

SHAWNEE HILLS AND PLAINS



Notes by Julian Campbell, June 2012 (bluegrasswoodland.com). Cover photo: “The Beautiful Hoosier National Forest” (tripadvisor.com/LocationPhotos-g36942-Bloomington_Indiana.html)

SHAWNEE HILLS ECOREGION
in relation to subsections of
the Interior Low Plateaus

Focal Areas for Conservation
(with provisional division into
higher versus lower priority)

-  higher priority
-  lower priority

-  Ecoregional Sections
-  State Boundaries

ADJACENT SUBSECTIONS

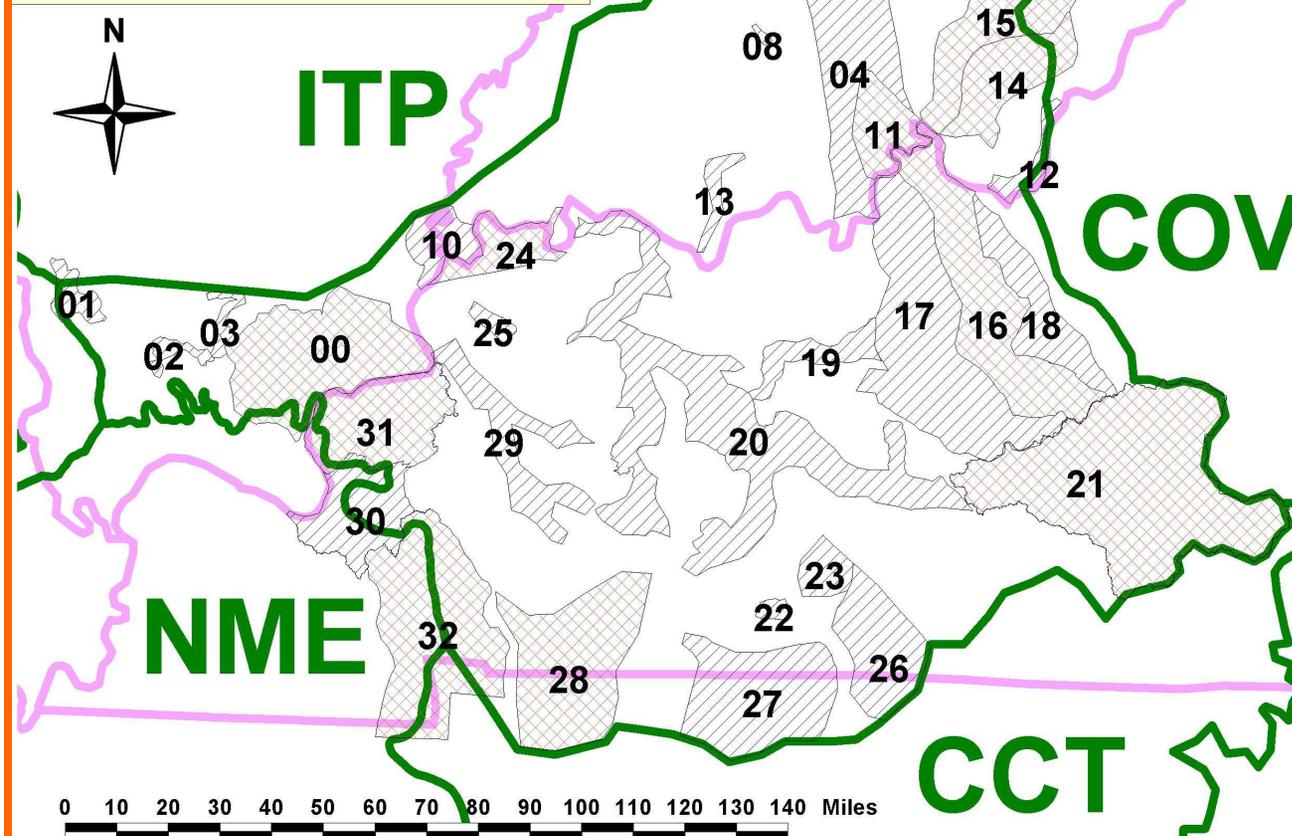
CCT: Central Cumberland
and Tennessee Valleys

COV: Central Ohio Valley

ITP: Illinoian Till Plain

NME: Northern Mississippi
Embayment

OTP: Upper Ohio River Till
Plain (Wisconsinian Age)



00	Shawnee National Forest (east)
01	Pomona Complex
02	Shawnee Hills Cliffs & Cypress Pond
03	Sugar Cr/SFK Saline Rv
04	Hoosier National Forest (approx. core)
05	Blue Spring Caverns
06	Thousand Acre Woods area
07	Martin County sites (loose cluster)
08	Buffalo Flats & Wening-Sherritt Seep
09	Owen County+ sites (loose cluster)
10	Lower Wabash Wetlands
11	Hoosier Hills Area
12	Harrison County sites (loose cluster)
13	Spencer County sites (loose cluster)
14	Blue River (south/east)
15	Blue River (north/west)
16	Northern Big Barrens (focus zone)
17	Northern Big Barrens-W extension
18	Northern Big Barrens-E extension
19	Rough River Corridor
20	Lower Green River Corridor
21	Middle Green River Watershed
22	Russellville Macrosite
23	Gasper River Corridors
24	Henderson Sloughs Area
25	Higginson-Henry WMA
26	Drakes Creek Watershed
27	Red River (West) Corridor
28	Fort Campbell-Little River Area
29	Tradewater River Corridor
30	Grand Rivers Corridor-South
31	Grand Rivers Corridor-North
32	Land-Between-the-Lakes Plus

SHAWNEE HILLS AND PLAINS: AN ECOREGION FOR FOCUS ON CONSERVATION. The Unglaciaded Lower Ohio River watershed, centered on the lower Wabash River (Illinois, Indiana) and Green River (Kentucky), including karst plains.

TEAMWORK. Natural regions can be defined for coordination among varied types of conservationist. Such regions should embrace somewhat similar ecological conditions in each case, and range over a reasonably moderate scale to allow frequent gathering, sharing and resolving. The ‘Shawnee Hills’—as mapped here—contained a traditional center for native American culture during a series of eras. Before use by the Shawnee tribe in recent centuries, a distinct phase of the Fort Ancient culture established here, and there was extensive development of agriculture during the ‘Woodland Period’ 1000-3000 years ago. The region is extended here for practical reasons to include karst plains on south and east sides of the hills. Major cities now include Bowling Green, Owensboro (KY), Evansville, Bloomington (IN); Carbondale (IL) and Clarksville (TN) are just outside. The various universities in these cities collaborate little on critical problems of natural history and conservation biology in this region.

In 1995-2005, The Nature Conservancy hosted planning for biodiversity across the whole “Interior Low Plateaus Ecoregion”—from northern Alabama to southern Indiana. This helped guide major projects—but details of their extensive analysis have not been widely shared with the community. In the Shawnee Hills section of the Interior Low Plateaus, there has until recently been little integration of efforts by different organizations. While many conservationists are employed across the Shawnee Hills, there are few opportunities for collaboration. Yet there are several highly significant large focal areas for conservation within this region. For several decades, programs have developed at the large federal tracts: National Forests (Shawnee, Hoosier, Land-Between-the-Lakes), Mammoth Cave National Park and Fort Campbell. Also, state governments own and manage large areas of wetlands on lowlands, mostly with emphasis on hunting and fishing. Smaller nature preserves tend to be more widely scattered.



More rugged sections include “Garden of the Gods,” Shawnee National Forest, Illinois [shawneeforest.com/Hiking]



More disturbed sections include coalfields, supplying TVA’s “Paradise Fossil Plant” [courier-journal.com/blogs/bruggers/]

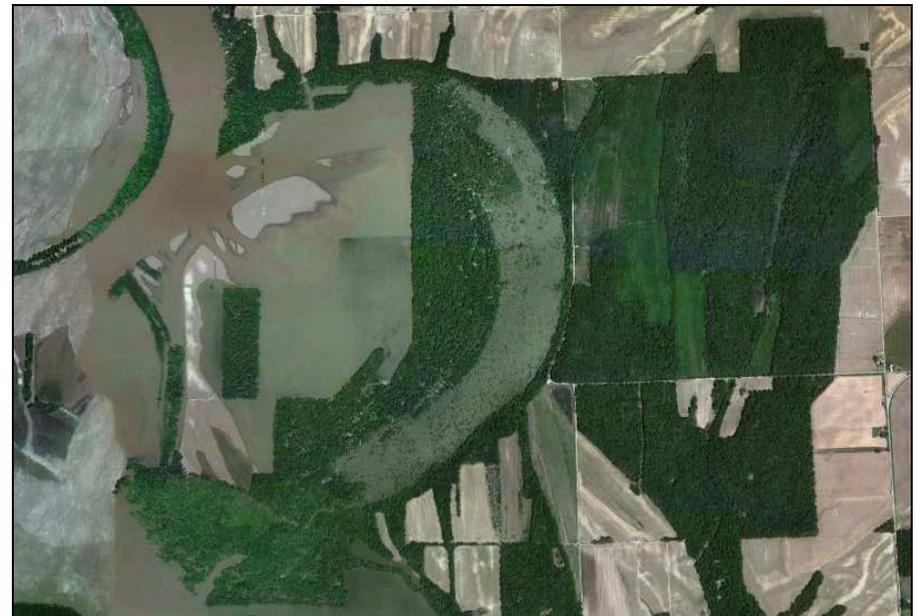
Within the past 10-20 years, more complex projects—involving much private land—have been initiated by TNC and partners for watersheds of the Middle Green River (KY) and Blue River (IN). And in Kentucky at least, some recent land acquisitions (using the federal Forest Legacy Program) have been related to a “Big Rivers Corridor Project.” That effort aims to connect large natural areas on lowlands in the Shawnee Hills, but relevant maps for the whole project have not yet been made public. It is often difficult for conservation-minded people and the public at large to appreciate what exactly is being planned, done and achieved by agencies. For example, it would be good to know if trends in populations of imperiled species show any signs of recovery, and if the effects of human actions—good or bad—can be quantified.

A hopeful development in Indiana has been the formation of the Southern Indiana Cooperative Weed Management Area (sicwma.org). The group aims to focus on critical problems with alien plants, but members also have general interests in stewardship. It would be useful if Kentucky and Illinois established parallel organizations—perhaps forming the core for a regional network.

The Shawnee Hills region has complex biodiversity at levels of landscape (or watershed), habitat (or community) and species (or other taxa). Cooperative projects can sometimes focus usefully on these targets, rather than the whole Interior Low Plateaus. If data can be shared more directly, completely and transparently across the region, it would be easier to develop honest measures of success or failure. True teamwork could then be advanced. Institutions tend to provide ‘rosy’ publicity about their own efforts, in order to retain and grow support. Instead, a regular conference could itself develop measures of success or failure with some independence. Interested parties could provide brief presentations, plus whatever appended documents they want. A democratically elected committee could assemble the presentations into an annual report and summarize results, with plenty of opportunity for ‘minority opinions.’ The Shawnee could even be invited to provide special comment and chair a session.



Green River in Mammoth Cave National Park (2002, Jan 3), from cedar cliffs to river pools [photo from nature.nps.gov/air/webcams]



Wabash Rv., Big Cypress Slough and other lowland woods in Posey Co., Indiana [from an FSA image 2.5 miles across, 28 May 2011].

TARGET-DEFINITION. At the broader landscape level, there are clear priorities in the larger federal tracts, river corridors and watershed projects already noted. The aquatic systems in these areas have some potential for long-term improvement, although several species are highly imperiled. Much effort has also been focused on the more extensive blocks of forest in these projects, especially in more rugged landscapes. Priorities are less obvious in more degraded landscapes, especially where there has been much mining, farming or other development. But such landscapes do contain significant remnants of distinctive woodland and grassland types that are now almost all destroyed. A more detailed natural history of these areas would still be useful, in order to guide protection of sites, management and restoration. And we need programs for replanting truly native vegetation in degraded landscapes, not just generic mixes.

At the habitat level, there are added priorities for protection of some smaller sites, such as individual caves and remnants of native grassland that do not fit readily within larger project areas. Also, there is a need for varied types of restoration to supplement programs of direct land protection at larger scales. For example, it is important to focus on enhancement of riparian vegetation at selected sites for watershed projects. Especially in less rugged landscapes, riparian zones and wetlands are often significant in themselves. Unusual conditions used to prevail in some types of streamheads, seeps and seasonal ponds, but settlement has greatly reduced or damaged them.

On drier land, the prevalent forest types may not need much site-specific focus, but the overall balance of older growth versus younger trees for timber is a controversial matter (and maples versus oaks), especially on public land. For biological conservation, it is also important to seek more consensus on the appropriate use of fire for restoring open grassy woodlands, where many rare plants and animals used to prosper. The few remnants of more open grassy vegetation are often overlooked in broader planning. These remnants include scattered rights-of-way where rare plants can be rescued for transplantation to safe sites, and for wider propagation.



Grassland (“barrens” or “prairie”) used to occur widely on karst plains (as here in Todd Co., Ky.), and locally on drier river terraces.



Mammoth Cave is the World’s longest documented cave system [photo from nationalgeographic.com/travel/national-parks/].

At the species level, there are priorities for micro-management in recovery of imperiled species—or in reduction of invasive aliens. Among endangered aquatics, it is tragic that several mussels and fishes have become at least locally extinct, but agencies are making progress in artificial raising of juveniles for reintroduction. A few vertebrates also receive special attention, although there are no plans for recovery of most larger mammals that have disappeared. The impending catastrophe for most bats appears largely unavoidable, but much relevant research is being conducted—there is interest in potential biological control using fungi (whitenosesyndrome.org/...wns_symposium_abstracts_2012_final.pdf).

For selected plants, there is a need to propagate species used in riparian restoration and other habitats. Several rare plants of more open woodland and grassland can probably be recovered, but will need propagation first (e.g. buffalo clovers and prairie phloxes). The demise of chestnut is now being followed by hemlocks, ashes and walnuts, so we must now collect seed from these trees and breed for resistance to pests and pathogens. It would be good to organize nurseries, arboreta and botanical gardens around such efforts. Local universities are well positioned to lead some of this work, based partly on their herbaria, but systematic botany has dwindled in the region.

In addition to pests and pathogens, aliens in this region include several invasive plants. Strategies to reduce them—let alone control them—are not clearly established in some cases. The most severe problems range from *Naias minor* and other aquatic plants, to privets, honeysuckles, sericea lespedeza and Johnson grass on uplands. There are fewer species in deeper shade, but they include the Japanese stilt-grass (already widespread), Japanese chaff-seed (spreading in riparian woods) and purple winter-creeper (spreading on calcareous slopes). While herbicides or other methods do exist to reduce such plants, we need sustainable programs to provide adequate long-term control, and there are fundamental questions of economy and ecology that must then be addressed.



Sandstone glade at Fern Clyffe State Park, Illinois, a rare habitat found in the region [photo: historylines.net/img/June_2009/big/...].



Mantle Rock (Livingston Co., Kentucky) has great ecological and cultural significance [photo: nature.org/ourinitiatives/regions/...].

TRADE-OFFS. While there is uncertainty about whether human beings can solve some problems of conservation, we can frame the most important questions that divide us, seek more consensus—or at least balance, and develop mutual support. Regular meeting, communication and debate would help these causes within the Shawnee Hills and Plains.

In defining targets, we often ascribe significance to large continuous blocks of wilder land, but the rationale is generally based on ecological supposition rather than clearly demonstrated facts, and on economic arguments given lower costs per acre for acquiring and managing larger tracts. The recent protection of large tracts along river corridors is commendable, but smaller sites with special significance can be overlooked on less rugged land with more fragmentation. In some landscapes, inventory and descriptive analysis are still urgent matters, in order to guide more balanced conservation across the region. More information should be combined from all four states, although ‘ownership issues’ can hinder this work.

Small remnants of natural wetlands with varied conditions, and of more open grassy woodland (with blackjack and post oak), are easily ignored in state or federal programs. Moreover, it can be difficult to promote habitats that need fire for restoration, since prescribed fire is troublesome in some cases. Small disrupted patches of native grassland can still harbor globally rare plants, such as *Phlox pilosa* ssp. *deamii* (largely endemic to this region) and *Silphium pinnatifidum* (centered in this region), plus many invertebrates.

In estimating the effects of human actions and associated environmental factors on targets, beyond just habitat destruction, there are several obvious scientific problems that remain controversial topics and deserve more coordinated research. Through TNC’s ecoregional planning and ongoing discussion, the most important areas of uncertainty have begun to emerge. For the community, it is particularly important to assess human effects that influence—or are influenced by—public funding. Some of the critical questions can be articulated as follows [see next page].



Pleurobema plenum, the rough pigtoe [museum.state.il.us/...]: an endangered species remaining in the Green River of Kentucky.



Kentucky Cave Shrimp, endemic to Mammoth Cave [photo by Dave Deiter at theinfinitesphere.blogspot.com/2007/10/...]

These six items are derived from an ecological viewpoint.

1. How are changes in climate influencing ecosystems, and what are the implications for conservation plans?
2. How can effects of coal mining on aquatic systems (especially mussel species) be reduced; and how can the post-mine environment be restored and managed for native biodiversity?
3. How can the entrenched impacts of dams and land-uses on large watersheds be mitigated?
4. How can fire be applied at appropriate intervals to restore native grasslands and open woodlands across their full presettlement range of sites, from hydric to xeric (with reduction of aliens)?
5. How can ungulates be managed to simulate natural interactions in woodlands, especially on eutrophic soils that have potential for locally concentrated effects (with reduction of aliens)?
6. How do differences in vegetation influence karst or cave systems, and how can karst landscapes be managed best for water quality?

From a more economic viewpoint, how can sustainable timber or other forest products be effectively marketed from the region? In more open habitats, how can management for game animals be combined optimally with use of fire to restore vegetation. And can we find some economic uses for material from invasive plants—perhaps involving use of livestock to browse out brushy alien thickets?

For sustainable economies, several critical themes need continual attention. For example, it has been difficult to establish ‘forest banks’ or similar cooperative programs between the private sector, non-profits and agencies. Indiana’s Blue River program is making some slow progress with a program of this type (extension.purdue.edu/extmedia/fnr/fnr-187.pdf). But the initial effort by TNC in Livingston Co., Kentucky, was suspended due to a legal dispute with the private buyer. A broadly transparent, community-based evaluation of such deals will be needed for decades to come. Biological monitoring of conserved lands is critical, especially if novel legal or financial mechanisms are used to establish protection and to guide stewardship. For example, it is important to determine how declining species of birds fair on these lands, and if alien plants are controlled.



Buffalo clover (*Trifolium reflexum*), endangered in the Ohio Valley and with distinct genetic segregates [[fs.fed.us/wildflowers/..](http://fs.fed.us/wildflowers/)]



French's shooting star (*Dodecatheon frenchii*) grows under sandstone cliffs, mostly in the Shawnee Hills [[naturalheritage.com/..](http://naturalheritage.com/)]

Integrating community and science into restoration of grassland (and other ecological systems) across the Shawnee Hills & Plains.

Julian Campbell (Aug 2014); see bluegrasswoodland.com for details.

Conservationists often seek to be science-based and community-based, but how exactly can we agree on pathways to cooperative work at local, regional or global levels? The science we need is so vast, especially when considering global problems, and the communities of “we” remain uncertain in terms of arrangements among varied organizations, interest-groups and individuals. Initial “Ecoregional Planning” by The Nature Conservancy and partners for the Interior Low Plateaus has not become linked with our work as a regular reference, means of assessment, or revisable guide for the future. In 2003, this plan stated: “The Core Team will have the responsibility for ensuring that future iterations of the plan are completed on a periodic basis. It is reasonable at this point to expect that, given the gaps in data identified above, the next iteration of the portfolio should be done within 5-6 years.” The Core Team has disbanded without a published new iteration or measures of success. There has been no continuing synthesis of Natural Heritage data.

A central issue in comprehensive, cooperative work across an ecoregion is the scale of our targets. The ILP is too large for regular team-building with at least monthly interaction, plus a proper annual meeting. But it can be usefully broken into three divisions (see map): Nashville Basin plus Highland Rim (CCT); Shawnee Hills plus Karst Plains (SHP); Bluegrass plus Knobs (COV). The SHP itself could have seven subdivisions. Karst Plains around the Shawnee Hills formerly supported the most extensive native grassland east of the Mississippi River, and there were also extensive grasslands or open post oak woodlands within the ring of more rugged hills, especially on high terraces of rivers where native people cleared land for villages and fields. Those people formed a cultural focus within this region; it would be logical—and natural—for us now to consider reforming that geographic focus. In addition to better scientific attention to local details within this region, it is particularly important that the general public be educated and engaged at a reasonably local scale—within groups of close counties that share common features.

I have two basic suggestions for how to proceed.

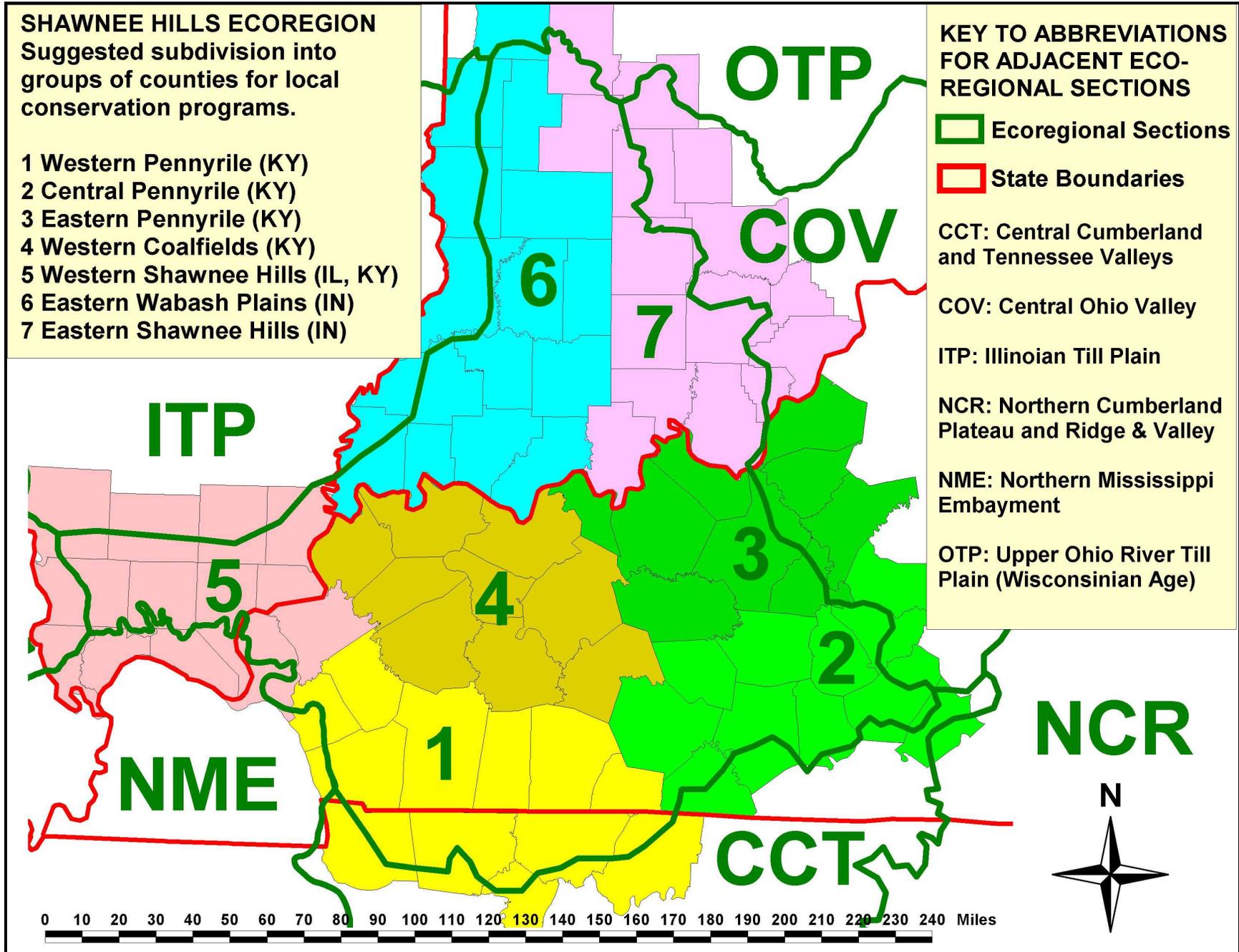
(1) Monthly field trips. These would be for interested public within each regional section—perhaps ideally groups of about 10-12 counties. A coordinating person within each of these areas would build up a list of contacts for notifications. The person would coordinate with landowners and managers of sites for permission and hosting, ideally with a rotation among sites of interest and plenty of interaction on each trip. With time, educational handouts could be generated and posted, evolving into a set of materials that could be used for academic use—perhaps summer programs affiliated with schools and colleges. In some cases where more formal programs are developed, a fee could be charged to support the operation. In other cases, the field trips could be connected with volunteered work—either physical stewardship or real science, such as biological surveys and monitoring. A central goal of this effort would be to build a local community of conservationists familiar with their ecological neighborhoods, and devoted to advancing the cause.

(2) Annual meetings. These could be rotated among the seven subdivisions (see map). There would be brief presentations from people doing significant work within the region—perhaps 15 minutes each during a morning session (with a public focus). There would also be general discussion to address goals, methods and progress of conservation—perhaps in breakout groups during an afternoon session (with a professional focus). As well as providing mutual education, this meeting would build consensus for cooperative work and to define the most critical (or divisive) issues for further research. Ideally, the meetings would become linked with an evolving website where contributions of participants are regularly posted. Moreover, this website could become the central publication for repeated professional measures of success—or failure?—in conservation and restoration across the region, including wildlife management.

‘Measures of success’ have been talked about for decades by some conservationists, but they have not yet been implemented here in a manner that can be understood by the general public—or even by the staff and membership of some relevant organizations. Through regular field trips and effective annual meetings, the “truth will out”.

This table and following map outline ecoregional sections for concentrated series of field trips, annual meetings and general coordination among conservation-minded people. With about 10-12 counties in each section, enough interest could be generated to support local leadership.

Practical Subdivisions of Shawnee Hills and Plains for Locally Coordinated Conservation	
Suggested Name (provisional)	Larger Focal Areas
1: Western Pennyrile	Red River; Fort Campbell; Land-Between-the-Lakes; Russellville area (transitional to 2)
2: Central Pennyrile (Middle and Upper Green River Watershed)	Middle and Upper Green River; with Barren River, Gasper River and Drakes Creek to south
3: Eastern Pennyrile	Northern Big Barrens; includes upper Nolin River area (to Green River), Corners Glades, Lapland Barrens, etc.
4. Western Coal Field (KY)	Lower Green River corridor; including extensions along Cypress Creek, Rough River, etc.
5. Western Shawnee Hills (IL, KY)	Shawnee National Forest; Saline River; Grand Rivers area (more/less = “Big Rivers Corridor” of TNC)
6. Eastern Wabash Plains (IN)	Almost none: highly agricultural except to south in Lower Wabash Wetlands and limited areas in “Booneville Hills”
7. Eastern Shawnee Hills (IN)	Hoosier National Forest; Blue River; Harrison County glades, etc.



**Summary of Targets for Conservation in the Middle & Upper Green River Watershed:
a suggested framework for desired condition, problems, solutions and progress to date**

Targets	Status → Goal	Major Problems	Major Solutions	Progress to date
1: large blocks of restorable landscapes in useful positions for watershed protection (with mussel beds+)	fair → good with 100+ years of minimal management; program to be developed across watershed	shortage of funds and willing sellers; need to enhance leadership and legwork at WKU and across the community	persist with HLCF, other sources of funds; develop broader, deeper program across watershed	solid core of land secured; diverse research program initiated
2: restored forest on most bottomland & other appropriate areas	poor → good with 100+ years of planting and minimal management	past clearance; locally abundant alien plants	allow appropriate areas to recover; make selected plantings; initiate alien reduction	several planting blocks established
3: restored grassy open woods & glades using pre-scribed fire	poor → good with 100+ years of burning and perhaps thinning; 10,000+ acres	200 years with declined fire frequency; local abundance of alien plants	establish regular fire regime; selective thinning; micromanagement of worst aliens	a few burn units established, but unclear how much thinning will be needed

4: restored sub-mesic woods and thickets (with cane, plum, hazel+)	poor → fair with some flexibility in selecting most practical phases of vegetation	past clearance, overgrazing; local abundance of alien plants	research on historical ecology and future options; need experiments	little progress so far, other than concept floated, and sites scouted
5: recovery of trees with pest problems: elm chestnut, ash butternut, heml.	catastrophic or threatening → fair (?); needs decades of dedicated work	globalization; inadequate control; lack of resistant genotypes	work with state, national, global programs to develop resistance and recovery	small trials with chestnuts done; planning across region remains unclear
6: recovery of woodland herbs impacted by settlement	poor/fair → good with decades of work on selected species	past farming, livestock, collection (esp. <i>Panax</i> , <i>Hydrastis</i>)	develop propagation, recovery trials, harvesting plans	initial trials with a few species
7: recovery of grassland plants impacted by settlement	poor → good with decades of work on selected species	past farming, lack of fire, local abundance of alien plants	propagation and recovery trials; develop on-site seed production	initial trials with a few species
8: recovery of mussels fishes+	poor → good after decades	pollution, hydro-logical changes	propagation and recovery trials	excellent initial work on WKU

APPENDIX 1. Shawnee Hills: Home-sweet-home for the Mammoth Cave Shrimp and Copperbelly Water Snake
[adapted here from original Kentucky TNC newsletter of 1990s].

To many Kentuckians driving along the Western Kentucky Parkway and its tributaries during daytime the region between Leitchfield and Dawson Springs can become rather monotonous. Then all of a sudden, if not paying attention, one is bedazzled by a strip-mining behemoth, narrowly misses a suicidal deer, and almost veers into a swampy morass of dead trees and presumed cottonmouth snakes. There is a lot more here than first meets the eye. These “Shawnee Hills” form the region generally known in Kentucky as the Western Coal Field. They also extend into much of southern Indiana and Illinois, where they were named after the Shawnee Indians, who were probably driven into refuges here after the first waves of settlement in the upper Ohio Valley. But during previous centuries other tribes, possibly related to the Chickasaw and Choctaw, appear to have been more typical.

Underlying bedrock is mostly of the same Pennsylvanian age (290-330 million years old) and upper Mississippian age as the Appalachian Plateaus (or Eastern Coal Field), with sandstone, shale and coal. At one time, this bedrock presumably covered most of south-central Kentucky, but eons of erosion have removed all direct connection between the two remaining “coal fields”—exposing the underlying Mississippian rocks and thereby forming the Pennyrhile Region (see Appendix 2). A partly slumped ridge of this sandstone, perhaps remnant from an ancient river channel, extends east across the Mississippian Plateau (the Brush Creek Hills between Elizabethtown and Munfordville). In the west, another wrinkle in the general pattern is caused by faults—the sandy Marion Hills (with TNC’s famous Mantle Rock preserve) are partly mixed up with a western piece of the Pennyrhile.

Unlike the relatively rugged Appalachian Hills, the Shawnee Hills mostly consists of low hills and broad bottomlands. Much land is more or less poorly drained. Another difference from Appalachia is that the soils contain a large amount of loess (dust blown east from

river valleys dried up during glacial eras), and this material appears to have increased the fertility of upland soils. Also, the bedrock contains some thin layers of limestone. However, the inland swamps are locally quite acid and infertile, compared to more recent or mixed alluvium downstream. Within the more rugged transition to Mississippian bedrock, in the Pottsville Escarpment (sandstone) and the Dripping Springs Hills, there is more geological and biological diversity. This transition, which is well-represented in the Mammoth Cave area, resembles the Cliff Section of the Appalachian Plateaus, with some extensive sandstone cliffs and limestone caves.

Before settlement, forests developed over most of the region, but some drier, fire-prone uplands and high terraces became more open, and some swamps became too wet for trees, especially when dammed by beavers. Bottomlands have several southern wetland species here at their northern limit, including overcup oak, swamp chestnut oak, cherrybark oak, and even small areas of water hickory and bald cypress—upstream as far as Cypress Creek in Muhlenberg County.

Southern animals in the swamps include some rare fishes, e.g., Cypress Darter (*Etheostoma proeliare*), Cypress Minnow (*Hybognathus hayi*) and Redspotted Sunfish (*Lepomis miniatus*). Also, the Bird-voiced Treefrog (*Hyla avivoca*) and cottonmouth snake (*Agkistrodon piscivorus*) are present in outlying populations. The copper-bellied water-snake (*Nerodia erythrogaster neglecta*) is endemic to the region and recently proposed for federal threatened status. Free-flowing rivers and streams used to have a diverse native fauna, but impoundments and pollution have reduced this drastically. For example, a fish called the Pallid Shiner (*Hybopsis amnis*) has not been seen here—or anywhere else in the state—for decades; and an endemic mussel, the Kentucky Creekshell (*Villosa ortmanni*) is now globally threatened.

Presumably due to the moderately base-rich soils, acid-loving plants are less abundant in the native vegetation here than in Appalachian Kentucky, except near sandy outcrops of the Pottsville Escarpment and at some seeps or swamp margins. Several generally Appalachian species in Kentucky, e.g., hemlock, yellow birch and

bigleaf magnolia trees, Woodrats and Corn Snakes, have disjunct populations along the escarpment. The limestone caves form essential habitat for several endemic invertebrates, including the federally endangered Mammoth Cave Shrimp (*Palaemonias ganteri*) and Northern Cavefish (*Amblyopsis spelaea*), plus the federally endangered Gray Bat and Indiana Bat.

In the Dripping Springs Hills, another focus of biological interest is the rare remnants of native grasslands and open woodlands, especially on drier slopes intermixed with the karst plains. These remnants are mostly on limestone, but there are also a few on sandy soils with some particularly rare plants, e.g., Frostweed (*Helianthemum bicknellii*) and Beardgrass (*Gymnopogon ambiguus*).

Early Indians had seasonal settlements, and they made special culinary use of the wild clams in the calcium-rich Green River, as well as hunting on the uplands. During later ages, agriculture developed on the lowlands, and societies approached the complexity and organization of peoples further downstream along the Mississippi. There is growing circumstantial evidence that these prehistoric inhabitants often burned the uplands and lowlands when dry enough, creating open woodlands. Some of this evidence is botanical. Buffalo clover (*Trifolium reflexum*) is a rare species of the southeastern U.S.A. that probably benefits from the more open vegetation after burning, and this has been found at scattered sites where there may have been some concentrated human activity before Virginian settlement. Another rare plant that appears to benefit from burning is Eggert's sunflower (*Helianthus eggertii*), which is proposed for federal threatened status, being restricted to a few hilly regions of central Kentucky, central Tennessee and north Alabama.

The first century of settlement by Europeans was concentrated on uplands with deeper soils, but in recent decades there has also been extensive surface-mining on drier ground, and much drainage of the damper bottomlands for farmland. Drier uplands have some extensive, albeit much cutover, forests left, but most uplands are cleared for agriculture or surface-mines—the most devastating in Kentucky (recall John Prine's song, "What have they done to

Muhlenberg County?"). Upland forests have almost disappeared from deeper, moister soils. On the broader bottomlands of the Green River and its major tributaries there is less coal, but a huge amount of swampy forest has been cleared, drained and converted to cropland since 1950. Some large wetlands still exist, but these often have trees killed by flooding and sedimentation from disturbed uplands. Water quality has been greatly affected by coal-mining in the watersheds, causing acid 'red-dog' deposits. Also, brine pumped into oil wells has caused serious pollution. Mining enterprises have even progressed into the edges of some swamps, after channelizing streams and draining the land. Very few sites in the low hills and bottoms are managed as natural areas, though the wetlands have come under increased scrutiny due to federal regulations, and some may become restored by Kentucky Dept. of Fish & Wildlife.

Out of the vast original bottomland forests, so far as we know, only one 10 acre remnant has never been logged ("Floyd's Woods"). And on uplands, the best known remnant, though probably much grazed in the past, is the "Big Woods" of Mammoth Cave National Park. However, several opportunities for restoration of larger areas exist in the various bottomland tracts managed by Kentucky Dept. of Fish & Wildlife, and in Mammoth Cave National Park. Also, some of the larger wetlands damaged by drainage, pollution and sedimentation could be restored with wise partnerships between private and public interests. The recent conservation plan for the Copperbelly Water Snake will hopefully be a step in that direction.

The significance of native grassland and open woodland areas in this region is uncertain since we have little historical information, but experimental management with fire is being introduced at several sites. Cave systems are threatened by pollution from the adjacent Pennyriple Karst Plain (see Appendix 2), but the Mammoth Cave "Man-and-Biosphere" zone (supported by UNESCO) should provide a model of cooperation between government agencies and the communities that lie on top on such complex ecological systems. The particularly severe reduction in natural qualities of this region during recent decades should demand new commitments and imaginative solutions for restoration and conservation.

APPENDIX 2. Mississippian Plateaus: The Pennyrile--land of Big Barrens, River Oysters, Karst and Caves [adapted here from the 1990s Kentucky TNC newsletter]. Note that the large complex region described here can be divided into sections, and it is useful to combine some with the more strictly defined Shawnee Hills.

This south-central region of Kentucky has been referred to with multifarious, sometimes confusing terms in popular literature. In a simple definition, it corresponds to the predominantly calcareous sections with Mississippian bedrock in Kentucky (ca. 340-350 million years old). Within our state, this is a large complex region with several fingers, attenuations and broken-off pieces. Its truly massive identity only becomes clear when Tennessee is added to the picture—it extends south through the center of that state, enveloping (but not including) the Nashville Basin, and it ends in northern Alabama. The “Mississippian Plateaus” is a traditional scientific name, followed by Lucy Braun in her famous 1950 book on Eastern Deciduous Forests. Other names include the “Highland Rim”—best applied to the eastern subsection—and the “Pennyrile” [also Pennyrhile or Pennyroyal]—best applied to the western subsection. The latter name comes from the pennyroyal plant (*Hedeoma pulegioides*), a highly aromatic browsing-resistant native annual that sprang up abundantly when the region was first settled.

The region forms a vast plateau south of the extensive Bluegrass limestones and the Knobs Region, and it contains the other great limestone plains and rolling hills of Kentucky. Its limestones were made from compacted bodies of countless microscopic algae (diatoms and others), embedded with fossil worms and shellfish. These rocks, plus associated shales and siltstones, were laid down during a long period when seas covered Kentucky. The older, lower layers of rock contain less pure limestone (with more shale and siltstone) and are exposed towards the northern rim along the Knobs (“Muldraugh's Hill”), in the more hilly center, and in the deep valley of Cumberland River, which has cut down into the much older Ordovician bedrock that connects with the Nashville Basin. The younger layers contain more siltstone and sandstone, especially in the western transition to the Shawnee Hills (see Appendix 1).

The most extensive pure limestone occurs in a large western band—forming the true Pennyrile region (in a strict sense)—arching from Elizabethtown to Bowling Green to Hopkinsville—plus a minor eastern band from Mount Vernon to Somerset to Monticello. These “karst plains” are particularly flat, and water has dissolved the surface into sinkholes and extensive cave systems, flowing through the rock to springs and valleys at lower levels. Despite the historical term “barrens” for some areas, many of the upland soils are moderately fertile, though prone to drought in dry years. The term “prairie” (or even “Bowling Green”) may have been appropriate for sites on better soils. Some transitions from the karst plains to more hilly landscapes on the SE side have zones with extensive depressions and old sinkholes, filled with less permeable clays and poorly drained to swampy in places..

Through millenia of evolution, caves and rivers came to support unique groups of animal species, including bats, fishes, crustaceans and a high diversity of clams or mussels (unionid bivalves), popularly known as “oysters”. The abundance and diversity of mussels in free-flowing sections of these rivers can be unusually high, which is presumably related to the old calcium-rich nature of these drainages. This region, together with its upstream watersheds, still appears to have the most diverse group of fresh-water mussel species in the world. The Green River still has the most diverse mussel fauna remaining in Kentucky, and similar numbers of species occur in the Duck River and Elk River in the adjacent region of Tennessee.

Common forest types used to cover much of the uplands, and wet depressions support swampy forest with several unusual plant species. However, on the droughty karst plains during warmer climates after the last ice age, forest gave way to native grassland, eventually including the extensive “Big Barrens” and “Great Meadows” of pioneers. Fires were a major cause of this change, and became frequently set by Native Americans in recent millenia. Their culture did not become particularly elaborate or distinctive compared to the river bottoms further south and west, but it was notable for their extraction of various minerals from caves, which were exported to Adena peoples of the Bluegrass and elsewhere.

Parts of this large region became rapidly settled by Virginians, and the conversion from woodland to farmland promptly followed that in the Bluegrass. There was some initial delay in farming the karst plains, because of doubts and problems in converting the grasslands, which, meanwhile, became invaded by trees as fire frequency declined. But the productivity of these areas was eventually realized and exploited to the full, so that there are now virtually no remnants of the native grasslands on deeper soils. More hilly sections with poorer soils have remained largely forested, though interrupted by extensive settlement on lower slopes and bottoms, forming a mosaic of forest and farms that has changed little in the past 150 years. Minor, localized environmental changes have resulted from extraction of minerals, including limestone itself and various specialities like fluorspar (around the faulted Marion Hills) and saltpeter (from caves).

Water quality and its flow through the region have been greatly affected by man due to pollution from farms and towns, and due to impoundments. Also, most of the original sinkhole ponds and other damp upland depressions have been greatly disturbed. Most of the large artificial lakes in Kentucky are to be found in this region or in the transitions to surrounding hills. These impoundments have caused many mussels and other aquatic species to become locally extinct. In the Cumberland River, the following endemic mussels became globally extinct in the 1950s because of Lake Cumberland—Sugarspoon (*Epioblasma arcaeformis*), Angled Riffleshell (*E. biemarginata*), Acornshell (*E. haysiana*), Forkshell (*E. lewisii*) and Cumberland Leafshell (*E. stewardsoni*). This litany of the dead is perhaps the saddest part of our recent natural history in Kentucky.

Currently protected natural areas in this region are relatively low in number and acreage. However, with suburban expansion and industry not yet developed to a high degree, there are many opportunities for conservation that need not conflict with development. Much of the region has still not been thoroughly surveyed for conservation interests. Priorities for conservation include river corridors, cave systems, swamps, natural ponds, old-growth forests and native grassland remnants. The Nature Conservancy and Kentucky State

Nature Preserves Commission are working to protect many significant areas in this region. A major focus of current effort, including other state agencies and U.S. Fish & Wildlife Service, is the Green River watershed, where so many rare mussels still persist, including the state's only endemic mussel—Kentucky Creekshell (*Villosa ortmanni*). Even local governments have taken significant action, e.g., the banning of mussel collection within Hart County. Downstream, in the transition to the Shawnee Hills, Mammoth Cave National Park also has great potential as a natural area, and there has been some recent success in improving the water quality draining from the karst region into the cave systems.

On the karst plains, virtually all native grassland and open woodland on deep, well-drained soil has been converted to farmland, and even at drier or wetter extremes, there are only a few small remnants. Many grassland species appear to have become endangered or locally extinct since settlement, including several typical of damp to wet areas, e.g., Fly-poison (*Amianthium muscaetoxicum*), White Lady's Slipper (*Cypripedium candidum*), Hall's Bulrush (*Scirpus hallii*), Turkeybeard (*Xerophyllum asphodeloides*), and others typical of dry “flat rock” outcrops, e.g., Butler's Quillwort (*Isoetes butleri*), Evening Primrose (*Oenothera triloba*), Gattinger's Lobelia (*L. gattingeri*), and Fame-flower (*Talinum calcaricum*). Many grassland animals have also declined, including the Greater Prairie-chicken, which is now extinct in the state.

There are only a handful of significant old growth forest remnants known in this region. Some of these are probably going to be logged in the near future unless large amounts of money can be raised to pay for the high timber values.

[Update in 2014: Exie Woods (now “Wyatt Jeffries Woods” in Green County, and Dry Fork Gorge in Metcalfe County have now been protected using the Natural Heritage Land Conservation Fund. Murphy’s Woods in Todd County remains privately owned, but still largely intact and much enjoyed by travelers on Route 79 from Russellville to Clarksville. Some larger peripheral tracts with less old-growth in Adair County have also been protected.]