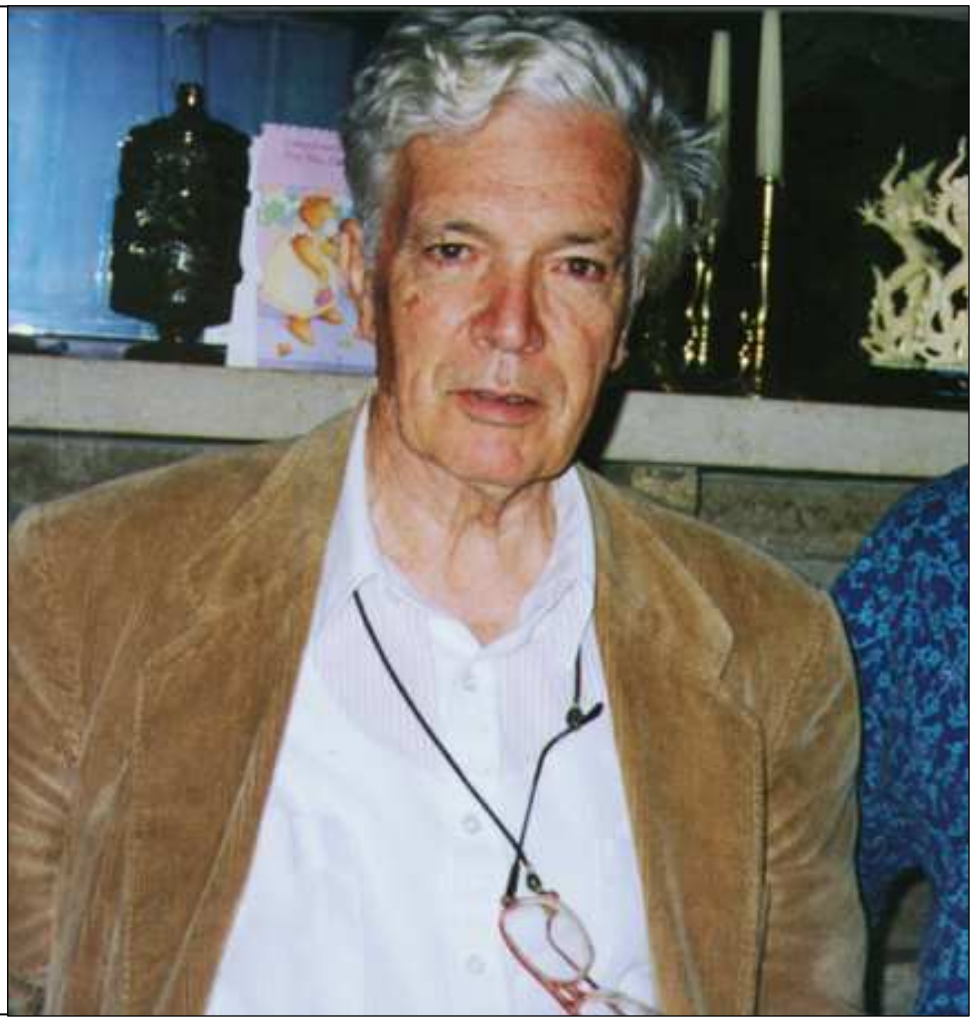
Meijer, W., J.J.N. Campbell, H. Setser and L.E. Meade. 1981. Swamp forests on high terrace deposits in the Bluegrass and Knobs regions of Kentucky. Castanea 46: 122-135.

Errata [2015]
p. 123: wetter areas on Maxey Flats and Sharkley Flats do include deep (non-rocky) soils that supported somewhat swampy forest and somewhat marshy glades before settlement (Feeman, K.L. 2002. The vascular flora of the tablelands : a natural region in the northeastern section of the knobs of Kentucky. M.Sc. thesis, Morehead State University).
p. 128: Casey Creek is in Adair and Casey Counties (not Pulaski).
p. 131: "*Panicum dichomiflorum*" should have been *P. microcarpon* (= *Dichanthelium microcarpon* or *D. dichotomum* var. *ramulosum*).



Willem Meijer (right) drew attention to these wetlands and others in central Kentucky. Almost none of these sites have become legally protected, and we need a renewed effort to study them and establish more interest in their conservation and restoration.

Swamp Forests on High Terrace Deposits in the Bluegrass and Knobs Regions of Kentucky

WILLEM MEIJER, J. J. N. CAMPBELL, HOWARD SETSER and LESLIE E. MEADE

ABSTRACT

The distribution of swamp forest sites as indicated by *Quercus bicolor* is mapped for the Bluegrass and Knobs regions of Kentucky. Most of these are on high level terraces probably deposited by rivers ponded during glaciation. For some sites species lists are presented and a preliminary analysis reveals compositional variation related to soil moisture and perhaps pH. Records of *Q. bicolor, Q. michauxii* and *Habenaria* spp. from these previously little described forests extend their known ranges. The urgent need for conservation of these swamp forests is discussed.

INTRODUCTION

During recent explorative study on the flora and vegetation of the Bluegrass and Knobs of Kentucky, our attention has been drawn to the swamp forests. These are previously undescribed except for the brief notes of Braun (1950). They are generally on clayey to sandy alluvial soils outside the flood zones of major rivers. The original forest composition along the present river channels is unknown; much more of this forest has been cleared for agriculture than the forest of the higher level alluvium, probably due to the rather stagnant water of the latter. Nevertheless all forests described here are highly disturbed. County soil surveys (U.S.D.A.) indicate that they are waterlogged during winter but during summer they dry out allowing easy access by foot. Thus "swamp forest" is here used in the broad sense of Braun to include forest with at least seasonal waterlogging. Good indicator species of this environment were found to be *Quercus palustris, Q. bicolor* and, less frequently, *Liquidambar styraciflua.* This paper reports on the distribution of *Q. bicolor* throughout the Bluegrass, Knobs and adjacent Mississippian Plateau to the south, and on the composition of some of these forests in the Knobs.

TOPOGRAPHY AND GEOMORPHOLOGY OF THE SITES

Inspection of topographical and geological maps suggested the best places to look for swamp forests. They (Fig. 1) are mainly in valleys west of, and between, the Knobs at altitudes of 700-840 feet (210-260 meters), above the present levels of the Licking and Red Rivers at 600-700 feet (200-300 m). In flat areas on top of the

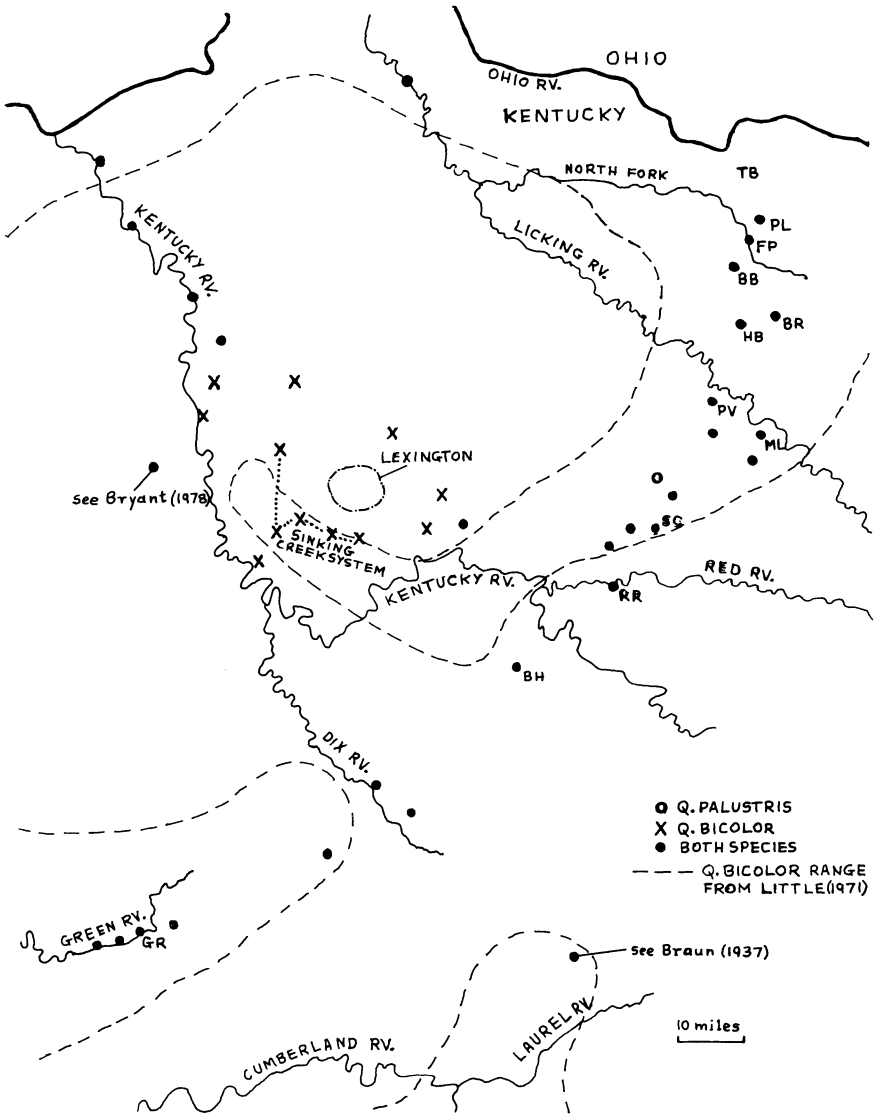


Figure 1. Location of swamp forest sites.

Knobs (such as Maxey Flats in Fleming County and Sharkley Flats in Rowan County) at about 1000 feet (310 m) the rocky terrain supports only forests in which *Quercus alba* and *Carya* spp. dominate. West of these valleys the land rises toward the Lexington Peneplain at 900-1000 feet (275-310 m); however, in this area we found swamp forest remnants, mostly in old courses of the

Table 1. Locations, Elevations and Abbreviations for Sites

Site and Abbreviation	*Location*		*Elevation*
	Lat.	*Long.*	*(meters)*
Red River, RR	N37° 51′	W83° 56′	200-250
Slate Creek, SC	N37° 57′	W83° 49′	240-250
Mud Lick Creek, ML	N38° 04′	W83° 39′	210-215
Polksville, PV	N38° 10′	W83° 38′	215-220
Hillsboro, HB	N38° 19′	W83° 38′	250-260
Big Run, BR	N38° 20′	W83° 33′	215
Bluebank, BB	N38° 25′	W83° 39′	265-270
Foxport, FP	N38° 28′	W83° 34′	240-250
Powderlick, PL	N38° 30′	W83° 34′	240-250
Green River, GR	N37° 12½′	W85° 02½′	220-230
Tollesboro, TB	N38° 32′	W83° 36′	260-270
Brodhead, BH (no species list)	N37° 25½′	W84° 23′	375

Kentucky River. Some of these are at the same level as those along the Knobs, others are higher, up to 950 feet (290 m).

The forests along the Knobs are mainly on clayey terrace deposits derived from the Silurian Upper Crab Orchard Formation, a clay-shale which is relatively impermeable and very plastic when wet, and the superior Devonian Ohio Shale (Kentucky Geological Survey Quadrangle Maps). At the Big Run site (Table 1) we found sandstone boulders, probably Devonian and from the slopes of a nearby Knob. Sites in the Bluegrass are on deposits derived from Ordovician limestone and shale (Eden), those on the Mississippian Plateau from limestone, and those on the Cumberland Plateau from Pennsylvanian sandstone (Pottsville and Lee) and shale.

Some old Kentucky River course sites are on Pliocene or Pleistocene deposits as interpreted by Jillson (1943, 1947). Others may date back to the Mesozoic (Sinking Creek system and nearby—Fig. 1) and are described by Meijer (1976). Fenneman (1938) and Thornbury (1965) correlate the more recent high level terraces along the Kentucky, Red, Licking and Alleghany Rivers with abandoned river valleys on the Allegheny Plateau in-

cluding the preglacial Teays River. As described by Versteeg (1946), the Teays River, before being diverted by glaciation to the present Ohio Valley, rose in the eastern escarpment of the Blue Ridge in North Carolina and Virginia and flowed to north of the glacial boundary. He explains the upper limit of 860 feet (265 m) for silt deposits in the Teays system of southeast Ohio and adjacent Kentucky as far west as the Licking River, by assuming that valleys were ponded in glacial periods. Glacial boulders of large size have been found in and around this ponded area (Jillson, 1924, 1925). In southern Ohio, Wolfe (1942) gives a map of the hypothetical Lake Tight using the 900 foot (275 m) contour line. He explains the great amount of deposit washed into the lake and ponded rivers by assuming there was high rainfall when cold glacial winds contacted warmer gulf air masses. The Kansan glaciation may have been the period with most deposition (Thornbury, 1965). The botanically unexplored Scottsburg lowlands of Jefferson County might correlate with these terraces, but are at a lower level of 450 feet (140 m).

METHODS

During 1974, forests with *Quercus bicolor* were mapped. At nine sites in the Knobs (Table 1), species lists were made, though these remain incomplete for herbaceous species at several sites. Also, lists were made at the Tollesboro site, which is relatively dry and lacks *Q. bicolor* though on high level alluvium, and at a Green River site to the southwest (Fig. 1). The areas covered by these lists range from 5 to 20 hectares. Collections of species were deposited in the Herbaria of the University of Kentucky and Morehead State University. Some duplicates were sent to the Herbarium of the Missouri Botanical Gardens. Plant nomenclature follows Fernald (1950).

To establish the floristic differences among these eleven sites, an ordination was made using the reference-stand method of Bray and Curtis (1957). Table 2 arranges species and sites according to their order along the primary compositional gradient.

RESULTS AND DISCUSSION

Phytogeography

Table 2 lists tree species at the eleven sites studied. It provides many more tree species than the preliminary descriptions

Table 2. Tree Distribution in the Swamp Forests in Relation to the Dominant Compositional Gradient[1]

Site abbreviation[2]:	*FP*	*BR*	*ML*	*PV*	*SC*	*RR*	*GR*	*BB*	*TB*	*HB*	*PL*
Height above stream (m):	4	0	0	7	0	15	0-10	0	20	10	7
Viburnum prunifolium										+	+
Carya ovata									+	+	+
Sassafras albidum								+	+		+
Celtis occidentalis								+	+	+	
Quercus rubra								+	+		+
Q. shumardii								+	+	+	
Ulmus americana							+		+	+	
Q. velutina							+	+			
Cornus florida							+	+		+	
Carya laciniosa							+				+
Corylus americana							+			+	+
Asimina triloba							+			+	+
Carpinus caroliniana					+	+	+	+	+		+
Q. stellata					+	+	+	+		+	
Q. imbricaria					+	+	+			+	
Liriodendron tulipifera					+	+	+	+	+		
Fagus grandifolia				+	+	+	+	+	+		
Q. alba			+	+	+	+	+	+	+		
Q. falcata					+	+	+				

Betula nigra					+	+					
Oxydendrum arboreum				+	+		+				
Alnus serrulata			+	+	+	+	+				
Ilex verticillata		+		+	+	+	+				
Liquidambar styraciflua	+	+	+	+	+	+	+				
Platanus occidentalis	+	+									
Fraxinus pennsylvanica[3]	+		+	+	+	+	+	+	+	+	+
Nyssa sylvatica	+	+	+	+	+	+	+	+	+	+	
Q. bicolor	+	+	+	+	+	+	+	+		+	+
Q. palustris	+	+	+	+	+	+	+	+		+	+
Rhus radicans	+	+	+	+	+	+	+	+		+	+
Acer rubrum	+	+	+	+	+	+	+	+	+	+	+

[1]Single occurrences are: GR—*Carya tomentosa, Parthenocissus quinquefolia, Lindera benzoin, Cephalanthus occidentalis, Q. michauxii*; PL—*Ulmus rubra, Morus rubra, Carya ovalis, Robinia pseudoacacia*; TB—*Acer saccharum, Carya glabra, C. cordiformis, Cercis canadensis*; RR—*Cornus ammomum.*

[2]See Table 1.

[3]Includes some *F. americana.*

by Braun (1950) of swamp forest in central Kentucky. In particular, she omits *Nyssa sylvatica* and *Quercus bicolor* from the Knobs, though found at most sites by us; she does not mention swamp forests in the Bluegrass. However, our list very generally fits her descriptions of swamp forests in the Knobs, Mississippian Plateau, Cliff Section and Illinoian Glaciated Section. The only southern species on the list are *Q. michauxii, Q. falcata* and *Liquidambar,* in contrast to her description of more southwestern swamp forests. The two northern species, *Q. palustris* and *Q. bicolor,* are more frequent. Braun describes the Knobs swamp forests as being on glacially ponded stream alluvium or on impervious Devonian shale (Ohio Black Shale) in line with the discussion above.

The record for *Quercus michauxii* at the Green River site adds a locality to its scattered known distribution in Kentucky (Little, 1971). This disjunct occurrence may be related to the discovery in the Bluegrass of *Taxodium distichum, Q. lyrata, Celtis laevigata* and *Carya illinoensis* (Braun 1943; Meijer 1971, 1976, unpublished), all disjunct from their more southwesterly continuous ranges and all bottomland species. These disjunctions could indicate a former extension of their continuous ranges, perhaps during warmer or wetter conditions. However, *C. illinoensis* may have been planted. In related discussion, Braun (1950) suggested that the extension of southern swamp forest in the Wabash and Green River valleys of Indiana is either a relic of warmer climate or is due to fragmentation of swamp habitat with spreading alluviation from the western edge of the Interior Low Plateau.

This study, with that of Meijer (1976), adds several new localities (Fig. 1) to the known range of *Quercus bicolor* (Little, 1971). Further discoveries might be made along Casey Creek in Pulaski County. It would be interesting to know when and where this species and *Q. palustris* originated. They have similar distributions (Little, 1971) though *Q. palustris* has slightly more southern north and south boundaries. From this study it appears that, at least in the Knobs and Bluegrass, their southern extensions are mostly on glacially ponded river deposits. Conceivably, they originated in such areas, isolated from the main deciduous

forest belt shifted southward during cold, dry glacial periods (Whitehead, 1973).

The discovery of *Habenaria flava, H. clavellata* and *H. lacera* adds to their occurrence in southeastern Kentucky described by Braun (1943). *H. clavellata* has also been found along Tygarts Creek in Carter County by Michael Huffacker (personal communication).

Floristic Differences Between Sites

Height above nearest permanent stream is shown in relation to the major compositional gradient in Table 2. The trend suggests that much variation in the tree stratum composition is related to soil moisture. *Fagus, Liriodendron, Quercus alba, Q. velutina, Q. stellata, Carpinus caroliniana* and others concentrate on raised sites, while *Liquidambar, Betula nigra, Platanus, Ilex verticillata* and *Alnus serrulata* concentrate on the wetter sites. This distribution of species is well known (Braun, 1950; Fowells, 1965). Within the Green River and Licking River sites a gradual transition can be clearly observed from swamp forest to *Fagus-Liriodendron-Quercus alba*-dominated forest at the bases of hills.

At the upland extreme of the gradient (Table 2), the Powderlick and Hillsboro sites appear especially distinct. They lack many of the common species but are characterized by the occurrence of *Carya* spp., *Asimina, Corylus* and *Viburnum prunifolium,* though *Carya laciniosa, Asimina* and *Corylus* also occur at Green River, and *Carya ovata* occurs at Tollesboro. These four sites are the only ones around which limestone or dolomite occurs on geological quadrangle maps, with the addition of the Foxport site which also lacks several common species. There is only scattered pH data available from county soil surveys (U.S.D.A., 1963, unpublished); in general pH is 4-5. However, *Liquidambar, Platanus, Fagus, Quercus alba, Oxydendrum, Betula nigra* and *Ilex* spp. are relatively acidophilous or acid tolerant (Fowells, 1965; Meijer 1971). Thus, their absence at Powderlick and Hillsboro, and the presence of species such as *Carya* spp., often associated with less acid soil (Braun, 1950; Fowells, 1965), support the idea that pH is involved. Possibly differences in degree of disturbance are also involved; *Fagus* is generally late-successional (Fowells, 1965) and *Liquidambar* often follows *Q. palustris* in

Table 3. Herbaceous Species Found in the Swamp Forests[1]

Site abbreviation[2]:	*FP*	*BR*	*ML*	*PV*	*SC*	*RR*	*GR*	*BB*	*TB*	*HB*	*PL*
Liparis lilifolia									+	+	
Podophyllum peltatum							+	+	+	+	
Sedum ternatum							+		+		
Lobelia cardinalis							+				+
Lycopodium complanatum						+				+	
Carex crinata					+	+	+			+	
Scutellaria incana					+	+				+	
Tipularia discolor					+	+				+	
Carex lurida		+								+	+
Asclepias incarnata		+								+	
Habenaria ciliaris			+		+	+					
Carex lupulina		+			+	+	+				
Carex debilis		+		+	+	+	+				
Scutellaria laterifolia	+	+			+	+	+				
Onoclea sensibilis	+	+			+	+	+				
Osmunda regalis		+		+	+	+					
Rubus hispidus		+			+	+					
Osmunda cinnamomea		+			+	+					
Athyrium felix-foemina		+			+	+					
Rhexia virginica		+			+	+					

Panicum dichotomiflora		+			+	+
Carex frankii		+	+		+	+
Spiraea tomentosa	+	+			+	+

[1]Single occurrences are: TB—*Botrychium dissectum, Thelypteris hexagonoptera, Collinsonia canadensis, Mitchella repens, Phryma leptostachya, Uvularia perfoliata*; BR—*Habenaria clavellata, H. lacera, Lygodium palmatum*; HB—*Goodyera pubescens, Smilacina racemosa*; FP—*Penthorum sedoides*; SC—*Habenaria peramoena*; GR—*Alisma subcordatum, Arisaema triphyllum, Sagittaria engelmania, Smilax herbacea, Cinna arundinacea, Glyceria striata, Leersia virginica, Panicum dichotomum, P. stipitatum, Angelica triquinata, Boehmeria cylindrica, Chelone glabra, Cuscuta compacta, Eupatorium perfoliatum, Hypericum tubulosum, Impatiens capensis, Lycopus virginicus, Mimulus alatus, Polygonum biflorum, P. sagittatum, P. setaceum, Saururus cernuus, Thalictrum polygamum.*

[2]See Table 1.

secondary succession on the Illinoian Till Plain (Chapman, 1942; Braun, 1936).

The typical swamp forests in the Inner Bluegrass, underlain by limestone, lack *Liquidambar, Fagus, Quercus Alba, Q. stellata, Q. palustris, Betula nigra, Ilex verticillata, Alnus serrulata, Nyssa, Acer rubrum, Corylus,* and *Liriodendron,* but they have in common with the Knobs sites *Celtis occidentalis, Ulmus americana, Platanus, Carya laciniosa, Fraxinus* spp. *Asimina, Q. shumardii* and *Q. bicolor* (Meijer, 1976; Campbell, unpublished). Their composition is more similar to the Powderlick and Hillsboro sites than to others described in Table 2. But where forest grows on recent Pliocene terraces in the Inner Bluegrass (e.g., Bryant, 1978), with increased acidity, composition is more similar to the other gradient extreme. To summarize, this gradient may be part of the rough regional association between limestone bedrock, increased drainage and disturbance (Braun, 1950; Campbell, unpublished).

In Table 3 the occurrences of herbaceous species are shown in relation to the tree stratum gradient. It should be remembered that most sites have been only partially searched for species. So far *Podophyllum, Sedum, Liparis,* etc., are associated with dry sites, while *Habenaria* spp., *Carex debilis, C. frankii, C. lupulina, Spiraea, Onoclea, Tipularia* and *Scutellaria* spp., etc., are associated with wetter sites.

Though not yet surveyed in detail, the moss flora is probably the best indicator of soil acidity. On neutral to basic soil *Fontinalis* and *Climacium americanum* are found; on acid soil *Atrichum undulatum, Polytrichum, Sphagnum capillaceum* and locally *S. palustre* are found. *Osmunda regalis, Thelypteris palustris* and *Habenaria clavellata* are associated with *Sphagnum.* The most abundant *Sphagnum* is at the Big Run site in keeping with its extreme position on the gradient, presumably due to very wet and acid conditions.

Conservation

The swamp forest sites may all disappear as a consequence of the following environmental changes:

(a) Urban development on flood plains. An example is the area around Clay City.

(b) Conversion to agricultural land for crops under increased pressure on farmers for production. Examples are the Slate Creek site and along the Dix River near Crab Orchard.

(c) Cutting without cultivation. For oil and gas pipeline rights-of-way this is not serious. At the Slate Creek site the openings created are populated with *Sphagnum, Polytrichum, Rhexia* and *Habenaria ciliaris.* Timber logging as long as it is selective does not much affect the flora.

(d) Grazing. Especially when done by pigs. This has a serious effect on the flora; they dig up most herbaceous growth except ferns. Cattle grazing involves a great deal of trampling and hence a sparser undergrowth.

(e) Drainage. This may be a special danger where spring floods no longer occur due to upstream dam projects, for example, along the Green and Licking Rivers.

(f) Flooding from dam projects of the Army Corps of Engineers. The resulting Cave Run Lake on the Licking River, the Green River Lake and the Cumberland Lake have probably destroyed many swamp forest sites. Under the Cumberland Lake many such sites existed as noted on old topographic maps. The proposed Falmouth Dam on the Licking River will flood some areas protected from flooding by the Cave Run Dam.

The following reasons can be given for keeping the swamp forests intact.

(a) They contain some of the most endangered plants of Kentucky.

(b) Their ecology has been very little studied, for example, their variation in relation to the many geological formations on which they occur.

(c) They and their history are part of the natural heritage of the State. It is possible that they contain peat or sediment deposits containing prehistoric pollen; this would be of great value since Kentucky has not yet yielded such sites. However, soil aeration may be too high for pollen preservation.

(d) They can serve as flood water buffers and reservoirs.

(e) They are locally productive forests, being more suited to woodland than agricultural management (U.S.D.A., 1963).

None of the forests is in a National Forest, a State Forest or a wildlife preserve. The only measures available at present for conservation are:

(a) Protection in agreement with landowners. Under the new Scenic Easement Law and Nature Preservation Law (Kentucky Revised Statutes, 1976 Supplements November 4 and 27), the State may guarantee such protection after the landowner's death.

(b) Cooperation with the Soil Conservation Service and its program for endangered plants and animals.

(c) Cooperation with the State Forest Service for continued inventory and investigation of the swamp forests.

(d) Their purchase by private nature conservation organizations.

(e) Their inclusion in a system of state-owned natural areas seems the best answer to the problem. The only area in Kentucky which is state-owned as a purely natural area is the Lilley Cornett Woods (Martin, 1975).

Of these sites, the Brodhead site is especially rich and undisturbed and most deserves protections. Fortunately, the Little Laurel River site to the south (Fig. 1), which was described by Braun (1937), still remains with its local rarities. It also deserves high priority in protection.

ACKNOWLEDGEMENTS

William Bryant drew our attention to the Anderson County site. Charles Andre, John MacGregor and Ray Cranfill assisted in plant collection. William Martin made useful comments on the manuscript and independently discovered the Brodhead site.

LITERATURE CITED

BRAUN, E. L. 1936. Forests of the Illinoian till plain of Ohio. Ecol. Monog. 6:89-149.

————————. 1937. A remarkable colony of coastal plain plants on the Cumberland Plateau in Laurel County, Kentucky. Amer. Midl. Nat. 18:363-366.

————————. 1943. An annotated catalog of spermatophytes of Kentucky. J. S. Swift Co., Inc., Cincinnati. 161 pp.

————————. 1950. Deciduous forests of Eastern North America. Blakiston Co., Philadelphia. 596 pp.

BRAY, J. R., and J. T. CURTIS. 1957. An ordination of the upland forest continuum of South Wisconsin. Ecol. Monog. 27:325-349.

BRYANT, W. S. 1978. An unusual forest type, hydro-mesophytic, for the Inner Bluegrass region of Kentucky. Castanea 43:129-137.

CHAPMAN, A. G. 1942. Forests of the Illinoian till plain of southeastern Indiana. Ecology 23:189-198.

FENNEMAN, N. M. 1938. Physiography of the United States. McGraw-Hill Book Co., New York. 714 pp.

FERNALD, M. L. 1950. Gray's manual of botany. American Book Co., New York, N.Y. 1632 pp.
FOWELLS, H. A. 1965. Silvics of forest trees of the United States. U.S.D.A. Agriculture Handbook 271. 762 pp.
JILLSON, W. R. 1924. Glaciation in Eastern Kentucky. Pan-American Geologist 42:125-132.
————————. 1925. Early glaciation in Kentucky. Ibid 44:17-21.
————————. 1943. An abandoned Pliocene channel of the Kentucky River. Roberts Printing Co., Frankfort, Kentucky. 16 pp. (Abstract in Amer. J. Science 241: 761-763).
————————. 1947. Pliocene deposits of the lower Kentucky River valley. Roberts Printing Co., Frankfort, Kentucky. 15 pp.
LITTLE, E. L. 1971. Atlas of United States trees. Vol. 1, U.S.D.A. Misc. Publ. 1146.
MARTIN, W. H. 1975. The Lilley Cornett Woods: a stable mixed mesophytic forest in Kentucky. Bot. Gaz. 136:171-183.
MEIJER, W. 1971. Tree Flora of Kentucky. University of Kentucky. 141 pp.
————————. 1976. Notes on the flora of the Sinking Creek system and the Elkhorn source areas in the Inner Bluegrass Region of Kentucky. Trans. Ky. Acad. Sci. 37: 77-84.
THORNBURY, W. D. 1965. Regional Geomorphology of the United States. John Wiley & Sons. 609 pp.
U.S.D.A. 1963. Soil Survey of Bath County Kentucky. 126 pp.
VERSTEEG, K. 1946. The Teays River. Ohio J. Sci. 46:297-307.
WHITEHEAD, D. R. 1973. Late Wisconsin vegetational change in unglaciated North America. Quaternary Res. 3:621-631.
WOLFE, J. N. 1942. Species isolation and a Postglacial lake in southern Ohio. Ohio J. Sci. 42:2-12.

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