Chapter 2

History of Forests and Land-use

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Abstract

Oaks (*Quercus*) have been a dominant component of eastern forests, including the forests of southeastern Ohio, for more than 5,000 years. Prior to Euro-American settlement, written accounts (1700s) described open, park-like forests and the use of fire by Native Americans for hunting and land management. In seven townships encompassing the four study areas, early land surveys (ca. 1800) indicate that 45 to 71 percent of the witness trees were oaks. White oak (*Quercus alba*) was the most common species; "black" oak (*Q. velutina* and *Q. coccinea*) and hickory (*Carya*) also were major components. Euro-American settlement of southeastern Ohio occurred in the early 1800s, but timber harvesting in the uplands was limited until the mid-1800s when the charcoal iron industry became prominent in the region. Iron furnaces were located near each study area, and the forests were clearcut for charcoal production until the industry declined in the 1880s and 1890s. These sites have since been undergoing secondary succession, though dendroecological analysis of release events in 119 white oak trees suggests some disturbance, likely from both anthropogenic (selective harvesting) and natural factors, since stand initiation in the mid- to late-1800s. Larger-scale releases have been more common at the Arch Rock and Watch Rock study areas. Oaks continue to dominate the overstory layer, but shade-tolerant species such as red maple (*Acer rubrum*), sugar maple (*A. saccharum*), blackgum (*Nyssa sylvatica*), and beech (*Fagus grandifolia*) now dominate the midstory and understory layers of all four study sites.

Introduction

To better understand the current characteristics of the mixed-oak forests in southern Ohio and to implement appropriate management strategies, it is important to know the land-use history and forest compositional trends of this region. Whitney (1994) noted that there are two primary sources of information available for historical ecology studies, written evidence (e.g., travelers' accounts, local histories, government documents) and field evidence (e.g., pollen analysis, disturbance history). In this chapter we use both written and field evidence to summarize the forest history of this region, with emphasis on land-use, disturbance, and forest composition of the landscape encompassing our four study areas since ca. 1800. The study areas are Arch Rock (AR) and Watch Rock (WR) in Vinton County, and Young's Branch (YB) and Bluegrass Ridge (BR) in Lawrence County. For a description of the study areas and experimental design, see Chapter 1.

Long-Term Forest Dynamics

Studies of pollen deposited in the sediments of bogs, ponds, and lakes provide a general view of broad-scale forest composition in Eastern North America over thousands of years (e.g., Delcourt and Delcourt 1987). Regional paleovegetation maps interpolated from numerous studies indicate that from 18,000 BP, the maximum advance of the Wisconsin glaciation, to 14,000 BP, southern Ohio was covered by boreal forest dominated by spruce (*Picea*) (Delcourt and Delcourt 1987). By 10,000 BP, the glacial front had retreated to southern Canada, and deciduous forests, with oaks (*Quercus*) as a major component, had replaced the northern mixed conifer-hardwood forest in most of Ohio (Webb 1981; Delcourt and Delcourt 1987). Oak pollen increased from 10,000 to 6,000 BP, and oak remained the dominant pollen type through 500 BP (Table 1).

Palynology studies have not been conducted near our study sites, but long-term pollen records have been documented within 250 km (Table 1). At Silver Lake, Ohio, oak pollen accounted for more than 40 percent of

Table 1. — Pollen percentages at several periods over the last 10,000 years in the general region of study areas.

Location	10,000 BP	6,000 BP	2,000 BP	500 BP
Silver Lake, OH[a]				
Oak	10-20	40-50	50-60	50-60
Hickory	<5	10-20	10-20	10-20
Maple	<5	<5	<5	<5
Cliff Palace Pond, KY[b]				
Oak	5-15	40-50	30-40	40-50
Chestnut	<5	<5	5-15	10-20
Pine	<5	<5	5-15	5-15
Maple	<5	<5	<5	<5
Regional interpolation for southern Ohio[c]				
Oak	20-40	40-60	40-60	40-60
Hickory	0-10	10-20	10-20	10-20
Maple	10-20	10-20	10-20	10-20

[a]Silver Lake located in Glacial Till Plains region, ca. 220 km northwest of Vinton County (data from Ogden 1966).
[b]Cliff Palace Pond located in Cumberland Plateau region, ca. 200 km southwest of Bluegrass Ridge (data from Delcourt et al. 1998).
[c]Data from Delcourt and Delcourt 1987.

the total pollen from 6000 to 500 BP; hickory also was a major component during that time. Maple (*Acer*) pollen accounted for less than 5 percent of total pollen throughout the pollen sequence. Similarly, oak pollen was the most abundant type at Cliff Palace Pond, Kentucky, for most of the period from 6000 to 500 BP, accounting for 30 to 50 percent of pollen. Hickory (*Carya*) was uncommon, but from 2000 to 500 BP, chestnut (*Castanea dentata*) and pine (*Pinus*) pollen were fairly abundant at the site. Maple pollen also occurred at less than 5 percent throughout the sequence at Cliff Palace Pond.

Native American Occupation and Land Use

Ohio was occupied by hunter-gatherers during the Paleo-Indian (ca. 17000 to 10500 BP) and Archaic (ca. 10500 to 3000 BP) Periods (Bush et al. 1995). More evidence of occupation exists for the Woodland Period (ca. 3000 to 400 BP), which is commonly divided into the Adena, Hopewell, and Late Woodland Phases.

Although southeastern Ohio was almost entirely forested at the onset of Euro-American settlement (ca. 1800; Gordon 1969), written accounts of the landscape prior to 1800 describe more open conditions in some areas. In 1751, Christopher Gist described the landscape approximately 60 km north of WR and AR study areas (near present-day Lancaster): "All the way from Licking Creek to this place is fine rich level land with large meadows, fine clover bottoms and spacious plains covered with wild rye" (Darlington 1893).

In several accounts, forests were described as open and park-like. In 1765, George Croghan frequently described "clear Woods" in eastern Ohio. Thaddeus Harris, traveling from Marietta, Ohio, to Wheeling, West Virginia, in 1802, wrote, "There is but little underwood; but on the sides of the creeks and near the river, the papaw, spicebush, or wild pimento and the dogberry grow in the greatest abundance" (Thwaites 1904).

Descriptions of open areas and park-like forests in the Eastern United States, in addition to direct accounts of Native Americans using fire, have led ecologists and historians to conclude that the use of fire as a land-management tool was widespread and had significant effects on the structure and composition of the landscape (Day 1953; Williams 1989; Whitney 1994). However, this conclusion is not universally accepted (e.g., Russell 1983), or may not be applicable to all forest types in the region (McCarthy et al. 2001).

Several accounts provide direct evidence of Native Americans using fire in the Ohio Valley. Joseph Barker ([1790] 1958), described burning near Marietta, Ohio

(85 km east of AR and WR study areas), "The Indians, by burning the Woods every Year, kept down the undergrowth and made good pasture for the deer and good hunting for himself." Traveling west from Pittsburgh, Pennsylvania, David McClure ([1772] 1899) noted that, "the woods were clear from underbrush, the oaks and black walnut do not grow very compact, and there is scarcely anything to incommode a traveler in riding, almost in any direction, in the woods of the Ohio. The Indians have been in the practice of burning over the ground, that they may have the advantage of seeing game at a distance among the trees." G. H. Loskiel, a missionary who lived among the Delaware and Iroquois in eastern Ohio and western Pennsylvania, described the use of fire during hunting (Loskiel 1794): "The Indians prefer hunting deer in large companies. Having surrounded a considerable tract of country, they let the dry leaves and grass on fire. The poor animals fly toward the middle to escape the flames, and the hunters closing in upon them, by following the fire, kill them with certainty, so that hardly one escapes."

Forest Composition from Early Land Surveys

Prior to significant settlement by Euro-Americans (ca. 1800), land surveys were conducted using the township and range system, and surveyors recorded the species and diameter of witness trees at section corners. Survey notes provide a unique quantitative record of forest composition and were used by Sears (1925) and Gordon (1969) to reconstruct the vegetation of Ohio just prior to Euro-American settlement.

In general, mixed-oak forests dominated much of the unglaciated Allegheny Plateau of southeastern Ohio (Gordon 1969). To develop a better understanding of the forests in the vicinity of our four study areas, witness-tree data were examined for townships encompassing and adjacent to the four sites. Summary data for three Vinton County townships adjacent to WR and AR were taken from Beatley (1959) and the original survey records for four townships adjacent to YB and BR were consulted; witness trees ranged from 7 to more than 100 cm in diameter at breast height (d.b.h.).

The most common witness tree in all seven townships was white oak (*Quercus alba*), which accounted for 32 to 45 percent of total witness trees per township (Table 2). "Black oaks," which probably included *Q. velutina* and Q. *coccinea* (Beatley 1959), and hickories (*Carya spp.*) also were major components. Less frequent upland species were chestnut oak (*Q. prinus*), American chestnut (*Castanea dentata*), and pine (*Pinus spp.*). Oaks accounted for 45 to 71 percent of all witness trees in the townships (Table 2).

Table 2. — Percentage of witness trees recorded in seven townships that included or were adjacent to the four study areas, recorded 1798-1805; for townships associated with AR and WR study areas (M/K = Madison and Knox, VI = Vinton, WI = Wilkesville), summary data are from Beatley (1959); for townships associated with YB and BR study areas (DE = Decatur, WA = Washington, AID = Aid, LA = Lawrence), original land survey notes were consulted.

		Arch Rock and Watch Rock			Young's Branch		Bluegrass Ridge	
Species	Survey name	M/K	VI	WI	DE	WA	AID	LA
Acer rubrum[a]	Maple	-	-	-	5	3	4	0
Acer saccharum	Sugartree	5	3	3	6	6	9	6
Carya spp.	Hickory	18	19	18	22	13	12	6
Castanea dentata	Chesnut	5	3	0	3	5	0	0
Fagus grandifolia	Beech	10	5	7	3	3	9	6
Liriodendron tulipifera	Poplar	4	1	2	3	3	3	3
Pinus spp.	Pine	0	0	0	1	0	2	2
Quercus alba	White oak	32	40	36	32	33	33	45
Quercus prinus	Chestnut oak	1	2	4	7	7	5	2
Quercus rubra	Red oak	0	0	0	1	0	1	0
Quercus velutina[b]	Black oak	12	18	18	3	3	12	24
Other tree species		13	9	12	15	25	11	4
Total trees[c]		196	163	115	180	120	152	161

[a]*Acer rubrum* may have been included with 'other tree species' or sugar maple in the AR and WR townships.
[b]Likely also included *Q. coccinea* (scarlet oak).
[c]Total number of witness trees used to calculate the percentages.

Species frequently recorded in the "bottoms" (stream valleys) but not abundant overall included beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and yellow-poplar (*Liriodendron tulipifera*). Beech and poplar also were tallied in uplands, but sugar maple was confined primarily to the stream valleys. The surveyors recorded both "maple" and "sugartree," suggesting a distinction between red maple and sugar maple. "Maple," presumably red maple (*Acer rubrum*), was infrequent in the Lawrence County townships (zero to 5 percent of witness trees) and apparently was lumped into "other species" in the Vinton County townships (Beatley 1959).

In Washington and Lawrence townships, the surveyors also made brief mention of the "underbrush" in their line descriptions. Virtually every upland observation was of "oak and hickory underbrush" (presumably saplings and large seedlings); dogwood also was noted frequently. Spicebush (*Lindera benzoin*) was recorded in several stream valleys. Sapling species abundant in current forests, including red maple, sugar maple, blackgum (*Nyssa sylvatica*), and beech, were not recorded in the underbrush descriptions.

Euro-American Settlement

Euro-American settlement of Vinton County (WR and AR) began in 1805 (Willard 1916), and Aid Township (includes BR) was settled in 1815 (Bush et al. 1995). By 1850, 20 to 39 percent of forests had been cleared in Vinton County while less than 20 percent had been cleared in Lawrence County (Williams 1989). However, it is unknown whether forest clearing was significant in and around the study areas prior to the development of the charcoal iron industry. Unfortunately, we could not gather information on land use in our study areas for this period. Homesteading in the eastern United States generally consisted of creating a clearing in the forest for a house and crops (Williams 1989). Timber also was used for fencing and fuel while stock (both swine and cattle) was grazed in the surrounding forest (Williams 1989; Whitney 1994). In eastern Ohio, Howels (1895) described forest grazing in the mid-1800s: "In the summer our cows ran in the woods, which were unfenced, and the pigs... all they asked was a free range of the woods." In many wooded areas, fire was used to encourage the growth of grasses for livestock (Williams 1989).

Forest Clearcutting: The Charcoal Iron Industry

The charcoal iron industry (ca. 1830-1890) was the primary cause of the clearcutting of many forest stands in southeastern Ohio, including the landscapes containing the four study areas. In 1875 there were 69 iron furnaces in the Hanging Rock Iron District of southeastern Ohio and northeastern Kentucky (Stout 1933). The region had an abundance of iron ore deposits, limestone, and large tracts of old-growth timber for charcoal production (Stout 1933). The ore, usually less than 4 m beneath the surface, was mined and transported to the furnaces via ox carts. To supply charcoal for a typical furnace, 80 to 250 ha of forest were harvested annually, and secondary forests were harvested again at intervals of 20 to 30 years (Stout 1933). The timber was stacked into meilers, where it was slowly burned for 10 to 20 days to produce charcoal. Meiler locations have been noted in all four study areas (T. Hutchinson, pers. observ.).

Each study area is located within 2.5 km of at least one charcoal iron furnace (Table 3), and it is likely that each study area was clearcut when nearby furnaces operated. The iron industry began earlier and was more intense in the area surrounding YB (Table 3, Fig. 1). With the estimated cutting rotation of 20 to 25 years, the study areas probably were harvested more than once.

The discovery of richer iron ores near Lake Superior led to the decline of the charcoal iron industry in southern Ohio in the late 1800s (Morrow 1956). The depletion of the timber resource was also noted by Lord (1884): "It may be safely stated, that at present eight-ninths of this available timber land of the southern Ohio iron manufacturing districts has been cleared."

Land Use Since 1890

Following the decline of the charcoal iron industry, the study areas have been undergoing secondary succession. In 1991, Lawrence and Vinton were the most densely forested counties in the state with 77 and 79 percent forest land, respectively (Griffith et al. 1993).

Table 3.-- Charcoal iron furnaces located within 5km of the four study areas.

Study area	Furnace	Distance km	Date[a]
Watch Rock	Vinton	2.3	1853
Arch Rock	Eagle	3.1	1852
Young's Branch	Howard	1.8	1853
	Buckhorn	2.0	1833
	Mt. Vernon	4.1	1833
	Olive	4.4	1846
	Clinton	4.6	1832
	Bloom	4.8	1832
Bluegrass Ridge	Oak Ridge	1.0	1856

[a]Year that furnace began operating.

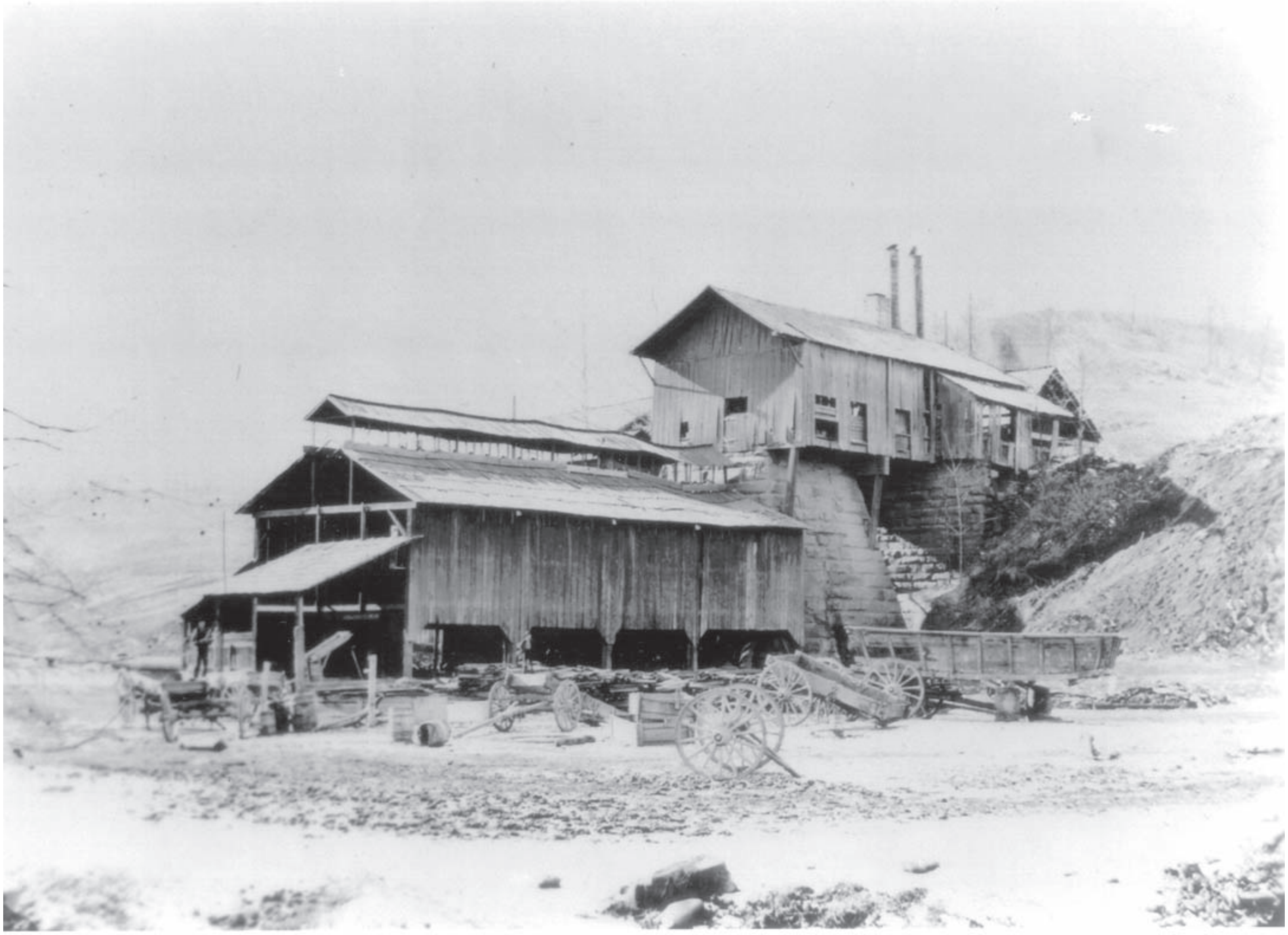

Figure 1.--The Buckhorn Iron Furnace (approximately 1875) was located 2 km from the current Young's Branch study area. Ox carts were used to transport rock containing iron ore and charcoal from the forests to the furnace. Note the cleared hillsides behind the furnace. (Ohio Historical Society photo).

Arch Rock and Watch Rock study areas

Vinton County plat maps indicate that the township sections that contain AR and WR study areas have never been subdivided into smaller parcels, which would indicate homesteading. There were small homesteads just west of AR until the 1930s; these were gradually abandoned during the Great Depression. Aerial photos from 1939 show a considerable amount of cleared land associated with the homesteads; however, the AR study area was closed-canopy forest. The families usually owned hogs or cows, which were grazed in the surrounding forest. Although there was no large-scale timbering during this time, the homesteaders did harvest some trees for cordwood, fencing, and railroad ties. Forests in the area were burned to improve visibility for detection of rattlesnakes and to increase blueberry (*Vaccinium*) production (Bill Pierce, pers. comm.) Aerial photos from 1939 show the area surrounding and including WR to be completely forested.

The D. B. Frampton Company owned much of the land that is now the Vinton Furnace Experimental Forest (within the Raccoon Ecological Management Area) from 1944 to 1962. The land was then acquired by Mead Paper Corp., the current owner (Kingsley and Dale 1985). The USDA Forest Service has conducted silvicultural research on these lands since 1952. There have been few fires and no grazing by domestic stock since the 1930s (Bill Pierce, pers. comm.).

Young's Branch study area

The YB units were acquired by the Forest Service in 1943. Nearly all of the land was closed-canopy forest in 1939 aerial photos, though the valley of Young's Branch (adjacent to the infrequent burn unit) was cleared and in agricultural use. Two of the mesic plots in the infrequent burn unit are only 65 to 70 years old, and some barbed-wire fencing is visible within the plots. Young's Branch is the only study area with evidence of iron ore mining. There are numerous ore pits (1 to 2 m deep), primarily on ridges and upper slopes, in all three units.

Bluegrass Ridge study area

The Forest Service acquired BR units FREQ (frequent burn) and INFR (infrequent burn) in 1936. The area had been divided into two major parcels prior to Forest Service ownership. Since the early 1940s, grazing by escaped livestock has been minimal and there have been no large fires (Ollie Bowling, pers. comm.). In the INFR unit, several of the intermediate and mesic plots are only about 65 years old.

The area encompassing the CONT (control) unit had been divided into three 40-acre parcels with different landowners prior to acquisition by the Forest Service; two parcels were acquired in 1965, one in 1992. Aerial photos from 1939 indicate that agricultural fields were present in the eastern drainage and hillsides adjacent to several of the vegetation plots. Tree cores indicated that these plots were relatively young, with the largest trees establishing between 1920 and 1925.

Dendroecological Analysis of Stand Histories

Tree rings offer a unique opportunity to assess the dynamics of individual stand conditions and disturbance regimes over relatively long periods, particularly when coupled with historical documents such as plat maps, travel journals, aerial photos, witness-tree records, and interviews (Lorimer 1985). The width of tree rings in a given year represents the radial-growth response of the trees to prevailing environmental conditions. Dendroecological analyses can determine how trees have responded historically to local stand conditions and stand dynamics (Fritts and Swetnam 1989).

To better understand the disturbance history of the four study sites, we performed a dendroecological analysis using 119 white oak trees (AR = 40, WR = 34, BR = 20, YB = 25). Tree cores were collected at a height of one meter using an increment borer. The cores were glued in grooved, wooden mounts and sanded with progressively finer grits of sandpaper for accurate dating and measurement (± 0.01 mm) of rings (Stokes and Smiley 1968). The dates and measurements were verified using COFECHA, a computer program that assists in scrutinizing date assignments and ring-width measurements (Holmes 1997).

For this study, we assume that stand disturbances can be discerned by identifying growth releases (i.e., sustained periods of high radial growth). Release events occur when favorable changes in the microenvironment (e.g., removal of a competitor) result in an increase of available resources (White and Pickett 1985). To describe the disturbance history of the study sites, we used a running median technique (an increase in radial growth of at least 25 percent when medians of adjacent 10-year growth segments are compared) to objectively identify release events. The criteria used in this method are adapted from Nowacki and Abrams (1997), who stated that 10-year growth increments are appropriate for the study of oak species growing in temperate, closed-canopy forests. Also, 10 years is longer than the duration of climatic events (e.g., prolonged drought) in the region, so sustained increases in radial growth should not be attributed to climate.

The approximate age for each stand was determined by calculating the mean age of the three oldest cored trees at each site; estimated stand initiation dates are shown in Figure 2. The exact year of stand initiation cannot be determined due to the presence of advance reproduction, missed inner rings (i.e., some increment cores were off-center and missed the pith), and trees were cored at one meter height (the time needed for a tree to reach one meter height is unknown). The current stands at all four study sites likely were initiated in the mid- to late-1800's. This period coincides with the period of decline in the charcoal iron industry in southern Ohio and subsequent land abandonment.

Comparison of the historical disturbance regimes of the four sites reveals several similarities but also differences in stand dynamics (Figs. 2-3). In the two Vinton County sites, AR and WR, many trees exhibit synchronous releases (at least 25 percent of the trees releasing in a given year) during the 1920s, 1940s, and 1960s-1970s. This synchronicity in release might be the result of several different disturbance agents. Given the regular periodicity (ca. 25 years), this disturbance probably is anthropogenic in origin and resulted from selective harvest or thinning. One can argue that the synchronous release during the 1940s might have resulted from the death of chestnuts during the 1930s. However, this scenario is unlikely because chestnut was not a major stand component (Braun 1950) and therefore, could not account for the high percentage of trees releasing (60 percent of AR and 42 percent of WR; Fig. 3). Further, a similar, synchronous release is absent at the YB and BR sites (Figs. 2-3). Finally, it is unlikely these synchronous release events are a natural stand development (e.g., self thinning) since the two sites differ in age (WR is about 20 years older than AR; Fig. 2).

One or more of these synchronous releases might have resulted from a major climatic event such as a severe windstorm or ice storm (i.e., glaze). However, we do not believe that the events were caused by wind because such a large area with different slope aspects and positions would have had to have been affected simultaneously. Also,

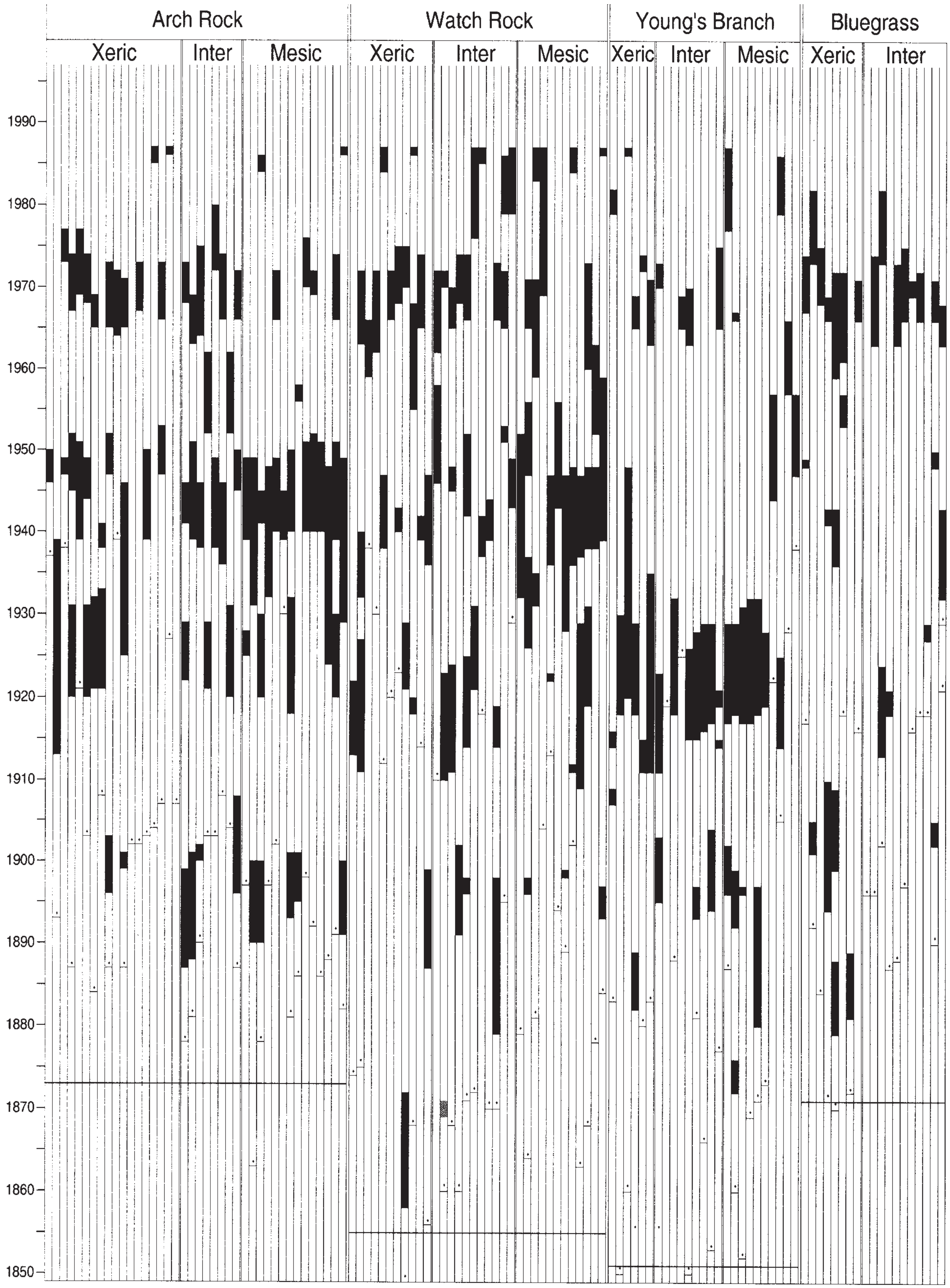

Figure 2.--Dendroecological recreation of historical disturbance events at the four study areas. Each column is a white oak and the shaded bars represent release events identified by the running median technique (see text). The first year of measured growth for each tree is indicated by the ⊥ symbol. The solid horizontal lines for reach study area represent approximate stand origination dates.

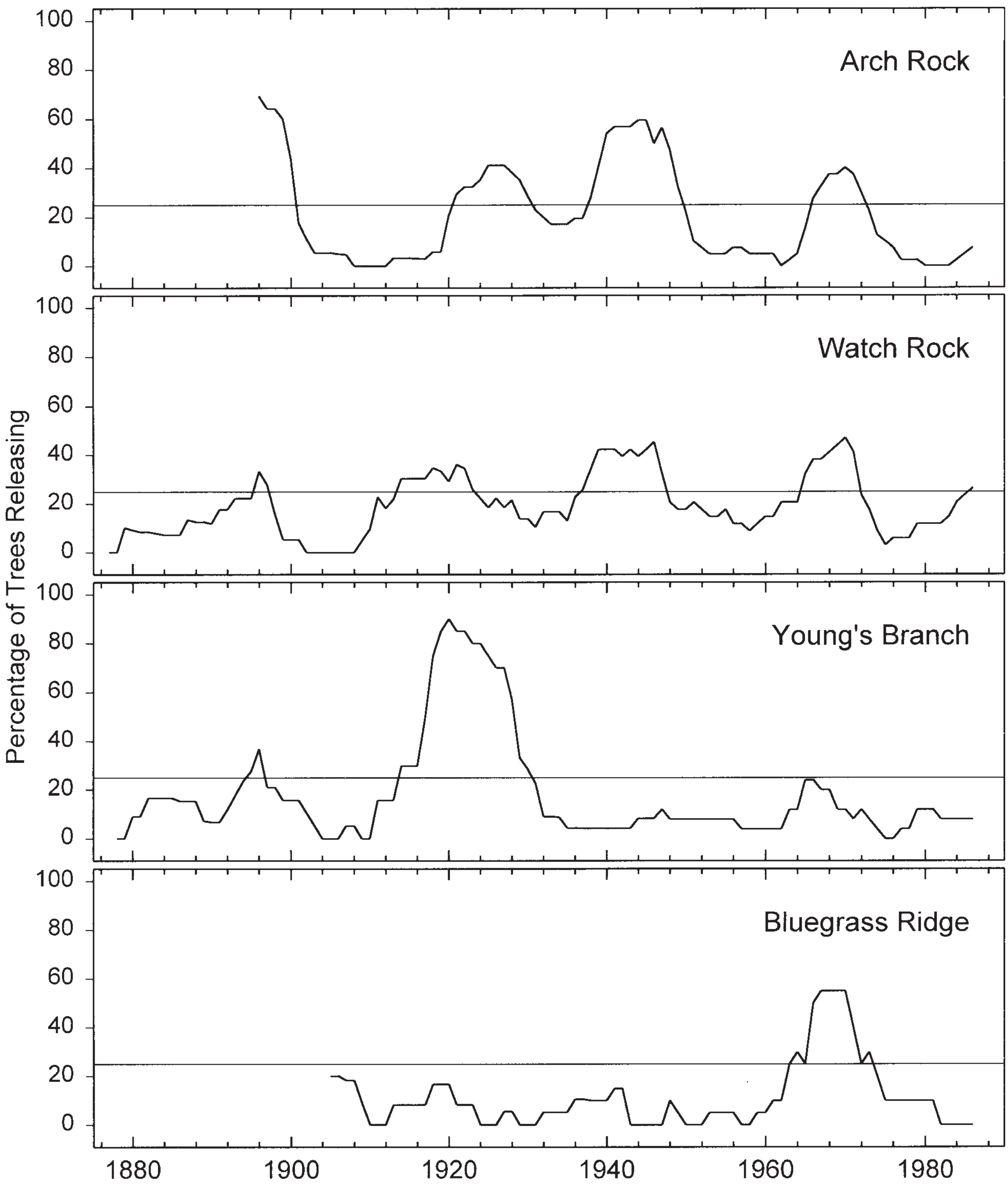

Figure 3.--Disturbance chronology of the four study sites. The percentage of trees releasing was determined by the running median technique. A synchronous release year is characterized by at least 25 percent of the trees releasing simultaneously.

strong winds and tornadoes are infrequent in southern Ohio, and the tornadoes that do occur in this region are likely not of a magnitude great enough to cause the widespread release patterns observed (Schmidlin 1996). Ice storms do represent a plausible explanation for the releases observed at the Vinton County sites. Ice storms affect trees differently according to canopy class, species, and topographic position (Bruederle and Stearns 1985; Mou and Warrillow 2000). Species such as white oak, which are considered moderate to low in susceptibility to ice damage, can survive ice storms and show accelerated growth following removal or damage of neighboring, susceptible trees (Boerner et al. 1988). Also, trees in the understory often are not as adversely affected as canopy trees and may fill storm-induced gaps and exhibit releases in radial-growth rate (Boerner et al. 1988).

At YB, many trees exhibit a simultaneous release from the 1910s through the 1930s; 90 percent of the cored trees released in 1920 (Fig. 3). Due to the magnitude of the release and the lack of a similar pattern at BR, the closest study site to YB, it is hypothesized that this massive release likely resulted from a silvicultural treatment.

All four study sites are characterized by a large number of trees exhibiting a release in the mid- to late-1960s through the 1970s. During the mid-1960s, drought was experienced in southern Ohio for several years. Of the 51 trees releasing during the postdrought period, 23, 20, and 8 were found in xeric, intermediate, and mesic Integrated Moisture Index (IMI) classes, respectively (Fig. 3). A chi-square test of homogeneity analysis revealed that the number of trees releasing in the various IMI classes was significantly different from an expected ratio of 1:1:1 ($\chi^2 = 7.41$; $P < 0.05$). Such results may be attributed to white oak's ability to tolerate drought conditions and regain normal growth following adverse conditions better than other species in more water-stressed microenvironments (xeric and intermediate sites). The AR study area contains stumps that may be the result of salvage logging in the area following the drought period or a coincidental silvicultural treatment.

Dendroecological analysis reveals both synchronous and asynchronous releases throughout the four study sites (Figs. 2-3). Such patterns suggest that both anthropogenic and natural processes (gap-phase dynamics or large-scale climatic events; Runkle 1985) likely influenced stand structure and dynamics here.

Current forest trends

Shade-tolerant tree species (e.g., red maple, sugar maple, blackgum, and beech) now dominate the sapling layer (see Chapter 8) and the smaller size classes (10 to 20 cm d.b.h.) of the tree layer (Chapter 9) in all four study areas. Similar shifts in species composition have been documented in oak forests throughout the Eastern United States. Although numerous factors have been implicated in the widespread decline of oak regeneration, suppression of fire since the 1940s is hypothesized to be a primary cause (e.g., Lorimer 1984; Abrams 1992).

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