HISTORICAL EVIDENCE OF FOREST COMPOSITION IN THE BLUEGRASS REGION OF KENTUCKY[1]

Julian J.N. Campbell[2]

Abstract.-- This study summarizes early records of forests in the Bluegrass, a fertile region that is now largely agricultural. More fertile soils had much sugar (and black) maple, walnuts (mostly black), hickories (mostly bitternut), ashes (mostly white and blue), oaks (mostly bur and yellow) and other species. The abundance of successional species like black walnut is attributable to prior disturbance involving Indians and large herbivores. Trees marking property boundaries included less of the successional species, which may have been concentrated near the more disturbed centers of settlements. Less fertile soils generally had oak-hickory forest dominated by white oak, or beech forest with some yellow poplar, but there was much mixture with species of more fertile soils. Beech was dominant in some of the western and northern areas, where soils have more loess content. Hypotheses are advanced to explain the region's unusual composition and its historical changes, especially in the blue ash-oak woodland-pastures.

INTRODUCTION

The Bluegrass Region is the area in north-central Kentucky that is underlain by Ordovician bedrock, mostly limestones and calcareous shales. It is now predominantly agricultural, and the remaining woodland receives little management for timber production. However, there is much interest in the original forests here (Braun 1950), and the potential role for forestry in the region (Kingsley & Powell 1978). Because of its high soil fertility, the Bluegrass was one of the first regions west of the Appalachian Mountains to be settled, during 1775-1800. This led to the rapid, early destruction, or at least great modification, of most original vegetation. It is difficult to estimate the presettlement conditions from what little remains. Braun called the Inner Bluegrass, which is particularly fertile and agriculturally developed, "the most anomalous of all vegetation areas of eastern United States." In the Eden Shale Belt and the Outer Bluegrass, somewhat more forest remains, but virtually no old growth. Braun included the whole region in her Western Mesophytic Region, which she generally defined as a mosaic of mesophytic forest and oak-hickory forest. Kuchler (1964) mapped the potential natural vegetation of the area as oak-hickory forest. However, within less disturbed areas today, this type is only prevalent in the Eden Shale Belt (Bryant 1981). Data adequate for an accurate mapping of this region are not currently available in the scientific literature. The purpose of this paper is to summarize some important historical evidence concerning the composition of the original forests, and to discuss the ecological implications of this evidence.

Considerable attention has been given to the degree of openness in the presettlement vegetation (Davidson 1950, Campbell 1980, Bryant et al. 1980, Bryant 1983). Old accounts indicate that the region was generally "well timbered" and that there were no treeless areas like the prairies or barrens further west. However, some areas on "rich" (fertile) soils were more thinly wooded, with canebrakes, successional forest and perhaps savanna-woodland (Bryant et al. 1980). Exactly what maintained these more open areas is unknown. They may have been influenced by Indians, using fire, and they were much used by buffalo, elk and deer; periodic droughts may also have been a factor (Campbell et al. 1988, and unpublished). Some frequent trees at the time of settlement are indicative of successional conditions, based on general knowledge of their ecology (Campbell 1980). These included black walnut, cherry, honey and black locust. The relative abundance of these species, and hence the extent of successional conditions, can be

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[2]School of Biological Sciences, University of Kentucky, Lexington, Kentucky 40506.

estimated from data presented in this paper. Modern woodland-pasture areas that resemble mid-western savanna-woodland are dominated by blue ash and oaks, which are relatively drought-tolerant and perhaps fire-tolerant. However, if grazing and mowing of these areas ceases, they are currently invaded by more mesic species. The original status of these woodland-pastures is not well understood.

The division of this region into different geological and edaphic sections is crucial for interpretation of patterns in forest composition (fig. 1; see also McDowell et al. 1981, U.S.D.A. 1974 and county soil surveys). The Inner Bluegrass lies on Middle Ordovician limestones, most of which are phosphatic; it has highly fertile hapludalf and paleudult soils. Outside the Inner Bluegrass, the Eden Shale Belt lies mostly on Upper Ordovician calcareous shales (the Clays Ferry Formation) and the Garrard Siltstone; it generally has less fertile hapludalf soils. In the east, typical Eden Shale soils are less extensive and there is generally a direct transition from Inner to Outer Bluegrass soils. The Outer Bluegrass lies mostly on Upper Ordovician limestones and calcareous shales; in addition, there are some overlying loess deposits in the west (Barnhisel et al. 1971), and pre-Wisconsin glacial deposits in the north. Outer Bluegrass soils are generally hapludalfs, intermediate in fertility between the Inner Bluegrass and the Eden Shale Belt. Surrounding most of the Bluegrass Region in Kentucky is a narrow zone of Silurian bedrock, including some dolomitic limestone with natural "cedar glades", and the Knobs Region, which lies mostly on non-calcareous shale of Devonian and Mississippian age and on Mississippian limestone. Further to the south and west is the Mississipian Plateau, which is mostly calcareous, including the former "Big Barrens" region. Further to the east is the Appalachian Plateau, which lies mostly on non-calcareous Pennsylvanian rocks.

NOTES ON COMMON NAMES

Some preliminary interpretation of the common names used in early sources is needed. Many names can be reliably attributed to a single species, especially in genera that have only one species present. However, some genera with several species present problems.

Acer (maple). "Sugar tree", and "sugar maple" in later sources, refer to A. saccharum (sensu lato), including var. nigrum, which is frequent on the most moist and fertile soils (Campbell 1980). The few plain "maple" references in early sources are assumed to be A. saccharinum, which is restricted to larger watercourses, or A. rubrum, which rarely occurs in old river channels (Campbell 1980).

Aesculus (buckeye). A. glabra is not distinguished from A. octandra in most sources, but Rafinesque (1819) and Short (1828) indicated that A. glabra was much more abundant. Today A. octandra is also much less common, being restricted to the eastern transition and some areas near the larger rivers.

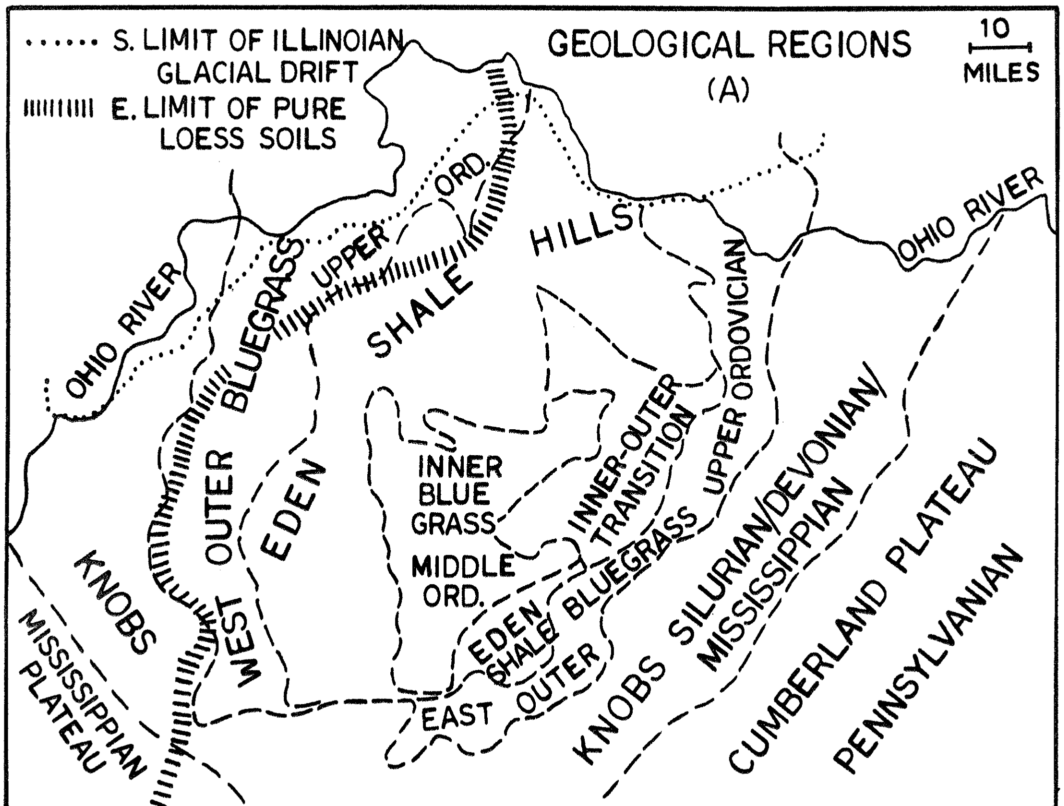
Carya (hickory). Species are rarely separated in early sources, and where they are the names are not reliably identifiable (white, black, pignut, bitternut, shellbark, scalybark). Short (1828) noted that "C. porcina" ("pignut") was the most common species on more fertile soil near Lexington, but his description of its leaves suggests C. cordiformis. A few other notes (Short 1828, Owen 1857, Linney 1882-87) indicate that, among the two shagbarks, C. laciniosa was typical of more fertile soils than C. ovata. In modern forests, C. cordiformis and C. laciniosa are typical of more fertile soils; C. ovata, C. glabra and, rarely, C. tomentosa are typical of less fertile soils (Campbell 1980).

Celtis (hackberry). C. occidentalis is not distinguished from C. tenuifolia, which was probably infrequent, since it is today a small tree largely restricted to dry and wet soil extremes. "Hoopwood" probably refers to C. occidentalis, because it was used in several sources that did not use "hackberry"; also, C. occidentalis has been known locally as "hoopash", e.g., in New England (Dame and Brooks 1972).

Fraxinus (ash). Most sources do not distinguish species. However, according to reliable accounts of "richer" soils, blue ash (F. quadrangularis) about equalled (Short 1828) or exceeded (Owen 1857, Linney 1882-87) white ash (F. americana) in abundance. On fertile soils today, blue ash is more common among older trees, but white ash is much more common in young stands (Campbell 1980, Bryant et al. 1980). Green ash (F. pennsylvanica), a wetland species, is not listed in any source, and it must have been usually included under "white ash". "Black ash" and "hoopash" are frequently listed, but the meaning of these names remains uncertain. Further north, these names generally refer to F. nigra, whose presence in Kentucky has not been confirmed, though it was described here by Short (1828) under the synonym F. sambucifolia.

Juglans (walnut). Most references do not separate species, and may usually refer to J. nigra. However, some deeds specify "white walnut" (J. cinerea), generally with a frequency similar to "black walnut" (J. nigra), and even more in some less fertile areas. Short (1828) noted that J. cinerea was "even more abundant" than J. nigra around Lexington. In contrast, J. cinerea now comprises less than 0.1% of Juglans in the region; its decline here and elsewhere is due to disease (Kuntz & Tisserat 1983).

Quercus (oak). Most sources distinguish the white oak and the black (or red) oak groups, but not the species. In the white oak group, Short (1828) noted that Q. macrocarpa was most abundant on fertile soil near Lexington; Q. muhlenbergii was also frequent; and Q. alba was more typical of less fertile soil. In the black oak group, he described Q. shumardii (under "palustris") as most frequent around Lexington; Q. imbricaria was less common but typical of fertile soil; and Q. velutina was restricted to less fertile soil. He did not list Q. rubra, which today is restricted to more mature forest on steeper slopes. Later



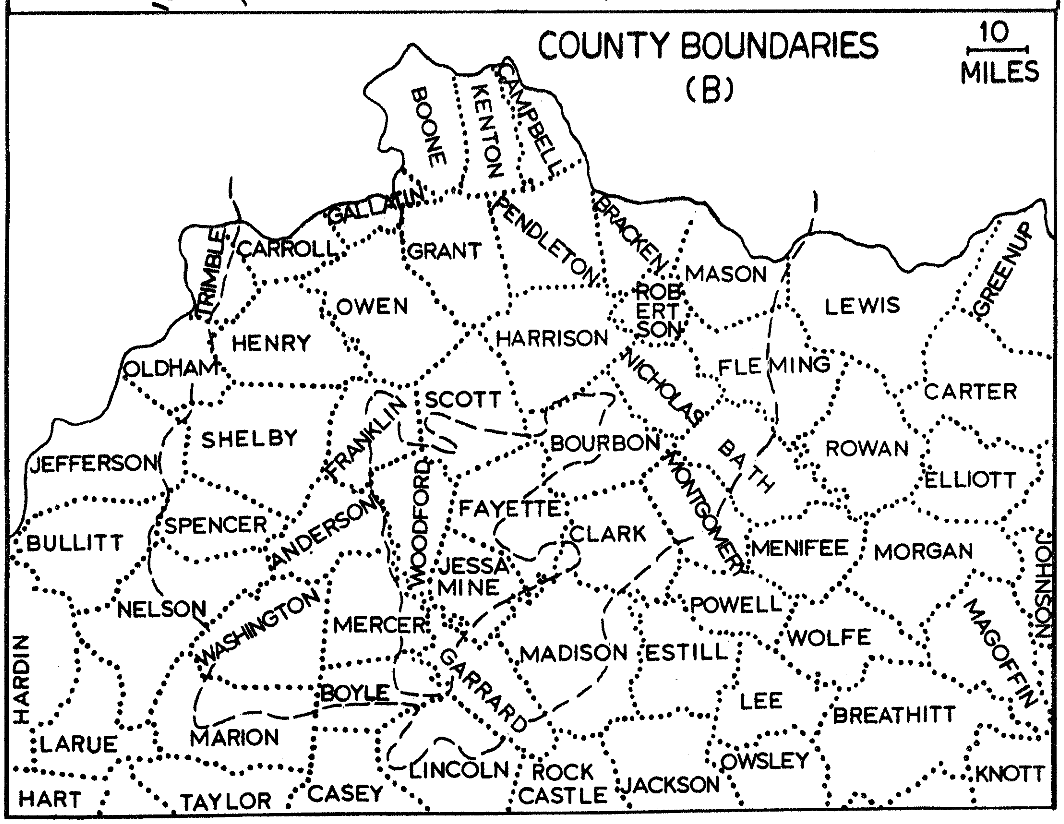


Figure 1.— The Bluegrass Region, showing: (a) subdivisions based on geology (McDowell et al. 1981) and soils (U.S.D.A. 1974); and (b) county boundaries and names.

sources confirm these trends (Owen 1857, Linney 1882-87, Campbell 1980, Bryant 1983).

Tilia (lynn, basswood). *T. americana* and *T. heterophylla* are both widespread, but these closely related species were never distinguished in early sources. Their relative abundance remains poorly documented in modern forests.

Ulmus (elm). Most records do not distinguish species. Early deed surveys listed red elm (*U. rubra*) about twice as often as white elm (*U. americana*), and F. Michaux (1805) noted a similar difference. However, Short (1828) later noted that *U. rubra* "has almost disappeared from the forest around Lexington in consequence of its destruction by cattle... [but] In the more accessible situations among the cliffs of Elkhorn and the Kentucky River, it is occasionally met with..." Today, it is much less common than *U. americana* on more fertile agricultural uplands. Other elms (*U. thomasii*, *U. alata*) were reported from rocky sites by Linney (1882-87), and they are rare and restricted to such sites today.

Some confusion may also exist in a few cases at the genus level. Honey locust (*Gleditsia triacanthos*) and black locust (*Robinia pseudoacacia*) were not always distinguished. However, it is likely that "locust" by itself generally referred to *Robinia*, as suggested by Linney's (1882-87) joint listing of common and Latin names. Among the "gums", "blackgum" (*Nyssa sylvatica*) and "sweetgum" (*Liquidambar styraciflua*) were often not specified, but the latter was never listed for certain within the Bluegrass Region, and it is much rarer today.

EARLY LANDSCAPE DESCRIPTIONS

Many pioneers and travellers at the time of settlement supplied comments about the vegetation in journals, letters, books and interviews (L.C. Draper's Manuscripts of the 1840s). In several cases, these people provided lists of trees seen in particular areas. After searching for as many sources as possible, these notes were condensed into an estimate of forest composition (table 1). The percentages in this table are based on the number of times each tree taxon is mentioned in the various sources.

Several sources provide separate lists for areas with "richer" (more fertile) soil and "poorer" (less fertile) soil. The 28 lists for more fertile areas (table 1, combined as column B) indicate that the forest was typically composed of walnuts, sugar maple, ashes, cherry, buckeye, honey locusts, black locust, coffee bean tree, elms, hickories, oaks, mulberry, hackberry, yellow poplar and others (in approximate order of decreasing frequency at the genus level). Walnut and sugar maple were both listed in almost all accounts of more fertile soils, sometimes with notes about the particularly large size of these trees. Walnut was noted as a major component, or at least listed first, about twice as often as sugar maple. Ash, cherry and buckeye were listed in most accounts but indicated as major components only about half as often as sugar maple. Honey and black locust were listed in only half the accounts, but honey locust was noted as a major species as often as sugar maple, and black locust trees were noted as especially large as often as sugar maple. Other trees were listed in no more than half the accounts, though coffee tree was consistently regarded as one of the best indicators of the most fertile soils. Small tree species that were most frequently listed include pawpaw and hawthorns. Short (1828) wrote that "This portion of Kentucky was once the paradise of pawpaws, where immense orchards of large trees were everywhere met with."

Only 12 tree lists referring to less fertile areas were found in early literature. Some of these lists include transitions to the Knobs Region, or to glaciated land in the north. They indicate that the forest was primarily composed of oaks, beech, poplar, sugar maple, ashes, walnut, hickories, black locust, sassafras and others (column A in table 1). While the oaks were generally dominant, beech and poplar were apparently more abundant in areas close to the Ohio River. Sassafras, persimmon, blackgum, sweetgum, chestnut oak and pines were minor species, and their records in table 1 (A and B) are mostly from accounts that include areas peripheral to the Bluegrass Region in its strict definition. They were essentially absent from the more fertile soils. The only small tree species listed more than once was dogwood.

EARLY DEED SURVEYS

Unlike several states further west or north, there was no systematic land survey in this region during settlement. However, each county courthouse has deed books that incorporate miscellaneous surveys of individual properties dating back to when the county was established, except for a few counties in which such books were destroyed by fire. In the Bluegrass Region most counties began during 1785-1810, though a few peripheral counties did not begin until 1820-1870. The early deed surveys generally noted about 5-20 individual marked trees, with common names, at the corners of property boundaries. For a preliminary summary of these data, the first 100-200 trees in each county's first deed book were used to calculate percentages for different types of tree.

Various uncertainties and biases exist regarding these data. There is no information on the sizes of trees listed in these surveys, though it is likely that trees at least 10-20 cm dbh were used in the great majority of cases. There may also be biases in the types of topographic and edaphic site that were sampled by these deed surveys, since property boundaries were often associated with natural features like ridges and streams. Despite such problems, these data provide an important reference point in attempts to estimate early forest composition.

Table 1. Percentage composition of tree taxa estimated from early accounts and data from the Bluegrass Region*.

TREE TAXA	ACCOUNTS OF 1750–1850		DEED SURVEYS OF 1780–1840				GEOLOGICAL SURVEY OF OWEN (1857)				GEOLOGICAL SURVEY OF LINNEY (1882–87)				TIMBER REPORT OF BARTON (1919)			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Acer saccharum (sugar tree, s. maple)	9.8	9.5	15.6	2.1	23.7	11.5	10.6	11.1	18.8	10.7	12.0	10.6	10.3	6.0	14.3	8.1	9.7	9.9
Acer negundo (boxelder)	-	0.8	1.6	0.6	2.0	2.6	-	-	1.3	-	-	-	-	-	-	-	-	-
Acer saccharinum/*rubrum* (maple)	-	1.1	0.6	1.1	0.3	0.1	-	-	-	-	-	-	-	-	(included with above)			
Aesculus glabra/*octandra* (buckeye)	3.7	6.0	3.4	1.4	6.8	8.5	1.1	1.6	5.0	6.6	-	-	3.4	1.2	-	+	-	-
Asimina triloba (pawpaw)	1.2	5.2	-	-	+	0.3	1.1	-	2.5	-	-	-	-	-	-	-	-	-
Carpinus caroliniana (hornbeam)	-	-	0.4	0.2	0.3	0.4	-	-	-	-	-	-	1.7	-	-	-	-	-
Carya spp. (see text) (hickory)	6.1	4.9	8.1	11.7	11.0	18.9	9.4	14.3	11.3	6.6	-	10.6	5.2	7.2	6.3	10.0	8.0	8.8
Castanea dentata (chestnut)	2.4	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	+
Celtis occidentalis (hackberry)	-	3.4	1.4	0.1	3.6	2.6	-	1.6	1.3	4.9	-	-	1.7	12.0	-	+	1.8	2.5
Cercis canadensis (redbud)	1.2	0.8	0.4	0.1	+	0.3	-	+	1.3	0.8	2.0	-	1.7	-	-	-	-	-
Cladrastis kentukea (yellowwood)	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cornus florida (dogwood)	2.4	0.4	2.8	12.2	1.9	2.3	1.1	-	1.3	0.8	2.0	4.3	-	-	-	-	-	-
Crataegus mollis/*crus-g.* (thorn, haw)	-	2.2	0.2	-	0.8	0.6	-	-	-	0.8	-	-	-	-	-	-	-	-
Diospyros virginiana (persimmon)	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fagus grandifolia (beech)	12.2	1.5	29.1	6.0	7.1	6.6	29.5	11.1	2.5	0.8	18.0	2.1	3.4	-	26.2	8.6	2.6	1.5
Fraxinus spp. (see text) (ash)	7.3	7.5	9.1	7.4	12.2	9.0	8.2	3.2	12.5	13.1	4.0	4.3	10.3	16.7	5.4	3.7	14.9	21.8
Gleditsia triacanthos (honey locust)	1.2	5.6	0.9	0.6	1.1	1.8	-	3.2	2.5	4.9	-	-	-	-	-	-	-	-
Gymnocladus dioica (coffee tree)	-	4.5	-	-	0.3	0.7	-	-	-	0.8	-	-	1.7	6.0	-	-	-	-
Hamamelis virginiana (witch hazel)	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Juglans nigra/*cinerea* (walnut)	6.1	9.1	4.3	3.7	3.6	4.3	7.1	9.5	16.3	13.9	16.0	8.5	13.8	4.8	1.2	2.4	12.9	29.8

Table 1 (continued).

Juniperus virginiana (cedar)	1.2	0.8	–	–	0.3	+	–	–	–	–	–	4.3	–	–	–	+	0.9	0.2
Liriodendron tulipifera (poplar)	7.3	2.6	2.1	2.5	0.5	1.3	12.9	6.3	5.0	2.5	18.0	2.1	8.6	1.2	2.1	1.5	0.1	0.1
Liquidambar styraciflua (sweetgum)	1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Magnolia acuminata? (cucumber tree)	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Malus coronaria (crab apple)	1.2	0.8	–	–	–	0.1	–	–	–	–	–	–	–	–	–	–	–	–
Morus rubra (mulberry)	–	4.1	0.4	1.0	1.2	1.2	–	–	2.5	3.3	–	2.1	5.2	4.8	–	–	–	–
Nyssa sylvatica (gum, blackgum)	2.4	–	0.6	1.9	0.2	0.4	1.1	1.6	–	–	2.0	–	–	–	–	1.3	0.3	0.2
Ostrya virginiana (ironwood)	–	0.8	1.3	1.4	1.3	0.6	–	–	1.3	–	–	2.1	–	–	–	–	–	–
Quercus Lepidobalanus (white oak spp.)	13.4	4.1	7.3	21.4	9.1	10.4	11.8	22.2	3.8	8.2	14.0	27.7	15.5	15.7	18.2	31.1	25.1	12.2
Quercus Erythrobalanus (red, black oak spp.)	6.1	–	1.5	5.6	3.6	5.3	1.1	14.2	2.5	4.1	4.0	14.9	5.2	3.6	16.4	21.0	13.5	7.1
Pinus virginiana/echin. (pine)	1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0	–	–
Platanus occidentalis (sycamore)	–	1.5	1.7	1.8	0.4	0.6	–	–	–	–	–	–	–	1.2	3.9	1.6	2.0	1.7
Populus deltoides (cottonwood)	–	–	+	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Prunus serotina (cherry)	–	6.4	0.2	0.7	0.4	0.8	1.1	–	3.8	5.7	–	–	5.2	13.3	–	–	–	–
Prunus spp. (plum)	–	1.9	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Robinia pseudoacacia (locust, black locust)	3.7	5.3	0.4	0.3	0.8	1.0	2.2	–	2.5	6.6	2.0	–	–	1.2	–	1.5	0.7	–
Sassafras albidum (sassafras)	3.7	–	0.3	0.3	–	0.1	–	–	1.3	–	2.0	2.1	–	–	–	–	–	–
Tilia americana/hetero. (lynn, basswood)	1.2	0.8	1.7	0.5	1.9	1.0	–	–	–	–	4.0	–	3.4	2.4	0.2	0.8	0.4	0.2
Ulmus rubra/americana (elm)	1.2	4.9	4.8	4.8	5.7	6.7	1.1	–	1.3	3.3	–	2.1	3.4	2.4	2.3	1.7	1.5	1.3
Viburnum prunif./rufid. (blackhaw)	–	1.1	–	0.4	–	–	–	–	–	–	–	2.1	–	–	–	–	–	–
Other	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.4	3.3	5.6	2.7
Total tree records	82	266	(>100 per county)				91	63	77	122	50	47	58	83	(board-feet basis)			

*Table 1 (explanation).

ACCOUNTS OF 1750-1850. These include a few peripheral areas in S Ohio and the Knobs Region.
A. Areas on poorer soil dominated by beech, oaks or poplar (Anon. 1791, Imlay 1792, Parry 1794, Barrow 1795, Smith 1797, Bartlett 1805, F. Michaux 1805, Melish 1807, David 1816, Short 1828, Lyell 1842, Collins 1847).
B. Areas on richer soil dominated by walnut, sugar maple, ash, honey locust, cherry, buckeye, etc. (Gist 1751, Hanson 1774, Fleming 1780, Filson 1784, Morse 1789, Imlay 1792, A. Michaux 1793, Parry 1794, Barrow 1795, Smith 1795, Harris 1797, Ellicott 1803, F. Michaux 1805 and 1819, Melish 1807, Marshall 1812, Flint 1822, Short 1828, Flint 1832, Drake 1840s, Clinkenbeard 1840s, Matthew 1840s, Collins 1847, Finley 1853, Chenault 1880s).

DEED SURVEYS OF 1780-1840 (and Robertson Co. in 1866). See figure 3 for geographic details.
C. Counties with beech as the most frequent tree.
D. Counties with the white oak group as the most frequent trees.
E. Counties with sugar maple or buckeye as the most frequent trees.
F. Counties with hickories most frequent.

GEOLOGICAL SURVEY OF OWEN (1857).
G. Areas dominated by beech or poplar.
H. Areas dominated by white oak.
I. Areas dominated by sugar maple, mixed with walnut and ash.
J. Areas dominated by black walnut, bur oak or blue ash.

GEOLOGICAL SURVEY OF LINNEY (1882-87).
K. Areas dominated by beech or poplar.
L. Areas dominated by white oak.
M. Areas dominated by sugar maple, mixed with walnut and ash.
N. Areas dominated by blue ash, mixed with oaks and hickories.

FOREST REPORT OF BARTON (1919).
See Figure 4 for geographic details.
O. Counties with beech or beech and maple as the most abundant trees.
P. Counties with oaks and hickories as the most abundant trees.
Q. Counties with oaks and ashes or oaks and walnut as the most abundant trees.
R. Counties with walnut as the most abundant tree.

The trees most frequently listed in early deed surveys were sugar maple, beech, white oaks (as a group) and hickories (table 1). Sugar maple was the most frequent tree in central, southern and eastern sections, while beech was most frequent in western and northern sections (fig. 2). The oaks were most frequent in a few northeastern and southwestern counties, while the hickories were most frequent in a few south-eastern counties. In addition, buckeye and ashes were locally abundant in some areas, but less often to the west and north. Outside the Bluegrass Region, in the Knobs Region and on the adjacent Mississipian Plateau and Appalachian Plateaus, white oaks or black oaks were generally the most frequent trees in these surveys.

In general, the tree composition indicated by these deed surveys is similar to that indicated by the early landscape descriptions. However, there are considerable differences in the frequencies of some trees, especially on more fertile soils (table 1, comparing columns C-F with A-B). Species that are generally at least 25% more frequent (as a proportion of the total) in deed surveys are sugar maple, boxelder, buckeye, hornbeam, hickory, dogwood, beech, ash, oaks, basswood and elm; those that are at least 25% less frequent are pawpaw, redbud, hawthorn, honey locust, coffee tree, walnut, yellow poplar, mulberry, sycamore, cherry and black locust. The latter species are generally more early successional (Campbell 1980). Early successional species may have been listed less often at boundaries because disturbed areas were concentrated on broad ridges or bottoms with relatively deep soils, where pioneers would have centered settlements. Also, some of these species may have been avoided for marking boundaries due to their shorter lifespans. In contrast, people who attempted to describe the landscape may have given early successional trees a positive bias, because they were seen more frequently along trails and at the centers of settlements.

EARLY GEOLOGICAL AND FOREST SURVEYS

Owen (1857)

David Dale Owen (1857) included many notes on forest composition in his geological surveys of individual counties. Wherever possible, he referred to areas of "primitive", "virgin" or "original" growth. His notes were fairly systematic, with a few typical sites described in each county. He referred to soil analyses by Robert Peter (1857-61), which indicate the forest types that were associated with high or low fertility. In order to summarize these data, his various sites were grouped into forest types, based on dominant species and characteristic associates. The percentage composition of each forest type was estimated from the number of times that tree taxa were listed at individual sites (table 1). Into this synthesis are also incorporated a few additional notes made by N.S. Shaler and other workers in the Geological Survey during a slightly later period (Peter 1876-1884).

The generalized forest types can be described as follows (see also table 1, which combines d-f).
(a) Beech-dominated forest (26 sites), with occasional dominance of poplar, also including sugar maple, oaks (mostly "white"), hickories

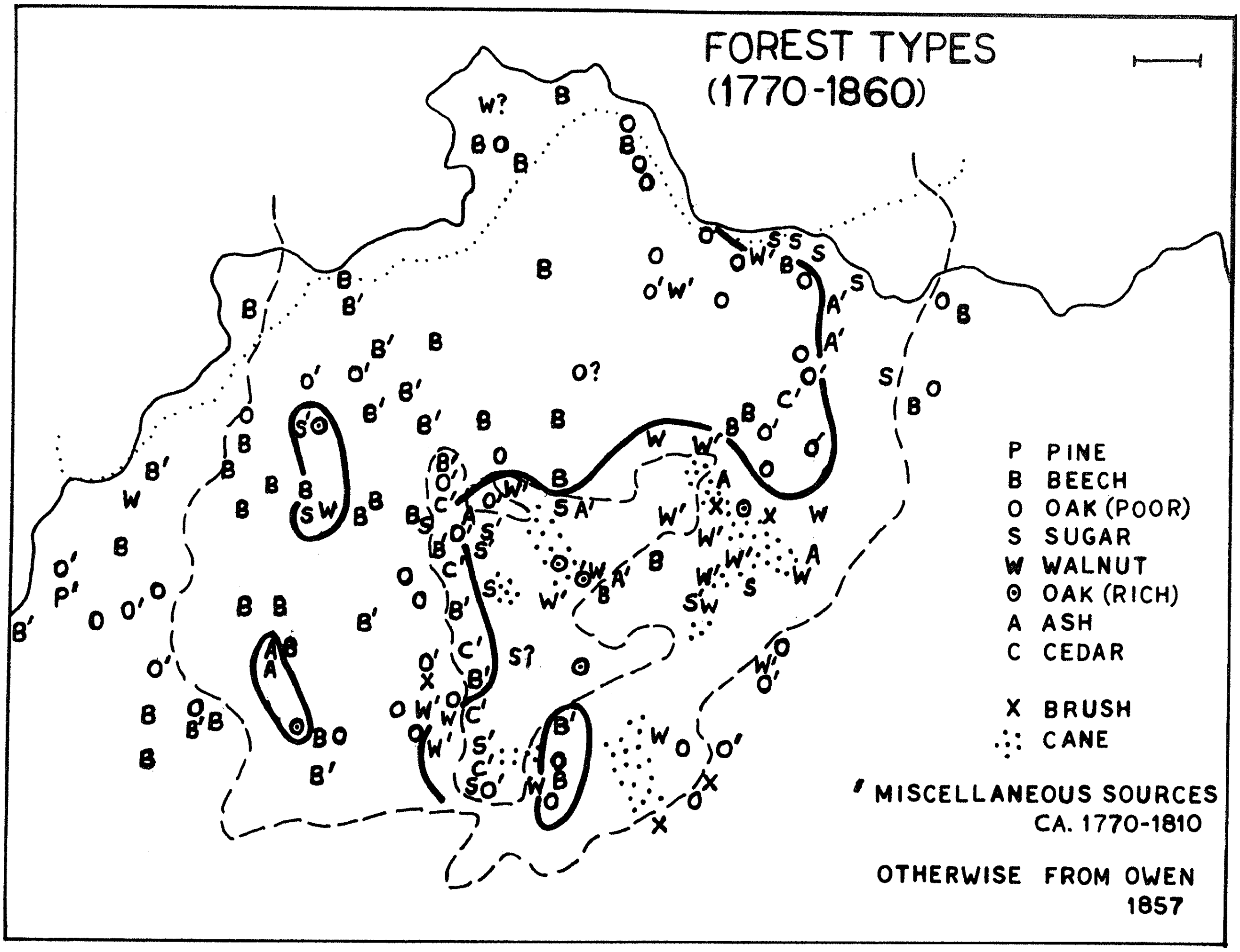


Figure 2.-- Indications of forest type distributions, derived from early (ca. 1770-1810) accounts (shown with ') and Owen (1857). Dashed lines are boundaries of the Bluegrass and Inner Bluegrass Regions (see Figure 1). Symbols indicate the commonest woody species noted by an observer at that location. Some less abundant trees have been combined with their associated dominants: locust and buckeye with walnut; elm with ash; yellow poplar with beech. "Poor" oak refers to white oak and associates on less fertile soil; "rich" oak refers to bur oak, yellow oak and associates on more fertile soil. Solid lines show the separation between trees typical of more or less fertile soils (see text).

(mostly "shellbark"), walnuts, ashes and other minor species.
(b) Oak-dominated forest (mostly "white" with some "red"; 23 sites), including hickories, beech, sugar maple and other minor species.
(c) Sugar maple forest (with no pronounced dominance; 15 sites), including black walnut, ashes (mostly "black"), oaks, buckeye and other minor species.
(d) Black walnut forest (with no pronounced dominance; 13 sites), including sugar maple, ashes (mostly "blue"), oaks, locusts (mostly unspecified), cherry and other minor species.
(e) Bur oak forest (with no pronounced dominance; 4 sites), including ashes, hickories, honey locust, buckeye, sugar maple and other minor species.
(f) Blue ash forest (with other ashes; 6 sites), including sugar maple, walnut (unspecified), hackberry, oaks and other minor species.

Most of these types occurred on the most fertile soils in the Inner and Outer Bluegrass, except for the beech and white oak types, which were mostly on less fertile soils in the Eden Shale or Outer Bluegrass. Shaler (1880s) wrote that blue ash, black walnut, black locust and coffee tree indicated the "best" soils, while beech, white oak, red oak, black oak and blackjack oak indicated progressively "worse" soils (see also R. Peter in Perrin 1882, p. 11, 20).

On the adjacent Silurian dolomitic rocks, Owen indicated that beech and poplar were the most frequent dominants, and that white oak, hickories, sugar maple, black walnut and ashes were also widespread. However, the "Beargrass Lands" of Jefferson County, near the old buffalo route between Louisville and Frankfort, were quite distinct. This area was dominated by black walnut, together with others typical of the more

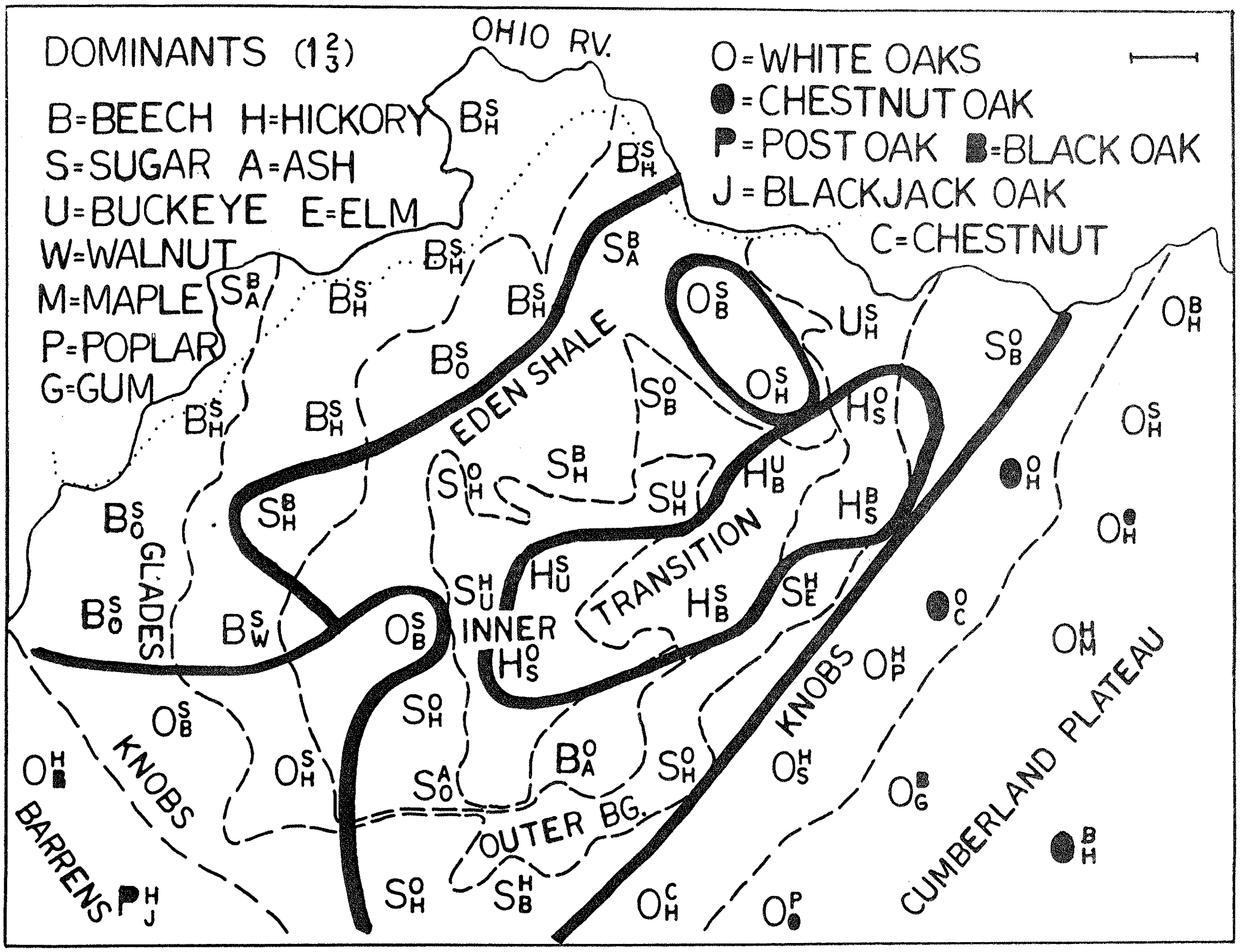


Figure 3.-- Dominant trees in each county (see fig. 1) based on samples from early deed surveys (mostly 1780-1840). Types of tree are indicated by single letter symbols. The second and third most frequent trees in each county are shown by the smaller symbols to the right of the most frequent tree symbol.

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fertile Bluegrass soils: black locust, cherry, elm, ash, hackberry, boxelder, buckeye, hickories ("pignut and shellbark"), coffee, oaks ("red" and "overcup"), sugar maple and beech.

The geographic aspects of Owen's (1857) data, together with the various notes of earlier observers (from the previous section), are summarized here in the form of a preliminary natural vegetation map of the Bluegrass Region (fig. 2). This map shows that trees typical of more fertile soils were concentrated in central and southeastern sections. There were also small concentrations of these trees in the western Outer Bluegrass. Beech was predominant in the west and oaks (mostly white oak) in the north.

Linney (1882-87)

William Linney (1882-1887) also made notes on forests during some geological surveys, allowing percentage compositions to be estimated in the same way. He made more precise species identifications and geological correlations. However, his work covered only some western, southern and eastern sections of the Bluegrass Region, excluding most of the Inner Bluegrass. He had difficulty finding undisturbed forests representative of each county, and he often deplored the wasteful deforestation that had occurred.

His notes largely confirm the patterns shown by Owen. The following forest types can be described from his data (tables 1 and 2).

(a) Beech forest. This was largely restricted to Upper Ordovician Garrard Siltstone ("Middle Hudson siliceous mudstone"). Poplar again was a locally dominant associate; other species included sugar maple, walnuts and white oak.

(b) White oak forest. This was concentrated on shaley soil on lower and upper strata of the Upper Ordovician, i.e., the Clays Ferry ("Lower Hudson") and the Drakes Formation, etc. ("Upper Hudson"). Associates on the lower strata

Table 2.--Common trees noted by Linney (1882-87) on different geological strata in several counties*.

	Western Counties				Southern Counties					Eastern Counties				
Geological Strata	Old	She	Spe	Nel	Was	Mar	Gar	Lin	Mad	Cla	Mon	Bat	Fle	Mas
Silurian Strata	B g			P o c	G o c	G W o c	G o c	G o c	G o c			W	B g p o	
Outer Bluegrass Limestones ("Upper Hudson")	B W S a	B s a	B W(u) s a(1)	a(1)	W A	W s a(1)	W a(1)	W a(1)	W a(1)		b w A	W(u) a(1)	W(u) a(1)	W(u) a
Garrard Siltstone ("Middle Hudson")			B	B	B	B w s	B w s	B w s	B w s	W S	a S	b s	b w s	B o s
Clay's Ferry Shale ("Lower Hudson")			W		W s	W	W	W	W	W			W	
Inner Bluegrass Limestones ("Trenton")					c(u) A w(1) b(1)	c(u) A w(1) b(1)	c(u) A w(1) b(1)	c(u) A w(1) b(1)	c(u) A w(1) b(1)	A y				
High Bridge Strata					c	c	c	c	c					

* Symbols for different trees are:
a = ash (mostly blue); b = beech; c = cedar;
g = sweetgum; o = post oak; p = yellow poplar;
w = white oak; y = yellow (chinquapin) oak.

Upper case symbols indicate the most widespread dominant species. In parentheses, symbols show restriction to upper (u) or lower (1) strata. See fig. 1b for full county names and locations.

included sugar maple, red oak and hickories, with some groves of post oak and "laurel" (shingle) oak. Associates on the upper strata included black oak, hickories, post oak, sugar maple and walnuts.

(c) Mixed forest with sugar maple or walnuts (mostly black) most abundant. This was typical of some soils on Garrard Siltstone and on the overlying Ashlock or Calloway Limestones. Associates included yellow (chinquapin) oak, blue ash, white oak, poplar, red oak, hickories, cherry and mulberry.

(d) Mixed forest dominated by blue ash or yellow oak. This was typical of the Ashlock and Calloway Limestones in the Outer Bluegrass, and the Lexington ("Trenton") Limestone in the Inner Bluegrass. Cherry and hackberry were consistent associates. Less frequent species included shellbark hickory, coffee tree, sugar maple and mulberry.

Linney noted that there was an east-west shift on the Garrard Siltstone, and he added some detail to the geographic pattern in earlier data (Table 2). In the west, beech alone was the typical dominant. In the east, sugar maple was a local dominant as well as, or instead of, beech and white oak.

On the narrow zone of Silurian dolomite and shale surrounding the Bluegrass, Linney reported some distinct types indicative of poorer soils, though intermixed with species of more fertile soil. The forest on less fertile soil included "Spanish oak" (specified as Quercus falcata) and sweetgum, which are virtually absent from past or present records of the Bluegrass Region.

Barton (1919)

One final source that provides some insight to natural forest composition is the 1919 report of J.E. Barton, Commissioner of Geology and Forestry in the State Government. This was the first estimate of timber volumes throughout the state, giving details of composition by county. However, no information on survey methods was given. Barton simply stated: "The only figures available date back some years and a large share of the removal of the timber in Kentucky, due to large operations, has taken place within a recent period... the figures here given were compiled under conditions which do not permit an extremely close and careful estimate... experience heretofore has shown that estimates of standing timber usually fall considerably below the actual cut." The forest cover estimated for the

Bluegrass Region in this report was only 5-6%, but much of this was probably old growth. Currently, "commercial forest land" is estimated to cover about 20% of the region (Kingsley & Powell 1978), much of which is on farmland abandoned since 1900.

There is some consistency between Barton's (1919) data and notes in contemporary county histories. In Franklin County, Johnson (1912) listed 12 major tree genera, as did Barton, and 10 were shared. Johnson listed walnut, ash, beech and oak as the major timber sources; these were all among the five most abundant trees in Barton's data (adding hickory). In Fayette County, Perrin (1882) listed seven major tree genera in common with Barton, out of 10-11 in each source. Those noted at least twice in Perrin's account were mostly (except honey locust and buckeye) the five most abundant trees in Barton's data: walnut, ash, oak, hickory and maple.

Barton's (1919) report listed seven Bluegrass counties that had forests dominated by beech, or by beech codominant with maple (table 1, fig. 4) or with oaks (all species combined). These counties were mostly in the western section. Another 14 counties, mostly to the north and east, were dominated by "white oaks", with almost equal amounts of "red oaks" and lesser amounts of hickories, beech, maple, etc. Eight counties were transitional from this oak dominance to ash and walnut, mostly in central and southeastern sections. Only the two most central Inner Bluegrass counties (Woodford and Fayette) were dominated by walnut, with ashes almost as abundant, followed by oaks, hickories, maple and other minor trees. Unlike earlier data, the peak abundance of walnut and ash was only in the central Bluegrass, without much extension towards the southeast. Most minor trees showed little geographic pattern, except for hackberry, which was only listed in the Inner Bluegrass and the transitional counties.

When other regions of the state are compared, these data clearly show the distinctiveness of the Bluegrass Region (fig. 5). The only Kentucky counties reportedly dominated by trees typical of the most fertile soils (oak-ash and walnut-maple) occurred in this region. Among major successional trees on moist sites, walnut exceeded yellow poplar in 23 of the 33 Bluegrass counties, but in no other Kentucky counties. Among major mesic climax trees, maple (mostly sugar maple in the Bluegrass) exceeded beech in 21 of the 33 Bluegrass counties, compared to 20 of the other 87 (including 12 in the western bottomlands probably referring to red maple). However, beech was still dominant in seven Bluegrass counties, in contrast to only four elsewhere in the state. Moreover, sugar maple was nowhere the county dominant, being replaced on the more fertile soils by more early successional trees like walnut.

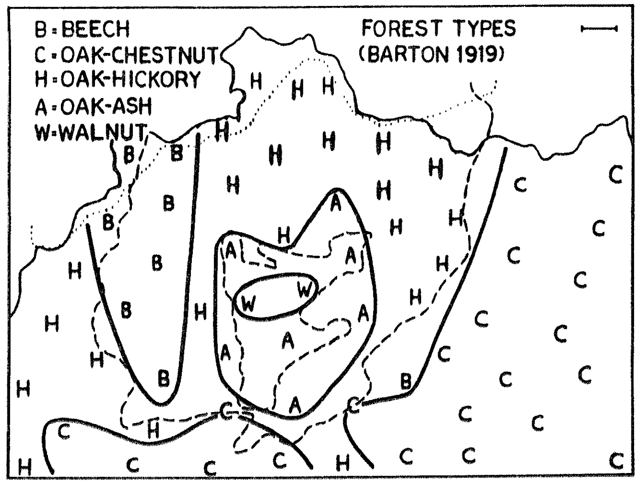

Figure 4.--Dominant trees in each county (see fig. 1) according to Barton (1919). Congeners are combined. One "B" has maple slightly more abundant than beech; one "A" has walnut slightly more abundant than ash.

Among trees generally typical of somewhat drier sites (subxeric), ash exceeded hickory in 11 Bluegrass counties, but in only two marginal counties elsewhere in the state. Also, the white oak group was more abundant than the black (or red) oak group in contrast to most other regions of the state. In the whole state, beech and walnut were the only county dominants that are truly mesic trees; both were concentrated in the Bluegrass Region. Elsewhere in Kentucky, subxeric trees were dominant in almost all 87 counties: oak-chestnut mostly in the east, and oak-hickory mostly in the west. The only exceptions were four scattered counties with beech, and four western bottomland counties with gum (<u>Nyssa</u> or <u>Liquidambar</u>).

DISCUSSION

Interpretation of presettlement composition

The major patterns of presettlement species composition suggested by these data can be interpreted with the aid of a general scheme of compositional gradients generated from modern data in the Central Hardwood Region (Campbell 1987). Much of the special character of Inner Bluegrass forest composition can be attributed to the moist, fertile soils that predominate here, favoring sugar maple, black walnut, ashes and other species that are generally concentrated on such soils in eastern North America. Also, the presettlement importance of early successional species like black walnut may be attributed to prior disturbance by Indians and large native herbivores (see Introduction).

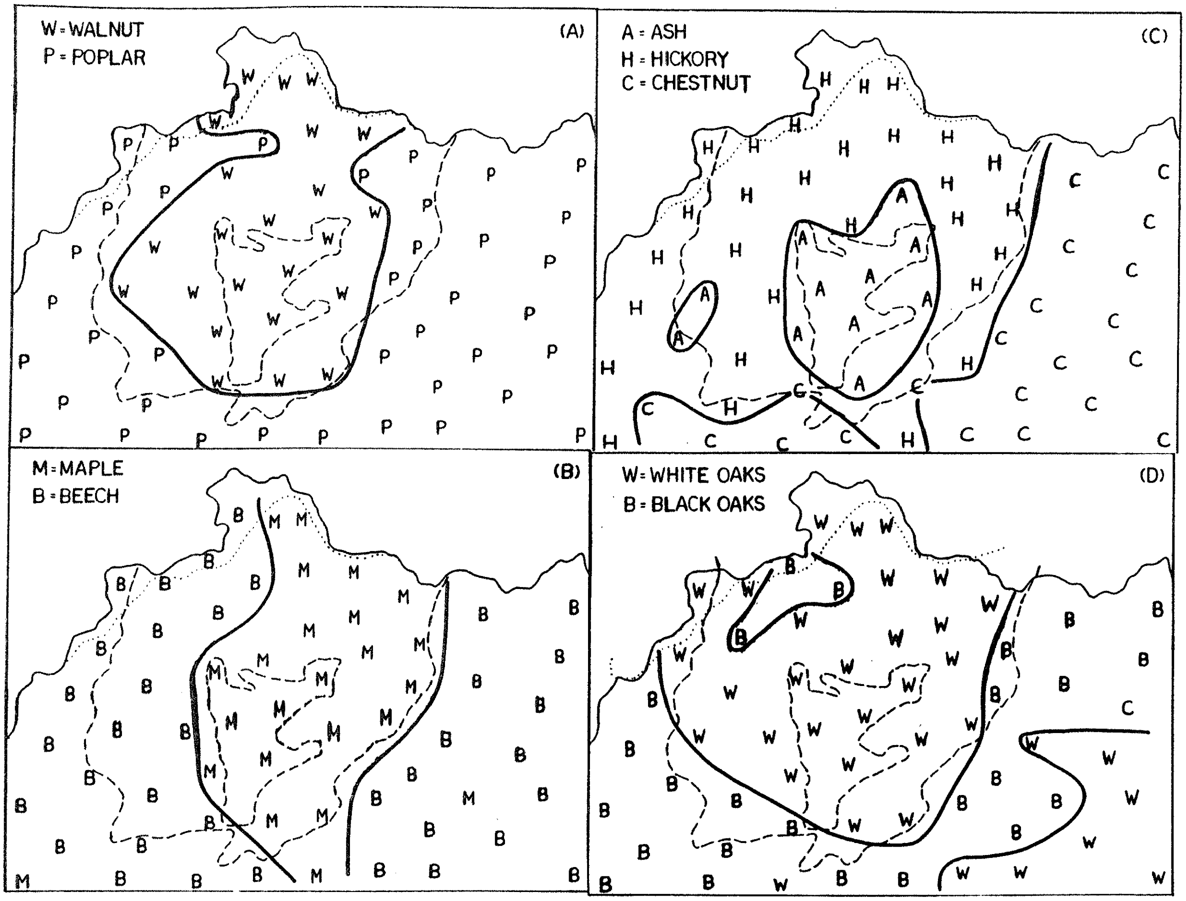

Figure 5.-- Contrasts in some tree distributions, from data in Barton (1919). In each county (see fig. 1), symbols show the most abundant tree within small ecological groups of taxa selected to show geological relationships.
(a) Walnut versus yellow poplar (successional dominants on moist sites).
(b) Maple (mostly sugar) versus beech (climax dominants on moist sites).
(c) Ash, hickory and chestnut (codominants with oaks on drier sites).
(d) White oak group versus black (or red) oak group (drier site dominants).

However, there was also a group of species in the presettlement forests on more fertile soils whose frequency gave this region some further unusual character that is not easily interpreted in terms of major regional compositional gradients. These species are Ohio buckeye, honey locust, coffee tree, pawpaw and, in the shrub layer, cane (Arundinaria gigantea). They appear to have been loosely associated with each other (Campbell 1980, and unpublished). It has been hypothesized that these species were formerly concentrated in ecotonal areas between the most frequently disturbed areas and the less disturbed forests of sugar maples, hickories, ashes and oaks (Campbell 1980). Such ecotonal vegetation may have been relatively stable, being maintained by small-scale oscillation of forest boundaries rather than long-term directional succession. These species have defenses (toxins, thorns) or reproductive characteristics (strong vegetative regeneration, poor seed dispersal) which may suit them to stable regimes of moderate disturbance. The extremes of clearance or abandonment that prevail over the landscape today do not appear optimal for them. In general, these species remain vigorous competitors in areas where they have not been cleared out, but they do not spread rapidly into either early or late successional forest types.

The geographic separation between trees typical of more fertile and less fertile soils approximately matches the soil differences mapped by U.S.D.A. (1974), but an unexpected trend shown above is the predominance of beech in the western and northern Bluegrass. In the highly disturbed modern landscape, beech is uncommon even within less disturbed forest remnants. However, if the general concentration of beech on soils of moderate pH and fertility is considered (see also Campbell 1987), this particular geographic pattern may be attributed to two general edaphic factors: (a) in the west and north, there is more land within the Eden Shale Belt, including the

Garrard Siltstone where beech was concentrated; and (b) there are also increases in loess content towards the west (deposited during glacial eras), and in pre-Wisconsin glacial material towards the north, both of which may reduce the pure limestone influence on flatter Outer Bluegrass soils.

Changes since settlement

In the modern landscape, typical early successional species have generally increased due to human disturbance (Campbell 1980). However, there appear to be some further changes in composition that are not simply attributable to the younger stand ages today. The possible importance of special ecotonal conditions for maintaining certain species before settlement has already been mentioned. The apparent decline of beech in the northwest has also been noted. It is conceivable that erosion of more acid upper soil horizons, along with forest clearance, has made the area less suitable for beech growth, but much more ecological work is needed to test this and other hypotheses.

Other important shifts appear to have occurred among the dominant species on more fertile soils, based on the data presented above (fig. 6). These shifts cannot be taken as conclusive results, since the various sources may have important differences in sampling biases, but they do suggest hypotheses for further research. Even in Owen's (1857) survey, some early shifts are indicated, though sugar maple and walnut remained about equally dominant in his data. In the later data of Linney (1882-87) and Barton (1919), there was a large shift to dominance by oaks and ashes. Then, in modern forests of the Inner Bluegrass, which are largely early successional, there has been some return to walnut, but with much more hackberry and other species instead of sugar maple.

The apparent increase in importance of the oak-ash component during the previous century may be explained by two general hypotheses.
(1) There may have been selective clearance of the maple-walnut component. This component is typical of soils with lower moisture stress that are most suitable for intensive agriculture. Much of the somewhat drier land dominated by oaks and ashes, especially blue ash, may have been set aside for less intensive use as "woodland pasture". Possibly there was also a higher demand for sugar maple and black walnut timber. The selective effects of livestock should also be considered. Sugar maple, in particular, is highly palatable to large herbivores (unpublished data) and may have been prevented from regenerating in many areas.
(2) There may have been ecological changes within the forests, due to natural factors (including climatic fluctuations) or human factors (deforestation and drainage). Drier conditions would have have reduced growth and survival of the maple-walnut component relative to the oak-ash component. Possibly pests and pathogens also played a role. Barrow (1795) noted that the region had been "much afflicted with caterpillars for seven or eight years past. They have done much damage in the woodlands especially among the sugar trees. By leaving them bare so many years an abundance of that valuable growth is dead." The disease of white walnut (_J. cinerea_) may also be involved (see Notes on Common Names).

Today, older trees on the more fertile soils are typically scattered in pastures. Blue ash is most common, with yellow (chinquapin) oak, bur oak, shumard oak (_Quercus shumardii_) and shellbark hickory (_Carya laciniosa_) also frequent. The size-class distributions of trees in the best preserved woodland-pastures or "savanna-woodlands" suggest that most of the trees originated during the 19th century, though the oldest are up to 450 years old (Bryant et al. 1979, Bryant 1983). If there really was some resurgence of more drought-tolerant species (oaks, ashes and hickories) within forest remnants during this period, actual change in moisture levels might be suspected. Some subsequent reversal might be suggested by the current failure of blue ash and yellow oak to regenerate in either ungrazed or grazed woodland-pasture remnants, which instead are often invaded by hackberry, black walnut and other mesic successional species. This hypothesis could be examined by looking for relationships between tree growth and land-use history or climatic factors. There is much potential for studies of tree rings in this context.

In conclusion, there is much to be learnt from historical data on forests in the Bluegrass Region, where so much of the modern landscape is agricultural. This initial study has shown that natural forest composition, and its variation over the landscape, can be estimated from such data. Some results are unexpected or difficult to interpret, but several hypothesis concerning ecological factors can be put forward to explain them. To test these hypotheses will require more analysis of spatial patterns in historical data, together with more intensive studies of modern forest ecology, including some population dynamics and physiology.

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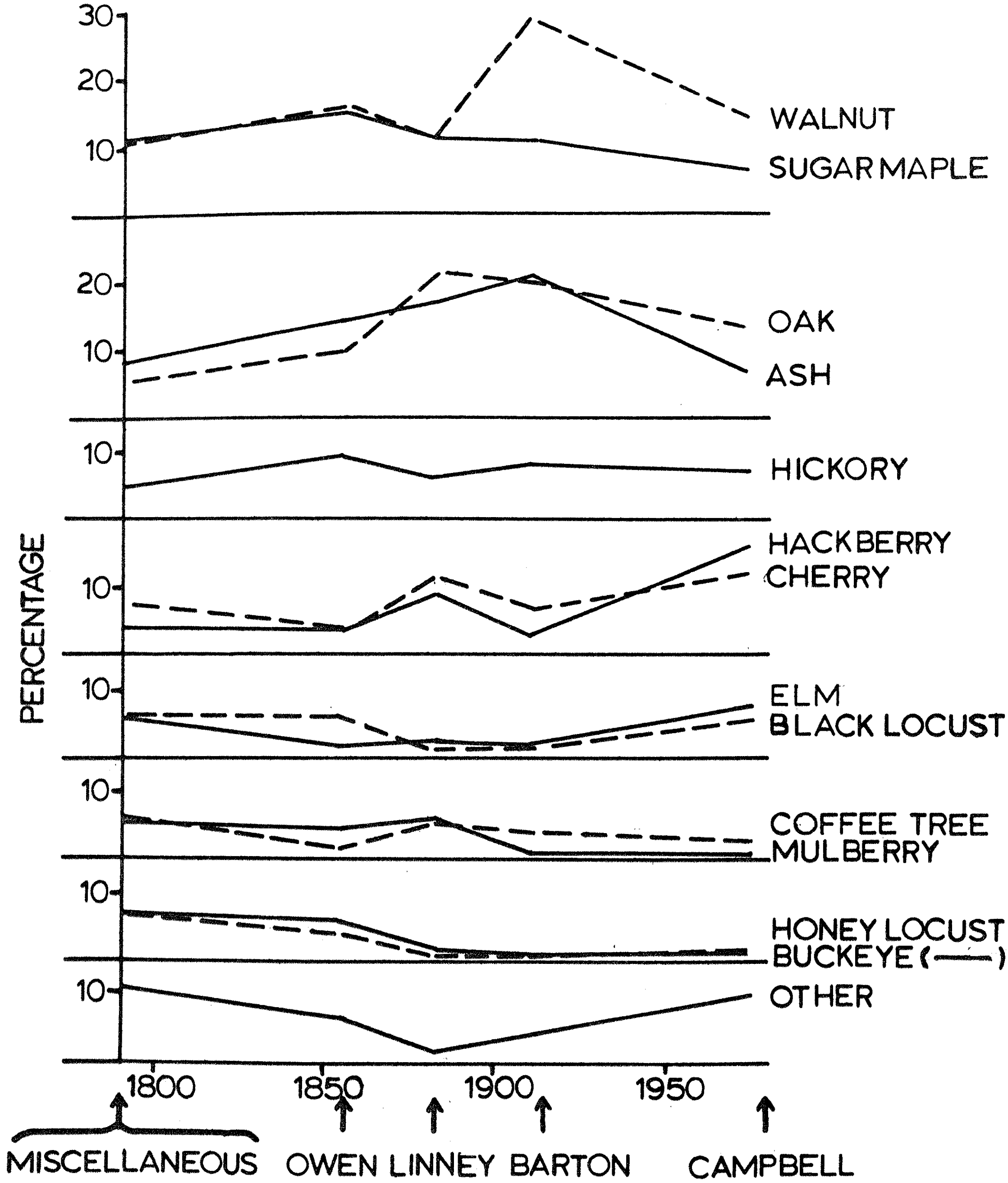

Figure 6.--Temporal shifts in forest composition on more fertile soils (mostly in the Inner Bluegrasss), as suggested by miscellaneous early landscape descriptions (Table 1:B), Owen (Table 1:J), Linney (Table 1:N), Barton (Table 1:R) and Campbell (1980, p. 63; mean basal area of successional phases D-G). Small trees like pawpaw, dogwood, redbud, hawthorn, hornbeam and ironwood are excluded from these percentages.

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