-rot made precise aging impossible (Appendix Table 2-3). Seventeen trees with center-rot were bur oaks, most of which likely have

Table 1. Number of Large- and Intermediate-sized trees in each age category grouped into Upper-, Mid- and Lower-slope locations. Numbers are from combined transects with Lower slopes = sum of Elevational Segments 1 and 2 from all transects, Mid slopes = sum of Elevational Segments 3-4 on Transects A and B and Elevational Segments 3-6 from Transect C, and and Upper slopes = sum of Elevational Segments 5-6 from Transects A and B and 7-8 from Transect C. Only tree species with >2 individuals in the large-size class are shown. Parenthesis indicate number of trees that had center-rot, and thus may be older than indicated on table. Decimals are used instead of zeros for visual clarity.

		Number of Trees						
		Large-sized				Intermediate- sized		
Species	Elevational segments	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
American linden	Upper slopes			.	1		2	
	Mid slopes	.		$7^{(2)}$	6		.	
	Lower slopes	.	.	1	1			
bur oak	Upper slopes	1	$24^{(3)}$	$4^{(2)}$	1		.	
	Mid slopes	.	18	$1^{(1)}$	.		1	
	Lower slopes	1	$23^{(7)}$	$5^{(4)}$	.		.	
green ash	Upper slopes			$52^{(2)}$	$3^{(3)}$	2		
	Mid slopes	.		26	$3^{(2)}$	1		.
	Lower slopes	.		8	$4^{(1)}$	1		2

Table 1. (Continued) Number of Large- and Intermediate-sized trees in each age category grouped into Upper-, Mid- and Lower-slope locations. Numbers are from combined transects with Lower slopes = sum of Elevational Segments 1 and 2 from all transects, Mid slopes = sum of Elevational Segments 3-4 on Transects A and B and Elevational Segments 3-6 from Transect C, and and Upper slopes = sum of Elevational Segments 5-6 from Transects A and B and 7-8 from Transect C. Only tree species with >2 individuals in the large-size class are shown. Parenthesis indicate number of trees that had center-rot, and thus may be older than indicated on table. Decimals are used instead of zeros for visual clarity.

		Number of Trees						
		Large-sized				Intermediate-sized		
Species	Elevational segments	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
hackberry	Upper slopes	.	.	.	.	.	.	.
	Mid slopes	.	1	5(1)	.	.	2	.
	Lower slopes	.	4	19	.	5	5	9
ironwood	Upper slopes			3	2(1)		3	1
	Mid slopes	.		2	2		15	23
	Lower slopes	.		.	1		15	8
elm species	Upper slopes	.		1(1)	.	.		
	Mid slopes	.		7	2	1		.
	Lower slopes	.	.	3(1)	.	2	.	2

Table 2. Dominance and density of tree species in the Large- and Intermediate-size classes. Only species with > 2 trees in the large-size class are shown. Numbers are averages for all elevational segments and transects (n = 20).

	Size-class				
	Large-sized		Intermediate- sized		Small-sized
Species	Dominance (cm^2 /100 m^2)	Density (No. /100 m^2)	Dominance (cm^2 /100 m^2)	Density (No. /100 m^2)	Density (No. /100 m^2)
American linden	69.8	0.12	6.6	0.19	0.00
bur oak	933.8	0.65	2.3	0.09	1.28
green ash	305.1	0.64	135.0	1.96	0.56
hackberry	170.4	0.25	40.9	3.23	40.44
ironwood	26.1	0.08	261.4	11.45	19.37
elm species	34.8	0.08	12.8	0.47	6.06

stem ages dating to the 1870s and 1880s. Other species with center-rot include green ash with eight individuals, most of which likely have stem ages dating to the 1920s and 1930s; American linden with two individuals, likely to date to the 1940s; elm species with two individuals likely to date to the 1930s; one ironwood likely to date to the 1950s; and one hackberry likely to date to the 1930s. No effort was made to estimate the true age of these individuals, although they are identified parenthetically where they occur in tables relating to age data (Table 1, Appendix Table 6).

Past woody plant communities.—Ring counts date only two trees to before 1850, approximately the time that European settlement in the region began. The oldest tree sampled (1826) was a solitary bur oak located near the hilltop (114 meters upslope) (Table 1; Appendix Table 3,6). The second oldest tree, also a bur oak, was located near the base of the slope (14 meters upslope) with a ring count dating to 1846. The majority of the remaining bur oaks (65) have ring counts dating between 1851-1900 with 51 of these dating to the 1870s and 1880s indicating that an even-aged stand was established by approximately this time period. Thus by 1900, bur oak establishment occurred uniformly across all elevational segments (Table 1; Appendix Table 6). Five hackberry trees, located on lower slopes, also date to this period.

From 1901-1950, but principally in the 1920s and 1930s, 88 green ash colonized the upper- and mid-slope locations (Table 1; Appendix Table 6). Twenty-four hackberry also colonized the lower slopes, principally during the 1930s, while 16 American linden colonized the mid-slope locations during the 1940s and 1950s. Also during the 1940s and 1950s, 10 ironwoods colonized all but two elevational segments on Transect C.

Ironwood also colonized Transects A and B during this time, but those individuals did not grow into the large-size class, most likely because Transect C was not as steep as Transects A and B and thus was less prone to precipitation run-off, which may have resulted in better growing conditions.

Intermediate-sized trees germinating prior to 1950 include four green ash, five hackberry and three elms (Table 1; Appendix Table 4,6). Ring counts of these individuals show them to be cohorts of the large-sized trees of the same species, but ones that did not grow into the large-size class, again most likely the result of more severe growing conditions related to the steep terrain from which they were sampled. Ironwood easily dominates all other intermediate-sized trees dated to the periods 1951-1975 (33) and 1976-2000 (32).

Small-sized trees sampled have stem ages dating to the 1980s (10 individuals) and 1990s (120 individuals) (Table 1; Appendix Table 5).

Present woody plant communities.— Presently, bur oak dominates the large-size tree component of most slope locations (933.8 $cm^2/100\ m^2$ and 0.65 ind./100 m^2), followed by green ash (305.1 $cm^2/100\ m^2$ and 0.64 ind./100 m^2), principally on upper-and mid-slope locations (Table 2; Appendix Table 3,7). Hackberries (170.7 $cm^2/100\ m^2$ and 0.25 ind./100 m^2) are prominent on lower-slope locations, and American lindens (69.8 $cm^2/100\ m^2$ and 0.12 ind./100 m^2) are noteworthy on mid-slope locations.

Among intermediate-sized trees ironwood (261.4 $cm^2/100\ m^2$ and 11.45 ind./100 m^2) was the dominant species, whereas only one bur oak (2.3 $cm^2/100\ m^2$ and 0.09 ind./100 m^2) was observed (Table 2; Appendix Table 4,7). Other species in the intermediate-size class included hackberry (40.9 $cm^2/100\ m^2$ and 3.23ind./100 m^2) again on lower slopes, elm (12.8 $cm^2/100\ m^2$ and 0.47 ind./100 m^2) on mid- and lower-slope locations, and green ash (135.0 $cm^2/100\ m^2$ and 1.96 ind./100 m^2), on lower-, mid- and upper-slope locations.

Future communities—Small-sized trees are dominated by hackberry (40.44 ind./100 m^2) and ironwood (19.37 ind./100 m^2) (Table 2; Appendix Table 5,8). Bur oak (1.28 ind./100 m^2), however, is poorly represented, with only three individuals found. Green ash (0.56 ind./100 m^2), a prevalent species in the large-size class and, to a lesser extent, the intermediate-size class, is found infrequently among small-sized trees. American linden, another tree in both the large- and intermediate-size classes is absent in the small-size class.

Discussion

The number and distribution of trees predating 1850 (Table 1; Appendix Table 6) suggest a prairie-like physiognomy with sparse trees, primarily bur oak, widely spaced from lowland to hilltop. These results are consistent with observations by the General Land Office Survey (1852), Loomis and McComb (1944), Heineman (1982), Novacek *et al.* (1985), and Nuzzo (1986) that describe a similar physiognomy. The subsequent rapid occurrence of bur oak that dated to the 1870s and 1880s suggest either widespread germination or, more likely, release of grubs from fire suppression.

During the early 19th Century and before, frequent fires would have most likely only top killed small-diameter bur oak preventing them from growing but not from resprouting. With European settlement came the suppression of fire that would then have allowed resprouting grubs to mature into the canopy-sized, even-aged, stand recorded in this study. Despite a uniform age structure among bur oaks dating to the 1870s and 1880s, stem size for individuals varied widely ranging from 24.5cm to 65.3cm DBH. This indicates variable growing conditions throughout the study area and provides further evidence for the unreliability of equating tree size with tree age. The uniform stand age would be consistent with release from fire suppression. Logging, however, could also result in an even-aged stand. This seems unlikely on the steep terrain of the study area, even though Pammel *et al.* (1915) note that all the Misssouri River bottomland in Pottawattamie County was logged prior to 1915. Whether, and to what extent, logging occurred in the hills cannot be known with certainty.

A second period of apparent increased tree germination or release occurred during the 1930s. Since fire had long been suppressed, this increase is more likely the result of environmental conditions, even though it came during a major midwestern drought. This response, however, is consistent with observations by Loomis and McComb (1944), who noted, for areas of the Loess Hills north of Pottawattamie County, that invasion of woody plants seemed to be increasing in the 1930s despite the recent dry cycle.

Previous studies posited that trees invading the Loess Hills would reflect an age gradient from the oldest trees at the base of the slope to younger trees on the hilltop, assuming that trees invaded upslope from protected low-lying areas (Heineman, 1982). This study, however, found no such gradient at the study site, rather each species invaded with its own pattern. Principal tree species appear to follow three trends of invasion: uniform establishment across all elevational segments, establishment from hilltops downslope, and establishment from lower slopes to upper slopes. Bur oak, the dominant tree historically, and one that was widely scattered among various elevational segments, expanded uniformly across the landscape during the late 1800s, perhaps through rapid growth from established, but fire-suppressed root systems (Table 1; Appendix Table 6). Ironwood did likewise, although nearly a century later and almost certainly by seedling establishment (Table 1; Appendix Table 6). Green ash, however, established first on upper- and mid-slope elevational segments, expanding downslope over several decades, whereas hackberry established first on lower-slope elevational segments, and expanded upslope (Table 1; Appendix Table 6).

A successional progression of tree species can be projected from my data based on dates of first occurrence of different tree species (Table 3). In general, with the release from fire or due to some other factor, bur oak trees rapidly develop and dominate the tree canopy of early woodlands. In more mesic, lower slopes, hackberry follows bur oak, and is joined later by elm, while green ash arrives principally on upper-slopes moving downslope. In subsequent decades ironwood arrives and dominates the understory in all elevational segments while American linden invades lower- and mid-slope locations. Based on the data obtained in this study, the future Loess Hills woodland will be dominated by deciduous species but not bur oak, as regeneration of bur oak is low and intermediate-sized trees are scarce (Tables 1-2; Appendix Tables 4,5). Future dominants on upper slopes may be hackberry with an understory of ironwood and perhaps red oak, which is present at the HNA and is increasing in the Loess Hills less than 20 km to the south (Bragg, 2001, pers. comm.). American linden and black walnut

Table 3. General successional sequence suggested by trees ages of an Iowa Loess Hills woodland.

Elevational segment	Time Period and Species Occurrence				
	≤1850	1851-1900	1901-1950	1951-2000	*Future*
Upper slopes	Bur oak savanna	Woodland of bur oak	Woodland of bur oak, green ash	Woodland of bur oak, green ash ironwood	*Woodland of ironwood, hackberry, black walnut, red oak*
Mid slopes	Bur oak savanna	Woodland of bur oak	Woodland of bur oak, green ash, elms, hackberry, American linden, ironwood	Woodland of bur oak, green ash elms, hackberry, American linden, ironwood	*Woodland of hackberry, ironwood, elms, American linden, black walnut, hickory*
Lower slopes	Bur oak savanna	Woodland of bur oak, hackberry	Woodland of bur oak, hackberry elms, American linden, ironwood	Woodland of bur oak, hackberry, elms, American linden, ironwood	*Woodland of hackberry, ironwood, elms, American linden, black walnut, hickory*

may also increase in lowlands along with the already prominent hackberry. While hickory was not found at the study site, it is known to occur in other areas surrounding the study site, and may also become a part of future woody plant communities.

Overall this study quantifies our understanding of the dynamics of the Loess Hills woody-plant invasion and its historic physiognomy. Both of these contributions will be important as we attempt to improve our management of this unique resource.

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Appendix

Appendix Table 1. Distribution of tree and shrub species in the Loess Hills counties of western Iowa. Adapted from Novacek *et al.* (1985). Asterisks indicate species found in the present study in Pottawattamie County, Iowa.

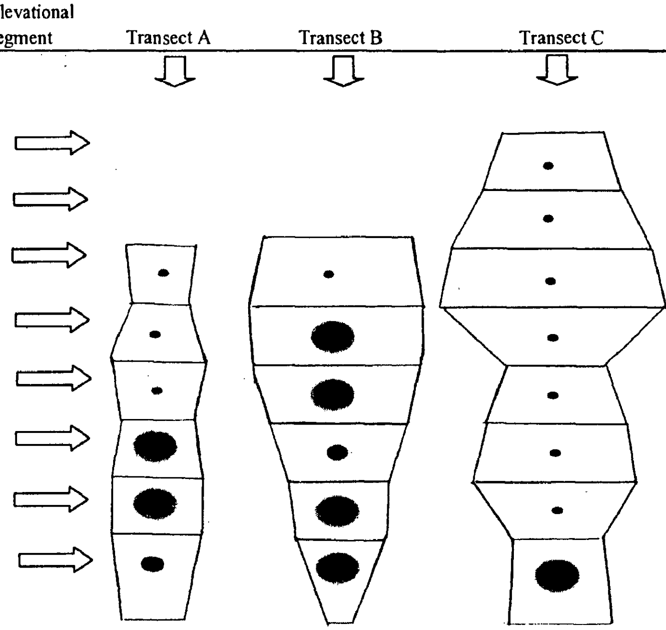
Species	County: North..South									
	Union	*Plymouth*	*Woodbury*	*Monona*	*Harrison*	*Pottawattamie*	*Mills*	*Fremont*	*Atchison*	*Holt*
Quercus alba										x
Acer nigrum										x
Quercus stellata									x	
Quercus prinoides									x	x
Asimina triloba								x	x	x
Quercus muhlenbergii							x	x	x	x
Quercus imbricaria						x		x		
Carya tomentosa						x		x		
Platanus occidentalis						x	x	x	x	x
Amelchier arborea						x	x	x	x	x
Quercus velutina					x	x	x	x	x	x
Fraxinus americana					x	x	x	x	x	x
Cercis canadensis					x	x	x	x	x	x
Carya ovata					x	x	x	x	x	x
*Morus rubra**				x	x	x	x	x	x	x
Corylus americana				x	x	x	x	x	x	x
Staphylea trifolia			x	x	x	x	x	x	x	x
*Quercus borealis**			x	x	x	x	x	x	x	x
*Ostrya virginiana**		x	x	x	x	x	x	x	x	x
Carya cordiformis		x	x	x	x	x	x	x	x	x
*Ulmus rubra**	x	x	x	x	x	x	x	x	x	x
*Ulmus americana**	x	x	x	x	x	x	x	x	x	x
*Tilia americana**	x	x	x	x	x	x	x	x	x	x
*Quercus macrocarpa**	x	x	x	x	x	x	x	x	x	x
*Ribes missouriense**	x	x	x	x	x	x	x	x	x	x
*Rhus glabra**	x	x	x	x	x	x	x	x	x	x
*Prunus virginiana**	x	x	x	x	x	x	x	x	x	x
*Prunus americana**	x	x	x	x	x	x	x	x	x	x
*Juglans nigra**	x	x	x	x	x	x	x	x	x	x
*Gymnocladus dioica**	x	x	x	x	x	x	x	x	x	x
*Fraxinus pennsylvanica**	x	x	x	x	x	x	x	x	x	x
Crategus mollis	x	x	x	x	x	x	x	x	x	x
*Cornus drummondii**	x	x	x	x	x	x	x	x	x	x
*Celtis occidentalis**	x	x	x	x	x	x	x	x	x	x

Appendix Table 2. Characteristics of belt transects. Line drawing (lower right) indicates approximate shape of elevational segments from which large-sized tree were sampled. Shaded circles within each segment indicate relative surface area from which intermediate- and small-sized trees were sampled.

	Transect A	Transect B	Transect C
Physical characteristics of belt transects			
Number of elevational segments	6	6	8
Length of transect (m)	130	133	180
Total surface area of transect (m^2)	2695	4243	6550
Average slope steepness (%)	26	26	20
***Large* tree characteristics within belt transects**			
Number of large-sized trees sampled	56	67	139
Number of large-sized trees with at least one core sample intercepting the pith	11	13	48
Number of large-sized trees with center-rot	10	3	18

Surface area measurements for elevational segments

Surface area (m^2) of each elevational segment for large-sized trees within transects A, B, and C respectively			Surface area (m^2) of each circle for intermediate- and small-sized trees within their respective elevational segment			Elevational segment
-	--	930	-	-	6	8
		880			14	7
330	978	1100	5	4	15	6
400	910	830	11	55	15	5
440	800	620	15	40	5	4
430	620	790	53	35	4	3
480	500	650	53	66	11	2
615	435	750	22	44	59	1



Appendix Table 3. Raw data for large-sized trees.

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Green ash	A	1	1	1947	53	19	20.8	yes	
Green ash	A	1	2	1948	52	18	21.1		
Green ash	A	1	3	1953	47	20	23.3		
Green ash	A	1	4	1955	45	24	16.1	yes	
Hackberry	A	1	6	1933	67	25	16.9		
Bur oak	A	1	7	1846	154	14	48.0		yes
Hackberry	A	1	8	1944	56	13	15.6		
American linden	A	1	9	1951	49	5	41.3		
Hackberry	A	1	10	1945	55	9	32.3		
Hackberry	A	1	11	1938	62	15	22.3	yes	
Hackberry	A	1	12	1947	53	9	34.4		
Bur oak	A	1	13	1882	118	25	30.2		yes
Bur oak	A	1	14	1882	118	25	38.0		
Bur oak	A	1	15	1875	125	25	52.0	yes	
Hackberry	A	1	16	1949	51	20	20.1		
Hackberry	A	1	17	1944	56	6	25.0		
Hackberry	A	1	18	1946	54	5	26.0		
Bur oak	A	2	1	1946	54	37	68.6		yes
Hackberry	A	2	2	1947	53	33	17.9		
Hackberry	A	2	3	1938	62	32	18.8		
Hackberry	A	2	4	1931	69	39	24.6		
Bur oak	A	2	5	1878	122	43	42.2		yes

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Bur oak	A	2	6	1874	126	42	34.7	yes	
Bur oak	A	2	7	1889	111	42	41.8		yes
Bur oak	A	2	8	1854	146	41	26.0		yes
Bur oak	A	2	9	1867	133	40	31.5		
Green ash	A	2	10	1937	63	42	23.6		
Green ash	A	2	11	1952	48	31	21.1		yes
Red oak	A	3	1	1970	30	69	17.4	yes	
Green ash	A	3	2	1930	70	65	18.6		
American linden	A	3	3	1959	41	54	20.6		
American elm	A	3	4	1946	54	54	15.2		
Bur oak	A	3	5	1870	130	51	51.9		
Green ash	A	3	6	1940	60	57	15.5		
Green ash	A	3	7	1925	75	63	15.6		
Green ash	A	3	8	1919	81	65	26.7	yes	
Green ash	A	3	9	1932	68	65	24.0		
Green ash	A	3	10	1938	62	67	15.5		
Green ash	A	3	11	1932	68	66	19.8		
American elm	A	3	12	1948	52	57	19.2		
Green ash	A	4	1	1931	69	73	22.5		
Green ash	A	4	2	1920	80	73	20.8		
Bur oak	A	4	3	1883	117	74	66.3		
Bur oak	A	4	4	1887	113	82	40.0		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Bur oak	A	4	5	1878	122	88	45.7	yes	
Bur oak	A	5	1	1881	119	98	24.8	yes	
Bur oak	A	5	2	1882	118	95	22.8	yes	
Bur oak	A	5	3	1896	104	97	16.6		yes
Bur oak	A	5	4	1920	80	98	17.0		yes
Bur oak	A	5	5	1883	117	98	31.0		
Bur oak	A	5	6	1907	93	101	21.3		yes
Bur oak	A	5	7	1885	115	101	22.5		
Bur oak	A	5	8	1885	115	103	39.8		
Bur oak	A	5	9	1884	116	106	49.0		
Bur oak	A	5	10	1885	115	103	37.8	yes	
Green ash	A	6	1	1927	73	111	28.6		
Bur oak	B	1	1	1877	123	18	37.8	yes	
Bur oak	B	1	2	1880	120	19	38.5		
Hackberry	B	1	3	1882	118	14	41.8		
Hackberry	B	1	4	1943	57	10	18.4		
Hackberry	B	1	5	1944	56	15	16.6		
Hackberry	B	1	6	1871	129	18	39.7	yes	
Bur oak	B	1	7	1875	125	28	42.4		
Bur oak	B	1	8	1876	124	28	61.8		
Hackberry	B	1	9	1874	126	28	38.7		
Kentucky coffee	B	1	10	1946	54	20	17.8		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Hackberry	B	1	11	1943	57	11	24.5	yes	
Hackberry	B	1	12	1946	54	4	15.3	yes	
Hackberry	B	1	13	1944	56	1	26.8		
Hackberry	B	1	14	1941	59	0	31.1	yes	
Bur oak	B	2	1	1887	113	42	48.5		yes
Bur oak	B	2	2	1885	115	34	43.4		yes
Bur oak	B	2	3	1875	125	34	38.4	yes	
Bur oak	B	2	4	1872	128	34	27.3		
Bur oak	B	2	5	1873	127	44	56.0		
Green ash	B	2	6	1955	45	46	20.8		
Hackberry	B	2	7	1874	126	48	54.4	yes	
Hackberry	B	2	10	1941	59	34	21.3		
Bur oak	B	2	11	1874	126	38	39.8		
Bur oak	B	3	1	1879	121	60	53.5		
Hackberry	B	3	2	1875	125	58	21.4	yes	
Bur oak	B	3	3	1875	125	66	49.7		
Green ash	B	3	4	1936	64	55	29.5		
Red elm	B	3	5	1941	59	51	21.5		
Red cedar	B	3	6	1936	64	51	16.2		
American linden	B	4	1	1957	43	78	18.9	yes	
American linden	B	4	2	1962	38	87	17.3	yes	
Green ash	B	4	3	1940	60	87	19.5		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Green ash	B	4	4	1916	84	80	33.3	yes	
Green ash	B	4	5	1931	69	82	18.9		
Red mulberry	B	4	6	1957	43	84	16.0		
Bur oak	B	4	7	1879	121	87	35.8	yes	
Green ash	B	4	8	1942	58	79	15.5		
American linden	B	4	9	1961	39	76	20.2		
Hackberry	B	4	10	1946	54	74	19.1		
Hackberry	B	4	11	1941	59	77	21.1		
Hackberry	B	4	12	1937	63	79	18.0		
Red elm	B	4	13	1934	66	53	28.9		
Green ash	B	5	1	1940	60	96	17.9		
Bur oak	B	5	2	1881	119	94	46.1		
Green ash	B	5	3	1936	64	93	17.2		
Bur oak	B	5	4	1884	116	104	65.3		
Green ash	B	5	5	1939	61	102	20.2		
Green ash	B	5	6	1931	69	102	16.7		
Green ash	B	5	7	1944	56	102	16.8		
American linden	B	5	8	1967	33	94	23.9		
Green ash	B	5	9	1930	70	92	17.1		
Green ash	B	5	12	1934	66	103	15.2		
Green ash	B	5	13	1931	69	90	19.3		
Green ash	B	6	1	1943	57	108	17.2		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Green ash	B	6	2	1930	70	110	22.6		
Bur oak	B	6	3	1860	140	109	44.3		
Bur oak	B	6	4	1942	58	120	18.5		
Bur oak	B	6	5	1928	72	120	35.5		
Green ash	B	6	6	1926	74	120	29.6		
Green ash	B	6	7	1932	68	123	21.7		
Green ash	B	6	8	1932	68	126	19.9		
Bur oak	B	6	9	1860	140	124	45.1		
Bur oak	B	6	10	1868	132	133	45.1		
Green ash	B	6	11	1953	47	127	21.9		yes
Bur oak	B	6	12	1887	113	113	37.1		
Bur oak	B	6	13	1881	119	109	24.5	yes	
Bur oak	B	6	15	1826	174	114	32.4		
Bur oak	C	1	1	1939	61	19	30.6		
Green ash	C	1	2	1940	60	20	23.2		
Hackberry	C	1	3	1942	58	18	22.0		
Bur oak	C	1	4	1882	118	17	36.9		
Bur oak	C	1	5	1888	112	25	45.7		
Bur oak	C	1	6	1895	105	23	41.7		
American linden	C	1	7	1942	58	18	22.0		
Red elm	C	1	8	1940	60	4	19.3	yes	
Red elm	C	1	9	1939	61	3	29.8		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Hackberry	C	1	10	1963	37	3	20.9		
Hackberry	C	1	11	1970	30	2	15.4		
Hackberry	C	1	12	1966	34	2	20.1		
Red elm	C	1	13	1942	58	5	21.5		yes
Green ash	C	1	14	1937	63	10	46.8		
Green ash	C	1	15	1924	76	16	32.2	yes	
Bur oak	C	1	16	1936	64	22	23.1		yes
Bur oak	C	1	17	1950	50	22	29.6		yes
Green ash	C	1	18	1947	53	20	20.9	yes	
Green ash	C	1	19	1938	62	16	21.8	yes	
Hackberry	C	1	20	1961	39	5	16.2		
Hackberry	C	1	21	1963	37	9	16.4		
Hackberry	C	1	22	1957	43	8	16.4	yes	
Bur oak	C	2	1	1881	119	33	36.6	yes	
Bur oak	C	2	2	1930	70	34	26.4		yes
Bur oak	C	2	3	1882	118	38	60.0	yes	
Ironwood	C	2	4	1956	44	43	17.6		
Green ash	C	2	5	1923	77	45	16.5	yes	
Green ash	C	2	6	1935	65	46	21.2		
Ironwood	C	3	1	1970	30	54	17.0	yes	
Green ash	C	3	2	1955	45	54	25.0		yes
Bur oak	C	3	3	1880	120	68	36.5	yes	

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Red elm	C	3	4	1939	61	68	25.7		
Red elm	C	3	5	1951	49	65	21.8		
American linden	C	3	6	1937	63	67	25.7	yes	
Ironwood	C	3	7	1945	55	64	19.5		
Red elm	C	3	8	1953	47	62	15.7		
Green ash	C	3	9	1928	72	56	21.8	yes	
Hackberry	C	3	10	1945	55	63	37.0		yes
American linden	C	3	11	1946	54	61	38.8		yes
American linden	C	3	12	1925	75	60	41.7		
Bur oak	C	4	1	1860	140	76	78.8		
Bur oak	C	4	3	1865	135	84	58.7		
Bur oak	C	4	4	1862	138	88	51.5		
Green ash	C	4	5	1965	35	89	16.7		yes
Green ash	C	4	6	1933	67	88	29.0		
Red elm	C	4	7	1937	63	88	18.8	yes	
Bur oak	C	4	8	1853	147	88	32.5	yes	
Red elm	C	4	9	1937	63	83	19.3	yes	
Bur oak	C	4	10	1870	130	79	46.8		
American linden	C	4	11	1940	60	74	23.9		
American linden	C	4	12	1932	68	74	36.2		
Hackberry	C	4	13	1925	75	73	17.8	yes	
Ironwood	C	4	14	Unable to age	Unable to age	70	18.9		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Ironwood	C	4	15	Unable to age	Unable to age	71	23.4		
Black walnut	C	4	16	1965	35	70	20.0		
Ironwood	C	5	1	1970	30	107	16.4		
Ironwood	C	5	2	Unable to age	Unable to age	98	15.2		
Bur oak	C	5	3	1914	86	93	53.8		yes
American linden	C	5	4	1957	43	96	15.3	yes	
Green ash	C	5	5	1940	60	97	17.2	yes	
Green ash	C	5	6	1939	61	97	19.5		
Bur oak	C	5	7	1878	122	99	40.1		
Bur oak	C	5	8	1876	124	94	34.2	yes	
American linden	C	5	9	1940	60	97	28.8		yes
American linden	C	5	10	1946	54	98	17.2		
Green ash	C	5	11	1923	77	102	31.4	yes	
Green ash	C	6	1	1932	68	115	19.3		
American linden	C	6	2	1959	41	118	22.3		
Green ash	C	6	3	1925	75	113	16.2	yes	
Green ash	C	6	4	1925	75	112	16.8	yes	
Bur oak	C	6	5	1880	120	112	50.9	yes	
Bur oak	C	6	6	1880	120	114	47.8	yes	
Ironwood	C	6	7	1936	64	122	17.5		
Green ash	C	6	8	1920	80	127	23.2		
Green ash	C	6	9	1921	79	128	25.3		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Bur oak	C	6	10	1864	136	128	46.5	yes	
Green ash	C	6	11	1928	72	125	20.2		
Green ash	C	6	12	1923	77	121	16.9	yes	
Green ash	C	6	13	1955	45	120	22.1		
Green ash	C	7	1	1930	70	140	20.9		
Green ash	C	7	2	1931	69	138	15.0		
Green ash	C	7	3	1914	86	131	24.7	yes	
Bur oak	C	7	4	1880	120	133	40.8		
Bur oak	C	7	5	1880	120	133	53.5	yes	
Green ash	C	7	6	1934	66	133	16.8		
Green ash	C	7	7	1915	85	139	22.8	yes	
Ironwood	C	7	8	1962	38	140	21.6		
Green ash	C	7	9	1932	68	142	19.0		
Green ash	C	7	10	1914	86	148	21.7	yes	
Bur oak	C	7	11	1878	122	144	33.7		
Green ash	C	7	12	1913	87	142	25.2	yes	
Bur oak	C	7	13	1895	105	139	64.2		yes
Red elm	C	7	14	1949	51	132	20.4		yes
Bur oak	C	7	15	1888	112	145	31.0	yes	
Bur oak	C	7	16	1877	123	140	46.7		
Green ash	C	7	17	1934	66	148	18.3		
Green ash	C	7	19	1924	76	148	15.5		

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Ironwood	C	8	1	1963	37	158	15.3	yes	
Green ash	C	8	2	1916	84	152	21.7	yes	
Green ash	C	8	3	1954	46	153	19.9		yes
Ironwood	C	8	4	1940	60	157	27.1		
Ironwood	C	8	5	Unable to age	Unable to age	166	24.5		
Green ash	C	8	6	1935	65	166	19.9		
Green ash	C	8	7	1941	59	171	19.1		yes
Green ash	C	8	8	1928	72	172	15.2	yes	
Green ash	C	8	9	1928	72	173	16.8	yes	
Green ash	C	8	10	1924	76	175	27.2		
Bur oak	C	8	11	1922	78	179	17.8		
Green ash	C	8	12	1922	78	180	24.9	yes	
Green ash	C	8	13	1922	78	177	18.5	yes	
Bur oak	C	8	14	1960	40	168	17.0		
Green ash	C	8	15	1932	68	169	16.0		
Bur oak	C	8	16	1897	103	177	57.2		yes
Green ash	C	8	17	1922	78	178	19.6	yes	
Green ash	C	8	18	1931	69	179	20.5		
Green ash	C	8	19	1935	65	180	18.8		
Green ash	C	8	20	1922	78	178	20.5		
Green ash	C	8	21	1918	82	178	26.2		
Bur oak	C	8	22	1881	119	171	46.5	yes	

Appendix Table 3. Raw data for large-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from ring count	Assigned age from ring count (years)	Upslope-distance (m)	DBH (cm)	Pith intercepted (yes)	Center-rot (yes)
Green ash	C	8	23	1918	82	168	23.8		
Green ash	C	8	24	1913	87	168	17.8	yes	
Green ash	C	8	25	1927	73	165	25.5	yes	
Green ash	C	8	26	1963	37	164	15.8		yes
Green ash	C	8	27	1938	62	163	16.3		
Green ash	C	8	28	1938	62	163	16.3		
Green ash	C	8	29	1932	68	161	24.1		yes
Green ash	C	8	30	1920	80	162	19.1	yes	
Kentucky coffee	C	8	31	1921	79	159	23.6		
Bur oak	C	8	32	1878	122	152	54.4		
Green ash	C	8	33	1910	90	156	16.7	yes	
Green ash	C	8	34	1910	90	157	17.4	yes	
Green ash	C	8	35	1918	82	154	23.9		
Green ash	C	8	36	1914	86	154	16.4	yes	
Ironwood	C	8	37	1941	59	151	16.6		
Ironwood	C	8	38	1942	58	153	21.0		
Black walnut	C	8	39	1960	40	152	19.5		
Green ash	C	8	40	1935	65	150	19.2		
Green ash	C	8	41	1915	85	151	22.9	yes	
Green ash	C	8	42	1910	90	151	17.9	yes	

Appendix Table 4. Raw data for intermediate-sized trees.

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Green ash	A	1	4	1951	49	5.0
Green ash	A	1	6	1946	54	10.7
Hackberry	A	1	7	1986	14	0.7
Ironwood	A	1	10	1981	19	2.7
Hackberry	A	2	4	1991	9	0.4
Hackberry	A	2	5	1945	55	5.8
Hackberry	A	2	6	1987	13	0.9
Hackberry	A	2	7	1942	58	4.6
Hackberry	A	2	8	1936	64	8.9
Hackberry	A	2	9	1985	15	0.6
Red cedar	A	2	11	1967	33	4.1
Red elm	A	2	12	1981	19	2.8
American elm	A	2	13	1940	60	10.0
Ironwood	A	2	14	1984	16	1.9
Hackberry	A	3	8	1975	25	1.1
American elm	A	3	9	1944	56	3.5
Bur oak	A	3	13	1960	40	5.5
Ironwood	A	3	15	1963	37	14.0
Ironwood	A	3	16	1971	29	6.3
Ironwood	A	3	19	1979	21	3.8
Ironwood	A	4	14	1978	22	1.6

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Green ash	A	4	15	1941	59	7.3
Dogwood	A	5	17	1983	17	0.1
Dogwood	A	6	11	1990	10	0.63
Green ash	B	1	2	1977	23	0.6
Green ash	B	1	5	1980	20	1.4
Red cedar	B	1	7	1963	37	0.4
Green ash	B	1	8	1973	27	1.3
Ironwood	B	1	9	1976	24	1.6
Ironwood	B	1	12	1974	26	4.1
Hackberry	B	1	13	1936	64	3.8
American elm	B	1	14	1978	22	0.8
Ironwood	B	1	15	1981	19	2.9
Hackberry	B	1	16	1935	65	6.6
Green ash	B	1	17	1974	26	1.7
Ironwood	B	1	18	1966	34	9.3
Ironwood	B	1	19	1970	30	3.0
Ironwood	B	2	1	1970	30	6.7
Ironwood	B	2	2	1980	20	2.4
Ironwood	B	2	3	1971	29	8.4
Ironwood	B	2	4	1969	31	5.2
Hackberry	B	2	5	1943	57	7.3

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Red elm	B	2	6	1937	63	8.0
Ironwood	B	2	7	1974	26	3.3
Ironwood	B	2	8	1971	29	5.8
Ironwood	B	2	9	1974	26	5.0
Ironwood	B	2	10	1973	27	6.3
Ironwood	B	2	11	1986	14	1.6
Ironwood	B	2	12	1966	34	10.3
Ironwood	B	2	13	1986	14	1.5
Ironwood	B	2	14	1965	35	10.3
Ironwood	B	2	15	1963	37	8.5
Ironwood	B	3	1	1984	16	2.7
Ironwood	B	3	2	1983	17	2.6
Ironwood	B	3	3	1981	19	3.2
Ironwood	B	3	4	1975	25	6.2
Ironwood	B	3	5	1971	29	6.6
Ironwood	B	3	6	1982	18	3.3
Ironwood	B	3	7	1965	35	8.0
Ironwood	B	3	8	1982	18	1.2
Ironwood	B	3	9	1984	16	1.7
Ironwood	B	3	10	1983	17	2.2
Ironwood	B	3	11	1989	11	0.9

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Ironwood	B	3	12	1977	23	4.1
Ironwood	B	3	13	1974	26	2.8
Ironwood	B	3	14	1988	12	1.0
Ironwood	B	3	15	1983	17	1.2
Ironwood	B	4	1	1985	15	1.9
Ironwood	B	4	2	1984	16	1.1
Ironwood	B	4	4	1976	24	3.5
Ironwood	B	4	6	1968	32	4.8
Ironwood	B	4	7	1971	29	3.4
Dogwood	B	4	8	1995	5	0.3
Ironwood	B	4	10	1991	9	0.7
Ironwood	B	4	11	1963	37	14.4
Ironwood	B	4	12	1970	30	4.0
Ironwood	B	4	13	1968	32	9.4
Ironwood	B	4	14	1974	26	3.4
Ironwood	B	4	15	1987	13	2.1
Ironwood	B	4	17	1971	29	4.3
Ironwood	B	4	18	1965	35	11.2
American linden	B	5	2	1970	30	8.5
Dogwood	B	5	4	1985	15	1.3
Smooth sumac	B	5	5	1990	10	1.1

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Dogwood	B	5	6	1990	10	2.6
Dogwood	B	5	7	1993	7	0.4
Smooth sumac	B	5	8	1991	9	1.2
Dogwood	B	5	9	1990	10	1.2
American linden	B	5	10	1968	32	4.7
Ironwood	B	5	11	1970	30	7.8
Dogwood	B	5	12	1989	11	1.2
Ironwood	B	5	13	1966	34	9.8
Dogwood	B	5	15	1986	14	3.6
Dogwood	B	6	1	1994	6	1.2
Dogwood	B	6	2	1994	6	0.1
Smooth sumac	B	6	5	1993	7	0.4
Smooth sumac	B	6	6	1994	6	1.1
Dogwood	B	6	7	1993	7	1.2
Dogwood	B	6	8	1994	6	0.6
Dogwood	B	6	11	1994	6	0.2
Dogwood	B	6	12	1993	7	0.2
Dogwood	B	6	13	1993	7	0.4
Dogwood	B	6	14	1994	6	0.7
Dogwood	B	6	16	1993	7	0.1
Dogwood	B	6	18	1990	10	0.5

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Dogwood	B	6	20	1987	13	0.7
Hackberry	C	1	1	1975	25	2.2
Hackberry	C	1	2	1974	26	1.2
Hackberry	C	1	3	1969	31	0.5
Hackberry	C	1	5	1958	42	8
Hackberry	C	1	6	1979	21	0.9
Hackberry	C	1	7	1989	11	0.5
Ironwood	C	1	8	1975	25	2.2
Hackberry	C	1	10	1967	33	5.5
Hackberry	C	1	12	1945	55	7.9
Hackberry	C	1	13	1938	62	11.7
Hackberry	C	1	15	1983	17	0.5
Hackberry	C	2	4	1990	10	0.4
Hackberry	C	2	5	1984	16	0.5
Ironwood	C	2	6	1991	9	0.1
Dogwood	C	2	8	1989	11	1.2
Ironwood	C	2	11	1968	32	5.4
Dogwood	C	3	15	1977	23	3.7
Ironwood	C	4	14	1987	13	0.7
Ironwood	C	4	15	1979	21	4.1
Ironwood	C	5	14	1974	26	6.3

Appendix Table 4. Raw data for intermediate-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Ironwood	C	5	15	1984	16	4.3
Ironwood	C	6	2	1979	21	5.6
Hackberry	C	6	3	1961	39	4.5
Ironwood	C	6	14	1977	23	6.5
Ironwood	C	7	12	1983	17	4.8
Ironwood	C	7	13	1960	40	10.8
Green ash	C	7	14	1928	72	12.5
Green ash	C	7	15	1918	82	13.4

Appendix Table 5. Raw data for small-sized trees.

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Hackberry	A	1	1	1990	10	0
Green ash	A	1	2	1982	18	0
Hackberry	A	1	3	1994	6	0
Hackberry	A	1	5	1992	8	0
Hackberry	A	1	8	1993	7	0
Hackberry	A	1	9	1986	14	0
Red elm	A	1	11	1984	16	0
Hackberry	A	1	12	1984	16	0
Hackberry	A	1	13	1993	7	0
Hackberry	A	1	14	1997	3	0
Hackberry	A	1	15	1984	16	0
Hackberry	A	2	1	1989	11	0
Hackberry	A	2	2	1991	9	0
Hackberry	A	2	3	1992	8	0
Hackberry	A	2	10	1995	5	0
Ironwood	A	2	15	1990	10	0
Hackberry	A	3	1	1996	4	0
Bur oak	A	3	2	1997	3	0
Hackberry	A	3	3	1990	10	0
Hackberry	A	3	4	1994	6	0
Bur oak	A	3	5	1995	5	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Hackberry	A	3	6	1993	7	0
Hackberry	A	3	7	1990	10	0
Hackberry	A	3	20	1996	4	0
Hackberry	A	3	21	1995	5	0
Smooth sumac	A	4	1	1996	4	0
Smooth sumac	A	4	2	1996	4	0
Smooth sumac	A	4	3	1996	4	0
Ironwood	A	4	4	1994	6	0
Smooth sumac	A	4	5	1997	3	0
Hackberry	A	4	6	1992	8	0
Ironwood	A	4	7	1993	7	0
Ironwood	A	4	8	1993	7	0
Ironwood	A	4	9	1995	5	0
Ironwood	A	4	10	1995	5	0
Ironwood	A	4	11	1994	6	0
Smooth sumac	A	4	12	1991	9	0
Green ash	A	4	13	1990	10	0
Smooth sumac	A	5	1	1997	3	0
Smooth sumac	A	5	2	1996	4	0
Smooth sumac	A	5	3	1997	3	0
Smooth sumac	A	5	4	1996	4	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Smooth sumac	A	5	5	1997	3	0
Smooth sumac	A	5	6	1995	5	0
Smooth sumac	A	5	7	1994	6	0
American elm	A	5	11	1987	13	0
American elm	A	5	12	1989	11	0
Hackberry	A	5	14	1995	5	0
Hackberry	A	5	15	1994	6	0
Dogwood	A	5	18	1993	7	0
Smooth sumac	A	5	19	1995	5	0
Hackberry	A	5	20	1994	6	0
Bur oak	A	6	1	1997	3	0
Smooth sumac	A	6	2	1996	4	0
Smooth sumac	A	6	3	1997	3	0
Dogwood	A	6	4	1997	3	0
Smooth sumac	A	6	5	1997	3	0
Smooth sumac	A	6	6	1997	3	0
Smooth sumac	A	6	7	1997	3	0
Dogwood	A	6	8	1996	4	0
Dogwood	A	6	9	1997	3	0
Dogwood	A	6	10	1995	5	0
Dogwood	A	6	12	1992	8	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Smooth sumac	A	6	13	1996	4	0
Smooth sumac	A	6	14	1996	4	0
Smooth sumac	A	6	15	1994	6	0
American elm	B	1	4	Unable to age	Jnable to ag	0
Ironwood	B	1	11	1987	13	0
Dogwood	B	4	9	1995	5	0
Dogwood	B	5	1	1994	6	0
Red cedar	B	5	3	1991	9	0
Dogwood	B	5	14	1996	4	0
Dogwood	B	6	3	1995	5	0
Dogwood	B	6	9	1994	6	0
Hackberry	C	1	4	1992	8	0
Hackberry	C	1	9	1994	6	0
Hackberry	C	1	11	1992	8	0
Hackberry	C	1	17	1991	9	0
Hackberry	C	2	1	1990	10	0
Ulmus	C	2	2	1997	3	0
Ironwood	C	2	3	1994	6	0
Hackberry	C	2	7	1996	4	0
Hackberry	C	2	9	1992	8	0
Hackberry	C	2	10	1989	11	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Hackberry	C	2	12	1991	9	0
Hackberry	C	2	13	1993	7	0
Hackberry	C	2	14	1996	4	0
Hackberry	C	2	15	1996	4	0
Hackberry	C	3	1	1999	1	0
Hackberry	C	3	2	1998	2	0
Dogwood	C	3	3	1998	2	0
Hackberry	C	3	4	1997	3	0
Hackberry	C	3	5	1999	1	0
Hackberry	C	3	6	1998	2	0
Hackberry	C	3	7	1997	3	0
Hackberry	C	3	8	1994	6	0
American elm	C	3	9	1995	5	0
Hackberry	C	3	10	1998	2	0
Hackberry	C	3	11	1994	6	0
Hackberry	C	3	12	1998	2	0
Hackberry	C	3	13	1997	3	0
American elm	C	3	14	1997	3	0
Hackberry	C	4	1	1997	3	0
Hackberry	C	4	2	1996	4	0
American elm	C	4	3	1997	3	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
White mulberry	C	4	4	1997	3	0
Hackberry	C	4	5	1999	1	0
Hackberry	C	4	6	1999	1	0
Hackberry	C	4	7	1999	1	0
Hackberry	C	4	8	1999	1	0
Hackberry	C	4	9	1996	4	0
Hackberry	C	4	10	1998	2	0
Hackberry	C	4	11	1999	1	0
Hackberry	C	4	12	1996	4	0
Hackberry	C	4	13	1998	2	0
Hackberry	C	5	1	1996	4	0
Hackberry	C	5	2	1997	3	0
Hackberry	C	5	3	1994	6	0
American elm	C	5	4	1996	4	0
Hackberry	C	5	6	1998	2	0
Ironwood	C	5	7	1998	2	0
Ironwood	C	5	8	1998	2	0
Hackberry	C	5	9	1996	4	0
Ironwood	C	5	10	1999	1	0
Hackberry	C	5	11	1998	2	0
Hackberry	C	5	12	1997	3	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Hackberry	C	5	13	1997	3	0
Hackberry	C	5	16	1994	6	0
Ironwood	C	6	1	1998	2	0
Hackberry	C	6	4	1998	2	0
Ironwood	C	6	5	1999	1	0
Ironwood	C	6	6	1998	2	0
Ironwood	C	6	7	1998	2	0
Ironwood	C	6	9	1999	1	0
Hackberry	C	6	11	1996	4	0
Ironwood	C	6	12	1998	2	0
Ironwood	C	6	13	1999	1	0
Ironwood	C	6	16	1998	2	0
Ironwood	C	6	17	1999	1	0
Ironwood	C	6	18	1999	1	0
American elm	C	7	1	1998	2	0
Hackberry	C	7	2	1998	2	0
Hackberry	C	7	3	1999	1	0
Ironwood	C	7	4	1999	1	0
Hackberry	C	7	5	1998	2	0
Ironwood	C	7	6	1998	2	0
Hackberry	C	7	7	1997	3	0

Appendix Table 5. Raw data for small-sized trees. (Continued)

Species	Transect	Elevational segment	Transect Tree ID No.	Assigned year from stem age	Stem age (years)	DBH (cm)
Ironwood	C	7	8	1998	2	0
Ironwood	C	7	9	1999	1	0
Ironwood	C	7	10	1999	1	0
Ironwood	C	7	11	1998	2	0
Ironwood	C	8	1	1999	1	0
Hackberry	C	8	2	1999	1	0
Ironwood	C	8	3	1999	1	0
Ironwood	C	8	4	1999	1	0
Ironwood	C	8	5	1999	1	0
Ironwood	C	8	6	1999	1	0
Ironwood	C	8	7	1999	1	0
Ironwood	C	8	8	1999	1	0
Hackberry	C	8	9	1999	1	0
Ironwood	C	8	10	1999	1	0
Ironwood	C	8	11	1999	1	0
Ironwood	C	8	12	1999	1	0
Ironwood	C	8	13	1998	2	0
Ironwood	C	8	14	1999	1	0
American elm	C	8	15	1999	1	0

Appendix Table 6a. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species American linden (*Tilia americana*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	1	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	1	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	1	.	2	.
4	.	.	.	3	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.
6	.	.	.	1	.	.	.
5	.	.	$2^{(1)}$	1	.	.	.
4	.	.	2	.	.	.	.
3	.	.	$3^{(1)}$	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	1	.	.	.	.

Appendix Table 6b. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species black walnut (*Juglans nigra*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	1	.	.	.
7	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	1	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6c. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species bur oak (*Quercus macrocarpa*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	8 (1)	2 (2)	.	.	.	.
4	.	3	.	.	.	.	.
3	.	1	.	.	.	1	.
2	.	5 (3)	1 (1)	.	.	.	.
Base of slope 1	1	3 (2)	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	1	5	2	.	.	.	.
5	.	2	.	.	.	.	.
4	.	1	.	.	.	.	.
3	.	2	.	.	.	.	.
2	.	6 (2)	.	.	.	.	.
Base of slope 1	.	4	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	3 (1)	1	1	.	.	.
7	.	6 (1)	.	.	.	.	.
6	.	3	.	.	.	.	.
5	.	2	1 (1)	.	.	.	.
4	.	5	.	.	.	.	.
3	.	1	.	.	.	.	.
2	.	2	1 (1)	.	.	.	.
Base of slope 1	.	3	3 (2)	.	.	.	.

Appendix Table 6d. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species green ash (*Fraxinus pennsylvanica*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	1	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	2	.	1	.	.
3	.	.	7	.	.	.	.
2	.	.	1	1$^{(1)}$	.	.	.
Base of slope 1	.	.	2	2	1	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	5	1$^{(1)}$	.		.
5	.	.	8	.	.		. .
4	.	.	4	.	.		.
3	.	.	1	.	.		.
2	.	.	.	1	.		.
Base of slope 1	.	.	.	.	.	.	2

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	28$^{(2)}$	2$^{(2)}$	.	.	
7	.	.	10	.	2	.	
6	.	.	7	1	.	.	
5	.	.	3	.		.	
4	.	.	1	1$^{(1)}$		.	
3	.	.	1	1$^{(1)}$		.	
2	.	.	2	.	.	.	.
Base of slope 1	.	.	5	.	.	.	.

Appendix Table 6e. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species hackberry (*Celtis occidentalis*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	1	.
2	.	.	3	.	.	.	3
Base of slope 1	.	.	8	.	.	.	1

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	3	.	.	.	.
3	.	1	.	.	.	.	.
2	.	1	1	.	1	.	.
Base of slope 1	.	3	6	.	2	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.
6	.	.	.	.	.	1	.
5	.	.	.	.	.	.	.
4	.	.	1	.	.	.	.
3	.	.	1 (1)	.	.	.	.
2	.	.	.	.	.	.	2
Base of slope 1	.	.	1	6	2	5	3

Appendix Table 6f. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species ironwood (*Oystra virginiana*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	1
3	.	.	.	.	.	2	1
2	.	.	.	.	.	.	1
Base of slope 1	.	.	.	.	.	.	1

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	2	.
4	.	.	.	.	.	8	5
3	.	.	.	.	.	4	11
2	.	.	.	.	.	10	3
Base of slope 1	.	.	.	.	.	3	2

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
-	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	1	.	.	.
7	.	.	3	1(1)	.	1	1
6	.	.	1	.	.	.	2
5	.	.	.	1	.	1	1
4	.	.	.	.	.	.	2
3	.	.	1	1	.	.	.
2	.	.	.	1	.	1	1
Base of slope 1	.	.	.	.	.	1	.

Appendix Table 6g. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species Kentucky coffee tree (*Gymnocladus dioica*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	1	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	1	.	.	.	.
7	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6h. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species red cedar (*Juniperus virginiana*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	
4	.	.	.	.	.	.	
3	.	.	.	.	.	.	
2	.	.	.	.	.	1	
Base of slope 1	.	.	.	.	.	.	

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	1	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	1	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
-	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.		.	
6	.	.		.		.	
5	.	.		.		.	
4	.			.		.	
3	.			.		.	
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6i. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species red mulberry (*Morus rubra*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	1	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.	.		
6	.	.	.	.	.		
5	.	.	.	.			
4	.	.	.	.			
3	.	.	.	.			
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6j. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species red oak (*Quercus rubra*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	1	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.		.	.	.
4	.	.	.		.	.	.
3	.	.	.		.	.	.
2	.	.	.		.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.	.	.	
6	.	.	.	.	.	.	
5	.	.	.	.	.	.	
4	.	.		.	.	.	
3	.	.		.	.	.	
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6k. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species roughleaf dogwood (*Cornus drummondii*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	1
5	.	.	.	.	.	.	1
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	11
5	.	.	.	.	.	.	6
4	.	.	.	.	.	.	1
3	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	.	.	.	.	1
2	.	.	.	.	.	.	1
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 61. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species smooth sumac (*Rhus glabra*)

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.		.	.
3	.	.	.	.		.	.
2	.	.	.	.		.	.
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	2
5	.	.	.	.		.	2
4	.	.	.	.		.	.
3	.	.	.	.		.	.
2	.	.	.	.		.	.
Base of slope 1	.	.	.	.		.	.

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	
7	.	.	.		.	.	
6	.	.	.		.	.	
5	.	.	.		.	.	
4	.	.	.		.	.	
3	.	.	.		.	.	
2	.	.	.	.	.	.	.
Base of slope 1	.	.	.	.	.	.	.

Appendix Table 6m. Number of individuals with stem ages dated to the category indicated. Parenthetic numbers indicate number of trees with center-rot; Age may be older than indicated. Decimals are used instead of zeros for visual clarity.

Species elm species

Elevational Segment	Transect A						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
3	.	.	2	.	1	.	.
2	.	.	.	.	1	.	1
Base of slope 1	.	.	.	.	.	.	.

Elevational Segment	Transect B						
	Large-sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	1	.	.	.	.
3	.	.	1	.	.	.	.
2	.	.	.	.	1	.	.
Base of slope 1	.	.	.	.	.	.	1

Elevational Segment	Transect C						
	Large- sized trees				Intermediate-sized trees		
	≤1850	1851-1900	1901-1950	1951-2000	≤1950	1951-1975	1976-2000
Hilltop 8	.	.	.	.	.	.	.
7	.	.	1(1)	.	.	.	.
6	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
4	.	.	2	.	.	.	.
3	.	.	1	2	.	.	.
2	.	.	.	.	.	.	.
Base of slope 1	.	.	3(1)	.	.	.	.

Appendix Table 7a. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species		American linden (*Tilia americana*)											
		Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
		Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment		A	B	C	A	B	C	A	B	C	A	B	C
Hilltop	8			.			.			.			.
	7			.			.			.			.
	6	.	.	.	.	.	.	.	.	.	.	.	.
	5	.	49.4	128.6	.	135.0		.	0.11	0.36		3.64	.
	4	.	104.5	238.4		.	.	.	0.69	0.32		.	.
	3	109.5	.	388.2	.	.	.	0.23	.	0.38		.	
	2	.	.	.	.	.	.	.	.	.			
Base of slope	1	217.8	.	50.7			.	0.16	.	0.13		.	

Appendix Table 7b. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **black walnut (*Juglans nigra*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			32.1			.			0.11			.
7			.			.			.			
6	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.		.	.
4	.	.	50.7	.	.	.	.	.	0.16		.	
3	.	.	.	.	.	.	.	.	.		.	
2	.	.	.	.	.	.	.	.	.		.	.
Base of slope 1		.			.	.	.	.	.			.

Appendix Table 7c. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **bur oak (*Quercus macrocarpa*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			760.0			.			0.54			.
7			1154			.			0.68			.
6	.	856.0	502.5	.	.	.	.	0.82	0.27	.	.	.
5	1773.9	551.4	536.7	.	.	.	2.50	0.22	0.36		.	.
4	1443.0	125.8	1970	.	.	.	0.68	0.13	0.81	.		.
3	492.0	675.5	132.5	45.0	.	.	0.23	0.32	0.13	1.89	.	.
2	1982.4	1756	681.2	.			1.25	1.20	0.46		.	
Base of slope 1	940.4	1540	789.1	.		.	0.65	0.92	0.80		.	

Appendix Table 7d. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **green ash (*Fraxinus pennsylvanica*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			1035			.			3.23			.
7			367.4			1904			1.14			14.40
6	194.7	243.3	234.0	.	.	.	0.30	0.61	0.73	.	.	.
5	.	214.2	157.3	.	.	.	.	0.88	0.36	.	.	.
4	167.6	204.9	141.9	275.3	.	.	0.45	0.50	0.32	6.58		.
3	502.4	110.2	109.4	.	.	.	1.63	0.16	0.25		.	.
2	164.0	680.0	872.0	.	.	.	0.42	0.20	0.31	.	.	
Base of slope 1	214.5	.	489.8	508.0	12.3	.	0.65	.	0.67	9.27	9.10	.

Appendix Table 7e. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **hackberry (*Celtis occidentalis*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.			.			.			.
6	.	.	.	.	.	106.5	.	.	.	.	.	6.70
5	.	.	.		.	.	.	.	.			.
4	.	111.3	40.1	.	.	.	.	0.38	0.16	.	.	
3	.	58.0	136.1	1.8	.	.	.	0.16	0.13	1.89	.	.
2	209.3	536.1	.	202.3	.	3.4	0.63	0.40	.	11.42	.	18.60
Base of slope 1	633.2	1436	247.4	1.8	103.7	398.1	0.13	2.07	0.93	4.64	4.55	16.82

Appendix Table 7f. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **ironwood (*Oystra virginiana*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			193.0			.			0.54			.
7			41.6			.			0.11			.
6	.	.	21.9	.	.	791.8	.	.	0.09	.	.	14.40
5	.	.	47.3	.	224.5	387.2	.		0.24	.	3.64	13.40
4	.		114.6	13.2	1016.0	242.3	.	.	0.32	6.58	32.11	10.61
3	.		66.5	372.0	495.0	282.2	.	.	0.25	5.68	43.32	41.40
2	.	.	37.4	283.5	654.4	213.1	.	.	0.15	1.89	19.81	18.60
Base of slope 1	.			26.6	220.3	6.4	.	.	.	4.64	11.38	1.68

Appendix Table 7g. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species	**Kentucky coffee tree (*Gymnocladus dioica*)**											
	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			47.0			.			0.11			.
7									.			
6	.	.	.	.	.	.	.	.	.	.	.	
5	.			.		.	.		.			
4			.	.	.	.	.	.	.		.	
3	.	.	.	.	.	.	.		.		.	
2	.	.	.	.	.	.	.	.	.		.	
Base of slope 1	.	57.2	.	.	.	.	.	0.23	.		.	.

Appendix Table 7h. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **red cedar (*Juniperus virginiana*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.			.			.			
6	.	.	.	.	.	.	.	.	.	.	.	
5	.	.	.	.	.	.	.	.	.		.	.
4	.	.		.	.	.	.	.	.		.	.
3	.	33.3	.	.	.	.	.	0.16	.	.	.	.
2				1.9	0.3	.	.	.	.	11.70	2.30	.
Base of slope 1	.	.	.	.	.	.	.	.	.		.	.

Appendix Table 7i. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **red mulberry (*Morus rubra*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.			.			.			
6	.			.	.	.	.	.	.	.	.	
5	.	.	.	.		.	.	.	.			
4	.	25.1		.	.	.		0.13	.		.	.
3				.			.	.	.		.	.
2			.	.	.	.	.	.	.		.	.
Base of slope 1	.	.	.	.	.	.	.	.	.			.

Appendix Table 7j. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **red oak (*Quercus rubra*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.			.			.			.
6	.	.	.	.	.	.	.	.	.	.	.	
5	.	.	.	.	.	.	.	.	.		.	
4	.	.	.	.	.	.	.	.	.	.	.	.
3	55.3	.	.	.	.	.	0.23	.	.		.	.
2		.		.	.	.	.	.	.		.	.
Base of slope 1	.	.	.	.	.	.		.	.		.	.

Appendix Table 7k. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **roughleaf dogwood (*Cornus drummondii*)**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.									.
6	.	.		6.8	97.7	.	.	.	.	21.70	289.3	.
5		.	.	<0.1	35.0	.	.			9.00	10.90	.
4	.	.	.	.	0.2	.	.		.		2.50	.
3					.	272.8	.	.	.		.	25.40
2		.	.	.	.	10.5	.					9.30
Base of slope 1	.	.	.				.					

Appendix Table 71. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **smooth sumac (*Rhus glabra*)**

	Dominance (cm^2/100 m^2)						Density (No./100 m^2)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			.			.			.			
6	.	.	.	.	28.3	.	.	.	.	.	52.6	.
5	.	.	.	.	3.8	.	.	.	.		3.64	.
4	.	.	.	.	.	.	.	.	.		.	.
3	.	.	.	.	.	.	.	.	.		.	.
2			.	.	.	.		.	.			
Base of slope 1							.	.	.		.	.

Appendix Table 7m. Dominance and density values for large- and intermediate-size class by transect and elevational segment. The upper elevational segment of each transect is the hilltop. Decimals are used instead of zeros for visual clarity.

Species **elm species**

	Dominance ($cm^2/100\ m^2$)						Density ($No./100\ m^2$)					
	Large-sized trees by Transect:			Intermediate-sized trees by Transect:			Large-sized trees by Transect:			Intermediate-sized trees by Transect:		
Elevational segment	A	B	C	A	B	C	A	B	C	A	B	C
Hilltop 8			.			.			.			.
7			37.1			.			0.11			
6	.	.	.	.	.	.		.		.	.	
5	.	.	.	.	.	.	.	.	.		.	
4	.	82.0	92.0	.	.	.	.	0.13	0.16	.	.	.
3	109.5	58.6	137.4	18.2	.	.	0.47	0.16	0.38	1.89	.	.
2		.	.	161.1	76.6	.	.	.	.	3.80	1.52	.
Base of slope 1			180.4	.	1.1	.	.	.	0.11		2.28	.

Appendix Table 8. Density (ind. /100 m^2) of small-sized trees sampled by transect and elevational segment. Periods are used instead of zeros for visual clarity.

Transect A

Species	Elevational segment: Base of slope 1	2	3	4	5	Hilltop 6
bur oak	.	.	3.79	.	.	21.74
green ash	4.64	.	.	6.57	.	.
hackberry	41.72	7.61	13.26	6.57	27.03	.
ironwood	.	1.90	.	39.45	.	.
red cedar	.	.	.	.	.	.
roughleaf dogwood	.	.	.	.	9.01	130.43
smooth sumac	.	.	.	32.87	72.01	173.9
elm species	4.64	.	.	.	18.02	.
white mulberry	.	.	.	.	.	.

Transect B

Species	Elevational segment: Base of slope 1	2	3	4	5	Hilltop 6
bur oak	.	.	.	.	.	.
green ash	.	.	.	.	.	.
hackberry	.	.	.	.	.	.
ironwood	2.28	.	.	.	1.82	.
red cedar	.	.	.	.	.	.
roughleaf dogwood	.	.	.	2.47	3.64	52.63
smooth sumac	.	.	.	.	.	.
elm species	2.28	.	.	.	.	.
white mulberry	.	.	.	.	.	.

Transect C

Species	Elevational segment: Base of slope 1	2	3	4	5	6	7	Hilltop 8
bur oak	.	.	.	.	.	.	.	.
green ash	.	.	.	.	.	.	.	.
hackberry	6.73	74.42	279.19	227.74	47.72	13.39	28.89	34.42
ironwood	.	9.30	.	.	15.91	66.97	43.32	206.54
red cedar	.	.	.	.	.	.	.	.
roughleaf dogwood	.	.	25.38	.	.	.	.	.
smooth sumac	.	.	.	.	.	.	.	.
elm species	.	9.30	50.76	20.70	5.30	.	7.22	2.96
white mulberry	.	.	.	20.70	.	.	.	.