PART THREE

Notes for a series of four classes on "Natural History and Conservation Planning in the Central Bluegrass Region of Kentucky" initially presented for Osher Lifelong Learning Institute at the University of Kentucky in April of 2016

Julian Campbell: bluegrasswoodland.com

3. Habitats: outline of ecological gradients in original vegetation; focus on problems for restoration of "Bluegrass Woodland", much browsed before settlement but now invaded by aliens.

Across the world, there has been a tortured history of classification and nomenclature for habitats—or "natural communities"—or "associations" of species—or types of "ecosystem". These vague terms are somewhat overlapping and interchangeable. As with climatic zones, it is most useful to consider more local variation in ecology as gradual rather than hierarchical. Yet the latter approach still predominates in much conservation-related literature.

Hydrological differences are usually the most obvious clues to fundamental gradients in native vegetation, from "xeric" (extremely dry) rock outcrops to "mesic" (relatively unstressed) sites to "hydric" (generally saturated) swamps and ponds. However, we must also recognize that it is more stagnant water that maintains truly hydric habitats, as opposed to more flowing water, which maintains well-oxygenated streams and their associated "rheic" (scoured riparian) zones. And, on uplands there is a significant difference between truly mesic sites, as in sheltered ravines, and sites with more range of dry-versus-damp conditions throughout the year, as in flats with only local collection of rainwater but poor drainage. Thus, dryness and wetness can be considered somewhat independent dimensions in ecology. There is a third major gradient, associated with chemical and physical differences from more acid soils (usually siliceous) to more basic soils (usually calcareous). This gradient is most obvious when comparing different geological regions of the state (as noted in Part 2). But it is also evident in more local contrasts, such as between regular soils of the Inner Bluegrass and old stream terraces with imported sand or with chert accumulated from weathered limestone.

Overlaid on these three major gradients in the original vegetation, we now have general degradation and intense disturbance by mankind, which tends to be concentrated on relatively gentle uplands with deeper soils. The challenge for conservation is to understand the history of human effects and then to reduce or modify them at carefully selected sites that contain significant or restorable remnants. In some cases, such sites lie outside the three 'megasites' that are priorities for conservation at a larger scale (as noted in Part 2).

Most habitats (without cliffs, caves, water-bodies) can be arranged along ecological gradients; asterisks show desired degree of targeting.

----------(Full Topographic Series)----------

1. River & stream corridors + riparian transitions (rheic); rice-grass, wild oats, big bluestem; devastated by dams, largely disappeared.***

4. Riparian woods (subrheic): elm, boxelder & sycamore; largely degraded but still widespread and often recovers without help.

5b. Moist woods (mesic): sugar maple, basswood, northern red oak or bitternut; relatively secure in ravines, and slowly recovers by itself.
5a. Variants on more acid soil: beech, tulip tree; highly degraded.**

11b. Medium dry woods (subxeric): oaks, ashes, hickories, elms, sugar maple; mostly secure in ravines; and slowly recovers by itself.
11a. Variants on more acid soil: white oak, black oak, pignut hickory; much degraded and deserving restoration but remnants widespread.*

12. Dry red cedar woods (xeric): red cedar, oaks, ashes, elms, hickories, shrubs; relatively stable near rocks, and spreads elsewhere.
12x. Open variants on cliffs and flatrocks; stonecrop, prickly pear.**

----------(Wetland Series)----------

2. Lakes, ponds, marshy transitions (hydric): buttonbush, pondweeds, other aquatics; much degraded but many new ponds created.**

6. Swampy woods (subhydric): white elm, green ash, swamp white oak; much degraded but widespread small remnants.**

9. Seasonally wet flatwoods and marshes (hydroxeric-tending): sedges, shrubs, oaks; largely disappeared, formerly with beavers.***

----------(Rolling Upland Series)----------

7. Average upland woods (submesic): (maple-bitternut with less disturbance), walnut-buckeye, ash-elm (oak-hickory with more stress): widespread but mostly degraded, without clover.**

8. Thickets maintained by repeated browsing or burning (submesic): locust, haws, pickly ash, sumac, cane, briars; scattered remnants but now highly degraded and unstable, mostly lacking cane.***

10. Seasonally dry open woods and canebrakes (xerohydric-tending): bur oak, honey locust, cane, forbs & grasses; partly developed by Virginian settlers into "woodland pasture". (Perhaps "savanna-like" but that term has been misapplied to combinations of 7, 8 and 10.)**

HABITATS: types of ecosystem, ‘natural community’ or vegetation

The following notes present a simple introduction to what can quickly become a ridiculously complicated subject—the classification (and understanding) of ecological variation. At the core of this introduction is a concept of three underlying gradients: (1) deep woods to open land; (2) wet to dry; and (3) low to high soil fertility. The latter (3) is actually more prominent than the other two when viewing the whole state of Kentucky or the whole Ohio Valley. But in the fertile Central Bluegrass (especially Inner), there is little variation along that gradient. On uplands here, the gradient from deep woods to open land (1) is most obvious.

This three-gradient concept allows most sites with native vegetation to be positioned in a meaningful manner, and then various arbitrary classifications can be imposed on the variation. It is important to realize that habitats do generally intergrade with each other—they do not behave as discrete “species” or “organisms”! At the most elementary level, it helps to consider the three broadest classes of habitat in a triangular relationship: wetland; woodland and grassland. Streams and ponds can be considered peripheral to the wetter side of this model, but various transitions, mixtures and combinations can be used in mapping at various scales. Similarly, cliffs and flatter outcrops can be considered peripheral to the drier side, but various combinations are often useful.

Wetness and dryness are not independant—sites on flatter ground often combine wet winters with dry summers, and can be called “xerohydric” in extreme cases. Before settlement, woodland on such sites tended to be more stressed and often more disturbed by browsing (or perhaps burning). After settlement, there has, of course been a massive shift towards the more open extreme and this may often be associated with more fluctuation between wet and dry extremes, especially on compacted soils (as gardeners often realize).

Glossary—it's all Greek to me!

Ecologists have employed several descriptive adjectives for habitats based on Greek roots. These terms do not have precisely consistent or quantitative definitions. My usage is as follows.

aquatic = with ground submerged for most of the year

hydric = with soil wet and anaerobic for much of the year

mesic = with neither hydric nor xeric tendencies; oak rare

pyric = with frequent fires greatly influencing the vegetation

rheic = with force of floods greatly influencing the vegetation

seral = successional; changing to more mature (often more mesic) forest

subhydric = with soil intermediate between hydric and mesic

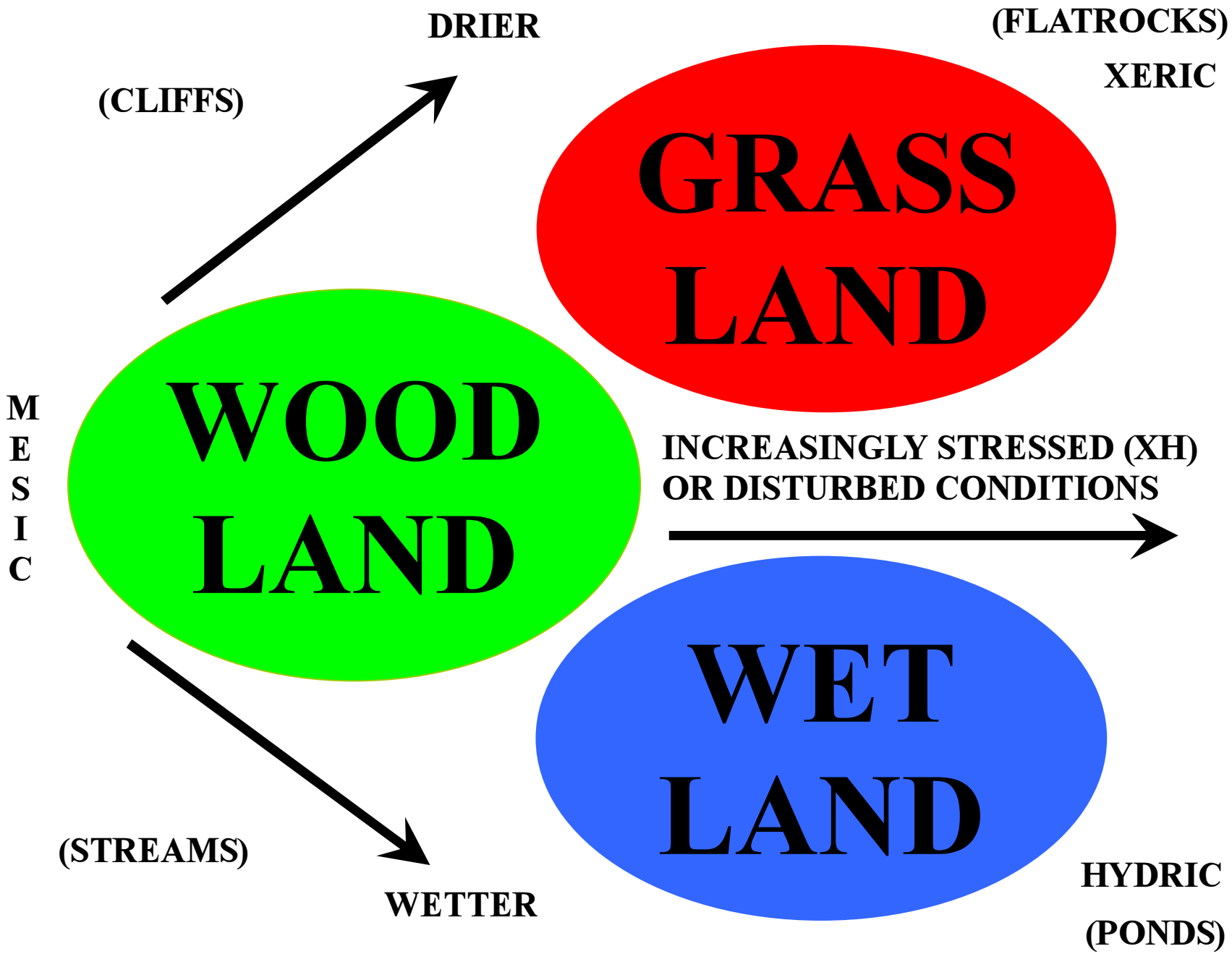
submesic = somewhat mesic but modified by stresses or disturbances

subxeric = with soil intermediate between xeric and mesic; oak abundant

xeric = with soil dry enough to maintain much red cedar or scrub pine

xerohydric = with soil usually dry in summer and wet in winter; opposite of mesic

Unfortunately, a confusing diversity of classification and terminologies has been applied to the science of vegetation, which often makes it hard to teach students. There is little hope for global standardization, although various national or international organizations have attempted to do develop one. I see more hope for gradual agreement within regions where ecologists attempt to combine data and meet regularly to discuss and interpret their patterns.


DRIER
(FLATROCKS)
XERIC
(CLIFFS)
GRASS LAND
WOOD LAND
M E S I C
INCREASINGLY STRESSED (XH)
OR DISTURBED CONDITIONS
WET LAND
(STREAMS)
WETTER
HYDRIC
(PONDS)

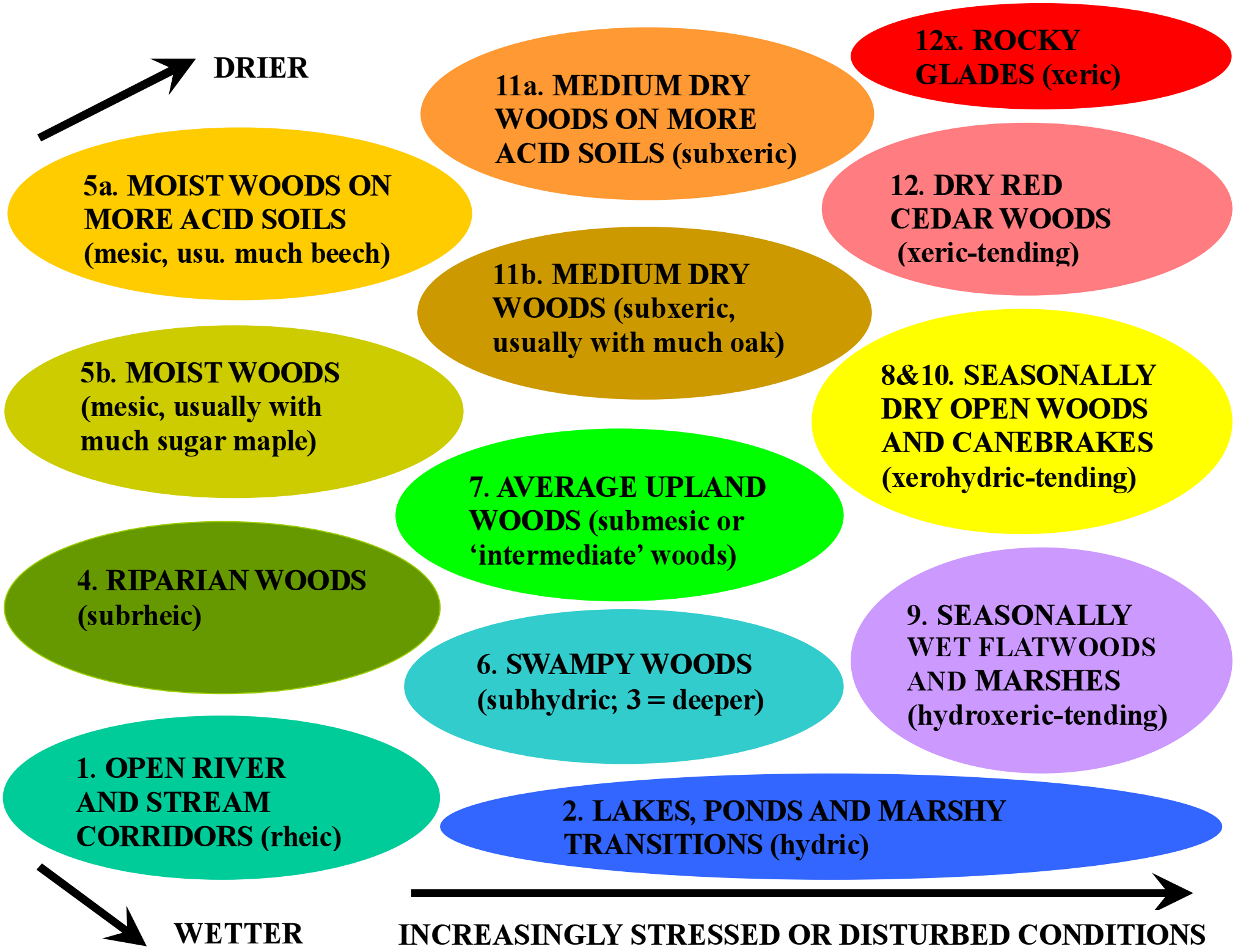

DRIER
11a. MEDIUM DRY WOODS ON MORE ACID SOILS (subxeric)
12x. ROCKY GLADES (xeric)
5a. MOIST WOODS ON MORE ACID SOILS (mesic, usu. much beech)
12. DRY RED CEDAR WOODS (xeric-tending)
11b. MEDIUM DRY WOODS (subxeric, usually with much oak)
5b. MOIST WOODS (mesic, usually with much sugar maple)
8&10. SEASONALLY DRY OPEN WOODS AND CANEBRAKES (xerohydric-tending)
7. AVERAGE UPLAND WOODS (submesic or 'intermediate' woods)
4. RIPARIAN WOODS (subrheic)
9. SEASONALLY WET FLATWOODS AND MARSHES (hydroxeric-tending)
6. SWAMPY WOODS (subhydric; 3 = deeper)
1. OPEN RIVER AND STREAM CORRIDORS (rheic)
2. LAKES, PONDS AND MARSHY TRANSITIONS (hydric)
WETTER
INCREASINGLY STRESSED OR DISTURBED CONDITIONS

DIAGRAM OF UPLAND FOREST CLASSES IN RELATION TO DRYNESS AND FERTILITY

XERIC & SERAL SITES Class 12 (+10)	Virginia pine HARD PINE pitch pine shortleaf pine		redbud RED CEDAR apple, haw, plum honey locust	
ridges sw slopes SUBXERIC SITES Class 11(+08)	scarlet oak chestnut oak OAK-CHESTNUT (white pine) sourwood	sassafras, persimmon black oak, white oak OAK-HICKORY black gum black locust red maple black cherry		shumard oak chinquapin oak OAK-ASH (yellowood) elm
MESIC SITES ne slopes bottoms Class 05 (+07)	birch magnolia HEMLOCK (typically Appalachian)	sweetgum tulip poplar BEECH (widespread in eastern states)	walnut basswood SUGAR MAPLE (typically mid-western)	coffee tree hackberry BUCKEYE (locally associated with ungulates)
NUTRIENT STATUS	pH ca. 4.0 nutrient-poor soil typically on sandstone	pH ca. 5.5 average soils on various parent materials		pH ca. 7.0 nutrient-rich soil typically on limestone

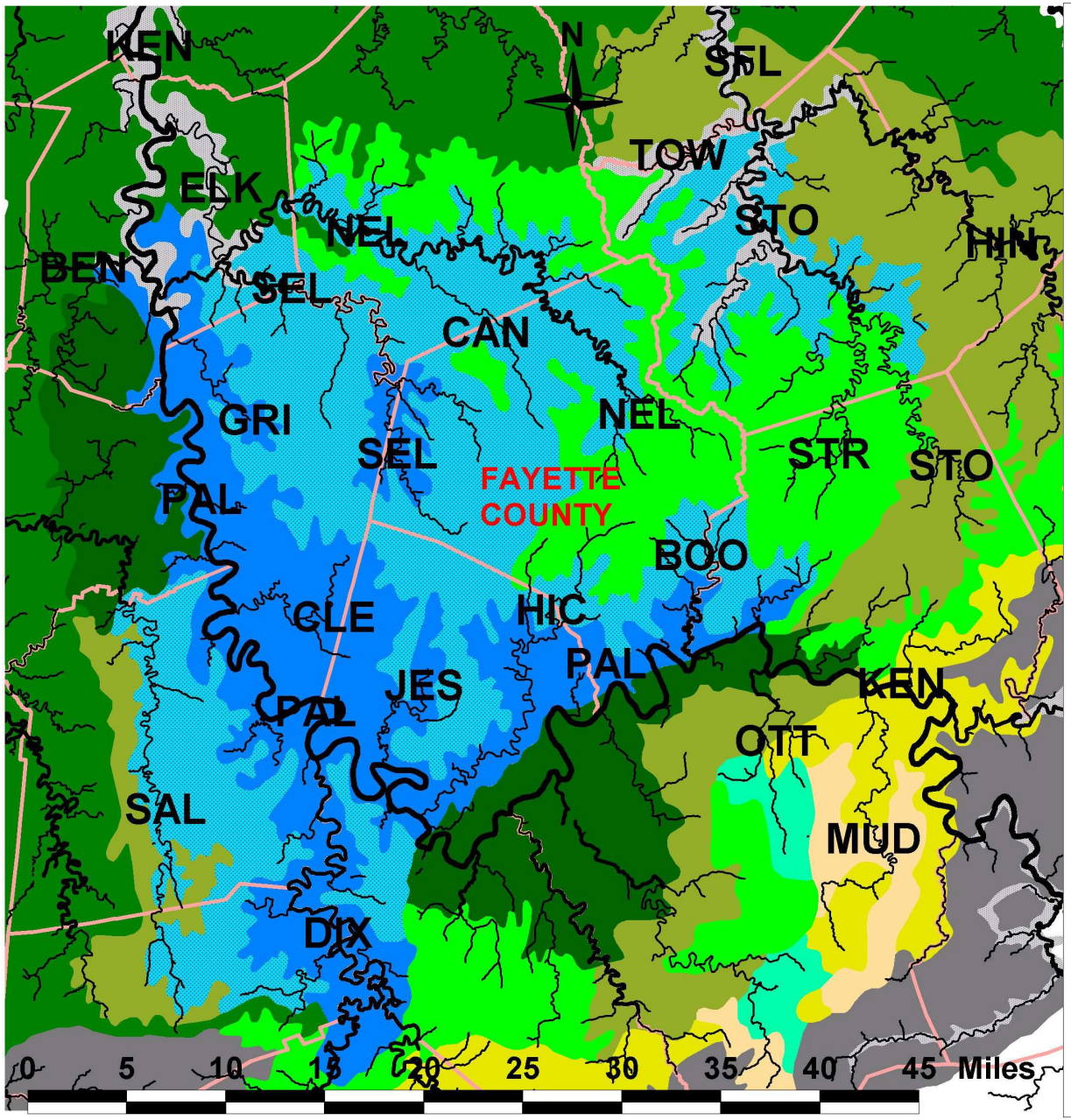
STREAM SYSTEMS: to be broadly defined, from caves to rivers

For broad mapping purposes, it useful to combine the stream itself with the scoured and flooded banks and even the adjacent riparian woods (as outlined below under "rheic" and "subrheic" habitats). However, there is great interest in the hydrology of stream channels that is somewhat independant of the adjacent vegetation. The "Rosgen Classification" of streams (Rosgen & Silvey 1996) has become a widely accepted standard for ecological work, but it has been somewhat controversial (Lave 2009, 2012). Unfortunately, we still do not have a simple booklet for use in Kentucky schools and colleges. Ideally, this booklet would link the physical classification of streams with biological features in a comprehensive fashion. It is curious (to an outsider) that three traditional attributes in stream classifications are not primary factors in the Rosgen system: stream order, watershed area and average annual flow. Also, there is concern that unnecessarily expensive systems of restoration can result from artificial classifications

Parola et al. (2007) have provided some initial quantification of Bluegrass stream features, as shown in the table below. There are three reasonable broad classes in terms of overall size.
1. Watersheds >42 square miles; bankfull flow >1000 cfs; Rosgen mostly E (especially E4/1).
2. Watersheds 3-42 sq. miles; bankfull flow 70-1000 cfs; Rosgen mostly C4/1 or B4/1c.
3. Watershed 0.25-3 sq. miles; bankfull flow 40-70 cfs; Rosgen highly variable with B, C or E.

Among smaller streams (3), those with high sinuosity (Rosgen E) tend to occur on clayey alluvium derived from more shaley bedrock, in contrast to watersheds that have developed in more pure limestone. Local variation in natural and artificial conditions of smaller streams is illustrated by the Cane Run situation in Fayette County, where the effect of karst on streamflow remains hard to quantify, but it is clearly important at some sites (Campbell 1913a). The city of Lexington proposed to "restore" 4415 feet of Cane Run with a new floodplain and wetlands, but this creek has been largely sinking into underground channels for millions of years.

Streams of the Central Bluegrass Region (north-central Kentucky)



Abbreviations for major streams

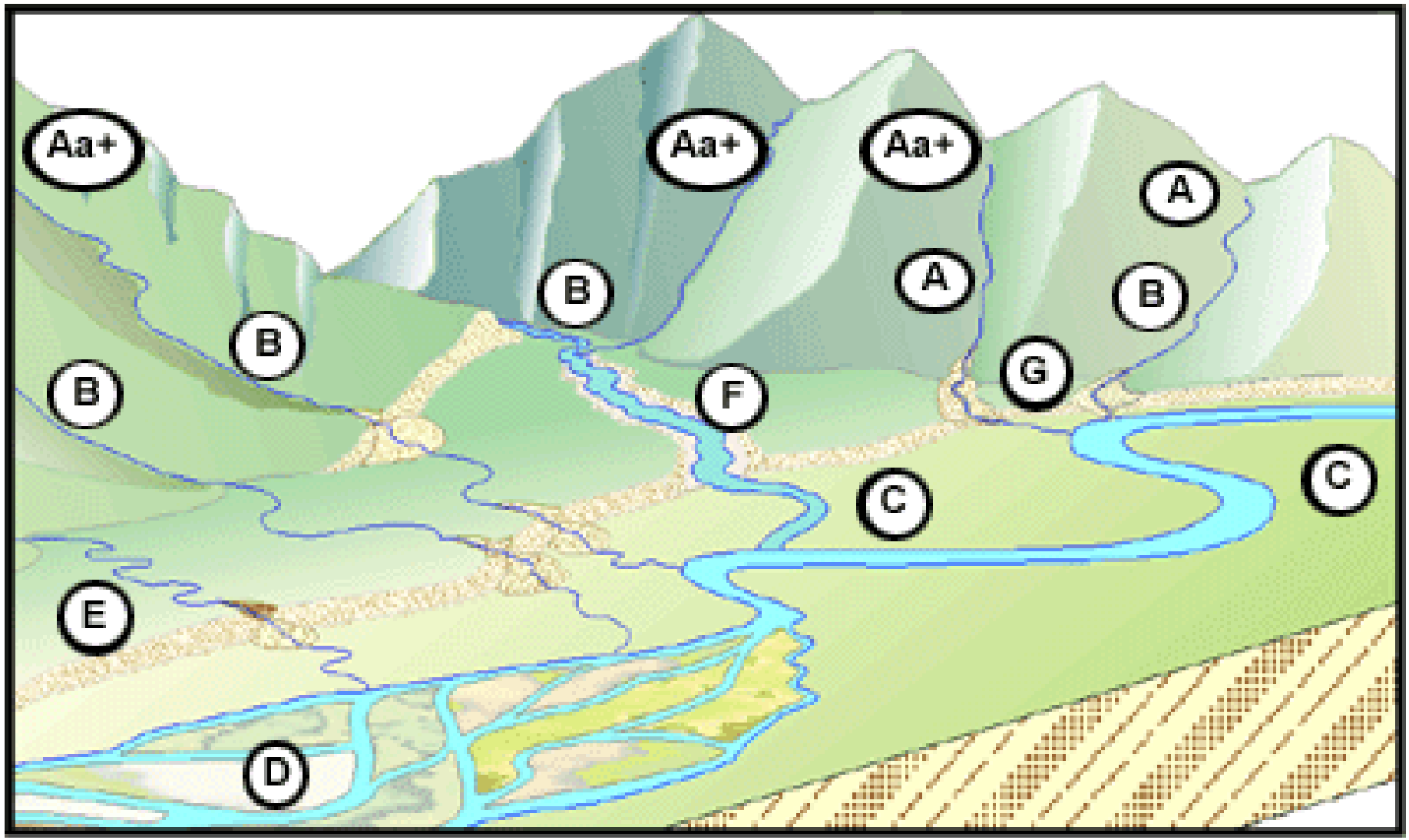
Smaller streams can also have special features, especially in the Palisades.

- BEN Benson Creek
- BOO Boone Creek
- CAN Cane Run
- CLE Clear Creek
- DIX Dix River
- ELK Elkhorn Creek
- GRI Griers Creek
- HIC Hickman Creek
- HIN Hinkston Creek
- KEN Kentucky River
- JES Jessamine Creek
- MUD Muddy Creek
- NEL North Elkhorn Creek
- OTT Otter Creek
- PAL Palisades Section of Ky. Rv.
- SAL Salt River
- SEL South Elkhorn Creek
- STO Stoner Creek
- STR Strodes Creek
- TOW Townsend Creek

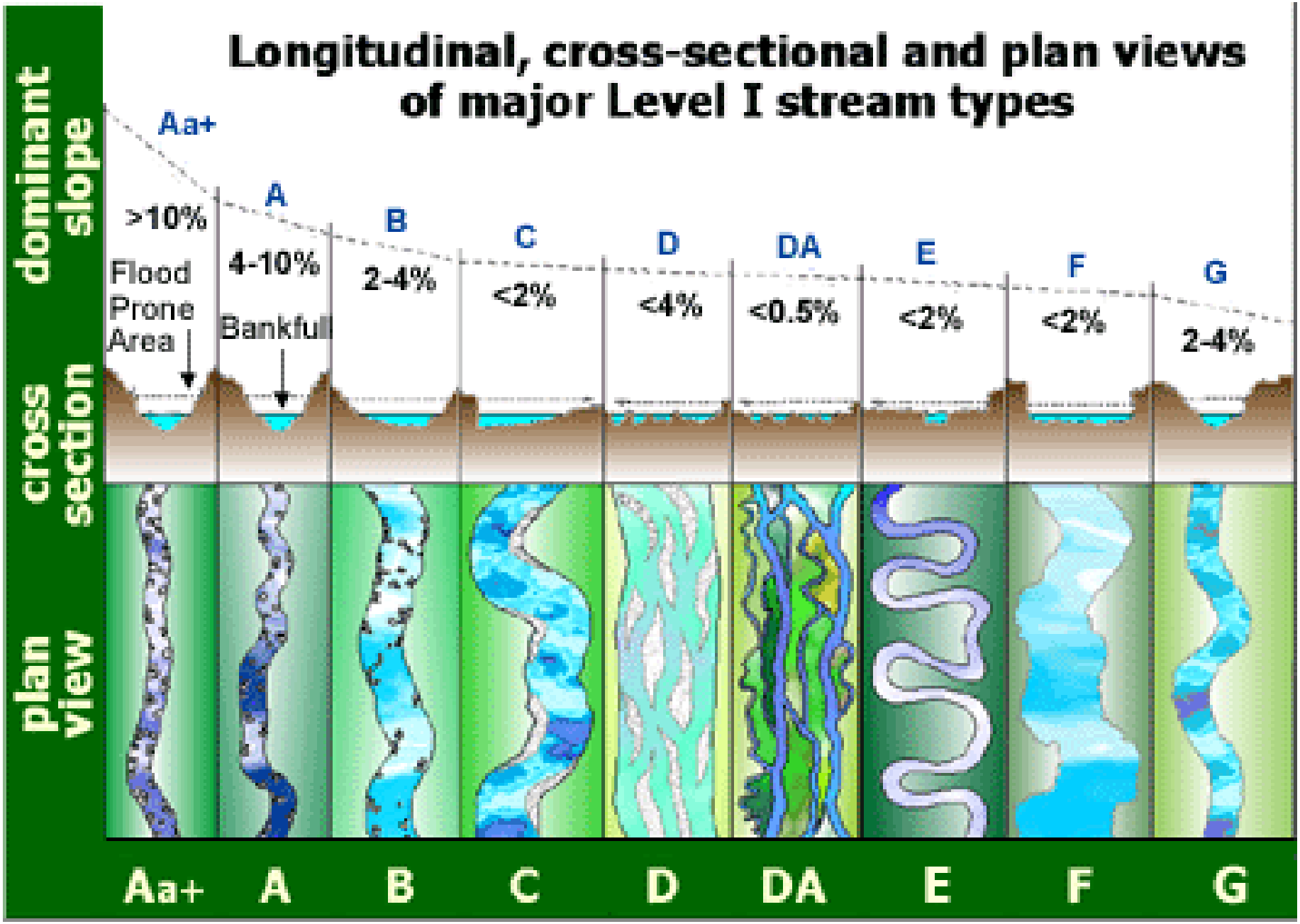
County Boundaries

Land Type Associations

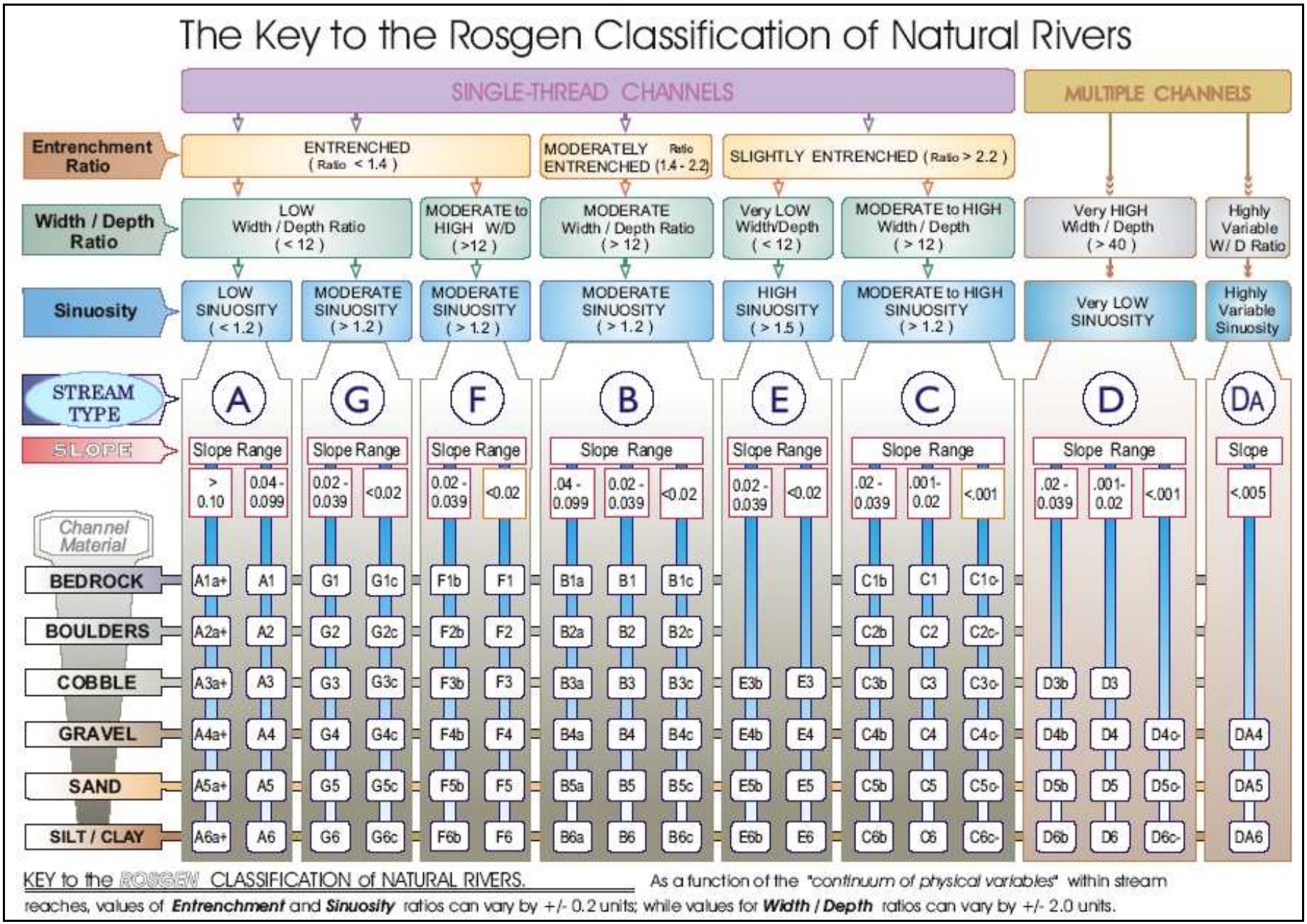
- Inner Bluegrass Ravines
- Inner Bluegrass Plains
- Garrard Siltstone Hills
- Eden Shale Hills
- E Bluegrass-Eden Shale Hills (mix)
- East-central Bluegrass Plains
- E Bluegrass-Damp Flats (transition)
- Eastern Foothill Flats
- Dolomitic Foothills to Knobs
- Eastern Dolomitic Plains
- Black Shale/Siltstone Knobs (varied)
- Calcareous Terraces (Licking Rv)
- Riverine Bottomland



From: "Fundamentals of Rosgen Stream Classification System... shows how different Level I stream types tend to appear in different parts of the landscape. With proper training, Level I classification can be delineated on common information sources such as topographic maps and aerial photographs." But see Lave (2009, 2012, etc.) for controversies in the "Rosgen Wars." [Posted at https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1202]



[https://cfpub.epa.gov/watertrain/images/stream_class/s06.gif]



This has become standardized since the 1990s but alternatives do exist (Buffington+ 2013)

Bluegrass stream data from Table 4.1 of Parola et al. (2007), ranked on watershed area.
WS = watershed. Area = cross-section. ER = entrenchment ratio (floodplain / bankfull width)
Qbkf = bankfull flow in cubic feet per second. Rosgen = the standard classification.

STREAM NAME	WS mi^2	Area ft^2	Width ft	Depth ft	ER	W/D	Qbkf	Rosgen	Notes
Trib A Dix Rv nr Crab Orchard	0.25	2.1	5.9	0.35	1.7	16.9	??	B4c	
Trib B Dix Rv nr Crab Orchard	0.51	3.4	5.5	0.62	3.5	8.9	??	E4/6	lower W/D
Hough Run at Mt Washington	1.11	12.9	14.8	0.87	2.0	17.0	42	B3/1c	
N Elkhorn Cr at MOW Blvd	2.20	24.8	17.5	1.41	>2.2	12.4	65	E4/1	higher A&W
Indian Cr nr Owingsville	2.43	23.5	16.7	1.40	2.3	11.9	55	C3/1	
Cave Cr nr Fort Spring	2.53	14.3	13.1	1.10	5.7	11.9	50	E4/1	
Harrison Fk nr Samuels-1	3.19	16.4	17.0	0.96	2.1	17.7	??	C4/1	
Harrison Fk nr Samuels-2	3.55	17.0	24.5	0.69	1.7	35.5	??	B4/1c	higher W/D
N Elkhorn Cr at Winchester Rd	4.05	29.5	18.9	1.56	4.8	12.1	82	C4/1	
Whittaker Run at Smithville	4.45	23.6	22.8	1.03	1.9	22.1	71	B4/1c	higher W/D
Long Lick at Clermont	7.91	88.1	37.1	2.38	1.8	15.6	366	B3/1c	
Salt Rv nr Harrodsburg	24.0	118	53.7	2.19	1.7	24.5	975	B4/1c	higher W/D
S Elkhorn Cr at Fort Spring	41.4	224	58.5	3.83	2.0	15.3	500	C4/1	
Eagle Cr at Sadieville	42.9	394	69.9	5.65	2.7	12.4	1700	E4/1	
Bullskin Fk nr Simpsonville	54.8	389	73.5	5.29	>2.2	13.9	1500	E4/1	
Beech Fk nr Springfield	85.9	849	87.7	9.68	3.5	9.1	3000	E4/1	
Beech Fk at Litsey	100.7	600	100	6.00	>2.2	16.7	??	C4/1	higher W/D
N Elkhorn Cr nr Georgetown	119	1029	123	8.36	>2.2	14.7	2700	E4/1	
Floyds Fk at Fisherville	138	1173	130	9.06	>2.2	14.3	4340	E4/1	
Hinkston Cr nr Carlisle	154	1119	87.8	12.76	>2.2	6.9	2150	E1	

Caves form a special type of habitat that deserves careful local management, beyond just protecting the landscape around them.

Upper left: Gray Bat, an endangered species that uses several caves along the Ky. River Palisades (body about 5 cm long)

Upper right: Greater Adams Cave Beetle, an endangered species that occurs only at one cave, in Madison County (body about 1 cm long)


By entrance to Overstreet Cave

TERRESTRIAL HABITATS: to be outlined here in three series

Based on the diagrams below, notes on habitat classes are grouped as follows.

The "Full Topographic Series": numbers 1 – 4 – 5 – 11 – 12; this is best illustrated by zonations along the Kentucky River Palisades, especially if the orginal free-flowing condition of the river is consisdered, as well as the terraces of various ages.

The "Wetland Series": numbers 2 – 3 – 6 – 9; based on our few small remnants, a picture of the original zonation from deeper swamps to marginal wetland is possible, but drier transitions have been highly degraded.

The "Rolling Upland Series": numbers 7 – 8 – 10 ; based on widespread but highly degraded remnants, together with much historical information, it is possible to present a detailed concept for the gradient from deeper woods to more open, disturbed or droughted woods or thickets.

Under each heading below, there is a brief description of the habitat class and its general needs as a target for conservation or restoration. Technical details are witheld, but will be appended in future developments of this document. These are broad initial comments, and should of course be modified for any specific site or project. They can be adapted for other regions of the eastern USA, but with more attention to the "pH-related" gradient from low to high fertility.

TYPES OF ROCK OUTCROP: to be detailed elsewhere

It is often possible to combine description of more rocky habitats with the broader terrestrial classes in which outcrops are usually embedded. However, this approach overlooks the diverse microcosms that exist on rock surfaces, often with distinctive lichens and mosses. In a more comprehensive treatment, these types of habitat should be given more attention.

1. OPEN RIVER AND STREAM CORRIDORS: rheic

Scoured but not to be scorned! Whilst most vegetation in Kentucky has received clear recognition, utilization or even admiration from modern mankind, this class is radically different yet relatively ignored. It is the haunt of flighty fisherfolk, casual canoeists, bolder botanists, and, more recently, ecological engineers. This odd collection of user groups rarely meets on site, and if they do, by chance, suspicions are often raised and people retire their separate ways into the shadows or shoals. But alone, or in small parties, these are places for deep meditation on the meaning of river life, wild conversation about conservation, basking in the sun, or just plain loafing. Perhaps yearning for the beach downstream, our experience in this environment seems to provoke a new look at our existence towards the continental interior.

Before settlement, shrubby or grassy streambanks were largely restricted to rockier banks of rivers and larger creek. They are temporarily flooded but often violently so, and they have gravelly or rocky substrate. Willows (with several species) are often abundant; other shrubs can include silky dogwood and indigo-bush. This vegetation forms a distinct but interrupted linear zone along most streams, ranging from only a few feet wide in most cases to several hundred feet wide along washed-out stretches of larger rivers. These habitats can accumulate a suprising diversity of plants. Each larger rivers tend to have a unique mixture of species. The larger streams and rivers have complex zonations, from shoals with partly submerged plants, to low lagoons with sedges, to high boulder bars and ledges with grasses (even big bluestem).

On the whole, this vegetation is moderately secure from human interferences—except for impoundments. Sadly, dams along the Kentucky River have largely eliminated these habitats, except for a few rocky banks at higher levels. Also, agriculture and other developments have modified much of this vegetation along smaller streams in more settled landscapes. Selected sections need to become targets for conservation or restoration.

Higher rocky banks along the Kentucky support remnants of the original grassy vegetation.
[http://www.nature.org/cs/groups/webcontent/@web/@kentucky/documents/media/kentucky-palisades-cliffs-3.jpg]


Big bluestem below
the lock-and-dam at
High Bridge

Beds of water-willow (*Justicia americana*) used to be common in riffles of free-flowing streams throughout the region, but changes in hydrology and chemistry appear to have greatly reduced this species (Howell 1975).

Images from:
http://herbarium.biol.sc.edu/herb/JJ/Justicia_americana2.jpg
http://maryland.sierraclub.org/hc/pictures/2004/20040606WaterWillow.jpg

Native plants lining a roadside ditch in southern Madison County (Moran-Summitt Road): walnut and cane along fence; reed grass (perhaps native) and meadow sunflower on roadside.

4. RIPARIAN WOODS: subrheic banks of rivers, creeks and runs

Although this class of vegetation usually develops deep shade, it has temporary flooding, scouring and siltation that greatly affects the canopy composition. The most typical trees on fresh alluvium are sycamore, box-elder and—along larger streams—silver maple. Common (white or American) elm and green ash are also frequent, especially on hydric-tending sites. Some willows are also characteristic of particular habitats: black willow along more stagnant pools, and more shrubby species along rocky banks and gravel bars. These typical riparian trees are often intermixed with typical upland trees, especially on more mature alluvium with less frequent flooding (black walnut, hackberry, white ash, shellbark hickory, shumard oak, bur oak). Diverse shrubs, herbs and grasses occur under the shade of these trees, but proliferate more along partially exposed stream-banks or within the open scoured channel itself.

Although these woods also intergrade with wetlands, they are not dominated by hydric or even subhydric soils. Most riparian vegetation here occurs on more or less well-drained soils: highly organic in low fresh alluvium (mollisols) or less organic on moderately weathered younger terraces (inceptisols). Transitions to uplands occur on more deeply weathered older terraces (alfisols). In addition to this gradient in soils, the vegetation varies much in relation to patterns of drainage, stream-flow and other local disturbances. Natural patterns in vegetation deserve some understanding before conservation and restoration proceeds.

This habitat is still widespread, though often confined to narrow strips or highly degraded. It should be treated as a target for conservation or restoration in more farmed or urban areas. Some typical species have been much reduced after two centuries of settlement, and most are not readily available from local nurseries. It is important to connect interested people with knowledge of these species, which have varied functional, aesthetic and economic potentials.


Mouth of
Jessamine
Creek at the
Kentucky
River

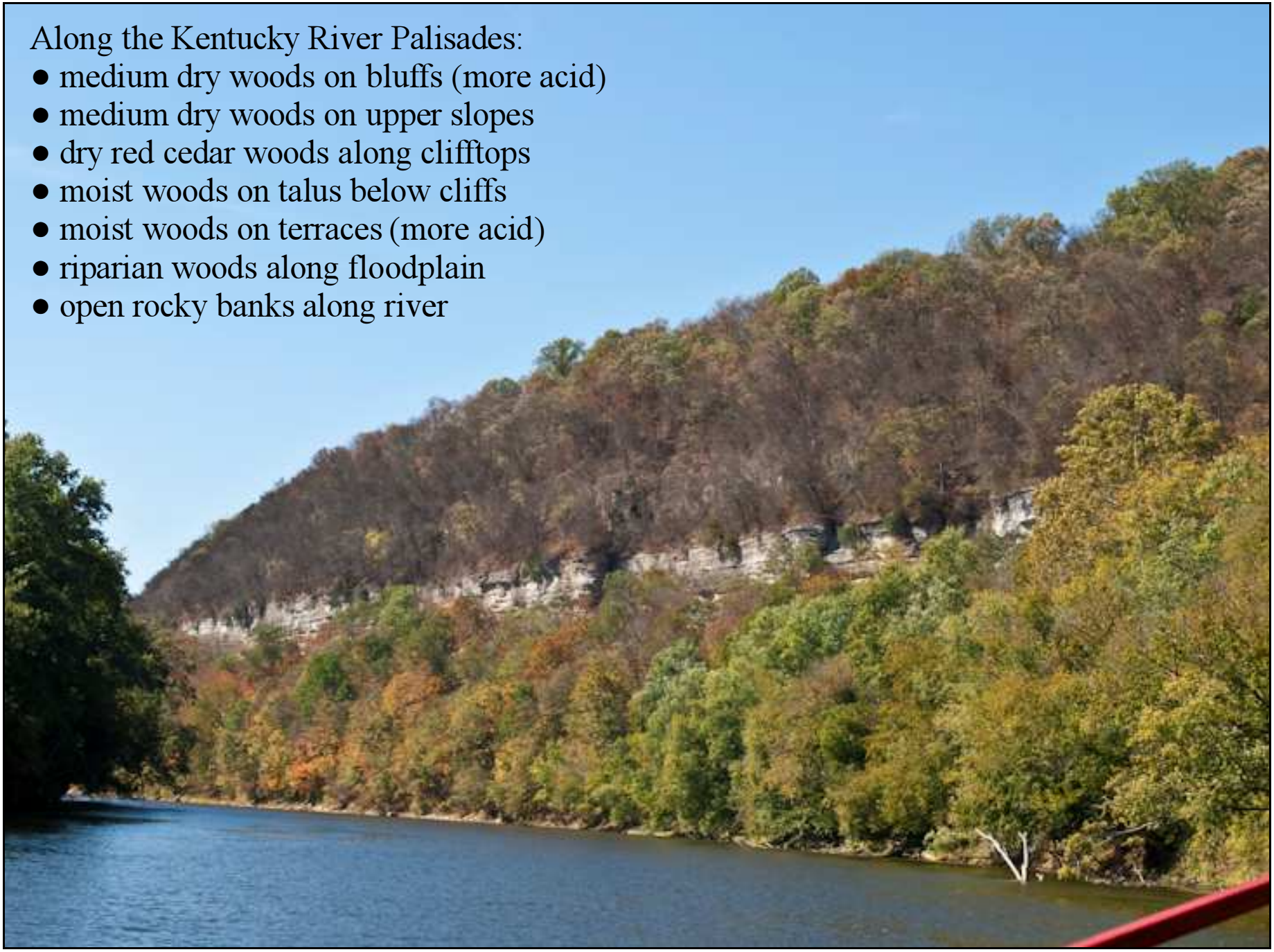
Wolf Run in town. Left: wild riparian woods with boxelder, plus roughleaf dogwood in front. Right: adjacent younger woods plus reed grass and tall dock, mowed until a few years ago.

5. MOIST WOODS: mesic, usually with much sugar maple

This habitat is where human beings tend to get most absorbed into nature, away from their urban homes, especially during the spring when diverse ephemeral flowers appear like magic. Lucy Braun (1950) was clearly in love with this type of forest, and she emphasized its importance for ecological evolution: "The Mixed Mesophytic association... is the most complex and the oldest association of the Deciduous Forest Formation. It occupies a central position in the deciduous forest as a whole, and from it or its ancestral progenitor, the mixed Tertiary forest, all other climaxes of the deciduous forest have arisen." Although her language is now considered old-fashioned, there are interested connections in the Central Bluegrass to mesic woods of the Appalachians, with some chracteristic species that extend west along the Kentucky River.

These woods are best developed on well-drained, temporarily flooded terraces or on slopes, especially northeast-facing with relatively little stress or disturbance. Trees here are mostly sugar maples (or black maple), basswoods, buckeyes, bitternut hickory and locally on steeper slopes, northern red oak. Beech and tulip poplar occur on more acid soils. More stressed or disturbed transitions also have hackberries, ashes, walnuts, elms and oaks (especially shumard and chinquapin). Spring flowers in more protected areas can be showy, including yellow poppy, bloodroot, twinleaf, larkspurs, waterleafs, nodding trillium, hyacinth and many others.

This habitat is still widespread in more hilly areas of the Central Bluegrass, especially along the Kentucky River. But variants on floodplain terraces and on calcareous uplands have become very rare or virtually eradicated. We need to improve our understanding of its former transitions to 'average', submesic woodland on the uplands, as outlined further below. There is probably much reasonable rationale for restoration of truly mesic woods on these uplands, even within urban areas—where people often seek summer shade. The most deeply shading (and shade tolerant) trees are sugar maples, basswoods and buckeyes—all agreeable species for urban environments.



[https://upload.wikimedia.org/wikipedia/commons/1/13/Kentucky_River_Palisades.jpg]

1

11. MEDIUM DRY WOODS: subxeric, usually with much oak

This is by far the most extensive class of native vegetation that remains in Kentucky, mostly on moderate to steep slopes and ridges with well-drained soils that are often rocky. Widespread browsing or burning may have occurred in these woods before settlement but not enough to open up the canopy. Typical trees in the Central Bluegrass include chinquapin oak, shumard oak, shagbark hickory, white ash and blue ash. On less fertile soils, there is more white oak, black oak, pignut hickory, mockernut hickory. The understory often has more mesic species such as sugar maple and slippery (red) elm, especially without browsing or burning.

In 1792, Gilbert Imlay summarized the remarkable beauty of Kentucky's forests as follows: "If here I should attempt to describe the colouring of these woods, I should be at a loss what season of the year to choose, whether the sober harmony of the greens that the woods in all their various tints display in summer, or whether the flaunting blush of spring, when the woods glow with a thousand hues that the flowering trees and shrubs exhibit. If the painter would attempt the real and accurate portrait of these woods in autumn, he must mix in upon his canvas all the colours of the rainbow, in order to copy all the various and varied dyes which the leaves at the fall assume; the red, the scarlet, the bright and the deep yellow, the warm brown, the white, which he must use, would produce a prismatic motley patchwork, from which the eye would turn away, and which the judgement would not bear; and yet the woods in this embroidered garb have in real nature a richness of appearance beyond conception. But this is not the only instance; there are many wherein nature will not bear a portrait, and wherein she is never less imitated than when she is attempted to be literally copied."

We do not generally need to treat these woods as a target for urgent action. It is still extensive, because it is not suitable for farming. There are few obvious examples of old-growth, but scattered trees are up to 300 years old or more, especially chinquapin oak and blue ash..

Beverly James coring a 372-yr old chinquapin oak at FloraCliff (Fayette Co.). The oldest documented tree in Ky. is a 398 year chinquapin oak nearby. [Photo by Neal Pederson in 2008.]

Subxeric-mesic woods; locally dominant *Diarrhena americana* in grassy ground-vegetation.

Medium dry (subxeric) woods near cliffs; local dominant *Muhlenbergia sobolifera* on ground.

12. DRY RED CEDAR WOODS AND GLADES
xeric-tending coniferous woods, locally open

Before settlement, this class of vegetation was concentrated on or near rocky SW-facing slopes, narrow ridges, clifftops, flatrocks and other outcrops or eroded areas. Included here in the defintion are transitions to oak forests on deeper soils. Other typical trees in these habitats include various oaks (especially post oak and shingle oak), hickories, ashes and elms, as well as many smaller trees and shrubs. There are several distinctive herbs associated with more ancient remnants, especially in more open areas on the driest sites. Rarer species include cleft phlox, gromwell, glade savory, Short's goldenrod and Great Plains ladies-tresses.

Early explorers and surveyors recorded red cedar rarely within the Central Bluegrass. For example, Cresswell (1775) noted "rocks, cedar hills and beech bottoms" at several places along the Kentucky River, in marked contrast to his companion James Nourse who travelled into the Elkhorn Plains. Cedar was not even noted then at Blue Licks—a well-known site in the Eden Shale Hills where open conditions had been maintained by bison. Yet Baskin & Baskin (1985) described the modern "cedar glade" at Blue Licks as an apparently natural feature.

After early clearance of much oak woodland and further changes in disturbance, especially spread of livestock into the woods, red cedar has now become much more extensive, especially in younger or more open woodland. It is important to distinguish this recently expanded type of cedar habitat from its restricted original extent on the driest sites. The truly xeric variants of this habitat class today do have some stable grassy openings, and these have generally survived fairly well since settlement. However, their subxeric transitions may have changed radically or virtually disappeared. There is no shortage of this habitat, but we need to understand the best balance of browsing, burning and cutting for its future role in more restored landscapes.

[http://garrardcounty.ky.gov/Parks-Recreation/Palisades/Photo-1.png]

[https://kentuckynaturelover.files.wordpress.com/2015/09/fall-astors-palisades-c-ken-brooks.jpg]

[http://kyvagabond.blogspot.com/2013/06/sally-brown-nature-preserve-surrounds.html]


Prickly Pear
(*Opuntia cespitosa*)
on rocky site in
old pasture

5a. MOIST WOODS ON MORE ACID SOILS: mesic, usually with much beech

Before settlement, this variant was largely restricted to "beech bottoms" along the Kentucky River, some higher river terraces on ancient alluvium, and some mesic sites within the Eden Shale Hills. On the east side of Lexington, Owen (1857) noted "sobby beech flats" around the modern Hamburg Shopping Center; and he described a "remarkable beech ridge" along the faulted exposure of Garrard Siltstone that runs along the southeast side of town. In addition to beech, characteristic trees include tulip poplar (locally common in younger woods), blackgum and sassafras (in transitions to farmland). Today, there are only a few small (1-10 acre) remnants within the Inner Bluegrass, but more widespread patches do occur in adjacent Eden Shale Hills. The most notable older growth is "Gregory Woods" in northeastern Franklin County. Such sites clearly deserve special targeting for conservation and good management.

11a. MEDIUM DRY WOODS ON MORE ACID SOILS: subxeric, usually with much white oak

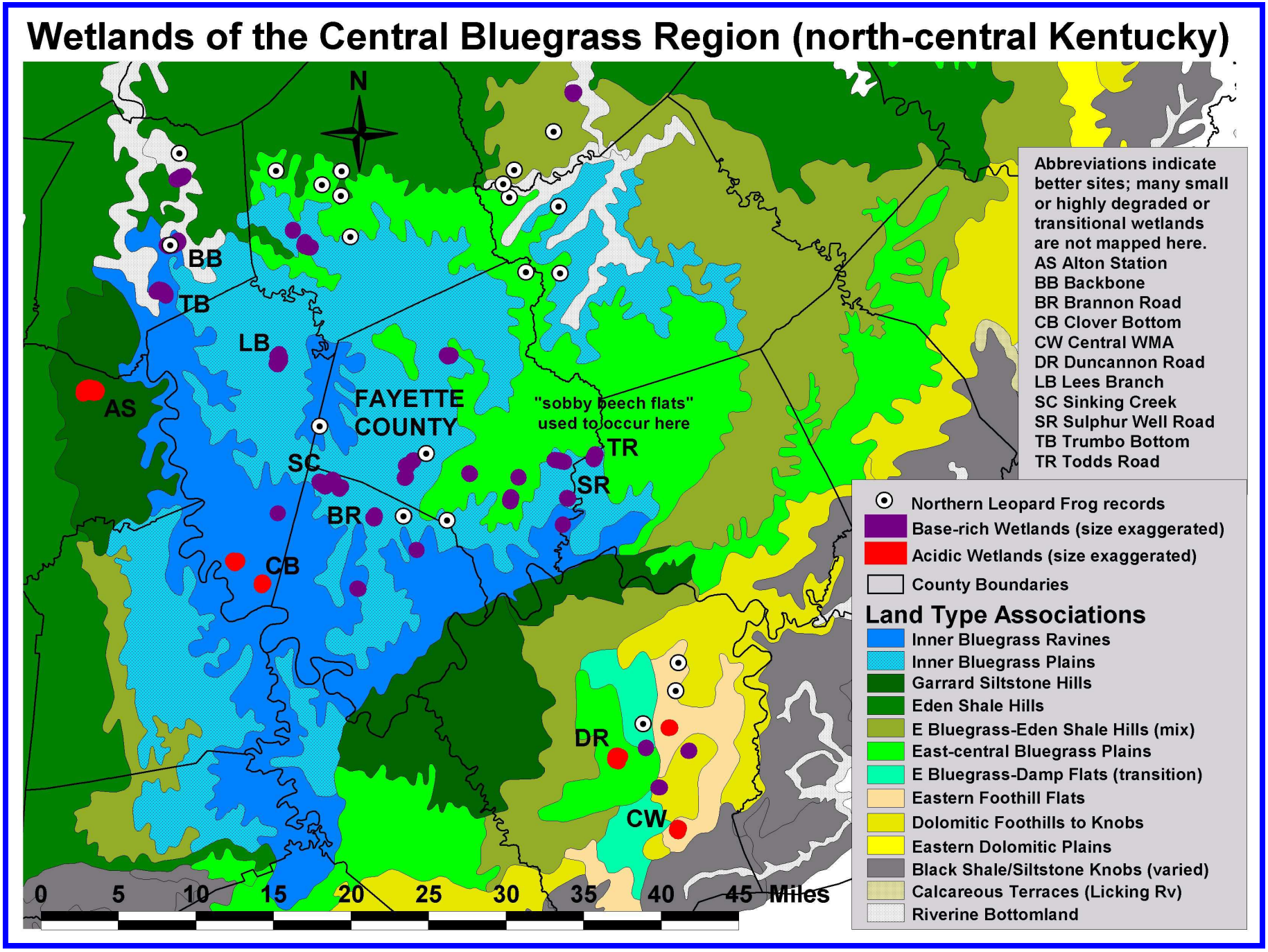
This variant used to be extensive in hills close to the Kentucky River: "The white oak is not often met with in the rich tract of land immediately surrounding Lexington; but is found abundantly in that part of Fayette county bordering the Kentucky river; where the soil becomes thinner and the face of the country more rolling. In these situations it attains its largest size..." (Short 1828-29). It was also dominant on ridges in the Eden Shale Hills. Other typical trees include black oak, hickories (shagbark, pignut, mockernut), sassafras and persimmon. Such woods are still widespread across Kentucky, but there are few good remnants in the Central Bluegrass, and it is reasonable to target some of these for conservation and restoration.


Higher river-terraces used to be dominated by beech, then farmed, now growing back.


Much older terraces are on uplands; one of best examples is Scott's Grove along US 27

Medium dry (subxeric) oak-hickory woods; locally frequent white oak and shagbark hickory.

Gregory Woods in SE Franklin County: a rare patch of old-growth in the Eden Shale Hills


Wetlands of the Central Bluegrass Region (north-central Kentucky)
N
BB
TB
LB
AS
FAYETTE COUNTY
"sobby beech flats" used to occur here
TR
SR
SC
BR
CB
DR
CW
0 5 10 15 20 25 30 35 40 45 Miles
Abbreviations indicate better sites; many small or highly degraded or transitional wetlands are not mapped here.
AS Alton Station
BB Backbone
BR Brannon Road
CB Clover Bottom
CW Central WMA
DR Duncannon Road
LB Lees Branch
SC Sinking Creek
SR Sulphur Well Road
TB Trumbo Bottom
TR Todds Road
Northern Leopard Frog records
Base-rich Wetlands (size exaggerated)
Acidic Wetlands (size exaggerated)
County Boundaries
Land Type Associations
Inner Bluegrass Ravines
Inner Bluegrass Plains
Garrard Siltstone Hills
Eden Shale Hills
E Bluegrass-Eden Shale Hills (mix)
East-central Bluegrass Plains
E Bluegrass-Damp Flats (transition)
Eastern Foothill Flats
Dolomitic Foothills to Knobs
Eastern Dolomitic Plains
Black Shale/Siltstone Knobs (varied)
Calcareous Terraces (Licking Rv)
Riverine Bottomland

1. LAKES, PONDS AND MARSHY TRANSITIONS: hydric

You have never really experienced the full potential of life until you have waded, up to the navel, unprotected by rubber leg-ware, on a sultry summer's day, into the black unknown muck of a stagnant water-body. Perhaps, like handling rattlers, or jumping out of a plane, it is the full-frontal confrontation of natural laws that provides such thrills. Quite apart from the slight danger of snapping turtles and snakes (with cottonmouths possible, after all, in western Kentucky), it may be the hugely unsanitary idea of sharing the primeval ooze with multifarious life forms, most of them invisible. And what if you trip on a root or get stuck? But to a true field biologist, this experience is really essential to an appreciation of where so much terrestrial life traces its ecological and evolutionary relationships—and what a good opportunity to challenge your immune system, develop a thick skin, and revert to a ‘swamp thing’.

Before settlement, such areas included a few oxbows along the Kentucky River, and scattered sites along smaller streams and streamheads. Beaver must have increased the extent of these habitats. These are seasonally or semipermanently flooded, and rarely rocky. Shrubs include black willow, swamp dogwood and buttonbush. At some sites there are complex zonations, including abundant grasses, sedges, knotweeds and other plants, grading into floating aquatic vegetation on still open water.

Although there are many artificial or semi-natural areas with this kind of vegetation, there are few good natural examples, in contrast to lowlands of western regions in the state. Many variants probably existed before settlement, and several may have virtually disappeared in some regions (considering the differences between oxbows, marshy openings, seasonal swale-ponds and beaver-ponds). Most artificial ponds lack complex zonation and lack high diversity of native species. Given the general loss or degradation of this class of habitats, it is often useful to treat it as a target for conservation. And we need much more careful restoration.


One Mile
Backbone Swamp on northeast side of Frankfort, one of best wetlands on lowlands in the region
Backbone Hill
Elkhorn Creek
Backbone Swamp
2517 ft
Google earth

Wolf Run at Allendale Drive: small artificially enhanced wetland below Moberly Spring in Lexington: rice cut-grass and snapping turtles have settled in to their new urban home.

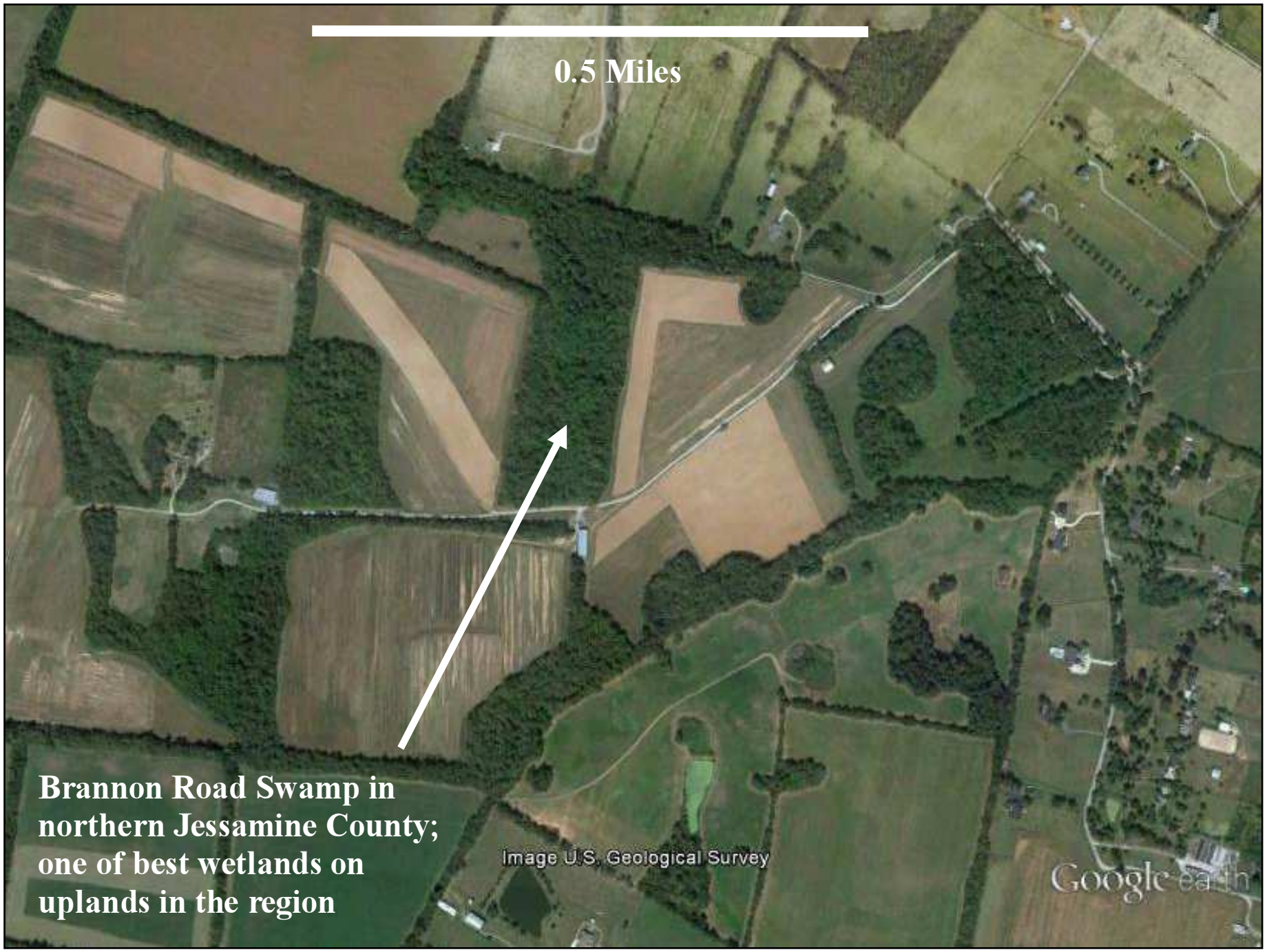
3. DEEPER SWAMPY WOODS: hydric

These woods are seasonally or semi-permanently flooded. Bald-cypresses and water tupelos are often abundant; other typical trees include swamp red maples, pumpkin ash, water locust, swamp cottonwood, water hickory and overcup oak. In Kentucky, good examples are restricted to southwestern regions. Further north and east suitable habitat does exists, but the above trees are mostly replaced by those less tolerant of flooding or by open shrubby/grassy vegetation. Meijer (1976) identified a few interesting sites in the Central Bluegrass with bald cypress, but these trees were probably planted. It is not useful to distinguish this class here.

6. SHALLOWER SWAMPY WOODS: subhydric

These woods are on lower floodplain terraces or swampy upland swales and seeps, with temporary to seasonal flooding or high water tables. Although average conditions are damp, there are occasional droughts, browsing or other disturbance. Common trees include green ash, white elm, shellbark hickory, swamp white oak, shumard oak and bur oak. Trees of more acid soils are largely restricted to old river terraces, including sweet-gum and pin oak. Sedges, grasses, cane and other shrubs are potentially common in the understory.

This class of habitat is widespread in the state, but good examples are mostly small and threatened. Due to drainage and agricultural conversion, only a few dozen identifiable remnants of the original wetland vegetation exist in this region, mostly just 1-10 acres in size. Despite this poor condition, there is increasing general interest by the general public and by government agencies in restoration of wetlands. If a more concerted effort begins to focus on the special problems of Bluegrass wetlands, we will first need a more detailed survey of the remnants and collection of propagules for local nurseries. There is clear justification for targeting.


0.5 Miles
Brannon Road Swamp in northern Jessamine County; one of best wetlands on uplands in the region
Image U.S. Geological Survey
Google earth

Duncannon Swamp, 5 miles south of Richmond, with more pin oak and other acidophiles compared to the Lexington area. Several old “licks” occurred in this part of Madison Co. before settlement, where unusually damp soils prevail. Coring indicates sediment 1000s of years old.

9. SEASONALLY WET FLATWOODS AND MARSHES: hydroxeric-tending woods, usually with much oak, often open

This class of habitat is seasonally to temporarily flooded or saturated, especially around springs and swales. But there can also be frequent drought, intensive browsing and perhaps even occasional fire in late summer or fall. Typical trees in the Central Bluegrass included swamp white oak, bur oak, shumard oak and shellbark hickory. Although small remnants of this habitat class are widely scattered across the Ohio Valley, better extensive examples are largely restricted to regions west of the Bluegrass. More open, grassy variants with a history of intense local effects of megafauna—and perhaps burning—have probably almost all disappeared. Typical herbs include swamp milk-weed, water-hemp, swamp bittercress and winged monkey-flower. Typical graminoids include several sedges, bull-rushes, reed-grass, fowl manna-grass, rice cut-grass and cat-tail. Because of habitat destruction, many typical species are now uncommon, rare or locally extinct. None of these plants or animals are globally imperiled, but several northern species have declined greatly within the central Ohio Valley.

It is likely that larger herbivores have always gravitated towards these sites for drinking, licking, stamping or wallowing. But although native animals probably had a seasonal rhythm of effects in these habitats, the livestock introduced after settlement appear to have caused excessive damage through continual access. Also, during early settlement some alien plants were probably introduced into these sites on purpose for food and medicine (especially water-cress, mints and calamus). There are virtually no remnants, except for scattered old trees, and it is difficult to estimate the original condition. Nevertheless, much local restoration of varied quality is already being undertaken by conservation-minded people. We need deeper historical, ecological and horticultural research into optimal designs for naturalistic restoration.


Native Wetlands of
the Central Bluegrass Region:
from seeps and streamheads to swamps and ponds

“Mastodons eat black ash trees as the last ice age begins to abate” (painting by B.R. Carlsen). Historical effects of large animals in should be considered; mastodons once were frequent

Beavers used to be widespread [https://www.flickr.com/photos/johnecollins/6172499150].

Left: plants typical of more open marshy places used to include the marsh marigold (*Caltha palustris*); here replanted at Allendale Wetland in Lexington. This species of more northern "fens" has disappeared from the wild in Kentucky.

Below: in contrast, a common species that remains in such habitats is swamp milkweed (*Asclepias incarnata*), which is more tolerant of disturbance and pollution.

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

7. AVERAGE UPLAND WOODS: "mixed messy-phytic forest" submesic or 'intermediate' woods, soils deep and well-drained

This varied class of habitats include terraces with temporary flooding, seasonally damp swales on uplands, and moister zones in rolling plains. Although generally somewhat mesic, the woodland does experience stresses from occasional dry or wet conditions, and it is often disturbed by grazing, cutting or perhaps (at least on poorer soils) burning. The tree composition includes white ash, hackberry, black walnut, shagbark hickory, Ohio buckeye, coffee tree, mulberry, sugar maple, chinquapin oak and shumard oak. In less disturbed areas, sugar maple and bitternut are locally abundant; in more disturbed areas bur oak and cane are typical. The understory is often dense with grasses (especially wild ryes), vines or thickets of cane, pawpaw, coralberry and other shrubs (grading into denser thickets outlined below). Running buffalo clover was locally abundant but it is now generally absent.

Most original herbs have disappeared from modern remnants. But some annuals and biennials recover if seed is available; these include Miami mist, yellow corydalis, corn salad, waterleaf and even blue-eyed-Mary. From a few early botanical records, perennial herbs that should also belong here include squirrel-corn, running rue-anemone, mayapple, harbinger of spring, wild hyacinth, midwestern lily and trout lilies. Much recently disturbed forest belongs in this class, but there are very few good natural examples. Although this class of woodland is not rare, its generally poor quality demands a special focus for restoration. Such restoration will have to focus much work at the "species level" (as discussed in Part IV). In addition to the need for propagation of many native plant species, there are severe problems from invasive alien plants. Without good experimentation using various disturbances to simulate the original regime, we do not yet know how best to restore this woodland.


Extraordinary tract in southwestern Jessamine County where the owners have allowed the woods to grow back for three decades; diverse native trees are present, some old, plus a patch of cane.
US 68
0.5 Mile
KY 29
Google earth

Left: typical ‘intermediate woods’ at Griffith Woods, with intense browsing by deer.
Right: old bur oak , in remnant of deeper woods with white trout lily (*Erythronium albidum*).

These young shagbarks came to dominate about five acres at Griffith Woods where mowing ceased during the 1980s. Continued cattle-grazing allowed the unpalatable hickories to prosper.

8. CANEBRAKES (evergreen) & OTHER THICKETS (deciduous) submesic to xerohydric-tending, seral, soils deep & well-drained

In the great 'ecotone' (ecological transition) between grasslands and forests of Kentucky, there is a complex class of vegetation, intergrading in space and time between more shady conditions and more open woodland maintained by disturbance. Sometimes there is a rapid transition after cutting, burning and browsing cease, when thickets of cedar, cherry, ashes, maples, tulip and other trees move in and more shade tolerant species eventually succeed. But in messier transitions, where simple successional strategies are confused by an ebb-and-flow of disturbance regimes with different degrees of intensity and uniformity, specially suited woody species can also take an ecotonal hold. In some cases these species do not readily relinquish their residual rights, recklessly rooting-around and rampantly reproducing with rambunctious resprouts of frequent prickly or poisonous quality.

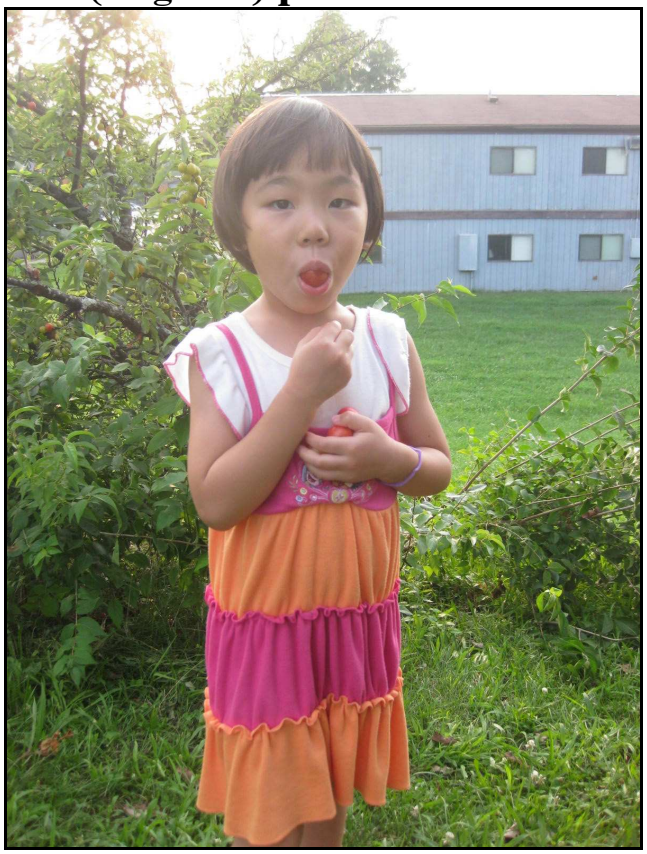
This varied vegetation, with thorny thickets of interesting root-sprouting species, is often overlooked by biologists. It occurs on a wide range of soils, but typical sites are usually not hydric or xeric enough for permanent openings. Much is in disturbed forest-edges, brushy grasslands, and old fields with frequent fire or grazing. Larger trees include honey locust, black locust, black cherry and osage orange; persimmon and sassafras occur on poorer soils. Smaller trees and shrubs include pawpaw, redbud, dogwoods, black haws, hawthorns, crabapples, plums, sumacs, roses, coralberry and prickly-ash.

Such vegetation is extensive in today's disturbed landscape, but, despite our poor knowledge of presettlement conditions, it appears that some variants have now virtually disappeared (e.g. along old animal trails and grassland margins). There is clear justification for treating this habitat class as a target—but for restoration much more often than conservation.

Restored cane, in remnant of ancient woodland with old bur oak along Cane Run. Cane used to extend along this creek from Lexington to Georgetown in 1775 but all was cleared. We planted 150 cane 5-year old seedlings here in 1999/2000, and plants have now spread over two acres.


Amazing remnant of running rue-anemone at Cane Run

Red (or goose) plum: *Prunus munsoniana*, a great native fruit formerly promoted around Indian villages



10. SEASONALLY DRY OPEN WOODS: “plagio-climax”* usually much oak, soils deep, well-drained but xerohydric-tending

This vegetation may have occurred here locally on gentle slopes, rolling plains and upland flats that are subxeric-xeric or xerohydric, with a history of much browsing and perhaps some burning, especially around Indian villages. The land was not typically flooded or saturated, but some soils were relatively impermeable or poorly drained soil in winter or spring. Common trees, especially in open woodlands, included locusts, oaks (bur, shumard, chinquapin, shingle) and hickories (shagbark, shellbark). Diverse grasses and wildflowers may have occurred in open variants. Such vegetation has been virtually all converted to farmland, and small forest remnants become too dense and mesic without fire or grazing.

Many people, including myself, when first pondering the great outdoors of Kentucky, have supposed that, apart from rock outcrops, streams and ponds, forests of large ancient trees covered virtually all of the state before settlement some two hundred and fifty years ago. We all know that the climate and soil of this state is generally quite capable of supporting tree growth, and we frequently see how young trees of cedars, cherries, locusts, walnuts, ashes and other species can quickly take over abandoned clearings within a decade or so. To be sure, occasional storms, fires, insect outbreaks, animals trails and other ‘natural’ disturbances may have caused temporary or local openings in the presettlement forest. But wasn't there usually such abundant undergrowth of saplings, and so many different types of tree—resistant to various stresses and pests, that forest quickly filled in such gaps. Of course, we also know that human beings were here before the Old World invaders, and they must have had camps, villages and small clearings for crops. But, as often repeated through book and lore, wasn’t this just a seasonal ‘hunting ground’ for those people, with little or no development of ‘civilized’ settlement?

Wrong! From clues still scattered over the landscape, from delving into early written records, and from growing ecological common sense, biologists now consider that grassy openings, ranging from treeless grasslands to thin savannas or open woodlands, were widespread in some regions of the state, especially more western plains. Within the Central Bluegrass, such habitats appear to have been present but covered only a minor proportion of the landscape, probably less than 10% (Campbell 1985, 2013b). The detailed mapping of bur oak in Fayette County by Davidson (1950) allows us to explore association with old Indian villages.

Although we have little direct evidence of causes, it seems likely that browsing beasts (especially the hooved ungulates)—or frequent fires further west (often set by human beings)—were largely responsible for maintenance of these habitats. Both beast and fire and can spread more quickly and thoroughly where not interrupted by gullies, ravines and streams. Indeed, the combination of browsing and burning cycles may well have been synergistic in more western plains—both consume grass and brush more vigorously than they do shady forest growth, and both can contribute to the grass and brush component in open woodlands.

Grasslands and open grassy woodlands are now among the most endangered ecosystem types in the state, because the gently sloping to flat, well-drained land types that they occurred on have become strongly favored for agriculture, suburban sprawl and industrial development. In a few places ancient trees remain in open woodland pastures, but alien grasses and herbs have been introduced to the ground vegetation. In other places, a few patches of native ground vegetation, sometimes with rare 'indicator' species of the presettlement condition, may remain along rights-of-way where occasional mowing may simulate the presettlement burning or browsing. But it is very rare to find both scattered ancient trees and extensive native grassland together in relatively intact remnants of these ecosystems. Together, these remnants present great challenges for conservation and restoration. [*Bill Martin's term is "aestheto-climax"!]

The abandoned tract in Jessamine at dusk; older trees are remnants of woodland-pasture


Spring-beauties persist in mowed areas
Cane-brake planted at the Arboretum

Some bluegrass may still be native

THE HERBIVORE HYPOTHESIS: for Bluegrass Woodland

The Hypothesis: "Before human civilization, patterns of herbivory in space and time, especially by larger animals, were a major factor maintaining the diversity of woodland on eutrophic soils in temperate regions." If so, the modern decline in naturally-behaving larger animals has often allowed browsing-sensitive plants to increase in situations where they would have been more controlled in the past. Such plants would include some aliens that have now prospered in more populated regions, where even deer and livestock are restricted. In contrast to fire, the original impact of herbivory was concentrated on mineral-rich soils with productive vegetation. Moreover, regular browsing as well as rapid decomposition would have reduced fuel-loads in woodland on such soils.

There is diverse circumstantial evidence for this concept. At the species level, several native plants are associated with the disturbances of cattle and deer, or with old human paths and mowed areas. These include the endangered species, running buffalo clover. At the habitat level, dynamic patterns in species composition are often correlated with apparent effects of larger herbivores, though historical details are usually obscure. In his book on grazing in forests, Vera (2000) delved deeply into such details for central Europe, suggesting a general theory that can also be applied to Bluegrass Woodland. At larger scales, there is a lot more work to do. For example, using a new tool—the analysis of dung-fungal spores in ancient sediments, Gill et al. (2012) have shown in midwestern regions that post-glacial collapse of megafauna was followed by anomalous woodland that included much of the relatively palatable ash and elm. Subsequently, there was an abrupt increase in charcoal, and within a millenium or so it appears that frequent burning by humans led to woods with more oak and hickory. Red cedar is one of the most unpalatable trees, but the 'cedar glades' of east-central states could have been refuges for larger migrating herbivores during cold periods (with forage in nearby cane).

Submesic woods at Buckley Hills: no artificial weeding, but intense browsing by deer prevents winter-creeper from covering ground.

Walnut-hackberry woods at the Griffith Farm, with wild rye dominant on the ground. Lack of honeysuckle seems due to deer browsing.

Submesic woods at UK Arboretum: honeysuckle cleared but winter-creeper remains dominant; perfect site for trials with goats or sheep.

Locust-cherry woods adjacent to above site, with much more honeysuckle and much less grass. There seems to be less deer browsing.

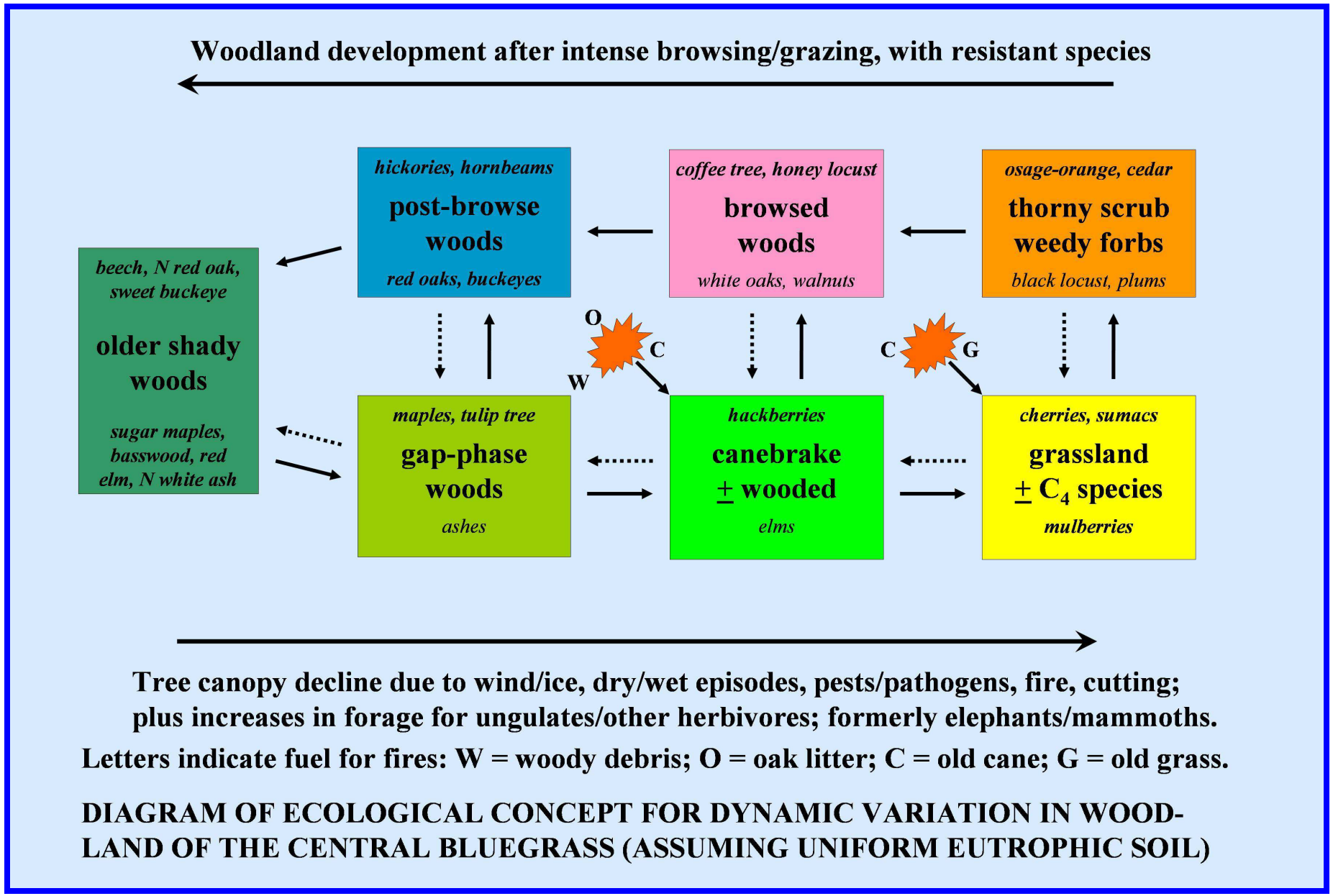


DIAGRAM OF ECOLOGICAL CONCEPT FOR DYNAMIC VARIATION IN WOODLAND OF THE CENTRAL BLUEGRASS (ASSUMING UNIFORM EUTROPHIC SOIL)

Footnote. This model can be extended to much of the eastern U.S.A. based on concepts developed in central Europe. For further discussion, see Vera, F.W.M. 2000. Grazing Ecology and Forest History. CABI Publishing, Wallingford, England. Critics (e.g., Mitchell in J. Ecol. 2005, 93: 168-177) have shown Vera's thesis to be exaggerated in some cases, but generally agree that herbivores often cause shifts in vegetation.

CONCLUSION: What is ecological realism in restoration?

BIBLIOGRAPHY

Baskin, J.M., & C.C. Baskin. 1985. A floristic study of a cedar glade in Blue Licks Battlefield State Park, Kentucky. Castanea 50: 19-25.

Braun, E.L. 1950. Deciduous Forests of Eastern North America. The Blakiston Company, Philadelphia, Pennsylvania.

Buffington, J.M., & D.R. Montgomery. 2013. Geomorphic classification of rivers. Pages 730-767 in: J. Shroder & E. Wohl (eds.). Treatise on Geomorphology. Vol. 9. Fluvial Geomorphology. Academic Press, San Diego, California.

Campbell, J.J.N. 1985. The Land of Cane and Clover: Presettlement Vegetation in the So-called Bluegrass Region. Report from the Herbarium, University of Kentucky. 93 pages.

Campbell, J.J.N. 2012. The Herbivore Hypothesis for Bluegrass Woodland. Posted at http://www.bluegrasswoodland.com/uploads/Herbivore_Hypothesis.pdf. 6 pages.

Campbell, J.J.N. 2013a. Notes on proposed Cane Run project at Coldstream Park. Posted at http://www.bluegrasswoodland.com/uploads/Julian_Campbell_s_Cane_Run_Notesxx.pdf. 120 pages.

Campbell, J.J.N. 2013b. Bluegrass Woodland and its eutrophic nature. Posted at http://www.bluegrasswoodland.com/uploads/Bluegrass_Woodland_and_Its_Eutrophic_Nature.pdf. 40 pages.

Cresswell, N. 1774-77 [1775 in Kentucky]. Journal. Printed with foreword by Samuel Thornely. 1924 (American edition). Journal of Nicholas Cresswell. 1774-1777. Lincoln MacVeagh, The Dial Press, New York.

Davidson, U.M. 1950. The original vegetation of Lexington, Kentucky, and vicinity. M.A. thesis, University of Kentucky.

Gill, J.L., J.W. Williams, S.T. Jackson, J.P. Donnelly & G.C. Schellinger. 2012. Climatic and megaherbivory controls on late-glacial vegetation dynamics: a new, high-resolution, multi-proxy record from Silver Lake, Ohio. Quaternary Science Reviews 34: 66–80.

Howell, H.H. 1975. Some ecological factors affecting the occurrence of water willow (*Justicia americana*) in Jessamine Creek, Kentucky. Transactions of the Kentucky Academy of Science 36: 43–50.

Imlay, G. 1792 (1st edition); 1797 (3rd edition). A Topographical Description of the Western Territory of North America. Debrett, London, England. [The third edition (1797), which is quoted here, was reprinted in 1969 by Augustus M. Kelley, New York.]

Lave, R., 2009. The controversy over natural channel design: substantive explanations and potential avenues for resolution. J. American Water Resources Association 45: 1519-1532.

Lave, R., 2012. Bridging political ecology and STS: a field analysis of the Rosgen Wars. Annals of the Association of American Geographers, 102: 1–17.

Meijer, W. 1976. Notes on the flora of the Sinking Creek System and Elkhorn Source Areas in the Inner Bluegrass Region of Kentucky. Trans. Kentucky Academy of Science 37: 77-84.

Mitchell, F. J. 2005. How open were European primeval forests? Hypothesis testing using palaeoecological data. Journal of Ecology, 93: 168-177.

Owen, D.D. 1857. Report of the Geological Survey of Kentucky. No. 2: 85-114. No. 3: 59-171.

Parola, A.C., W.S. Vesely, M.A. Croasdaile, C. Hannsen & M.S. Jones. 2007. Geomorphic Characteristics of Streams in the Bluegrass Physiographic Region of Kentucky; Kentucky Division of Water: Frankfort, Kentucky, USA.

Rosgen, D.L. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Books, Exit EPA Disclaimer Fort Collins, Colorado.

Short, C.W. 1828-29. Prodromus florulae Lexingtoniensis, secundum florendi aetatum digestae. Transylvania Journal of Medicine and the Associated Sciences 1: 92-99, 251-265, 407, 422, 560-575. 2: 438-453.

Vera, F.W.M. 2000. Grazing Ecology and Forest History. CABI Publishing, Wallingford, England. 506+ pages.