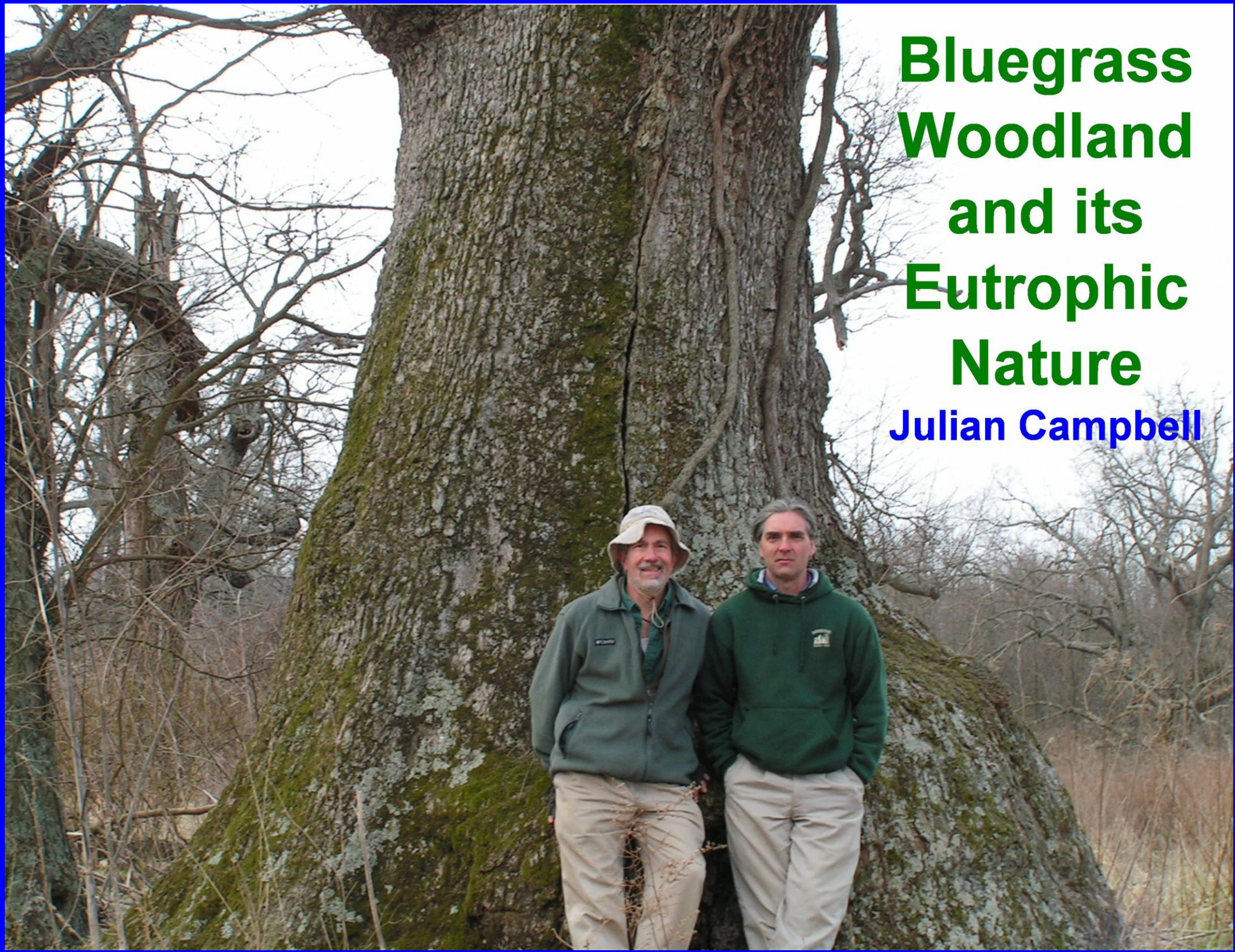


Bluegrass Woodland and its Eutrophic Nature

Julian Campbell

"The beautiful estate of Spring Hill, originally consisting of upward of 3,000 acres, comprised a military grant to Captain Nathaniel Hale."

Bluegrass Woodland and Its Eutrophic Nature: native vegetation on uplands with deep well-drained soils in the Bluegrass Region of Kentucky Notes by Julian Campbell, Aug 2013

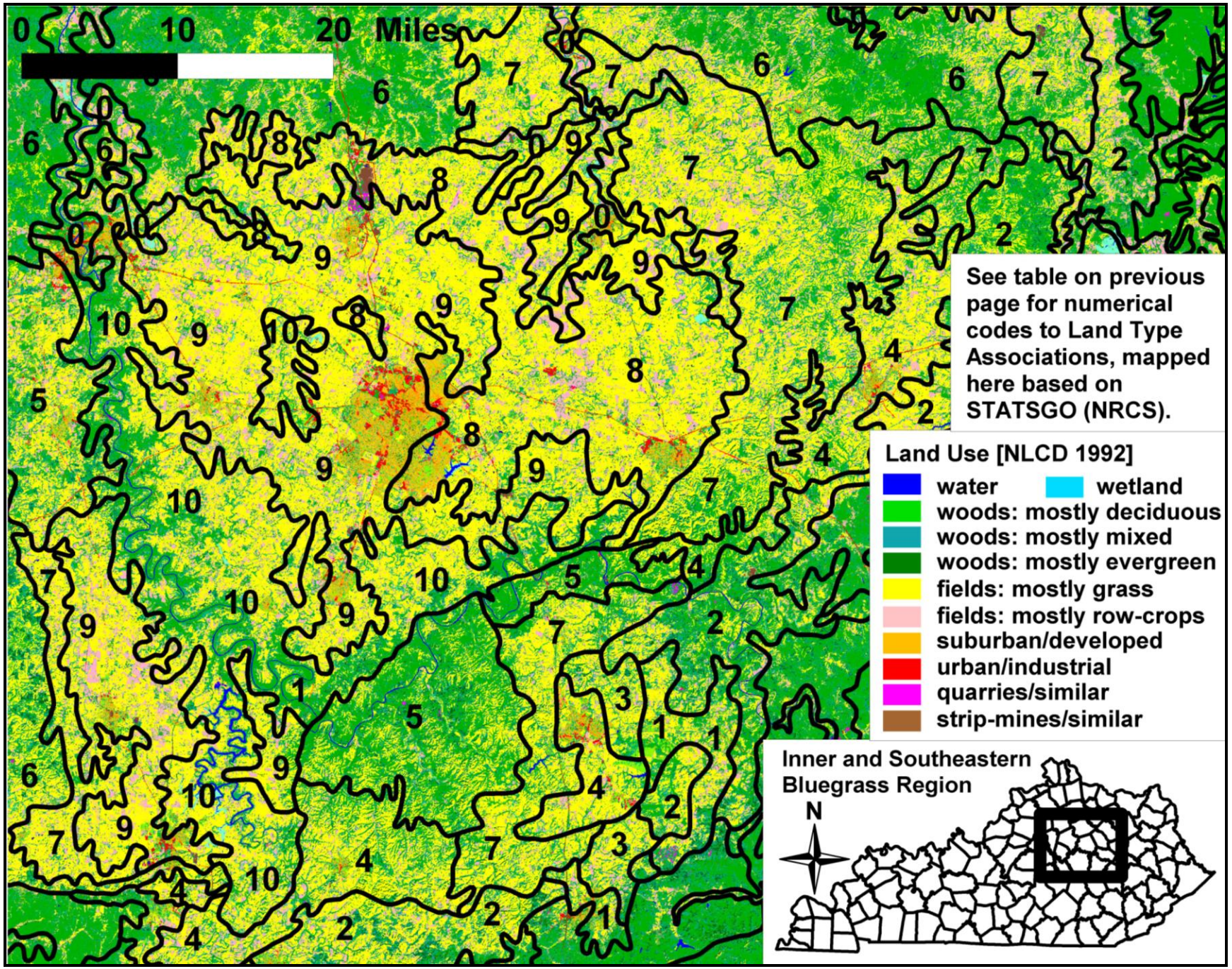
Summary. Bluegrass Woodland, as defined here, used to occupy most uplands within the Inner Bluegrass region of Kentucky, and it occurred locally on similar soils elsewhere in the Ohio Valley. Typical soils are eutrophic alphisols, formed in deep ancient residuum of weathered limestone that is phosphatic in places. Original topsoil was highly organic, especially in drier and wetter transitions (grading into mollisols). Riparian zones and wetlands are excluded from this description, although they are often intermixed and some woods on high terraces along larger streams closely resemble the general upland type. Also excluded are shallower, rocky soils along the Kentucky River Palisades, but there are broad gradual transitions.

For many millenia, there has been considerable disturbance here from herbivores, including elk and bison. Large animals concentrated in the region due to the productive, mineral-rich forage. Human disturbances have also played an increasing role, but there is virtually no evidence of fires before Virginian settlement, unlike in the "barrens" further west. Less disturbed areas had deeper woods with much sugar (or black) maple and bitternut hickory. Areas with intermediate influence of disturbance had frequent Ohio buckeye, ashes, elms, walnuts, hackberry, hickories and a few oaks. The most open disturbed areas had frequent bur oak, locusts and locally dominant cane.

Most of the original woodland has now been converted to farmland, then urban land in some places. Several plants and animals are now locally extinct, including the elk and bison, while many have become endangered, at least within the region. Alien plants have become abundant in the woods. Alien animals, pests and pathogens are also causing severe problems. Complete restoration is impossible, but much could be learned from experiments with livestock to simulate effects of the larger herbivores. There is also a great need to propagate and replant selected species of native plants. A program for restoration could be based at Griffith Woods, in Harrison County.

Below: table showing general sequence of geology, soils and original woodland on uplands of the southeastern Bluegrass. Zonation is irregular; more rugged Eden Shale Hills are interrupted to the east. Bluegrass Woodland was prevalent in 9, less so in 4, 8 &10.

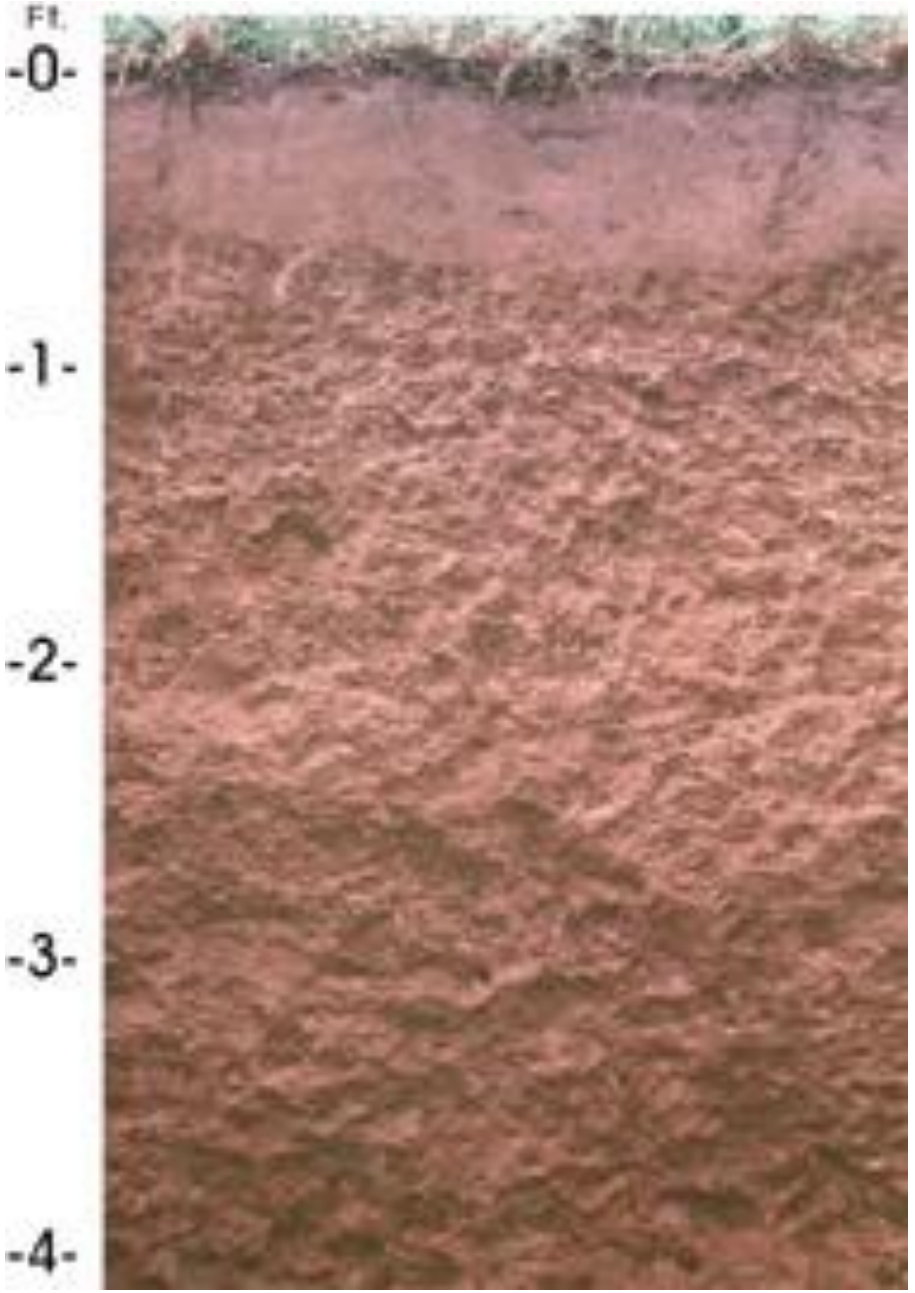
Land Type Associations: with typical geological strata	Typical soil series: from deeper to shallower	Typical trees in original woodland from historical data
0. River Bottoms	Huntington, Elk etc.	See riparian notes
1. Eastern Foothill Flats: acid shales etc.	Robertsville, Lawrence, Nicholson	red maple, pin oak sweetgum, black gum
2. Dolomitic Foothills: Silurian dolomite, shale, siltstone	Crider, Otway, Beasley, Shrouts, Brassfield	sugar maple etc., on mesic; post oak, red cedar, grass on xeric
3. Eastern Bluegrass: with damp flats	As in 4 but with local Robertsville, etc.	transitional mixes from 4 to 1
4. Eastern Bluegrass Plains: limestones, calcareous shales	Shelbyville, Caleast, Lowell, Faywood	sugar maple, beech and tulip (esp. on loess), varied oaks
5. Eden Shale Hills: with much siltstone, also calcareous shale	Eden, Culleoka, Lowell	sugar maple, beech, tulip, oaks (N red, white, black), ashes
6. Eden Shale Hills: with much calcareous shale, also limestone	Lowell, Faywood, Cynthiana, Eden	sugar maple, oaks (northern red, chinq., shum., white, black, post), hicks., ashes
7. Eastern Bluegrass Hills: transitional	Lowell, Faywood, Cynthiana	transitional mixes from 8 to 6 or 4
8. Eastern Bluegrass Plains: transitional	Nicholson, Lowell, Faywood	transitional mixes from 9 to 7
9. Inner Bluegrass: phosphatic limestone, local calcareous shale	Nicholson, Maury, McAfee	black maple, bitternut, buckeye, ashes, elms, walnut, oaks (with bur, no white)
10. Palisades section: varied limestones (some dolomitic)	Elk (old terraces), Maury, McAfee, Fairmount	maples, basswood, beech, oaks (with white instead of bur)


0 10 20 Miles
See table on previous page for numerical codes to Land Type Associations, mapped here based on STATSGO (NRCS).
Land Use [NLCD 1992]
water
wetland
woods: mostly deciduous
woods: mostly mixed
woods: mostly evergreen
fields: mostly grass
fields: mostly row-crops
suburban/developed
urban/industrial
quarries/similar
strip-mines/similar
Inner and Southeastern Bluegrass Region
N

Geology and soils. The Central Bluegrass region is loosely defined here to include the Inner Bluegrass, underlain by Middle Ordovician bedrock, plus southeastern transitions to shaley bedrock of the "Eden Shale Hills." The latter Upper Ordovician shale interdigitates in several areas with the partly phosphatic limestones of the Inner Bluegrass. Typical soils on uplands are well-drained hapludalfs (McAfee and local Faywood/Salvisa[1], Lowell[1], Ashton/Armour[3]), more ancient paleudalfs (Maury and local Braxton[2], Elk[3], Shelbyville[4]) or local fragiudalfs (Nicholson). Largely calcareous soils have relatively high pH (ca. 6-7). Soils with more shale ([1]), chert ([2]), old alluvium ([3]) or looess ([4]) tend to have greater acidity (pH of ca. 5-6). Loess (old wind-blown dust) is a more significant component of upper horizons further west within the Bluegrass region, formerly supporting much beech and tulip.

The first diagram below (p. 6) places Bluegrass Woodland within the broader context of major ecological gradients on uplands of the Ohio Valley. Native vegetation shifts greatly from eutrophic soils with relatively high pH and high nutrient levels, to more acid infertile soils. Clearance, farming and development has obliterated much of this pattern in the Bluegrass, but small remnants and clues still exist.

Although woodland on Bluegrass uplands appears to have been relatively homogeneous over large blocks of land, some variation may have been associated with patterns in soil. Before settlement, some soils were highly organic (mollic) in upper horizons, especially those that graded into hapludolls on shallower sites (Fairmount, Cynthiana), or hapludalfs with deeper loess (Shelbyville), or argiudolls on damper sites (Loradale, Donerail). It has been suggested that mollic soils in this region were promoted by high grass or cane content in the vegetation. Distinctive riparian zones or wetlands form a minor part of the landscape, and are generally excluded from definition of the woodland. However, riparian zones are often intermixed, and some woods on high terraces along larger streams closely resemble the general upland type. Also excluded in general are forest types of shallower, rocky soils along the Kentucky River Palisades, but there are broad gradual transitions to these types.



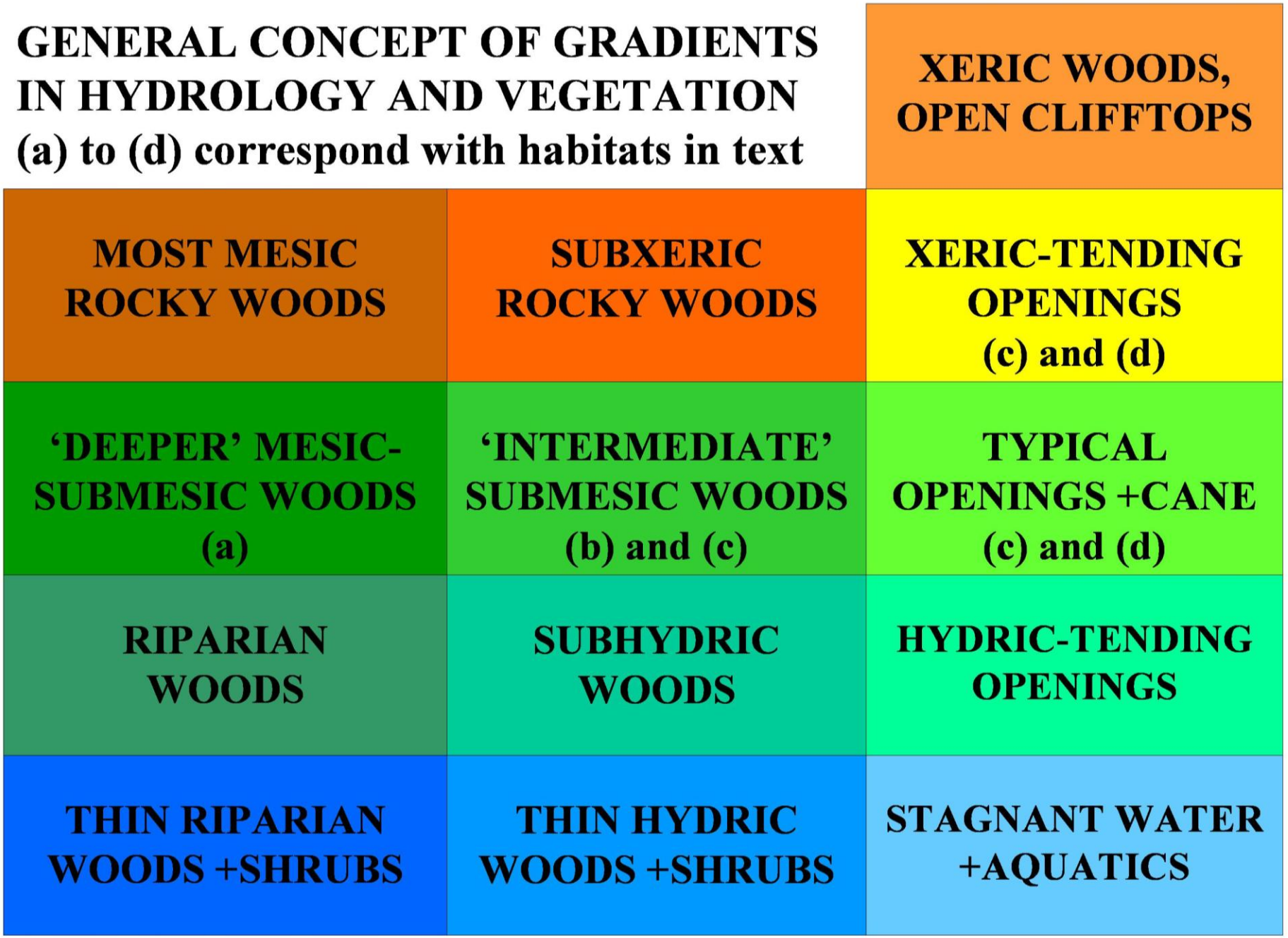
Maury silt loam in Woodford County, with reddish-breown color due to Fe_2O_3; blackish concretions with Mn and P occur at lower levels.

GRADIENTS IN ORIGINAL WOODS OF THE OHIO VALLEY ON GENTLE SLOPES WITH DEEP SOILS

Numbers are codes (CEGL) for vegetation types of NatureServe, followed by abbreviations for latin names of typical species. This is a general summary for Kentucky and parts of adjacent states. Excluded here is vegetation typical of steeper slopes or rocky sites with subxeric to xeric conditions. Also, distinct subhydric or hydric vegetation is excluded. However, historical interpretations remain uncertain in many areas, and the available classifications indicated here need not have exact matches with historical types. In particular, note that bur oak-blue ash "savanna" of the Bluegrass region (*) was created for pasture out of deeper woods.

open scrubby/grassy woods **oak woods** **hemlock woods** **beech/maple woods** **walnut+ woods**

POSITION ON DISTURBANCE GRADIENT	TYPICAL POSITION ALONG pH-RELATED GRADIENT IN SOILS		
	POOR ACID SOILS (pH ca 4-5) ultisols or dystrochrepts	**AVERAGE SOILS (pH ca. 5-6) mixed or intermediate classes**	**BASE-RICH SOILS (pH ca. 6-7) alfisols, eutrochrepts or mollisols**
SCRUB/GRASSY TRANSITIONS	ERICACEOUS SCRUB 8470: Kallat-Gaybac/bra ????: Vacarb	FORMER BARRENS SCRUB ????: Corame; Rhucop; Salhum 4732: Rubspp-Smispp (old fields)	CANEY OR THORNY SCRUB ????: Pruspp; Craspp; Rhugla; Rubpen 3836: Arugig
OPEN WOODS OR THICKETS	GRASSY/SCRUBBY PINE-OAK 3617: Pinrig 4445: Pinech-Quemon-Queste 3759: Pinech-Quealb/ste/fal/ste	POST OAK, SASSAFRAS+ 4686/2075/2417: Queste(mar/fal)-Carspp 4096: Sasalb-Quespp 4133: Pruser-Sasalb-(Fraame)	BUR OAK, LOCUST+ 7281/7279: Robpse-(Celocc) 4544: Quemac-Queshu-Carcor 4436/3835: Fraqua-Quemac-(Quemuh)*
SUBMESIC TO OPEN	SHORTLEAF PINE-OAK 7493: Pinech-Quemon/fal 8427: Pinech-Quealb 7244/7247: Quefal(alb/coc/ste)-Caralb	MIXED OAK+ (varied mixes) 7795: Quealb-Cartom-(Quevel) 5018: Quefal-Quealb-Queste-Quevel 6599: Pruser-Lir-Acerub-Fraame-(Rob)	WALNUT (O.BUCKEYE, ASH, ULM.) 4437: Jugnig-Aesgla-Gymdio 4693/7879: Jugnig-(Celocc) 7180: Fraame-Jugnig-Ulmrub
SUBMESIC WOODS	N.RED OAK, FORMER CHESTNUT 7286: Casden-Querub (formerly) 7300: Querub 6192: Querub-Acerub	WHITE OAK-N.RED OAK+ 2067/7233: Quealb-Querub-Carspp 5014: Faggra-Querub-Acerub-Jugnig 8428: Qua-(Lirtul, Liqsty)	BITTERNUT/WALNUT/ULMACEAE+ 4697: Cellae/occ-Ulmspp-(Aesgla) 6445: Carcor-Pruser 4741: Acesac-Carova-Jugnig
MESIC TO SUBMESIC	HEMLOCK+ (varied mixes) 6923: Tsucan-Quemon-Betlen 7565: Tsucan-Acerub-(Lirtul, Nyssyl)	BEECH-MAPLES-TULIP (varied mixes) 7881/5015: Faggra-Qua(mic)-(Acerub) 7201/6055: Faggra-Lirtul-(Carcor) 6201: Acesac-Lirtul-Fraame	S.MAPLE (BITTERNUT, W.ASH+) 4411: Acenig/sac-Carcor 6237: Acesac-Fraame-Tilame-Lirtul 7711/6054: Tilame-Fraame-(Ulmrub)
MESIC WOODS	HEMLOCK-BEECH (+magnolias) 7136: Tsucan 5043: Tsucan-Faggra-Acesac 8407: Tsucan-(Faggra, Tilhet)	BEECH-SUGAR MAPLE-TULIP 7200: Faggra 2411: Faggra-Acesac-Lirtul	S.MAPLE-BASSWOOD-S.BUCKEYE 7695: Aesfla-Acesac-(Fraame, Tilhet) 6471/6472: Acesac-Tilhet-(Aesfla) 8412: Acenig/sac-Tilame


GENERAL CONCEPT OF GRADIENTS IN HYDROLOGY AND VEGETATION
(a) to (d) correspond with habitats in text
XERIC WOODS, OPEN CLIFFTOPS
MOST MESIC ROCKY WOODS
SUBXERIC ROCKY WOODS
XERIC-TENDING OPENINGS (c) and (d)
'DEEPER' MESIC-SUBMESIC WOODS (a)
'INTERMEDIATE' SUBMESIC WOODS (b) and (c)
TYPICAL OPENINGS +CANE (c) and (d)
RIPARIAN WOODS
SUBHYDRIC WOODS
HYDRIC-TENDING OPENINGS
THIN RIPARIAN WOODS +SHRUBS
THIN HYDRIC WOODS +SHRUBS
STAGNANT WATER +AQUATICS

Diagrams on two previous pages [the color schemes are different]. The first summarizes forest types of mesic to submesic or disturbed sites across the Ohio Valley, illustrating gradients of increasing base-status (left to right) and stress or disturbance (lower to upper). The second is independant of base-status but expands gradients of hydrology and associated disturbance into two dimensions.

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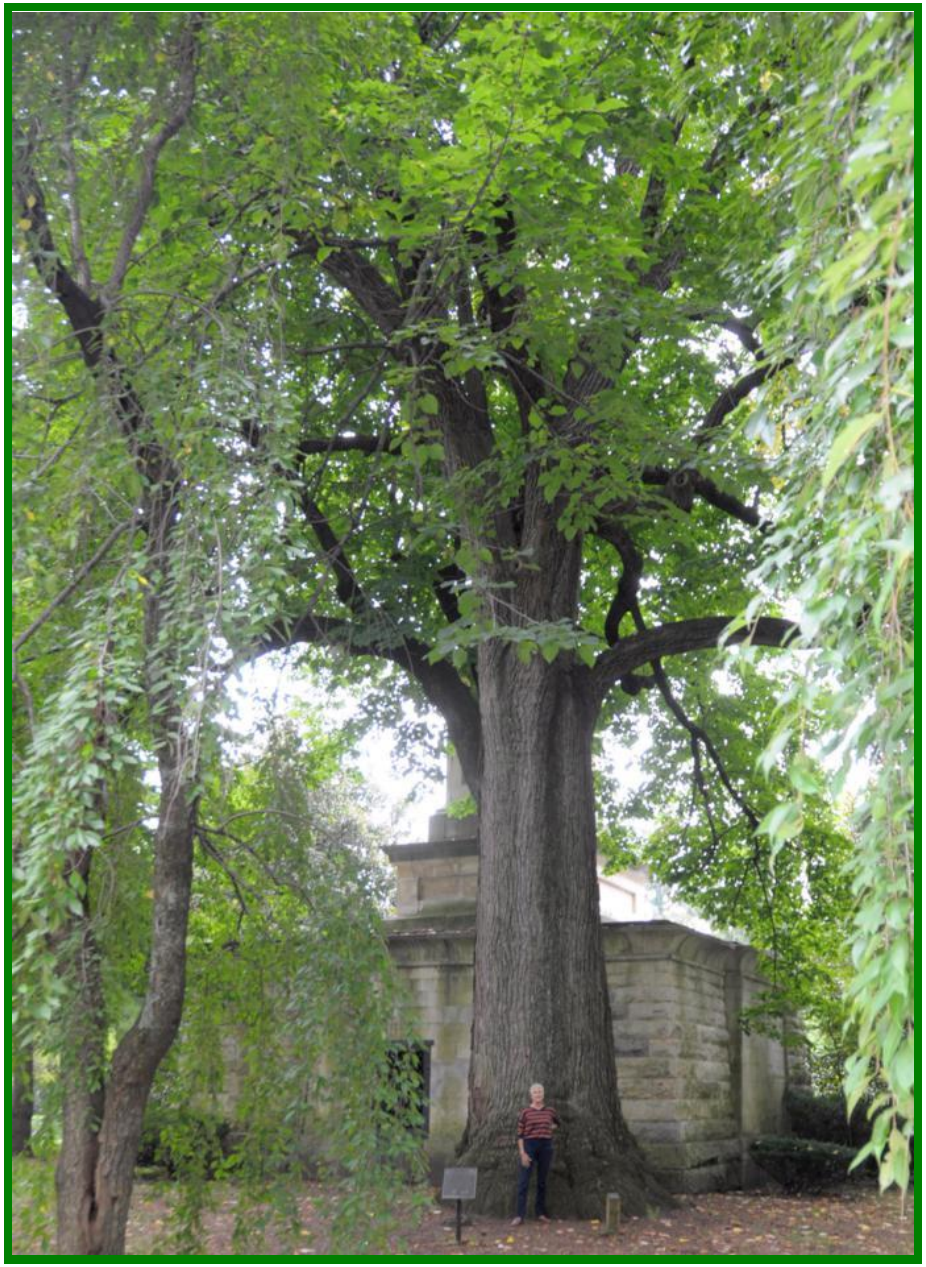
Gradients of hydrology and associated disturbance. It will be important to develop ecological concepts further, relating responses of individual species to major environmental factors. Particular descriptions of habitats, with listed species, should be viewed merely as reference points. Most sites are mixed or transitional, to some degree, between two or more of the habitat classes outlined below. And there is much local variation in habitats at scales of 10-100 feet.

The second diagram above (p. 7) illustrates the somewhat independant nature of hydrological gradients: from mesic to hydric (6 & 3 to 1 & 2); and from mesic to xeric (6 & 3 to 7 & 5). Many sites are prone to stress from both poor drainage, especially in winter, and drought, especially in the summer. Such seasonal fluctuations tend to be most pronounced on flatter uplands and high terraces, which are concentrated in the right-central sector of the diagram. Less hilly land, in general, also tends to have experienced more general disturbances from browsing, burning, clearing of woodland and development of human uses.

Within the original landscape of the central Bluegrass uplands, historical data and modern remnants indicate that there was a disturbance-related gradient of confluent vegetation types, as follows.

(a) Relatively deep, shady woods with abundant sugar or black maple and bitternut hickory; plus lesser amounts of elms, walnuts, ashes, hackberry, basswood, buckeyes, basswood; rare beech and tulip. Lower strata probably included hornbeam, spicebush, ginger, mayapple, hyacinth, sessile trillium and several sedges, but few grasses. Typical species are coded 1 or 2 in list below.



Large basswood at tomb of Henry Clay in Fayette Co., about 209 cm dbh and 29 m tall; it may be native, but the species is rare on uplands.

(b) Intermediate woodland with abundant ashes and elms; or walnuts and buckeyes; or oaks (bur, chinquapin, shumard) and hickories (bitternut, shellbark, shagbark); plus minor amounts of hackberry, mulberry, black cherry, coffee tree and locusts. Lower strata probably included pawpaw, blackhaws, buffalo clovers, white snakeroot, Solomon's seal, grasses (woodland species of rye, fescue, bluegrass) and several sedges. Typical species are coded 3 or 4 in list below

(c) Shrubby thickets, formerly widespread but now much restricted: especially cane or plums; also hawthorns, roughleaf dogwood, briars, sumacs etc. This varied class of vegetation mostly occupied transitions from intermediate woods (b) to more open land (d).

(d) More open woods with persistent seasonal disturbance or stress, characterized by some long-lived trees (especially bur oak), but much mixed with above types (especially locusts). Peavine (*Amphicarpaea*) was abundant, often growing on cane, also tall herbs such as goldenrods, asters, sunflowers, wingstems and ironweed. There were probably few abundant grasses, other than wild ryes (esp. *Elymus virginicus*) and early panic (*Dichanthelium clandestinum*) and more weedy warm-season species (nimble-will, purple-top, lens-grasses, etc.). Typical species are coded 5 or 6 in the list below.

The disturbance-related gradient tends to be more complex on base-rich soils (as indicated in the first diagram), which is interpreted here in terms of an ancient association with concentrated herbivory. Ashes, elms, hackberry and mulberry are relatively palatable trees typical of 'submesic' woods with intermediate influence of disturbance. But other submesic trees have distinctive toxic or thorny character that suggests evolution to resist herbivory by larger animals: buckeyes, shellbark hickory, walnuts, coffee tree*, honey-locust* and osage orange*. Also, a few of these trees (*) have fruit that is often dispersed through the guts of larger animals. Changing patterns of browsing and other disturbances probably used to cause much intermixing of vegetation (types a to d). An old bur oak (d) might become surrounded by younger maples (a) where disturbance has been relaxed. Patches of deeper woods might become opened up due to herbivores, especially if forage increaes under gaps in canopy.

Typical 'intermediate woods' at Griffith Woods, with buckeye, walnut, hackberry, wild rye and intense browsing by deer.

A hypothetical model of the original dynamics within this woodland (colored pink at right-center on p. 6) can be developed with reference to similar concepts in Europe (e.g. Vera 2000); see Campbell (2012a) for details. For intermediate woodland (b) in particular, such models could help explain the large amount of variation among the proportions of different trees species. This variation was probably associated with shifting patterns of herbivory, especially larger migrating animals such as bison. A somewhat cyclical process can be envisaged, with animals opening up gaps in deeper woods that became filled with palatable plants, then leaving more toxic or thorny plants to prevail in the eventual regrowth.

The more disturbed variants with much opening in the tree canopy (c and d above) appear to have covered only 1-10% of the region. However, canebrakes (c) were highly distinctive bands across the landscape, much noted by early settlers. It was only after settlement that the characteristic modern remnants of ancient woodland developed, dominated by large oaks and ashes (modified d). These savanna-like "woodland-pastures" were created on more prosperous estates by thinning of the original forest and sowing of bluegrass (often called "English grass"). However, it remains possible that some bluegrass (Poa pratensis) was native here—perhaps the narrow-leaved form (matching ssp. angustifolia) that is common in old fields, often mixed with goldenrod.

Cross-walk with other classifications. In the Kentucky Natural Heritage system (of Ky. State Nature Preserves Commission), the woodland types outlined above correspond approximately to their "calcareous" or "deep soil" mesophytic forest (a in part); "mesophytic cane forest" (b, c); and "Bluegrass woodland" (b, c, d). However, without some concept of the underlying ecological gradients among the classes of KSNPC, these concepts are often difficult to apply. NatureServe Explorer (see website) offers a more detailed classification, though still unconnected to gradients. Their closest matches (with CEGL codes) are as follows: 4411 (a); 2014, 4436, 4437, 4741 (b); 3835, 3836, 7281 (c, d); 6480 etc. (d in part).

Old bur oak at Griffith Woods, with younger 'intermediate woods' of walnut and hackberry around it; plus a remnant of deeper woods in the vernal herbs, *Erythronium albidum* (white trout lily).

The “hickory thicket” at Griffith Woods, behind some of the ancient trees. These young shagbarks (mostly *Carya laciniosa*) came to dominate about five acres where mowing ceased during the 1980s. Continued grazing by cattle allowed the unpalatable hickories to prosper.

Restored cane, with :Layton Register and bur oak along the stream known as Cane Run. Cane used to extend along this creek from Lexington to Georgetown in 1775. We planted 150 cane 5-year old seedlings here in 1999/2000, along rows either side of the creek, and plants have now spread over two acres. This remnant of old woodland is also remarkable for the large patches of the running rue-anemone, *Enemion biternatum*.

Characteristic native species. A list of vascular plants is appended below that includes those typical of the full range of conditions on well-drained uplands, from deeper woods to full sun. Each species is given a numerical code to indicate its average position along this disturbance-related gradient.
1 = deeper shade; usually with much sugar or black maple (type a).
2 = average woods; usually a mix of deeper and 'intermediate' woods
3 = thin woods, often with trails; usually within 'intermediate' woods
4 = edges of woods, brushy old-fields and similar vegetation.
5 = full sun in grass or forb; including much old field vegetation.
6 = full sun on bare ground, rock, shore or water; many annuals.

The book by Wharton & Barbour (1990) provides a more comprehensive listing of all native vascular plants and vertebrate animals in the region. But further work is needed to segregate those animals that would most likely have been part of the original upland fauna. A wealth of miscellaneous information on natural history exists in various museums, literature and personal records. A revival of research on restored remnants of the vegetation would be useful.

Rare species of plants and animals. Most of the typical plants in this woodland—together with its subxeric or riparian transitions and its most open variants—have become uncommon to locally extinct in more intensively farmed sections of this region. Some species are rare to endangered within most of the Ohio Valley: e.g. *Juglans cinerea, Floerkea proserpinacoides, Orbexilum onobrychis, Nabalus crepidineus, Lilium michiganense*. A few are globally imperiled: *Physaria globosa*, *Trifolium stoloniferum* and an undescribed species of *Trifolium*. See list below for details.

The larger mammals have mostly disappeared. Remaining vertebrates that are rare in the region are mostly restricted to more open areas, and in some cases may be adventive. These include the least weasel, grasshopper sparrow, Henslow's sparrow, bobolink and northern leopard frog. Several species of bat would have occurred in the original woodland. The Gray Bat and Indiana Bat are now globally endangered. Data on lepidoptera are still being assembled.

Clovers: *Trifolium kentuckiense* (above) and *T. stoloniferum* (below)

Kentucky Coffee Tree (*Gymnocladus dioicus*): a largely midwestern species that has unusual characteristics for a tree, with laterally suckering roots, large bipinnate toxic leaves, dioecious flowers and large fruits dispersed by ungulates or other large herbivores.

Honey Locust (*Gleditsia triacanthos*): related to coffee tree, also largely midwestern and with some similar characteristics, but it is protected against large herbivores by large spines rather than by toxicity. Both species are concentrated in eutrophic woodland.

Issues in conservation. Most original woodland has been converted to farmland, then urban land in some areas, and there is much uncertainty about how to proceed. More effort should be made to outline ecological concepts for the historical nature of this vegetation and its future desired condition. Much historical information exists, but more should be assembled, analyzed and reviewed. Ecological models need to be developed, generating functional hypotheses.

Some upland sites have been protected from development, including the 745 acres with Griffith Woods in Harrison County. However, there has been little development of cooperative programs for restoration, related research and education. There is also much more protected land along the Palisades, where some transitional areas could become managed with disturbance regimes that simulate the presettlement uplands. A good regional effort would enable regular meetings, sharing of information, and resolution of issues. Conservation, as a whole, would benefit greatly from more regular collaboration between government agencies, non-profit organizations and private land-owners. There appears to be little coordination in restoration methods. Synthesis of information from projects would be useful, building an accessible long-term record of activities that are designed to improve watersheds and restore riparian zones.

Some critical questions for research involve effects of browsing, burning, mowing or other cutting. There is much interest in how such disturbances might maintain diverse native composition. Most of the rarer plant species appear to have depended on disturbance for reducing competition from dense ground vegetation. Several of these species tend to be concentrated along trails within woodland today. There was probably much seasonal variation in the degree of disturbance. As summarized elsewhere, a “Herbivore Hypothesis” for Bluegrass Woodland can be developed from historical details, such as the seasons with most reports of bison in the region. During 1750-90, these reports were most frequent during May-June and, to a lesser extent, November; none were made during August and January. If fires were also a significant factor in some areas, they probably occurred mostly on drier uplands and in late summer to fall.

Horse farm scene: the most affluent land of the region is now highly manicured, but scattered old native trees remain (here ash and maple).

Cow in woods: this was a much more common sight 100-200 years ago; experimental use of livestock in the woods is now needed.

Much propagation of selected native plants is needed. The situation would be improved if 'plants-people' of any type with interests in restoration would meet regularly, share information and address critical issues. Leadership could come from TNC, Kentucky Native Plant Society, Nature Preserves Commission, Wild Ones and other relevant organizations. It would be especially useful to anchor such efforts partly at the University of Kentucky. That institution has much potential to help, but it needs a revival of mutual support involving the Arboretum, Herbarium and associated people.

Alien species have caused much decline in naturalness of the vegetation. There has been general devastation by invasive plants, especially bush honeysuckle, purple winter-creeper, garlic mustard and common chickweed. It is likely that appropriate disturbance regimes can reduce this problem, but experiments are needed. For example, intensive browsing during later summer to fall is expected to target the alien plants more than common natives, most of which tend to be relatively slow-growing or dormant during that season.

Even more insidious problems are the pests and pathogens on some common tree species, especially Dutch elm disease (during past decades), emerald ash borer (with current epidemic), and the cankers of walnuts (on white during past decades, and on black now expected). DED has done much damage, but many seedlings and young trees remain. Better assessment of the problem is needed, and selection of more resistant material for planting. EAB is starting to devastate green and white ashes, but may spare most blue ash, based on reports from Michigan and Ohio. Selected trees are being treated with insecticide. The USDA has begun to collect seed for future recovery and breeding. And some ecological research is being initiated at the University of Kentucky (by L. Rieske-Kinney et al.). It is likely that a comprehensive community-wide effort could be organized, but only if interested people would meet and communicate with more regularity. The new "Thousand Cankers" on black walnut may also become devastating. These profound challenges to our woodlands should cause deeper bonding among conservationists, in order to find common ground and improve our collective responses.

Bush honeysuckle tends to be most common along fencerows.

Winter-creeper often dominates ground within intermediate woods.

Running buffalo clover (*Trifolium stoloniferum*) in nursery: photo at Griffith Woods, by author. This experimental bed was established in 2006-2008, with artificial shade that enhanced growth. But management of the farm became fractured and this effort was suspended.

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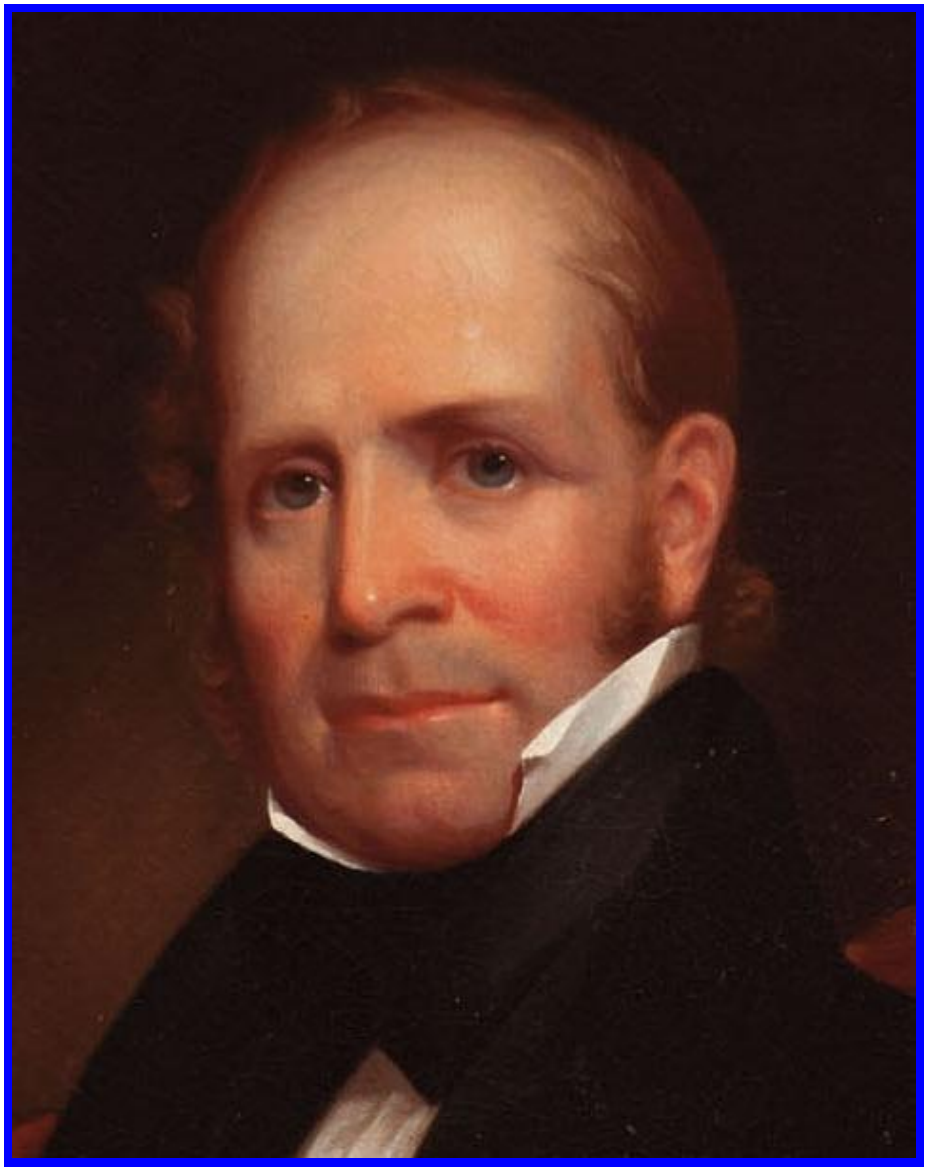


Charles Wilkins Short (1794-1863): first botanist to reside in Kentucky for most of his life. He collected and wrote much on botany, as well as being employed as a medical doctor. His 1828-29 notes on the Lexington area cover only the spring flora, but contain many insightful glimpses of the region's ecology at that time.

Typical Native Species
This list assembles species recorded from uplands of the central Bluegrass or their transitions. It excludes those largely restricted to springs, open stream corridors, subhydric or hydric sites, rocky soils along the Palisades, and acid soils typical of Eden Shale or alluvial sand. Decisions to include some species remain uncertain. For common names, see associated files at website and Jones' (2005) guide to Kentucky plants.

The following marginal marks, symbols or codes provide details for each species.

? = In these species, there is uncertainty about the appropriate native versus alien classification. Some of these may have spread up from the south after agricultural developments before 1492. Others may include mixed genotypes from North America and Eurasia. *Maclura pomifera* (osage orange) is a special case—relictual southwest of this region, without postglacial recolonization due to extinction of its equine agents of dispersal.

s.l. = sensu lato, implying that taxonomic segregates do occur.

[ ] = broader genus concept; mostly old-fashioned concepts replaced in usage of recent decades.

1 to 6: = openness scale; see text for further explanation
1 = deeper shade.
2 = average woods
3 = thin woods
4 = edges of woods etc.
5 = full sun in grass or forb
6 = full sun on bare ground etc.

Letter codes = habitat variations.
a = concentrated on more acid soils (especially Eden Shale).
h = some subhydric concentr.
r = some riparian concentration.
x = some subxeric concentration.
Many additional species can be expected in such transitions.

Underlined = locally common today, including some weedy habitats of modern landscape.

Bolded = may have been locally abundant in the presettlement landscape, based on historical accounts

* uncommon in most of region.
** regionally rare/state-listed.
*** regionally imperiled/gone.
Some rare species used to be much more extensive.

Larger trees
***Acer nigrum* 1**
***Acer saccharum* 1**
***Aesculus glabra* 2**
***Carya cordiformis* 1**
Carya laciniosa 2h
Carya ovata 2x
Celtis occidentalis 3
***Fraxinus americana* 3**
Fraxinus biltmoreana 3x
***Fraxinus quadrangulata* 2x**
Gleditsia triacanthos 4
Gymnocladus dioica 3
****Juglans cinerea* 3a**
***Juglans nigra* 3**
Liriodendron tulipifera 2a
?*Maclura pomifera* 4r
Morus rubra 3
Prunus serotina 4
Quercus imbricaria 4xh
Quercus macrocarpa 4
Quercus muhlenbergii 2
Quercus rubra 1a
Quercus shumardii 3
***Robinia pseudoacacia* 4**
Tilia americana s.l. 1
***Ulmus americana* 3r**
***Ulmus rubra* 2**

Small trees, shrubs and vines
***Arundinaria gigantea* 4**
***Asimina triloba* 3**
Bignonia capreolata 2
Campsis radicans 4
Carpinus caroliniana 2
Celastrus scandens 4x
Cornus drummondii 4
Corylus americana 4a
Crataegus crus-galli 4x
Crataegus mollis 4
Crataegus pruinosa 4a
Euonymus atropurpurea 3
Frangula caroliniana 4 [*Rhamnus*]
Lindera benzoin 1
Parthenocissus quinquefolia 2
Phoradendron leucocarpum 3
***Prunus americana* 3**
**Prunus munsoniana* 4
**Ptelea trifolia* 4rx
Rhus glabra 4
Rosa setigera 4xh
Rubus flagellaris s.l. 5
Rubus occidentalis 4
Rubus pensilvanicus 5
Sambucus canadensis 4
Smilax bona-nox 4x
Smilax hispida 3
***Symphoricarpus orbiculatus* 4**
Toxicodendron radicans 3 [*Rhus*
Viburnum prunifolium 3
Viburnum rufidulum 3x
***Vitis vulpina* 3**
***Zanthoxylum americanum* 4x**

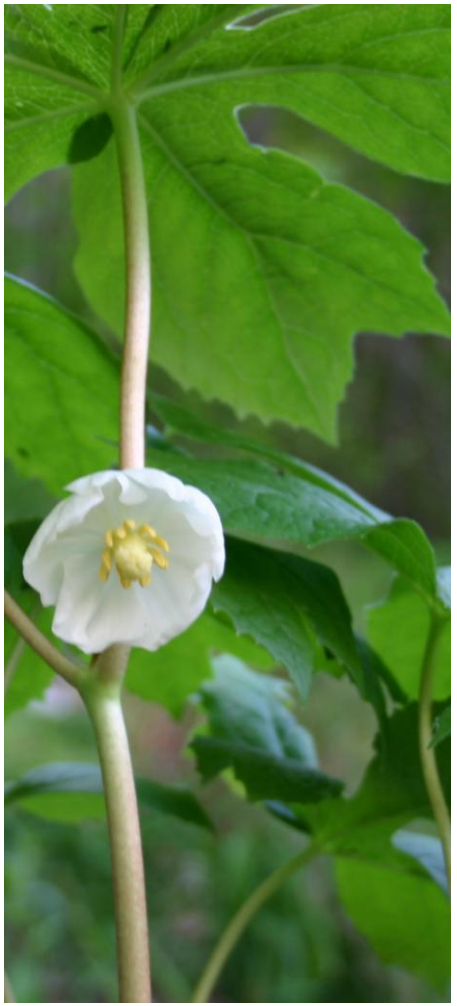
Ferns and allies
Asplenium platyneuron 3x
Botrypus virginianus 3 [*Botrychium*]
***Cystopteris protrusa* 2**
***Dryopteris carthusiana* 2h**
Ophioglossum pycnostichum 3a
Sceptridium dissectum s.l. 3a [*Botrychium*]

Some species of deeper woods (coded 1 or 2 in list)

These are largely restricted to better woodland remnants

Erythronium albidum
White trout lily
Locally common in a few remnants of upland woods, but mostly eradicated.

Camassia scilloides
Wild hyacinth
Locally common in a few remnants of upland woods, but mostly eradicated.



Podophyllum peltatum
Mayapple
Locally dominant in better remnants of upland woods, especially where browsed.

Solidago flexicaulis
Zig-zag goldenrod
Common in ravines, but virtually absent on uplands; may have been more widespread.

Herbs: not legumes/composites
Acalypha ostryifolia 6
Acalypha rhomboidea 6
Agastache nepetoides 4
Agrimonia pubescens 2x
Agrimonia rostellata 2
Amaranthus hybridus 6
Amaranthus retroflexus 6
Anemone virginiana 3x
Antenoron virginianum 2
[*Polygonum*]
Apocynum cannabinum 5xr
Arabis virginica 6
***Asarum canadense* s.l. 1**
Asclepias syriaca 5
Asclepias tuberosa 5ax
Asclepias viridis 5x
Blephilia ciliata 4x
**Blephilia hirsuta* 2
Calystegia fraterniflorus 5
[*Convolvulus*]
Campanula americana 3
Cardamine douglasii 2x
Cardamine pensylvanica 6
**Cerastium nutans* 4r?
***Chaerophyllum procumbens* 3**
Chamaesyce maculata 6
Chamaesyce nutans 6
[*Euphorbia*; and previous]
Circaea canadensis 2h
Claytonia virginica 3
***Collinsia verna* 2**
Corydalis flavula 3
Cryptotaenia canadensis 2r
Cuscuta pentagona s.l. 5
Cynanchum laeve 5
Delphinium tricorne 2x
Dentaria diphylla 1
***Dentaria laciniata* 3**
[*Cardamine concatenata*]
***Dicentra canadensis* 1**
Dicentra cucullaria 1r
Enemion biternatum 1r
***Erigenia bulbosa* 1**
***Euphorbia commutata* 2**
Fallopia scandens 4r
[*Polygonum*]
***Floerkea proserpinacoides* 2h**
Fragaria virginiana 5x
?*Galium aparine* 3
[uncertain status]
Galium triflorum 2
Gaura biennis 5r
Geranium carolinianum 6
Geranium maculatum 2a
Geum canadense 4
Geum vernum 3
Hackelia virginiana 3
Houstonia lanceolata 4x
**Hydrastis canadensis* 1ax
***Hydrophyllum appendiculat.* 2r**
**H. canadense* 1r
***H. macrophyllum* 1x**
Hypericum punctatum 5
Impatiens capensis 4r
**Impatiens pallida* 2r
Iodanthus pinnatifidus 2
Ipomaea hederacea 6
Ipomaea lacunosa 6r
***Jeffersonia diphylla* 1x**
***Laportea canadensis* 1r**
Lepidium virginicum 6
Leucospora multifida 6r
Lobelia inflata 3a
Lobelia siphilitica 5r
Menispermum canadense 4
Mertensia virginica 1r
Monarda fistulosa 5x
**Monarda "serotina"* 2r
Myosotis macrosperma 3
Oenothera biennis 6
****Onosmodium hispidissim.* 5x**
Osmorhiza claytoni 2
***Osmorhiza longistylis* 3**
Oxalis dillenii 3
Passiflora lutea 3
Penstemon calycosus 5
Penstemon digitalis 5h
***Perideridia americana* 3x**
***Phacelia purshii* 3**
***Phlox divaricata* 1**
Phlox paniculata 2r
Phryma leptostachya 2
Physalis heterophylla 5
Physalis subglabrata 5
****Physaria globosa* 4x**
[*Lesquerella*]
Phytolacca americana 4
***Pilea pumila* 2r**
Planodes virginica 6
Plantago rugelii 4
Plantago virginica 6x
***Podophyllum peltatum* 2**
Polemonium reptans 1
Polygala lonchophylla 1x
Persicaria erecta 6
Persicaria lapathifolia 6h
Persicaria pensylvanica 6h
Persicaria punctata 3r
[*Polygonum*]
Prunella lanceolata 4
***Ranunculus abortivus* 3**
Ranunculus hispidus 2
Ranunculus micranthus 2x
Ranunculus recurvatus 4
Ruellia strepens 4
Salvia lyrata 4a
Sanguinaria canadensis 1
Sanicula canadensis 3
***Sanicula odorata* [*gregaria*] 2**
Sanicula trifoliata 1
Scrophularia marilandica 3
Scutellaria incana 4a
Scutellaria nervosa 2
Sedum ternatum 1
Silene stellata 2x
Solanum carolinense 5
Solanum ptycanthum 6
***Stellaria corei* 1**
**Stellaria pubera* 1a
Teucrium canadense 4
Thalictrum dioicum 1
**Thalictrum pubescens* s.l. 3ar
Thalictrum thalictroides 1a
**Urtica chamaedryoides* 3
***Urtica gracilis* 4r?** (see text)
***Valerianella radiata* 3**
Verbena urticifolia 4
Veronica peregrina 6
Viola bicolor 6
***Viola papilionacea* 4**
Viola pubescens 1
Viola sororia 2x
***Viola striata* 3**
**Zizia aurea* 4r

Some species of intermediate woods (coded 3 or 4 in list)

These are widespread in thin woods, but not full sun.

Viola striata
White stemmed violet
Common in moderately disturbed woods; tolerates some browsing or mowing.

Phacelia purshii
Miami mist
Locally abundant in thin woods, especially where not browsed or mowed until mid-summer.

Osmorhiza longistylis
Smooth sweet cicely
Widely scattered but not generally common, except in moderately disturbed woods.

Ageratina altissima
White snakerroot
Common and locally dominant in moderately disturbed woods; generally avoided by herbivores.

Legumes

***Amphicarpaea bracteata* s.l. 4**
**Desmanthus illinoensis* 5r
**Desmodium cuspidatum* 4x
**Desmodium glutinosum* 2
Desmodium paniculatum 4a
**Demodium pauciflorum* 3
Desmodium perplexum 5
*Lespedeza frutescens*4x
****Orbexilum onobrychis* 4x
[*Psoralea*]
Senna marilandica 5 [*Cassia*]
****Trifolium kentuckiense* 3x
******Trifolium stoloniferum* 3**

Composites

***Ageratina altissima* 3**
[*Eupatorium rugosum*]
Ambrosia artemisifolia 6x
***Ambrosia trifida* 6r**
**Astranthium integrifolium* 5
Bidens bipinnata 6x
Bidens frondosa 4h
Brickellia eupatorioides 5x
Cirsium discolor 5
Conoclinium coelestinum 4h
[*Eupatorium*]
Conyza canadensis 6
[*Erigeron*]
***Elephantopus carolinianus* 3**
Erechtites hieracifolia 4a
Erigeron annuus 6
***Erigeron philadelphicus* 4**
Erigeron strigosus 6x
Eupatorium altissimum 5x
**Helianthus decapetalus* 3
**Helianthus grosseserratus* 5
***Helianthus tuberosus* 4r**
Heliopsis helianthoides 5
Lactuca biennis 4
Lactuca canadensis 6
Lactuca floridana 3
**Nabalus altissimus* 2
***Nabalus crepidineus* 3
[*Prenanthes*]
**Ratibida pinnata* 5x
Rudbeckia laciniata 3r
Rudbeckia serotina 5
Rudbeckia triloba 4
Packera aurea 3ar
Packera obovata 2x
[*Senecio*; and previous]
Silphium perfoliatum 4r
**Silphium trifoliatum* 4x
Smallanthus uvedalius 3
[*Polymnia*]
***Solidago altissima* 5**
Solidago flexicaulis 1
Solidago ulmifolia 2x
Symphyotrichum cordifolium 2
S. lateriflorum 3ar
S. novae-angliae 5
***S. ontarione* 4**
S. pilosum 5
S. prenanthoides 3ar
S. shortii 2x
[*Aster*; and previous six spp.]
***Verbesina alternifolia* 4r**
Verbesina occidentalis 4a
Verbesina virginica 4
***Vernonia gigantea* 5**

Monocots: non-graminoid

**Aplectrum hyemale* 2
**Arisaema dracontium* 3h
Arisaema triphyllum 1
***Erythronium americanum* 1**
***Erythronium albidum* 1xh**
***Galearis spectabilis* 2
Liparis liliifolia 3a
***Lilium michiganense* 4
Maianthemum racemosum 1
***Polygonatum biflorum* sl. 2-3xr**
Smilax herbacea s.l. 3
Spiranthes gracilis 5a
**Spiranthes ovalis* 3a
Spiranthes vernalis 5axh
***Trillium sessile* 2**

Monocots: graminoids

***Allium canadense* 3**
Andropogon virginicus 5
Bromus pubescens 2x
****Camassia scilloides* 2**
Carex aggregata 5
Carex annectans 5xh
***Carex blanda* 3**
***Carex brevior* s.l. 5
Carex communis 1x
Carex conjuncta 5h
***Carex davisii* 4**
Carex granularis 5h
***Carex grisea* 3**
**Carex hirtifolia* 1
***Carex jamesii* 2**
Carex laxiflora 1
Carex leavenworthii 5hx
Carex mesochorea 5
Carex molesta 5h
**Carex normalis* 3
***Carex oligocarpa* 2x**
***Carex rosea* 2**
Carex shortiana 4h
***Carex sparganioides* 3**
Carex texensis 6
Cyperus esculentus 6hx
Cyperus squarrosus 6xh
Cyperus strigosus 6h
**Chasmanthium latifolium* 4r
Dichanthelium acuminatum 5a
***Dichanthelium clandestinum* 4**
[*Panicum*; and previous]
?*Digitaria ciliaris* 6
[uncertain status]
***Elymus macgregorii* 2**
***Elymus villosus* 2**
***Elymus virginicus* 3**
Eragrostis pectinacea 6
Eragrostis spectabilis 5
****Festuca subverticillata* 2**
***Juncus tenuis* 3**
***Leersia virginica* 3**
***Muhlenbergia schreberi* 3**
Panicum anceps 5a
Panicum capillare s.l. 6
Panicum dichotomiflorum 6
Paspalum laeve 5a
Paspalum pubiflorum 5
?***Poa angustifolia* 5**
[uncertain status]
****Poa sylvestris* 2**
Setaria parviflora 5
**Sphenopholis intermedia* 3
Sisyrinchium angustifolia 5
Sporobolus compositus 5x
Tridens flavus 5

Some species of open land (coded 5 or 6 in list)

These are largely restricted to fields, roadsides & open woods

Senna marilandica
Upland Senna
Common, forming large patches in some old fields and roadsides; not preferred by deer or cattle.

Desmodium perplexum
Old field tick-trefoil
Widespread in most old field field; locally abundant but much browsed by deer and cattle.

Vernonia gigantea
Common ironweed
Widespread and locally dominant in old pastures; not browsed by deer or cattle.

Solidago altissima
Old-field goldenrod
Widespread and becoming dominant in most old fields; somewhat browsed.

Appendix: Notes on Similar Vegetation in North America.
The primary interest here is to characterize the woods that used to be prevalent on more gentle slopes, terraces and flats with eutrophic soils that are now largely agricultural, not the woods that remain on steeper slopes that cannot be farmed. See "Revised Notes..." of Campbell (2012b) for a detailed listing of historical sources from the Bluegrass region, plus references to similar vegetation types in the National Vegetation Classification (NVC) of NatureServe (with their CEGL numbers). Those notes focus on the whole Bluegrass region, not just the central and southeastern sections mapped here (on p. 4). In more northern and western sections, highly eutrophic conditions with similar woodland were less extensive over the landscape before settlement. But remnants indicate that many areas with similar conditions did exist, from deeper woods with dominant sugar maple (e.g. Betz & MacMillan 2003, Held et al. 2006) to more open pastured woods with oaks and ashes (e.g. Bryant 1983).

(a) Deeper woods (CEGL 4411): with abundant *Acer saccharum* (sensu lato) or *Carya cordiformis*. This type has virtually disappeared from uplands of the Bluegrass region, except for small patches and remnants (G1). Elsewhere in the Ohio Valley and along the Delaware River (Pennsylvanica Natural Heritage Program), similar forest does occur on floodplain terraces (CEGL 5035), but that is also somewhat rare (G2/G3). Both variants have some similarity to several other current forest types in eastern states (such as CEGLs 2060, 6017, 6020, 6211, 6237, 6288, 6459, 6914, 7811); for published examples, see Geiss & Boggess (1976), Fleckenstein & Pippen (1977), Adams & Anderson (1980), the forest interior of Brothers (1993), and Ebinger et al. (1997). Those other types mostly have dominant *Acer saccharum* (sensu lato), plus locally abundant *Fraxinus americana* (sensu lato), *Juglans nigra* (or local *cinerea*) and *Tilia americana* (sensu lato). But unlike the Bluegrass Woodland, those types mostly lack abundant *Carya cordiformis* (except CEGL 2060). Several other midwestern studies could be cited that illustrate transitions from such highly eutrophic woods to woods with more *Fagus grandifolia* (e.g., Ruch et al. 1998). The potential role of *Fagus* litter in reducing soil fertility deserves much further attention (e.g., Finzi et al. 1998).

Despite thin coverage in the literature, there is evidence that a local sugar maple-bitternut association does exist, or used to exist, elsewhere on uplands in northeastern states and adjacent Canada. Smith (1990; and see Charron & Gagnon, 1991) noted: "In the southern part of Quebec, there is a sugar maple-bitternut hickory subtype that is restricted to deep soils. Trees associated with it include basswood (*Tilia* spp.), eastern hophornbeam (*Ostrya virginiana),* northern red oak (*Quercus rubra*), butternut (*Juglans cinerea),* and black maple (*Acer nigrum*)." Also, *C. cordiformis* was the most commonly associated canopy tree in "rich mesic forest" of western Massachusetts that is dominated by *Acer saccharum* dating from before 1900 (Bellemare et al. 2002), and it was among the most frequent tree species in undergrowth of younger stands there, together with *Acer saccharum*, *Fraxinus americana* and *Prunus serotina* (in 80-100% of 10×10 m plots). Moreover, from historical survey data, Grimm (1984) showed that *C. cordiformis*, although not nearly as abundant as *A. saccharum*, was the tree most closely associated with *A. saccharum* in the original "Big Woods" of southern Minnesota, followed by *Tilia americana*, *Juglans cinerea*, *Ulmus* spp. and *Fraxinus* spp. In a simpler analysis of "climax adaptation numbers" for southern Wisconsin, Curtis & McIntosh (1951) also showed that *C. cordiformis* is the tree closest to *A. saccharum* on this scale. *Carpinus* or *Ostrya* were common smaller tree species in the studies cited above. But oaks in general were much less frequent associates of *A. saccharum* in these forest types.

To the east, in or near Appalachian regions, some variants of mesophytic forests overlap slightly in composition with Bluegrass Woodland, suggesting ecological parallels for further investigation (Braun 1950; CEGLs 7695, 5222, 6055). Similar sites occur on base-rich "coves", gullies, hollows and terraces, often with old fields or other semi-open conditions where species of *Fraxinus, Ulmus* and *Juglans* are locally common, together with dense ground cover of herbs and cool-season grasses. Pawpaw patches (*Asimina triloba*) and canebrakes (*Arundinaria gigantea*) are often present, and in more disturbed areas black locust thickets are common in some localities. However, such vegetation is usually intermixed with tree more

Slippery (or Red) Elm (*Ulmus rubra*): formerly abundant in moderately disturbed woods on eutrophic uplands of eastern North America

typical of acid soils, such as *Liriodendron*, *Liquidambar* and *Acer rubrum*. *Aesculus flava*—not the midwestern *A. glabra*—often regenerates well in the dense ground vegetation. Moreover, *Carya cordiformis* is not usually abundant, and distinctive minor species of more disturbed or open woodland are usually absent, e.g., *Gymnocladus* and *Gleditsia*.

Within some Appalachian regions, calcareous soils support woodland that is especially similar to Bluegrass Woodland. In particular, several outlying populations of running buffalo clover (*Trifolium stoloniferum*) occur in or near the Allegheny Mountains of West Virginia (Burkhart 2010). Trees currently associated with this clover at the Fernow Forest are mostly *Acer saccharum* and *Liriodendron*. Ground vegetation includes much *Laportea canadensis* and *Ageratina altissima*, together with several of the same species as in Bluegrass Woodland (see attached Excel file)..

To the southwest, there is a somewhat similar type in the Ozark region: *Acer saccharum - Quercus rubra - Carya cordiformis* (CEGL 2060; see also Hoagland, 2000). However, this is largely restricted to floodplain terraces. The NVC outlines several other forest types in southeastern states that have abundant *C. cordiformis*, but usually with codominant oaks (*rubra, alba, pagoda, stellata*; *muehlenbergii, shumardii, macrocarpa*), with little or no *Acer saccharum* (sensu lato), and usually on floodplains.

(b) Intermediate woods. Provisional matches in the NVC can be found for the three suggested segregates: from ash/elm (CEGLs 2014 and 4436), to walnut/buckeye (CEGL 4437), to oak/hickory (CEGL 4741). The table below (p. 34) illustrates this gradient, and the indicated relationship with browsing influences.

Forest types with abundant ashes or elms on mesic to submesic uplands with deep soils, instead of sugar maples or basswoods, are not well documented in eastern states and some may be imperiled (more or less G2). In contrast, there is widespread occurrence of types with abundant *Fraxinus pennsylvanica* or *Ulmus americana* on floodplains and other subhydric sites. The Bluegrass uplands still contains many young stands with abundant *F. americana* in varied successional situations, but there is no clear match for this largely native vegetation in the NVC. Further north, Grimm (1984) found that elms (*americana* and *rubra*) had been the most common tree type in the Big Woods of southern Minnesota when first surveyed, not *Acer saccharum* or *Tilia americana* as in the presumed "climax" condition. This region, somewhat like the Bluegrass, is now largely agricultural or urban with only small scattered, disturbed woodlots. Similar woods may have occurred locally on the Tipton Till Plain of central Indiana, where Dutch Elm Disease has contributed much to the decline of *U. americana*; however, young trees of this species plus its associates can often regenerate into the new canopy (Parker & Leopold 1983). To the south, an *Ulmus* (*americana, rubra*) – *Quercus muehlenbergii* type (CEGL 2091) has been outlined on lowlands in Oklahoma and Texas; see also *Acer saccharum – Ulmus rubra – Juglans nigra* on canyon floors of western Oklahoma (CEGL 4794). *Fraxinus americana - Celtis laevigata - Nyssa sylvatica - Quercus shumardii - Ulmus americana* (CEGL 7897) occurs on calcareous clays in Louisiana and probably Texas. *Fraxinus americana - Juglans nigra - Ulmus rubra* / *Acer barbatum - Ostrya virginiana* / *Ptelea trifoliata* (CEGL 7180) is largely restricted to limestone on the Florida Panhandle.

Forest types with abundant *Juglans nigra* or *Aesculus glabra* are even more limited or poorly known, based on available descriptions. In addition to the two rare southern types with *J. nigra* noted in previous paragraph, the following types have been outlined provisionally in the NVC but not currently applied in the on-line version (Milo Pyne and Mary Russo, pers. comm.): *Juglans nigra - Celtis occidentalis* (CEGL 4693); *Juglans nigra - Fraxinus americana* / *Lindera benzoin* (CEGL 6449); *Juglans nigra - Quercus muehlenbergii* Forest (CEGL 7214); and *Juglans nigra* / *Verbesina alternifolia* (CEGL 7879). In the case of *Aesculus glabra*, there are only two similarly rare or obscure types in the NVC: *Acer barbatum - Aesculus glabra - Carya myristiciformis - Quercus shumardii - Quercus muehlenbergii* of Alabama and Mississippi (CEGL 4687);

Stinking (or Ohio) Buckeye (*Aesculus glabra*): still locally common in eutrophic woods, especially where browsed by cattle.

and *Celtis* (*laevigata, occidentalis*) - *Ulmus* spp. - (*Aesculus glabra*) of perhaps Alabama, Tennessee and Kentucky (CEGL 4697, provisional type not on-line). A remarkably high degree of similarity with Bluegrass Woodland can be found in some remnants of lowland woods of this type in the midwest. For example, Steinauer & Rolfsmeier (2003) described *Juglans nigra-Celtis occidentalis-Quercus macrocarpa* forest types in Nebraska (combined with CEGL 2052), where at least 80% of the vascular flora are shared with the 'intermediate' woods defined here. *Celtis occidentalis* is a more weedy tree that is often associated with *Juglans nigra*, and sometimes dominant (e.g., Bell 1980, Hood et al. 2008), especially in the understory where it is relatively shade tolerant.

Forest types with abundant oaks or hickories, plus species associated with browsing, do exist on deep mesic to submesic, eutrophic upland soils. However, good examples of what might be considered a relatively natural condition are uncommon. Characteristic species in these types include *Quercus macrocarpa, Q. muehlenbergii, Q. shumardii, Q. imbricaria, Carya cordiformis, C. laciniosa* and *C. ovata*, plus some other minor species. Elsewhere in eastern or midwestern states, most forest types dominated by these species tend to be on dry rocky soils (such as CEGL 4685, 5021, 5055) or wet flooded soils (such as CEGL 2098, 2140, 4544). But some oak-dominated types do occur on relatively mesic sites, with a species composition similar to 'intermediate woods' of the Bluegrass uplands.

● As noted in the previous paragraph, some midwestern remnants of *Q. macrocarpa* woodland (such as CEGL 2012, 2052), especially in transitions to *Juglans nigra, Aesculus glabra, Acer saccharum* or *Tilia americana*; see also Geiss & Boggess (1976). Miceli et al. (1976), forest edges of Brothers (1993), McClain et al. (1993), Szafoni et al. (1994) and Roovers & Shifley (1997).

● In the largely agricultural Champlain Valley of Vermont, *Q. macrocarpa* is locally abundant in woodlands and fencerows, together with *A. saccharum, Tilia, Fraxinus american, Ulmus* spp. and other common species of eutrophic soils; conservation problems are similar to the Bluegrass, but with different alien shrubs, *Lonicera* spp. and *Rhamnus* spp. (Thompson & Sorenson 2000, p. 171-175 and their citations); on drier sites in this valley, there is more coverage of oak-hickory forest, "often used as woodland pasture... open park-like... with sparse shrubs".

● *Q. imbricaria-Q. muehlenbergii-Q. shumardii* forest (CEGL 3876) in more southern Kentucky and Tennessee.

● In the Central Basin of Tennessee, *Q. macrocarpa* and *Q. muehlenbergii* appear to have been locally abundant in the original woodland of deep fertile well drained soils, but historical details remain poorly known (Braun 1950, DeSelm 1994).

● *Q. muehlenbergii-Q. shumardii* forest (CEGL 4602) of Arkansas and Oklahoma.

● *Quercus muehlenbergii* - *Quercus* (*alba, rubra*) - *Carya cordiformis* / *Viburnum prunifolium* (CEGL 4793) of mid-Appalachian regions.

The leguminous trees (*Gymnocladus,Gleditsia,Robinia*) may also be locally frequent in *Juglans/Aesculus* or *Quercus/Carya* variants. *Gymnocladus dioica* is a generally minor tree species that is often associated with *J. nigra* or *A. glabra*; its associated vegetation exemplifies the epitome of eutrophic woodland in eastern states (McClain 1973). In more northern sites, black locust (*Robinia pseudoacacia*) is not native but has been introduced and is locally problematic in sites with marginal fertility, since it invades natural savannas, resists fire, fixes nitrogen, and leads to significant changes in the ground vegetation (e.g., Peloquin & Heibert 1999).

The original degree of openness in some of these "forest types" or "woodland types" has been overestimated in some regions, as it has in the Bluegrass. In central Illinois, Szafoni et al. (1994) found that at the 325 acre Funk's Grove the open grown bur oaks with stem diameter of 85-160 cm (dbh) were only 110-140 years old, dating from 30-70 years after settlement. They stated: "Indeed, the public land survey description for the 0.5 mile that passes through this bur oak stand reads "timber black walnut, ash"... Without the information supplied by these increment cores, the existence of a mesic forest at this location would have been misinterpreted in favor of an open bur

Bur Oak (*Quercus macrocarpa*): a long-lived tree that can survive in deeper woods for centuries but prospers in the open.

oak savanna." For the woods of Nebraska, Steinauer & Rolfsmeier (2003) stated: "Some land managers have been led to believe these sites represent "degraded" oak savannas and should be destructively managed to restore savanna conditions (although herbaceous dominants of savanna communities are rarely, if ever, present in these sites). It is believed that since these sites occur along permanent streams (now extremely downcut), that periodic spring flooding may have protected these sites from fire and allowed them to maintain forest species. Currently, no level, lowland open oak woodlands or savannas are known in Nebraska."

(c) Shrubby or thorny thickets: with cane (especially), locusts, hawthorns, roughleaf dogwood, sumacs, plums, prickly ash, briars, redbud, hazel (locally), etc. The original canebrakes and associated woodland of the Bluegrass have been included in "*Fraxinus quadrangulata-Quercus macrocarpa* / *Arundinaria gigantea* wooded shrubland" of NVC (CEGL 3835). However, that type is not closely supported by historical accounts—and it is likely that many of these ash and oaks trees originally grew up in less open conditions (Campbell 1989, McEwan & McCarthy 2010). A more generic canebrake type may be appropriate until more information is collected (CEGL 3836). In addition to large bur oaks, locusts appear to have been common in more open woods with cane, and there are similarities with NVC types that have abundant *Robinia* (CEGLs 6599, 7279) or *Gleditsia* (CEGLs 3686, 4345).

For shrubby species other than *Arundinaria*, there is even less representation of such vegetation in the NVC. For the whole of eastern North America, NatureServe lists only the following shrubland types that include species with records of local abundance in the Bluegrass region. In most of these cases, the types are described from regions that are distanct from the Bluegrass, with little overall similarity in the vegetation composition.

- *Rubus* (*argutus, trivialis*) - *Smilax* (*glauca, rotundifolia*) Shrubland (CEGL 4732; from provisional internal list)
- *Cornus drummondii* - (*Rhus glabra, Prunus* spp.) Shrubland (CEGL 5219); see also Ruch et al. (1998).
- On Pelee Island, Ontario, Hood et al. (2008) noted thickets of *C. drummondii* and *Zanthoxylum americanum* plus scattered old *Fraxinus quadrangulata, Quercus muehlenbergii* and *Carya ovata* in old wooded pastures (see also CEGL 5230).
- *Crataegus spathulata - Cornus drummondii - Berchemia scandens* Shrubland (CEGL 3879)
- *Crataegus crus-galli - Ilex decidua - Crataegus viridis* Shrubland (CEGL 4532); see also provisional types, *Crataegus viridis - Crataegus mollis* Shrubland (CEGL 4947) and *Crataegus* (*crus-galli, marshallii*) Shrubland (CEGL 3976).
- see also Wheeler & Kapp (1978), who outlined mixed *Crataegus*-dominated woods (probably including *C. mollis*) with much *Carya cordiformis, Acer negundo, Ulmus* spp., *Juglans* spp. *Celtis occidentalis* and *Sambucus canadensis*.
- *Prunus virginiana* - (*Prunus americana*) Shrubland (CEGL 1108).
- *Carya ovata* / *Zanthoxylum americanum* / *Panicum philadelphicum - Carex pensylvanica* Wooded Herbaceous Vegetation (CEGL 5230).
- *Corylus americana* Shrubland types (CEGL 5072 and 5073).

(d) More open woods and old fields. There is little direct historical information from the Bluegrass region that indicates species composition of sunny openings at the time of settlement, but there are several clues (Campbell 2012b). The closest matches provided by the NVC include a few of the more open woodland types noted already under (b) and (c); see especially CEGLs 7879 and 4345. A broader review of literature on old fields would be useful, in order to determine if the native species composition of openings in the Bluegrass is especially similar to old fields on eutrophic sites elsewhere. There is, of course, much general similarity to old fields elsewhere with abundant *Solidago canadensis* (sensu lato), *Andropogon virginicus*, *Rubus argutus* (sensu lato). But some other characteristic species on Bluegrass uplands suggest a strong affinity with open woods, disturbed areas and shorelines on rich lowland soils: e.g. *Dichanthelium clandestinum, Persicaria* spp., *Teucrium canadense, Verbesina alternifolia, Xanthium strumarium* and *Zizia aurea* (see CEGLs 2277, 2430, 4031, 4124, 6218, 6480, 6481, 7302).

Table below: the major gradient in forest types with moderate disturbance history on eutrophic sites of eastern North America, excluding deeper woods dominated by sugar maples, more open woods in transitions to grassland, and more xeric or hydric extremes. Listed down the left column are 4-digit "CEGL" codes to vegetation types in National Vegetation Classification (website & pers. comm.). TRSP: this row lists acronyms for tree genera (with first 3 letters of genus name) or other groups; see notes at right for details. xxx = most abundant; xx = also common; x = minor/local presence. The ranking of CEGLs and TRSPs has been set to maximize the segregation of tree genera from top to bottom of the table. BRWS: this top row is a provisional classification of susceptibility to browsing by generalist mammalian herbivores, with an emphasis on white-tailed deer, from A = most susceptible to D = least susceptible; below these letters are the numbers of studies cited by Atwood (1941) with significant browsing by deer. Color-coding indicates relationship to the compositional gradient: blue, susceptible, versus yellow not so.

Notes on sources and species.
A more thorough review of the literature is anticipated.
*4697: http://www.nps.gov/stri/naturescience/upload/STRI%20Final%20Report4.pdf
*5055: combined with 5230
ACENEG: *Acer negundo* and/or *A. saccharinum* in a few cases
ACESAC: *Acer saccharum*, sensu lato, including *nigrum* and *floridanum* (= *barbatum*).
AESSPP: *Aesculus glabra*, or *flava* in 4793.
CARC/I: *Carya*, mostly *cordiformis*, or *illinoinensis* in a few cases, or *myristiciformis* in 4671.
CARSPP: *Carya*, mostly *laciniosa* or *ovata*; some *ovalis* and *glabra*.
JUGSPP: all *Juglans nigra*, except *J. cinerea* in 6445.
QUEMAC: *Quercus macrocarpa*, or *stellata* in two cases (3876, 7897).
QUEM/A: *Quercus*, mostly *muehlenbergii*, some *alba* or others.
QUES/R: *Quercus, shumardii*, *rubra* or locally *imbricaria*.
ULMSPP: *Ulmus*, mostly *americana* or *rubra*; *thomasii* in 5055.

BRWS	A 6	C 3?	C 6	B 3	B 5	D 4	B 8	C 1	C 4	CD 5/1?	C? 1	CD 3/2	D 1/0	B? 10	C? 7	C? 1	D 3	
TRSP	TIL SPP	ACE NEG	ULM SPP	CEL SPP	FRA SPP	JUG SPP	ACE SAC	AES SPP	JUN VIR	PRU/ MOR	CAR C/I	LIR/ MAG	GLE/ GYM	QUE S/R	QUE M/A	QUE MAC	CAR SPP	Other
2081	xxx	xx	xx	xxx	xxx											xx		BETPAP POPTRE
2014	xx	xx	xxx	xxx	xxx	xx												POPDEL
4697*			xxx	xxx	xxx	x	xx	x	xx					xx				
7180	xx		xxx	xx	xxx	xxx	xx		x	x				xx	xx			
4794			xxx			xxx	xxx							xx	xx			
2090			xxx	xxx	xxx	xx					xx			xx		xx		
7897	xx		xxx	xxx	xxx						x		xx	xxx	xx	xx	xx	NYSSYL LIQ+DIO
2091			xxx	xx				xx						xx	xxx	xx		
4793	xx		xx		xx	xx	xx	x	x		xxx	xx		xxx	xxx		xx	
6445		xx	xx		xx	xx	x			xxx	xxx			xx				
4671	x		x	x	xx	x	xxx	xxx	x	x	xxx		x	xxx	xxx		x	PLAOCC POPDEL
4544		x	x		x						xxx			xxx		xxx		POPDEL PLAOCC
3876				xx						x				xxx	xxx	xx		QUEIMB
8458			x	x	xxx		xx		x					xxx	xx		xxx	
4685			x	x	xxx		x		xx			x		xxx	xx		xxx	MORRUB
5020					xxx		x		xx						xxx			
4436					xxx	xx		xx					xx	x	xxx	xxx	x	
4602			x	x	xx	x	x	xx			xx	x		xxx	xxx	xx	x	
2098			xx		xx									xx	xxx	xxx	xxx	
7633					xx		x							xxx	xxx			
2140			x	xx		x							x		xxx	xxx		PLAOCC
5055*			xx		xx										xx	xxx	xxx	

Summary.
Deeper woods in the Bluegrass had considerable similarity to the original woods elsewhere in northeastern states on deep mesic to submesic eutrophic soils, now largely farmed. Such woods had much *Acer saccharum* (sensu lato) and also abundant *Carya cordiformis*. Other common trees included *Carpinus caroliniana* (or locally *Ostrya virginiana*), *Fraxinus americana, Juglans* spp., *Tilia americana* and *Ulmus* spp., but *Quercus* spp. were less frequent.

The varied 'intermediate woods' had resembled some woods elsewhere, but, again, good documented examples are rare and comparisons are provisional. These woods appear to include a browsing-related gradient that could reflect ancient dynamic relationships with large herbivores. Variants with abundant ashes (especially *F. americana* or *F. quadrangulata*) or elms (especially *Ulmus americana* or *U. rubra*) are poorly documented on uplands, in contrast to lowlands, but they may have been widespread before settlement. Ashes and elms are generally much browsed by livestock. Variants with abundant *Juglans nigra* or *Aesculus glabra* are even less well known elsewhere, but scattered examples do exist. Variants with abundant *Quercus* spp. (especially *macrocarpa, shumardii, muehlenbergii* or *imbricaria*) or *Carya* spp. (especially *laciniosa* or *ovata*) are documented from several states, but usually on drier or wetter ground than the typical Bluegrass uplands. Such woods have often been used for marginal grazing of livestock in the past, or now have dense deer populations.

More open woods, shrubby thickets, canebrakes and old fields on Bluegrass uplands have few well-documented parallels among the native vegetation types outlined elsewhere. Somewhat clonal thickets of locusts, hawthorns, plums, dogwoods, hazel and similar species were probably widespread in east-central states before settlement, but they have been largely eliminated from what are now usually considered natural contexts. Typical old fields on uplands are similar to old fields elsewhere, but the frequency of some species indicates most similarity to lowland vegetation, as does the local abundance of woody species like *Juglans nigra* and *Arundinaria gigantea*.

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Sources of Images and Other Footnotes [for literature cited, see above]

Cover: photo by Alexa McKerrow, 2006 Mar 08; with Milo Pyne (left) and the author (right), by base of the largest chiquapin oak at Griffith Woods (Harrison Co.). This tree may be the global champion for this species. Milo still works for NatureServe, which was split off from The Nature Conservancy during the 1990s. Their mission is focussed on documenting the details of biological diversity, while TNC has focussed more and more on land-deals. Unfortunately, there is much less working relationship now, with little opportunity for good transparent dialog about such complex issues as restoration of Bluegrass Woodland.

Page 2. **Photograph from Knight & Greene (1904)**. These authors produced an historic picture book on horse farms of the Inner Bluegrass: Knight, T.A., & N.L. Greene. 1904. Country Estates of the Blue Grass. Published by the authors (Knight), Lexington, Kentucky. 200 pages. This book contains several views of old woodland that provide unique insight, some indicating less open-grown situations than typical modern remnants.

Page 5. **Maury silt loam**: https://jokko.bae.uky.edu/UK-ARC/soils.htm

Page 8. **Basswood**: http://www.dickndebbietravels.com/wp-content/uploads/2012/09/American-Basswood-Dating-from-Betore-the-Signing-of-the-US-Constitution-Lexington-Cemetery-Lexington-KY-2102-09-18_797x1200.jpg
Notes. Diane Olszowy (2007, Ky. Woodland Magazine 2: 22-23) described this tree (typical *Tilia americana*) and its context, in the Lexington Cemetery. Although it is sometimes rumored to be about 300 years old, other history indicates that Henry Clay (1777-1852) planted the tree himself, which would indicate a mean growth rate of about 1.1-1.35 cm dbh per year. Another large basswood in the cemetery was taken down in 2005 partly due to interference with headstones. That tree was ca. 150 cm dbh but only ca. 120 years old, with a mean growth rate of ca. 1.2 cm dbh per year (personal observations of the author). Two 1-2 m saplings (of typical *americana*) planted by the author in 1986 are now 33 cm dbh and 56 cm dbh in 2013: the first (var. *americana*), with a mean growth rate of 1.2 cm per year, is in dense young woods with nearby box-elder and sycamore (behind 3525 Willowood Road); the second (var. *heterophylla*), with 2.0 cm per year, is open grown with little competition (in front of 3468 Greentree Road). Thus, it is likely that the tree by Henry Clay's tomb does date from after settlement. Nevertheless, other large and small basswoods (mostly var. *heterophylla*) do occur in a few situations within Lexington or nearby that suggest native status (associated with *Acer nigrum, Aesculus glabra, Carya cordiformis, C. laciniosa, Quercus shumardii*, etc.). These include trees in the Shady Lane Woods at the University of Kentucky Arboretum, a few in old fencerows near Southview Drive, trees in the woods behind Landsdowne County Club, and an ancient-looking tree next to the Brannon Road Swamp in Jessamine County. There are also scattered records of "lin" or "lyn" (*Tilia*) among old land surveys on these uplands during the pioneer era (1775-1785).

Page 9. **Typical 'intermediate woods'**: by author at Griffith Woods, 2009 Mar 30; northwest side of farm near Shannon Run.

Page 10. **Old bur oak**: by author at Griffith Woods, 2009 Mar 30; west-central section of farm, just west of US 62 near entrance.

Page 11. **Hickory thicket**: by Milo Pyne at Griffith Woods (Harrison Co.), 2006 Mar 08.

Page 12. **Cane**: by author at Cane Run (Fayette Co.), 2011 Oct 20; cane was planted 1999/2000; in front, Layton Register, who has helped much.

Page 13.
Trifolium kentuckiense: by author from cultivated plants, 2011 May 10; the species is being described by Michael Vincent at Oxford, Ohio.
Trifolium stoloniferum: source to be determined (perhaps author or Tom Barnes).

Page 14.
Gymnocladus dioicus: http://sarahtakesapicture.files.wordpress.com/2012/01/img_2012-2.jpg;
inset from http://www.friendsofeloisebutler.org/pages/plants/kentuckycoffee.html
Gleditsia triacanthos: http://www.cas.vanderbilt.edu/bioimages/biohires/g/hgltr--brthornsD1104.jpg'
inset from http://www.hiltonpond.org/images/HoneylocustPod01.jpg

Page 15. **Horse farm scene**: http://www.kassw-ky.org/images/horse%20pasture.jpg
Cow in woods: http://hummingbirdhills.files.wordpress.com/2013/06/cow-006-800x531.jpg

Page 16. **Running buffalo clover in nursery**: by author at Griffith Woods, 2007 May 11.

Page 17. **Bush honeysuckle**, at Griffith Woods, by author, 2009 Mar 30.
Winter-creeper, at Shady Lane Woods, by author, 2011 May 02.

Page 18. **C.S. Rafinesque**: http://www.gardenbooks.org/programr.htm; cropped from The Popular Science Monthly, April 1892, p. 720.

Page 19. **C.W. Short**: cropped from original portrait by J.R. Lambdin, in possession of Thomas.A. Courtenay, a descendant of Short. Photo by Bill Roughen, courtesy of Cherry Valley Publications, from the book "Collecting Kentucky 1790-1860" by Genevieve Baird Lacer and Libby Turner Howard (2013).

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Erythronium albidum: http://d2yu7kf2857oao.cloudfront.net/wp-content/uploads/2010/07/troutlilygroup.jpg
Camassia scilloides: http://upload.wikimedia.org/wikipedia/commons/thumb/b/b3/Camassia_scilloides_Ozarks.jpg/220px-Camassia_scilloides_Ozarks.jpg
Podophyllum peltatum: http://www.gardensoftheblueridge.com/gardensoftheblueridge/Mayapple%203.jpg
Solidago flexicaulis: http://www.nps.gov/plants/pubs/chesapeake/img/Herbaceous/Solidago-flexicaulis-RHW.jpg

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Viola striata: http://www.missouriplants.com/Whitealt/Viola_striata_plant.jpg
Phacelia purshii: http://www.missouriplants.com/Bluealt/Phacelia_purshii_plant.jpg

Osmorhiza longistylis: http://www.namethatplant.net/Images/ImagesFire/pdmo/pdmolongistylis_swain1.jpg
Ageratina altissima: http://www.ct-botanical-society.org/galleries/pics_a/ageratinaalti.jpg

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Senna marilandica: http://www.shirleydenton.com/plants/web_pics/s/senna_marilandica_fl97521.jpg
Desmodium perplexum: http://delawarewildflowers.org/images/desmodium_perplexum.jpg
Vernonia gigantea: http://alabamaplants.com/Pinkalt/Vernonia_gigantea_plant.jpg
Solidago altissima: http://www.missouriplants.com/Yellowalt/Solidago_altissima_plant.jpg

Page 27. ***Ulmus rubra***: http://davesgarden.com/guides/pf/showimage/194019/

Page 29: ***Aesculus glabra***: http://www.cirrusimage.com/tree_ohio_buckeye.htm

Page 31: ***Quercus macrocarpa***: http://www.missouribotanicalgarden.org/Portals/0/PlantFinder/low/A902-0628052cs.jpg

Back cover

Amphicarpaea bracteata: http://species.wikimedia.org/wiki/Amphicarpaea_bracteata

This species deserves a comprehensive review of its own, in order to guide future recovery within Bluegrass Woodlands. Known historically as peavine, it appears to have been the most common herbaceous legume (Fabaceae, sensu lato) in the central Bluegrass before settlement, being locally abundant in "rich herbage" according to early accounts. Associates included cane (*Arundinaria*), wild ryes (especially *Elymus macgregorii*), richweed (*Ageratina* or *Pilea*), nettles (*Laportea* or *Urtica*) and running buffalo clover (*Trifolium stoloniferum*). Peavine is a twining annual, in morphological terms, but with additional cleistogamous flowers that are produced underground, so that the plants spread clonally as well. The underground fruits are known as hog-peanuts, and were much consumed by hogs when these animals used to roam freely in the woods after settlement. Recent research has shown that two or three distinct subspecific variants exist within *A. bracteata*, as traditionally defined, with distinct rhizobial associates (symbiotic bacteria that fix nitrogen).

Anonymous (1791), p. 53-60 [1973]: "The stories told of the abundance of grass in the woods are in many instances true. You frequently find beds of clover [*Trifolium stoloniferum*] to the horse's knees, sometimes a species of rush-grass commonly called wild rye [*Elymus macgregorii*, etc.], from the similarity of it's [sic] stalk to the rye so called among us; in other places we meet with tracts of wild cane [*Arundinaria gigantea*], very much esteemed by the wild and tame cattle, it continuing in verdure all the winter. There is also a species of vine called the pea vine [*Amphicarpaea bracteata*], from which its producing a small pod, resembling that of the garden pea, of which both horses and cattle are extremely fond. These are scattered generally through the country, according to the different soils, but are not to be met with universally. The woods, however, afford abundance of food for cattle, and in consequence of this abundance the people pay very little attention to making and improving pasture lands. The milk from this food is thin, and both that and the butter retain a strong taste of weeds..."

Imlay (1792), p. 233-235, in "Letter X", probably from Kentucky: "We have a variety of spontaneous kinds of grass, for many of which we have no name. I have spoken of the cane and its properties in a former letter, which the farmer may consider as a grass, since it will answer every purpose of grass to him. I have also mentioned our clover and rye-grass. Besides which, we have, of the grass kind, the pea-vine [*Amphicarpaea bracteata*], which in a small degree resembles your pea-vine. It has the same kind of tendril, and runs up the cane, shrubs and rye-grass, which frequently grows interspersed with it. Its blossoms are of a reddish hue, and it produces a small and imperfect pea. In very rich soil, it grows from 3 to 5 feet high; but in general it does not exceed 18 inches or 2 feet, and is not so luxuriant a growth as the vine of the cultivated pea, but it has a much nearer resemblance to grass."