Hancock Biological Station

Barrens Habitat Restoration Plan

May 2014

Hancock Biological Station

Murray State University

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In association with BIO 678

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Statement of Purpose

Prior to European settlement, prairie-like grasslands extended over more than 162 million hectares of the North American continent (Samson and Knopf 1994). However, major agricultural conversion, the elimination of large herbivores, fire suppression, and development accompanying settlement led to the decline of as much as 85-99% of these systems (Sampson and Knopf 1994, Barnes 2002). This loss has resulted in increased soil erosion, agricultural runoff, and water pollution, as well as concurrent reductions in the populations of grassland species, carbon sequestration rates, and total species diversity (Samson and Knopf 1994). Much interest exists in conserving or restoring the remaining fragments of these grasslands to mitigate the consequences of their degradation or loss.

Hancock Biological Station, and thereby Murray State University, possesses a potential site for barrens grassland restoration. Dr. Dick Marzolf, formerly associated with both the Konza Prairie and Hancock Biological Stations, identified the site as possessing several barrens indicator species in the late 1980s. A restoration attempt was initiated on the site in 1989, consisting of mechanical removal of several Eastern red cedar trees followed by a prescribed burn. Since this initial work, prescribed fire has been applied to the site in March or early April on an approximate 2-3 year rotation. No formal documentation or monitoring of the results of this restoration attempt has occurred, and efforts have achieved only limited success to date. Barrens grasslands remain to be restored to the site.

The purpose of this document is to reorganize, rejuvenate, and promote the future success of the HBS barrens restoration effort. This plan attempts to outline clear, measureable goals and objectives for the project, and also suggests several methods and procedures by which to attain them. Additionally, the plan suggests how restoration progress might be documented and details ways in which MSU courses and students can be involved in restoration activities. With proper implementation and future adaptation, this plan promises to result in successful restoration of barrens vegetation to the HBS site. Concurrently, the project will serve as a potential hands-on learning tool for MSU students and a means by which to enhance MSU's commitment to environmental conservation.

Background Information

A. Barrens Habitats - General

Prior to European settlement, much of the Interior Low Plateau Ecoregion (Fig. 1) was covered by a mosaic of prairie-like grassland openings and oak-hickory forest groves (Davis 1923, Baskin and Baskin 1981, Baskin et al. 1994, Heikens et al. 1994, Samson and Knopf 1994, Baskin et al. 1999, Barnes 2002, Rhoades et al. 2002, Guyette et al. 2003). This condition is reflected in the accounts of several early travelers that crossed the region:

> "The 12th passed through a country covered with grass and oaks which no longer exist as forests, having been burned every year [between N Larue Co. and NW Hart Co.]. These lands are called Barren lands although not really sterile. The grasses predominate…." – Andre Michaux, February 1796

> "It [the Barrens] is a high and dry plateau, where trees are sparse and grass and shrubs plentiful. One sees only small, stunted trees, most of them oaks and hickories, and everywhere lush grass dotted with charming flowers." – Louis-Phillipe, Duke of Orleans, 1797

> "The Barrens so-called from their sterile appearance, are found on the high plains in the west parts of Ohio and Kentucky, in Indiana, Illinois and Missouri…They have features in common with the prairies, but are essentially different in many respects. … They are spotted with innumerable groves or clusters of stinted oak and hickory trees, of about half the size which the same kind are on the timbered land." – Bourne, 1820

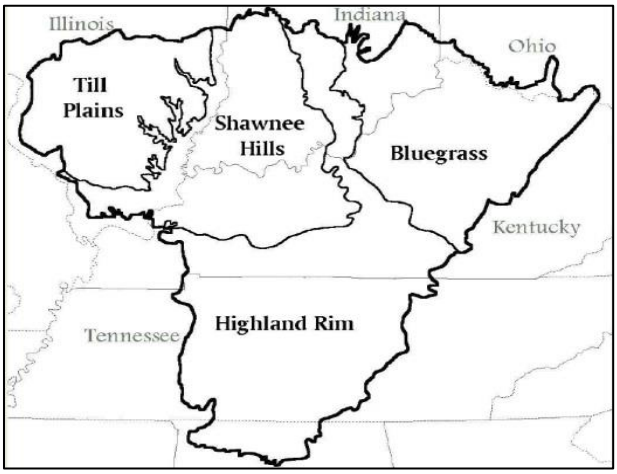


Figure 1: The extent and sub-regions of the Interior Low Plateau Ecoregion; prairie-like barrens were commonly interspersed with the region's oak-hickory forest prior to European settlement.

> "The old inhabitants of that part of Kentucky all declare that when the country was first settled it was, for the most part, an open prairie district, with hardly a stick of timber sufficient to make a rail, as far as the eye could reach…" – Owen, 1856

> "All around looked sad and dreary, especially, when the wind swept over the dry and withered grass, or rustled among the dead leaves of the post-oak and black-jack trees. None who ever witnessed the desolate appearance of the Kentucky Barrens in early times, during the winter season, can forget the feeling they produced. Far as the eye could reach, it seemed one barren, cheerless waste. … But if, in winter, the barrens looked cheerless and dreary, it was far otherwise in spring and early summer. It would be difficult to imagine anything more beautiful. Far as the eye could reach, they seemed one vast deep green meadow, adorned with countless numbers of bright flowers springing up in all directions…only a few clumps of trees and now and then a solitary post-oak were to be seen, far as the eye could reach…Here the wild strawberries grew in such profusion as to stain the horse's hoof a deep red color."– Ross, 1882, recalling his early life [circa. 1812]

Early travelers and settlers deemed the prairie-like grassland openings 'barrens', primarily due to the treeless nature of these areas versus any assumptions of infertility (Davis 1923, Baskin and Baskin 1981, Keith 1983, Baskin et al. 1999, Guyette et al. 2003). Barrens were forest-prairie intermediate habitats dominated by tall-growing, warm-season prairie grass species (e.g., *Schizachyrium scoparium*, *Andropogon gerardii*, and *Solidago altissima*). The shrubs or trees that did occur in these habitats - predominantly *Quercus* and *Carya* spp. - were few in number and suffered from noticeably stunted growth (Davis 1923, Baskin and Baskin 1981, Heikens et al. 1994, Baskin et al. 1994, Baskin et al. 1999, Anderson et al. 2000, Rhoades et al. 2002). Among a large suite of others, prairie species common in barrens habitats included: *Coreopsis tripteris, Eupatorium altissimum, Euphorbia corollata, Helenium autumnale, Helianthus hirsutus, Kuhnia eupatoroides, Liatris aspera, Lobelia spicata, Pycnanthemum tenuifolium,* and *Sorghastrum nutans* (Baskin and Baskin 1981, Baskin et al. 1994). Barrens occurred on karst limestone topography and on deep soils that had developed under forest vegetation types over geologic time (Baskin and Baskin 1981, Baskin et al. 1994, 1999).

Several theories have been proposed to explain the origin of barrens, including hydrology of the habitats' underlying topography, drought, grazing by large ungulates, and glaciation (Baskin and Baskin 1981, Keith 1983). However, most historical accounts (see below), as well as modern investigations into the subject, agree that barrens were anthropogenically-created and maintained (Baskin and Baskin 1981,Keith 1983,Baskin et al. 1994, 1999, Anderson et al. 2000, Rhoades et al. 2002). Beginning approximately 2000 years ago, Native Americans in the region set frequent fires, perhaps as often as annually, to attract grazing game species, improve hunting conditions, reduce pest species, or protect their settlements. These fires were set in late spring or late fall, were large in spatial extent, and enabled the enduring dominance of prairie grass species (Baskin and Baskin 1981, Keith 1983, Baskin et al. 1999).

> "Every year, in the course of the months of March or April, the inhabitants set fire to the grass, which at that time is dried up…The custom of burning the meadows was formerly practiced by the natives, who came in this part of the country to hunt" – Francois Michaux, 1805

> "I think it must be evident to everyone who will view the barrens attentively, that their present condition was caused by fires, which have consumed the trees and acorns from which they grow: because many of the trees that are standing are partially burnt, and almost everyone that is lying down has been burnt more or less….The fires in the barrens are generally kindled by the Indians for the convenience of travelling over the smooth surface, to enable them to approach game without noise, and also to ensure a good crop of grass for the next summer." – Bourne, 1820

> "It is the almost unanimous opinion of early observers competent to judge that the treeless character of the prairies [of the JP] was due to the firing of grass by the Indians" – Davis, 1923

Europeans began to settle throughout the Interior Low Plateau in the late 18th and early 19th centuries. This settlement displaced Native American tribes, halted their long-established burning practices, and initiated a long-lived fire suppression movement. As a result, barrens habitats experienced substantial woody encroachment and rapid succession to deciduous forest (Davis 1923, Baskin and Baskin 1981, Keith 1983, Heikens et al. 1994, Baskin et al. 1999). This transition is described in the following post-settlement accounts of the region:

> "With the advancing settlement of the country, the prairie fires were gradually extinguished, and the young timber had liberty to grow. The consequence is, that tracts which were destitute of shade ten to twenty years ago, are now covered with extensive forests of Black Jack, or scrub oak…." – Davidson, 1840

"Since leaving Clarksville [TN] we have been passing through what are called the Barrens, formerly an extensive prairie, now overgrown with a scrubby Oak called Black Jack." – Kite, 1847

"The old inhabitants of that part of Kentucky all declare that when the country was first settled it was, for the most part, an open prairie district, with hardly a stick of timber sufficient to make a rail, as far as the eye could reach, where now forests exist of trees of medium growth, obstructing entirely the view. They generally attribute this change to the wild fires which formerly use to sweep over the whole country, in dry seasons, being now, for the most part, avoided or subdued, if by accident they should break out… Since the settlement of the country this grass [barren grass] has almost become extinct, whereby opportunity has been afforded for timber to take root and flourish."" – Owen, 1856

"With the disappearance of the Indians trees sprang up, and this region is now well covered with a vigorous growth of black oaks of different species." – Sargent, 1884

Nearly all of the barrens that did remain were converted to crop land or pasturage, and native barrens species assemblages shifted or were eliminated as increasing numbers of non-native and invasive species were introduced into the region (e.g*., Poa pratensis* and *Festuca* spp.). As a result, barrens were eliminated from the landscape by the late 19th century, and no original barrens habitats remain today (Baskin and Baskin 1981, Keith 1983, Heikens et al. 1994, Baskin et al. 1999, Rhoades et al. 2002, Guyette et al. 2003). All that remains of this once extensive habitat are the historical accounts of its prior extent and several glade and prairie remnants scattered throughout today's second- growth forests. These remnants support small colonies of barrens-associated species and are the focus of the majority of contemporary barrens conservation (Baskin et al. 1999, Rhoades et al. 2002).

B. Barrens Habitats – Kentucky & the Jackson Purchase

At the time of European settlement (circa. 1780), the Kentucky Karst Plain (KKP) supported the most extensive tract of barrens vegetation (Fig. 2). This tract, located in mid-Kentucky and extending south into northwestern Tennessee, was referred to as the 'Big Barrens' and covered between 13,000 and 15,000 km^2 (Baskin and Baskin 1981, Baskin et al. 1999, Rhoades et al. 2002, Guyette et al. 2003). Like other barrens habitats, the Big Barrens are believed to have developed and been maintained by the periodic burning of Native American tribes. When this burning ceased as a consequence of settlement, the Big Barrens underwent rapid succession to deciduous forest or were converted to cattle pasturage or crop land. As a result, no fragments of the Big Barrens remain today. The majority of the region remains under

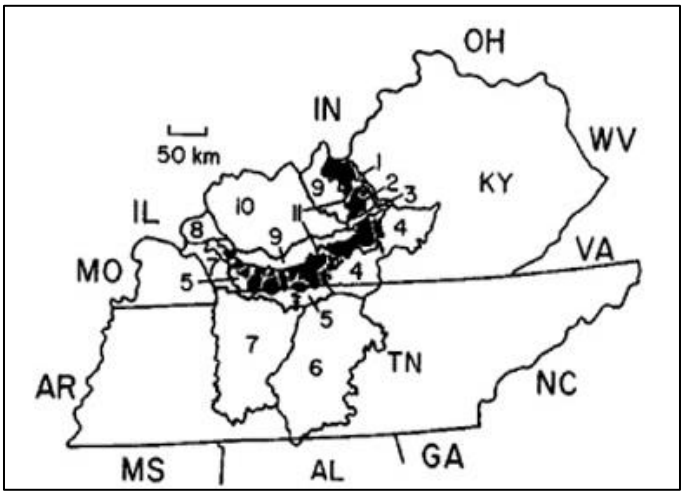


Figure 2: Historic extent of barrens vegetation throughout the Big Barrens Region of Kentucky and Tennessee. Prior to European settlement, this region contained the largest expanse of barrens vegetation in North America. Similar barrens vegetation also occurred throughout the Western Highland Rim and Jackson Purchase Regions of the state (Baskin et al. 1994)

crop and livestock production. The best remaining analogue of the Big Barrens are the deep-soil barrens that have been restored by prescribed fire and military incendiary activities on the Fort Campbell Military Reserve, Ft. Campbell, KY (Baskin and Baskin 1981, Baskin et al. 1994, 1999).

Historical accounts indicate that barrens vegetation also extended throughout the Western Highland Rim and Jackson Purchase regions (Davis 1923, Baskin et al. 1999). The Jackson Purchase was opened for settlement in 1820. At that time, William T. Henderson was charged with conducting General Land Office Surveys of the region (Baskin et al. 1999). His surveying notes state that, "a considerable portion of the country being open barrens where trees could not be found [required that] posts are fixed at the corners" (Bryant and Martin 1988). Unfortunately, Henderson did not record the distances of these surveying posts to trees, the diameter of any surrounding trees, or the floristic composition of these barrens areas. Thus, contemporary reconstruction of the Purchase's pre-settlement vegetation is rendered impossible (Bryant and Martin 1988, Baskin et al. 1999).

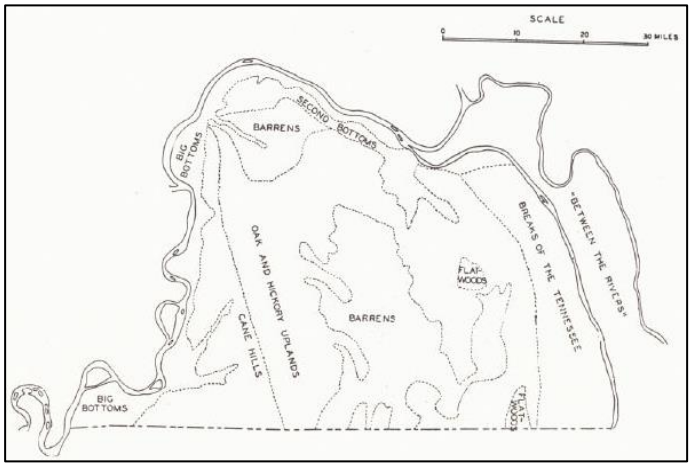


Figure 3: Divisions of the Jackson Purchase as identified by Davis (1923). Large extents of barrens habitat occurred throughout the Jackson Purchase Region, and the HBS site sits within the division formerly known as the Breaks of the Tennessee.

Several subsequent historical documents confirm the barrens-like nature of the Jackson Purchase described by Henderson. Loughridge's 1888 *Report on the Geologic and Economic Features of the Jackson Purchase Region* states that,

"There is within the Purchase counties a broad region which was formerly an open treeless prairie, but which, within the past thirty years, has been covered with a low growth of red and black jack oaks, and is still known as "Barrens". In the country west of Mayfield to Obion Creek it is said that 25 years ago the prairie grass was as high as the head of a man on horseback."

Loughridge (1888) goes on to describe further the woody encroachment of red and black jack oaks that overtook the region following settlement. Later, Davis (1923) depicts large tracts of barrens vegetation throughout the Jackson Purchase (Fig. 3) and attributes woody encroachment of the system to the cessation of regional Native American burning practices. More recently, both Transeau (1935) and Kuchler (1964) mapped a large portion of the Jackson Purchase as possessing the same prairie or bluestem grassland/oak-hickory vegetation found in the Big Barrens region of the state (Baskin et al. 1999).

C. Barrens versus Tallgrass Prairie Habitats

18th and 19th century accounts of pre-settlement vegetation typically refer to barrens and prairie as separate habitat types. These accounts cite different soil types, interspersion with timber, and the more fragmented and topographically-variable nature of the barrens as distinguishing features (Baskin et al. 1999, Anderson et al. 2000). In contrast, much 20th century work, beginning with Transeau's 1935 map of the Prairie Peninsula (Fig. 4), identifies barrens habitats as peripheral extensions of the tall grass prairie (TGP) that once dominated much of the surrounding landscape west of the Mississippi (Baskin et

al. 1999). This contradiction has sparked much debate as to whether the two habitats should be considered as one or distinct.

Baskin et al. (1994, 1999) posit that although the habitats share and are dominated by several of the same species (primarily *S. scoparium*, *A. gerardii*, and *S. altissima*), barrens should not be considered part of the Prairie Peninsula. The authors defend the TGP-barrens distinction with the following lines of evidence: (1) TGP developed during the Hypsithermal period of worldwide grassland expansion; pollen occurrence data indicates that barrens vegetation did not arise until approximately 2000 years before present, (2) the soils on which barrens occurred developed under forest versus grassland vegetation through geologic time, (3) the climate experienced by barrens vegetation is optimal for the long term maintenance of deciduous forest versus TGP, and (4) the rapid succession to deciduous forest following post-settlement fire suppression or agricultural abandonment indicates that prairie-like grasslands were never the climax or subclimax vegetation of the barrens region (Baskin et al. 1994, 1999). This evidence suggests that the two habitats are indeed distinct; however, the similarities that do exist between the two allow tall grass prairie to serve as a suitable reference or model system for barrens vegetation. This has proven useful to barrens research and restoration efforts as no intact, reference habitats remain.

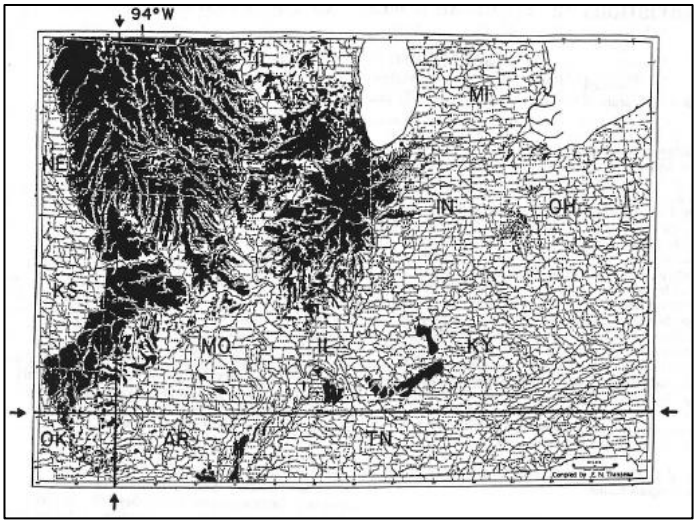


Figure 4: Edgar N. Transeaus's map of the Prairie Peninsula as it appeared in *Ecology* in 1935.

D. Barrens Habitat Restoration

Much interest exists in restoring barrens vegetation throughout its previous extent. Most restoration work to date has focused on preserving, improving, and expanding small colonies of barrens species that remain scattered in glade and forest openings throughout Kentucky, southern Illinois, southern Indiana, and northwestern Tennessee (Heikens et al. 1994, Baskin et al. 1999, Anderson et al. 2000, Rhoades et al. 2002, Guyette et al. 2003). State and federal agencies, non-profit organizations, university research programs, and private landowners are engaged in numerous restoration projects within the four-state region. Over a dozen restoration projects have been attempted at various sites throughout western and central Kentucky alone, including:

- Aimee Rosenfield Memorial Preserve
- Baumberger Barrens
- Crittenden Springs Glade Preserve
- Livingston County - Perkins and Reynolds Restoration Sites
- Mantle Rock Preserve
- Pine Creek Barrens Preserve
- Sunset Barrens Preserve/Macy Highway Barrens

} The Nature Conservancy

- Bouteloua Barrens State Nature Preserve
- Eastview Barrens State Nature Preserve
- Raymond Athey Barrens State Nature Preserve
- Springhouse Barrens State Nature Preserve
- Thompson Creek Glades State Nature Preserve

} KY State Nature Preserves Commission

- Logan County Experimental Sites — University of Kentucky
- Land Between the Lakes National Recreation Area — USDA US Forest Service

Various combinations of prescribed fire, mechanical removal, and herbicide application are used to mimic the anthropogenic-disturbance regimes that originally created and maintained barrens habitats. Together, and sometimes in conjunction with native species plantings, these activities promote the dominance of warm-season grasses, suppress woody encroachment, and facilitate the reestablishment of barrens vegetation on restoration sites (Heikens et al. 1994, Howe 1994, Anderson et al. 2000, Rhoades et al. 2002, Guyette et al. 2003, Towne and Kemp 2003, Gibson 2009).

Prescribed fire is well-documented as benefiting grassland ecosystems in numerous ways. Low-intensity fires suppress woody encroachment and can prevent the persistence and/or spread of non-native invaders. Simultaneously, fire stimulates growth and increased reproductive output of herbaceous species and creates gaps and/or exposed soils that facilitate greater native species recruitment. In doing so, prescribed fire can alter the composition and structure of grassland communities to achieve desired restoration conditions (Howe 1994, Copeland et al. 2002, Rhoades et al. 2002, Towne and Kemp 2003).

The ability of prescribed fire to establish or maintain desired vegetative conditions depends heavily on the seasonality and frequency at which burns are conducted. Plants may be damaged at more or less critical stages in their life cycle or development depending on the season in which fire occurs (Howe 1994, Copeland et al. 2002, Towne and Kemp 2003). For example, a spring fire causes maximum damage to early-emergent species investing in rapid growth, but inflicts little damage to still-dormant species that emerge later in the year. This variation in the severity of damage inflicted subsequently alters the growth, reproduction, and competitive abilities of species in the weeks, months, and growing seasons following fire. As a result, differences in the seasonality of burns can translate to fire-induced changes in species performance, relative abundances, and ultimately, desired shifts from woody- to gramminoid-dominated communities (Howe 1994, Copeland et al. 2002, Towne and Kemp 2003).

Barrens restoration fire is most commonly applied in mid- to late spring (late March – early May) (Howe 1994, Copeland et al. 2002, Rhoades et al. 2002, Towne and Kemp 2003, Gibson 2009). Spring burning typically occurs after woody vegetation and non-native cool-season grasses have initiated growth but before warm-season grasses have exited dormancy. Thus, these fires ensure maximum damage and reduction of woody and non-native species while promoting the dominance of warm-season grasses. Spring fires also stimulate the performance of many subordinate forbs, though some research indicates that the addition of periodic fall burning may be equally or more beneficial to these less abundant species (Howe 1994, Towne and Kemp 2003).

The frequency or interval at which burns occur also affects the ability of prescribed fire to create or maintain desired conditions. The length of time between burns influences the amount and condition of fuels that accumulate on a site, and thus, the intensity and duration of subsequent fire. More frequent fires or shorter burn intervals allow for reduced fuel accumulation and typically result in less intense fires of shorter duration; less frequent fires or longer burn intervals allow for greater fuel accumulations that typically generate high intensity fires of longer duration. Additionally, burn

frequency influences the vulnerability of non-desirable woody species. The longer the interval between burns, the more established, fire-resistant, and enduring woody invaders become.

Barrens restorations commonly employ frequent burn intervals or rotations, burning once every 2-3 years (Howe 1994, Anderson et al. 2000, personal communications with Shelly Morris, TNC - Western KY Project Director). This ensures that most woody encroachment is subjected to fire during vulnerable stages of juvenile growth while still allowing for the accumulation of fuels and fire intensities necessary to induce woody species mortality.

In some cases, fire alone is not capable of preventing woody encroachment or non-native invasion. Where encroachment and invasion continue to occur, prescribed fire is often supplemented with mechanical removal and herbicide application (Rhoades et al. 2002). Mechanical removal consists of the mowing, bush hogging, rototilling, hand removal, etc. of woody or non-native species. When mechanical removal is prohibitively difficult or ineffective, herbicides may be applied. Herbicides typically applied in prairie management (e.g., Plateau - BASF-American Cyanamid, Raleigh, NC, USA; active ingredient Imazapic) are cool-season grass or woody-species specific. These chemicals achieve prairie or barrens restoration objectives by eliminating non-native or encroaching species with little to no damage to native warm-season grasses (Rhoades et al. 2002).

Hancock Biological Station Barrens Site Description

A. Physical Description & Current Conditions

General Physical Characteristics:

The 0.15-0.25 acre site sits on the Hancock Biological Station property at approximately 36°43'58" N longitude and 88°07'07" W latitude (Fig. 5). Elevation of the site is approximately 400 feet above sea level, and slope on the site ranges from 3-20%.

Figure 5: Map (top) and aerial photographs (middle), and on-site photograph (bottom) detailing the location of the HBS restoration site.

Physiography:

The site is located within Calloway County and the Jackson Purchase region of Kentucky. Fennemen (1938) classified the area as belonging to the Mississippi Embayment Section of the East Gulf Coastal Plain, while Keys et al. (1995) placed the region within the Deep Loess Hills and Bluffs Subsection of the Upper Gulf Coastal Plain Section of the Eastern Broadleaf Forest Province. Woods et al. (2002) indicate that the area belongs to the Western Highland Rim and the Tennessee and Cumberland River Valleys.

Climate:

The site experiences a humid continental climate characterized by warm to hot summers and cool to moderately cold winters. Mean annual temperature between 1971 and 2000 was 14.9°C. The coldest month of the year is typically January (average temperature = 1.2°C) and the warmest July (average temperature = 26°C). The growing season is 209 days long on average. Total annual precipitation averages 127 cm and occurs in all months of the year. The wettest month of the year is usually December (average precipitation = 12.9 cm), and the driest month is August (average precipitation = 8.1 cm). Snowfall occurs predominantly between January and March and averages 10.8 cm annually (Thompson 2007).

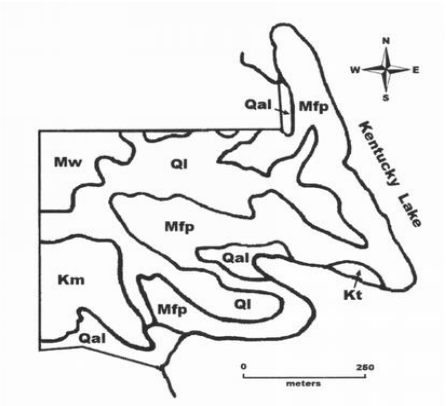


Figure 6: Geology of the Hancock Biological Station. The HBs restoration site sits primarily atop the Mississippian Fort Payne Formation (Mfp) (Thompson 2007).

Geology & Soils:

The majority of the site sits atop cherty limestone of the Mississippian Fort Payne Formation. This formation is bordered to the north and south by Quaternary alluvium and Quaternary loess respectively (Thompson 2007) (Fig. 6).

Approximately 80% of the site's soils are silt loams belonging to the Brandon series (Fig. 7). These are deep, well-drained, strongly acidic soils that occur along flat ridges and on 12-20% slopes across the site. The Brandon soils' parent material is thin, fine- silty noncalcareous loess over fluvomarine deposts, and the profile is typically silt loam (0-10 in.) over silty loam (10-29 in) that lies over extremely gravelly sandy loam (29-80 in.) (USGS Soil Survey).

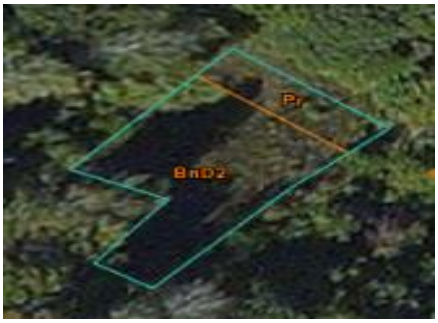


Figure 7: Map of the soil series present on the site; BnD2 represents Brandon silt loam soils and PR soils of the Pruitton-Riverby complex (obtained from USGS Web Soil Survey)

The remaining 20% of the site's soils belong to the Pruitton-Riverby soils complex (Fig. 7). These are deep, moderately acidic, well- to excessively-drained soils that occur in floodplains and along 0-3% slopes across the site. These soils have loamy alluvium parent material, and the profile is typically silt loam (0-34 in.) over very gravelly loam (34-80 in.) (USGS Soil Survey).

Vegetation:

Ralph Thompson conducted a floristic survey of the Hancock Biological Station property in the early 2000s (2007). At this time, he identified the HBS restoration site as a 'burned old field warm season grassland' completely surrounded by dry and dry-mesic oak-hickory forest. Thompson described the vegetation as similar to the warm season grasslands maintained on the Elk and Bison Prairie of the nearby Land Between the Lakes National Recreation Area and reported the presence of the following barrens indicator species:

Andropogon ternarius
Asclepias tuberosa
Carex hirsutella
Ceanothus americanus
Coreopsis major
Crotalaria sagittalis
Hypericum denticulatum
Euphorbia corollata
Linum medium var. *texanum*,
Lobelia puberula
Parthenium integrifolium
Polygala sanguinea
P. ambigua
Pycnanthemum tenuifolium
Oenothera fruticosa
Rudbeckia hirta
Scleria pauciflora
S. triglomerata
Schizachyrium scoparium
Sorghastrum nutans
Stylosanthes biflora
Tripsacum dactyloides

Thompson further identified the following as potential woody invaders on the site:

Acer rubrum
Diospyros virginiana
Juniperus virginiana
Liquidamber styraciflua
Liriodendron tulipfera
Nyssa sylvatica
Rhus copallina
R. glabra
Rubus argustus
Smilax bona-nox
S. glauca

Lastly, Thompson's survey detected the presence of the following potentially invasive species on the HBS property:

Fescuta arundinacea
Lespedeza cuneata
Lonicera japonica
Microstegium vimineum
Coronilla varia
Elaeagnus umbellata
Ligustrum sinense
Rosa multiflora
Sorghum halepense

Stellaria media	*Hedera helix*	*Polygonum caespitosum*
Daucus carota	*Ledpedeza stipulacea*	*P. persicaria*
Eleuine indica	*L. striata*	*Seteria faberi*
Glechoma hereracea	*Poa pratensis*	*Vinca minor*

The current presence and absence of the above species, as well as the relative abundance of these species, remain to be assessed with future vegetative surveys of the HBS site.

Figure 8: Photographs of the current vegetative conditions of the HBS restoration site (taken by W. Wallett, April 2014).

The HBS-TNC site comparison (completed in April 2014 for the purposes of this document and described in subsequent pages) indicated that the average total percent cover (as estimated within 1 m^2 sampling quadrats) ranged from 60-86.25% across the site. The mean average percent covers of five functional groups were also estimated on site; gramminoid species (μ=32.93%) comprised the majority of the total percent cover, followed by cryptogams (μ=15.57%), forbs (μ=12.21%), shrubs/vines (μ=7.32%), and trees (μ=5.43%) respectively. Despite the fact that trees were the least –represented functional group, observation of the site at the time of sampling indicated that several dozen saplings between 1-2 meters in height were established on the site. Woody encroachment of the site is substantial and remains an impediment to restoration success (Fig. 9).

Figure 9: Photographs demonstrating the substantial woody encroachment currently occurring on the HBS site despite prior restoration efforts. The white square in the middle image is 1 m in height and was positioned for scaling purposes (taken by W. Wallett, April 2014).

B. Historical Conditions & Land Use History

Prior to the acquisition of the Jackson Purchase from the Chickasaw Indians in late 1818, the HBS site existed within a territory of exceptionally limited occupation (Davis 1923, Thompson 2007). Those Native Americans that did occupy the area engaged in regular burning activities as noted by several early historical accounts of the region (Davis 1923). Consequently, barrens vegetation was a common occurrence throughout the Jackson Purchase, and perhaps on the HBS site, prior to 1820; it was this year that the region was declared open for European settlement. As European settlement of the region increased, the firing activities of the former inhabitants ceased, and barrens areas quickly succumbed to woody encroachment by blackjack and other oak species (Davis 1923, Baskin et al. 1999).

The HBS site occurs in the Breaks of the Tennessee River as delineated by Davis (1923) (Fig. 3). This area was exceptionally hilly and possessed cherty-rich, non-loess soils that were poor for most agriculture. As a result, the area remained sparsely populated, heavily timbered, and contained the highest portion of unimproved land in the Purchase region prior to the mid- to late-1800s. Land that was converted to agriculture was typically planted with tobacco or corn until soil erosion rendered slopes incapable of cultivation. At this point, most fields were abandoned to forest succession (Davis 1923).

Beginning in the mid- to late- 19th century, the timber within the Breaks of the Tennessee River region was removed at an incredible rate. This timber was easily transported on the nearby Tennessee River to supply local railroads, woodworking industries, factories, potteries, and households. By 1920, nearly all old growth forest in the area had been cleared and replaced by second growth forest of an inferior quality (Davis 1923).

Given this history of the area in which the HBS site is located, it seems likely that the site is what remains of either unimproved land or an abandoned agricultural field (tobacco or corn). This land was likely cleared of any old growth timber and then left to succession. A similar conclusion was drawn by Thompson (2007) who evaluated the floristic composition of the site in the early 2000s.

C. Previous Restoration & Management Activities

The ongoing restoration effort on the site was initiated by HBS staff in the late 1980s. Dr. Dick Marzolf, formerly affiliated with both the Konza Prairie and Hancock Biological stations, observed that the site possessed several barrens indicator species (e.g., *Spartina* and *Schziachryium* spp.) and advocated the site's restoration. The equipment necessary to burn the site (e.g., flappers, shovels, torches, etc.) was acquired, and site preparation began in early spring of 1989. This preparation involved the mechanical removal of one to two dozen Eastern red cedars (*Juniperus virginiana*) that were estimated to be approximately 15-20 years old at the time. Following cedar removals, an initial prescribed burn was conducted on the site in late spring 1989.

Since this initial burn, prescribed burns have been applied to the site in March or early April on an approximate 2-3 year rotation. No records of the burns' dates or natures of occurrence, nor any monitoring of their outcomes on the site's vegetative condition, has been conducted or documented to date. Informal observation indicates that substantial woody encroachment continues to affect the site (Fig. 9) and that a barrens community composition has yet to be established (Fig. 8). Consequently, the efficacy of this initial restoration attempt remains in question.

D. TNC Restoration Site Comparison

To assess the success of prior restoration efforts, describe the site's current vegetative condition, and gain insight into the site's potential future conditions, a vegetative comparison was made between the HBS site and ongoing barrens restorations in nearby areas of the state. Given the time of year at which the comparison was made, as well as the limited botanical expertise of the individual conducting the associated surveys, this comparison was restricted to the level of plant functional groups between sites. Species-level comparisons remain to be conducted before restoration efforts commence.

Comparison Sites:

The HBS site was compared to three restoration sites – Mantle Rock Preserve, the Reynold's tract, and the Perkin's tract - managed by The Nature Conservancy (TNC) (Fig. 10). All three sites are located in Livingston County, Kentucky, but vary in terms of total acreage, previous land use history, and time since restoration efforts began.

The Mantle Rock Preserve (MRP) consists of 367 acres owned by TNC that have been actively managed since the early 1990s. Soils on the site belong to the Hosmer and Zanesville series (USGS Soil Survey). The open field areas on the preserve were previously agricultural cropland dominated by *Festuca* spp. prior to TNC conversion to a mix of native warm-season grasses (*Sorghastrum nutans, Andropogon gerardii*, and *Schizachryium scoparium*). Fire has been applied to the site on an approximate 3 year rotation, and chemical and mechanical removals have been conducted as needed.

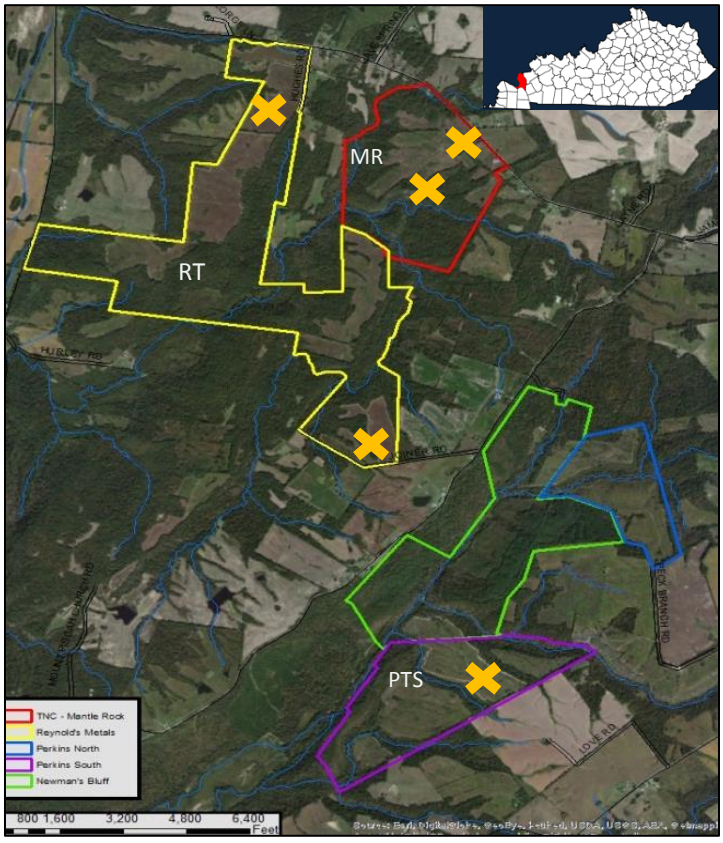


Figure 10: Aerial map of the Livingston County restoration sites (MR – Mantle Rock Preserve; RT – Reynold's Tract; PTS - Perkin's Tract South). Yellow Xs designate the sampling locations at each site.

The approximately 900 acres of the Reynold's tract were previously cropland acquired by TNC through the WHIP program. TNC has since transferred ownership of this land to Livingston County. Despite this change in ownership, TNC remains active in management of the site and has subjected the site to prescribed burns every 2-3 years since restoration efforts commenced 7 years ago. Similar to the MRP, restoration of the Reynold's tract has focused on facilitating the transition from *Festuca* spp. dominated vegetation to native warm-season grasses. Soils on this site belong to the Hosmer and Zanesville series (USGS Soil Survey).

The Perkin's tracts are two managed areas that are a part of the greater 1100-acre Newman's Bluff site that was originally acquired by TNC but later transferred to Livingston County. Both tracts were formerly loblolly plantations on Hosmer soils (USGS Soil Survey) that were clearcut approximately 8

years ago. Since then, TNC has performed extensive mechanical removals and applied prescribed fire to the site at least once every three years. Due to accessibility issues, only the Perkin's South site was evaluated in this study.

Methods:

The average percent cover of total vegetation and each of five plant functional groups – gramminoids, forbs, cryptogams, shrubs/vines, and trees – were estimated within 1 m^2 sampling quadrats at each site (Fig. 11). Sampling occurred at the Livingston County sites on March 28, 2014, while sampling of the HBS site was completed on April 8, 2014. Livingston County sampling locations were randomly selected through blind tosses of a quadrat frame. Due to size limitations of the HBS site, HBS sampling locations were evenly distributed along three transects – downslope, mid-slope, and upslope - that spanned the width of the site and ran perpendicular to the slope of the site.

Thirty-two total quadrat samples were collected from all four sites. Ten total quadrat samples were obtained from two separate areas of the MRP site, and the same total was similarly obtained from two separate areas of the Reynold's tract. Only five total quadrat samples were recorded from the southern Perkin's tract as road access to the Perkins north area was rendered impossible by recent rainfall. Seven total quadrat samples were recorded from the HBS site, three from the site's downslope transect, two from the mid-slope transect, and two from its upslope transect.

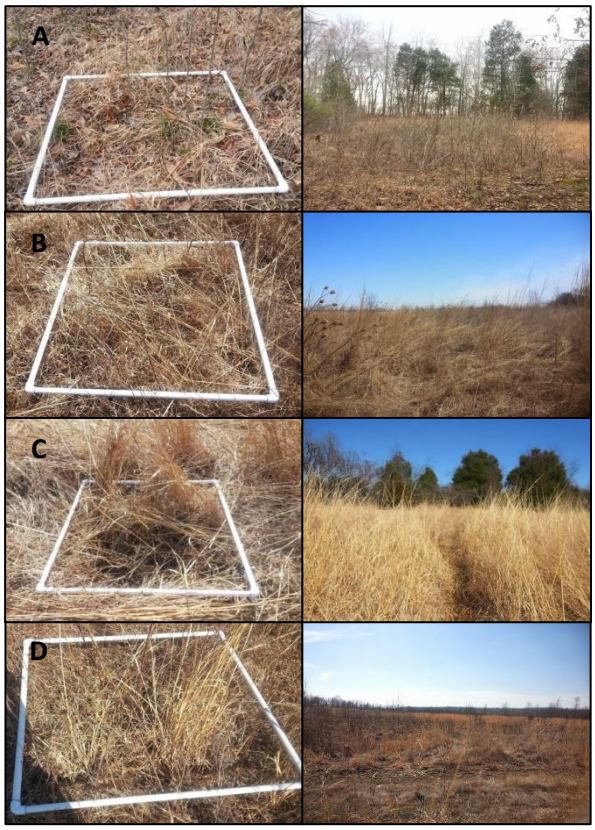


Figure 11: The vegetation typical within sampling quadrats and across each restoration site (A – HBS site; B- Mantle Rock Preserve; C – Reynold's tract; D – Perkin's Tract South)

All data analysis was conducted in R v. 3.0.2. Shapiro-Wilks tests of normality indicated that average percent cover values for each functional group were non-normally distributed and remained so despite transformation. Therefore, non-parametric Kruskal-Wallis tests were used to identify significant differences in the average percent cover of each functional group between restoration sites. Those functional groups identified as demonstrating significant differences between groups were evaluated with post-hoc analyses adjusted for unequal sampling group sizes. To account for multicomparisons, post-hoc p-values were Holm-Bonferroni adjusted.

Results:

Quadrats' average total percent cover ranged from 60-86.25% across the HBS site (Table 1). Gramminoid species (μ=32.93%) comprised the majority of the average total percent cover, followed by cryptogams (μ=15.57%), forbs (μ=12.21%), shrubs/vines (μ=7.32), and trees (μ=5.43) respectively (Table

1). The mean average percent cover values of total vegetation and of each functional group at the comparison sites are detailed in Table 1.

Table 1: The mean average percent cover of total vegetation and each of five functional groups for the HBS restoration site and the three Livingston County sites used for comparison.

Restoration Site	Mean Average Percent Cover Values					
	Total	Gramminoids	Forbs	Cryptogams	Shrubs/vines	Trees
HBS	74.29	32.93	12.21	15.57	7.32	5.43
Mantle Rock	74.63	49.25	12.08	3.05	5.15	1.50
Reynold's Tract	61.88	48.25	6.25	5.65	1.25	0.38
Perkin's Tract S.	88.75	52.50	14.95	2.75	15.75	1.85

Significant differences in the average total percent cover (df=3, P=0.0008) and average percent cover of cryptogams (df =3, P=0.0284), shrubs/vines (df=3, P=0.006), and trees (df=3, P=0.003) occurred between the sites. No significant differences occurred in the average percent cover of forbs (df=3, P=0.071) or gramminoids (df=3, P=0.163) between sites (Fig. 12). However, species composition of these non-significant functional groups was observed to vary between sites.

The HBS site's average total percent cover was significantly lower than that of the Perkin's tract, significantly higher than that of the Reynold's site, and comparable to that of the MRP (Fig. 12). A similar trend was mirrored by the average percent cover of shrubs/vines between the four sites. In contrast, the HBS site possessed significantly higher average percent covers of cryptogams and trees than the MRP. Average cryptogam and tree cover of the HBS site was also higher than the values obtained at the Perkin's and Reynold's tracts, but not to a significant extent (Fig. 12).

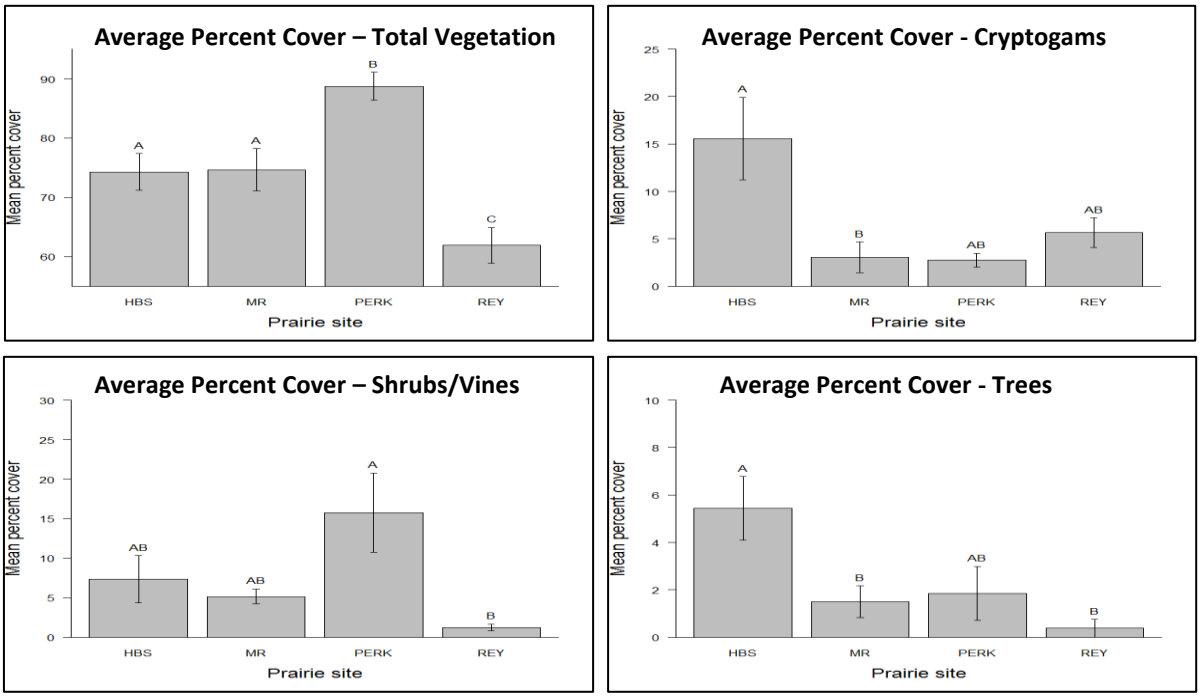


Figure 12: The mean average percent cover values of the functional groups that differed significantly between the four restoration sites (HBS – Hancock Biological Station; MR – Mantle Rock Preserve; PERK – Perkin's Tract South; REY – Reynold's Tract). The HBS site exhibited average percent covers of cryptogams and trees that were significantly higher than those of the Mantle Rock Preserve.

Conclusions:

As the MRP and HBS sites have undergone similar management for approximately the same time period (~25 years), one might expect the average percent cover of different functional groups to be similar between the two. Total percent cover did not vary between sites; however, the functional groups comprising the majority of these totals were markedly different. The HBS site had significantly higher cryptogam and tree cover, reflecting the relatively lower herbaceous density and substantial woody encroachment that is apparent on-site (Fig. 9). This indicates that the HBS restoration effort may not have been as effective as the MRP project to date. This is likely due to differences in the timing at which prescribed burns have been applied, differences in fuel-loading and the intensity of fires generated on each site, and supplemental native species plantings performed on the MRP site.

The HBS site did not differ significantly from the Perkin's tract in terms of any functional group. The Perkin's tract previously supported a loblolly pine plantation rather than agricultural fields, and as a result, requires greater transition to native barrens vegetation. As restoration on the site began relatively recently (~ 8 years ago), the site remains subject to substantial woody encroachment and largely in flux between forest and grassland habitat types. The fact that the HBS site did not differ significantly from the Perkin's tract in terms of shrub/vine and tree cover suggests that HBS remains in similar flux between the two vegetative types.

This state of flux is further supported by the lack of significant differences between the HBS site and Reynold's tract. As the Reynold's tract has been converted from cropland, its transition to barrens-like vegetation has occurred relatively rapidly. However, management has occurred on the site for only 7 years, and consequently, its conditions are not yet equivalent to those of the MRP. Both the Reynold's tract and HBS site appear to be at states of restoration intermediate of the still-degraded Perkin's tract and more successful MRP.

These results help to define the current condition of the HBS site as gramminoid-dominated but intermediate in the context of similar restorations. The lack of similarity between the MRP and HBS sites suggest that the efficacy of the HBS effort must be improved to reduce woody encroachment, maintain barrens-like conditions, and obtain comparable restoration success. Further insight as to how the sites compare, as well as a more informed restoration effort, will require future vegetative surveying at the species-level scale.

Restoration Goals and Objectives

Goals:

- To restore a native barrens-like community to the HBS site
- To manage the site so as to –
    - promote the dominance of native warm-season grasses
    - suppress woody encroachment
    - maintain populations of as many herbaceous prairie/barrens-indicator species as possible
    - prevent or reduce the occurrence of non-native or invasive species

Objectives:

- To complete preliminary vegetative surveys to identify –
    - the species composition of the site
    - the relative abundances of species present
    - the presence or absence of native warm-season grasses (primarily *S. nutans, A.gerardii*, and *S.scoparium*)
    - the presence or absence of non-native or potentially invasive species (e.g., *Fesuce* spp., *Poa pratensis*, etc.)

- To increase the relative abundance of –
    - native warm-season grasses
    - native prairie forb species

- To decrease the relative abundance of –
    - cryptogam species
    - shrub/vine species
    - tree species
    - non-native species, particularly cool-season grasses

Restoration Activities, Methods, and Timeline

The restoration plan detailed below consists of two phases of management activity. The first phase includes activities to be completed within the first year of restoration. The second phase consists of activities that should recur over the long term to ensure consistent and enduring restoration efforts. These phases are described below, with each section detailing an activity's purpose, the methods used to complete it, and the proposed frequency and/or timing of its completion. Additionally, suggestions are made as to the parties responsible for completion of and the outputs to be generated from each activity. Finally, involvement with MSU classes and curriculum is described, and a preliminary timeline of restoration activities is provided.

A. Phase 1 – Initial Management Activities

- Preliminary vegetative surveying to the species-level scale
    - Purpose:
        - to determine the current vegetative condition of the HBS site in terms of species composition and the relative abundance of the species present
        - to confirm the presence of desired native warm-season grasses
        - to identify the presence of any non-native or invasive species that may threaten populations of native barrens species
    - Methods:
        - Quadrat sampling should occur along 3-5 permanent transects established on the site. These transects should run parallel to the sites' topographic line and perpendicular to the site's slope. A minimum of three quadrats should be sampled at equidistant intervals along each transect.
        - Quadrats (1 m^2 in area) should be gridded into 25 equally sized cells.
        - Within each cell, the species present should be identified and the number of individuals of each species *rooted* within the cell recorded on an appropriate datasheet (see Appendix III).
        - After all cells have been sampled, the total number of individuals of each species, the total number of individuals of all species, and the relative abundance of each species within the quadrat should be calculated.
        - The barrens indicator species present within each quadrat should be noted.
        - The invasive species contained within each quadrat should also be noted.
        - See Appendix III for an example datasheet and calculations for this activity.
    - Proposed date of completion: Summer/Fall 2014
    - Completed by: MSU's Field Botany (BIO 553) and/or Systematic Botany (BIO 350) classes
    - Outputs: electronic data set; hardcopy of data set; report detailing the survey's results (e.g., list of species present, the relative abundance of each species, etc.)

- Pre-burn mechanical removal of saplings and woody vegetation established on the site
    - Purpose:
        - to cause direct mortality of saplings and woody vegetation on site
        - to eliminate the woody vegetation that low-intensity fire cannot
        - to promote the mortality of woody individuals and species during subsequent burning activities
        - to supplement fire in suppressing woody encroachment of the site
    - Methods: mowing, bush hogging, sawing, hand removal, etc.
    - Proposed date of completion: Winter/Early Spring 2015

- Completed by: HBS staff, students, and volunteers
- Outputs: Documented description of the activities completed; count or estimate of the amount of woody biomass removed

- Initial prescribed burn
  - Purpose:
    - To cause direct mortality of saplings and woody vegetation on site
    - To cause damage to or direct mortality of non-native cool-season grass species
    - To stimulate increased vigor, reproductive output, and recruitment of native warm-season grass and forb species
    - To help establish the dominance of native warm-season grasses
  - Methods:
    - Prior to the burn, the following should be completed:
      - Neighbors and local fire departments informed of upcoming burn activity
      - Adequate number of crew members obtained to complete the burn
      - Liability waiver forms signed by all crew members
      - 6-10' fire lines mowed/cleared around the perimeter of the HBS site
      - Completion and review of a burn plan document (see Appendices VI & VII)
      - Day-of-burn weather conditions confirmed as appropriate for the burn planned
      - All crew members briefed on burn objectives, procedures, safety, etc.

      * See Appendix V for a pre-burn checklist of these tasks
    - Burn completion
      - A backfire should be set on the upper side of the site to create a minimum of 6' of stable blackline (Fig. 13)
      - Ground ignitions should commence and proceed from the downslope side of the site until the flame front contacts and is extinguished by the blackline (Fig. 13)
      - Holding should be performed by crew members throughout active ignitions

Figure 13: Suggested ignitions strategy for the HBS restoration site.

    - Post-fire/Mop up
      - All smoking debris should be removed from within 15' of the site's perimeter
      - Hot spots should be extinguished with water or dry mop-up techniques
      - Monitoring and mop up should continue until burn is completely extinguished on site
  - Proposed date of completion: Late Spring (early April – early May) 2015
  - Completed by: MSU's Disturbance Ecology (BIO 590/690), Wildlife Management (BIO 580/680), or Conservation Biology (BIO 578/678) class(es)

- Outputs: Completed prescribed burn plan; documented post-burn description of burn activities, nature, and overall success

B. Phase 2 – Recurring Management Activities

- Vegetative Monitoring
  - Purpose:
    - to monitor the vegetative condition of the HBS site in terms of species composition and the relative abundance of the species present
    - to monitor the continued presence of desired native warm-season grasses
    - to document the presence of any non-native or invasive species that may threaten populations of native barrens species
    - to allow comparison with previous vegetative conditions and evaluation of restoration progress
  - Methods:
    - Quadrat sampling should occur along 3-5 permanent transects established on the site. These transects should run parallel to the sites' topographic line and perpendicular to the site's slope. A minimum of three quadrats should be sampled at equidistant intervals along each transect.
    - Quadrats (1 m^2 in area) should be gridded into 25 equally sized cells.
    - Within each cell, the species present should be identified and the number of individuals of each species *rooted* within the cell recorded on an appropriate datasheet (see Appendix III).
    - After all cells have been sampled, the total number of individuals of each species, the total number of individuals of all species, and the relative abundance of each species within the quadrat should be calculated.
    - The barrens indicator species present within each quadrat should be noted.
    - The invasive species contained within each quadrat should also be noted.
    - See Appendix III for an example datasheet and calculations for this activity.
  - Proposed frequency of completion: annually
  - Completed by: MSU's Field Botany (BIO 553) and/or Systematic Botany (BIO 350) classes
  - Outputs: electronic data set; hardcopy of data set; report detailing the survey's results (e.g., list of species present, the relative abundance of each species, etc.) and how they compare to the results of previous reports

- Mechanical Removal & Herbicide Application
  - Purpose:
    - to cause direct mortality of saplings and woody vegetation on site
    - to cause direct mortality of non-native cool-season grasses on site
    - to eliminate the woody vegetation that low-intensity fire cannot
    - to promote the mortality of woody individuals and non-native species during subsequent burning activities
    - to supplement fire in suppressing woody encroachment and non-native invasion of the site
  - Methods:
    - Mechanical removal: mowing, bush hogging, sawing, hand removal, etc.

        - Herbicide application: Glycophosate or Plateau (BASF-American Cyanamid, Raleigh, NC, USA; active ingredient Imazapic) applied according to the manufacturers' recommendations to woody vegetation or non-native cool season grasses respectively
    - Proposed frequency of completion: annually, as needed
    - Completed by: HBS staff, students, and volunteers
    - Outputs: documented description of the activities completed; count or estimate of the amount of grass or woody biomass removed

- Prescribed burning
    - Purpose:
        - To cause direct mortality of saplings and woody vegetation that have resprouted or established on the site
        - To cause damage or direct mortality of any remaining non-native cool-season grass species
        - To stimulate increased vigor, reproductive output, and recruitment of native warm-season grass and forb species
        - To further establish and maintain the dominance of native warm-season grasses
    - Methods:
        - Prior to the burn, the following should be completed:
            - Neighbors and local fire departments informed of upcoming burn activity
            - Adequate number of crew members obtained to complete the burn
            - Liability waiver forms signed by all crew members
            - 6-10' fire lines mowed/cleared around the perimeter of the HBS site
            - Completion and review of a burn plan document (see Appendices VI & VII)
            - Day-of-burn weather conditions confirmed as appropriate for the burn planned
            - All crew members briefed on burn objectives, procedures, safety, etc.

        * See Appendix V for a pre-burn checklist of these tasks
        - Burn completion (see Fig. 13)
            - A backfire should be set on the upper side of the site to create a minimum of 6' of stable blackline
            - Ground ignitions should commence and proceed from the downslope side of the site until the flame front contacts and is extinguished by the blackline
            - Holding should be performed by crew members throughout active ignitions
        - Post-fire/Mop up
            - All smoking debris should be removed from within 15' of the site's perimeter
            - Hot spots should be extinguished with water or dry mop-up techniques
            - Monitoring and mop up should continue until burn is completely extinguished on site
    - Proposed timing of completion: early April – early May
    - Proposed frequency of completion: bi- or triennially

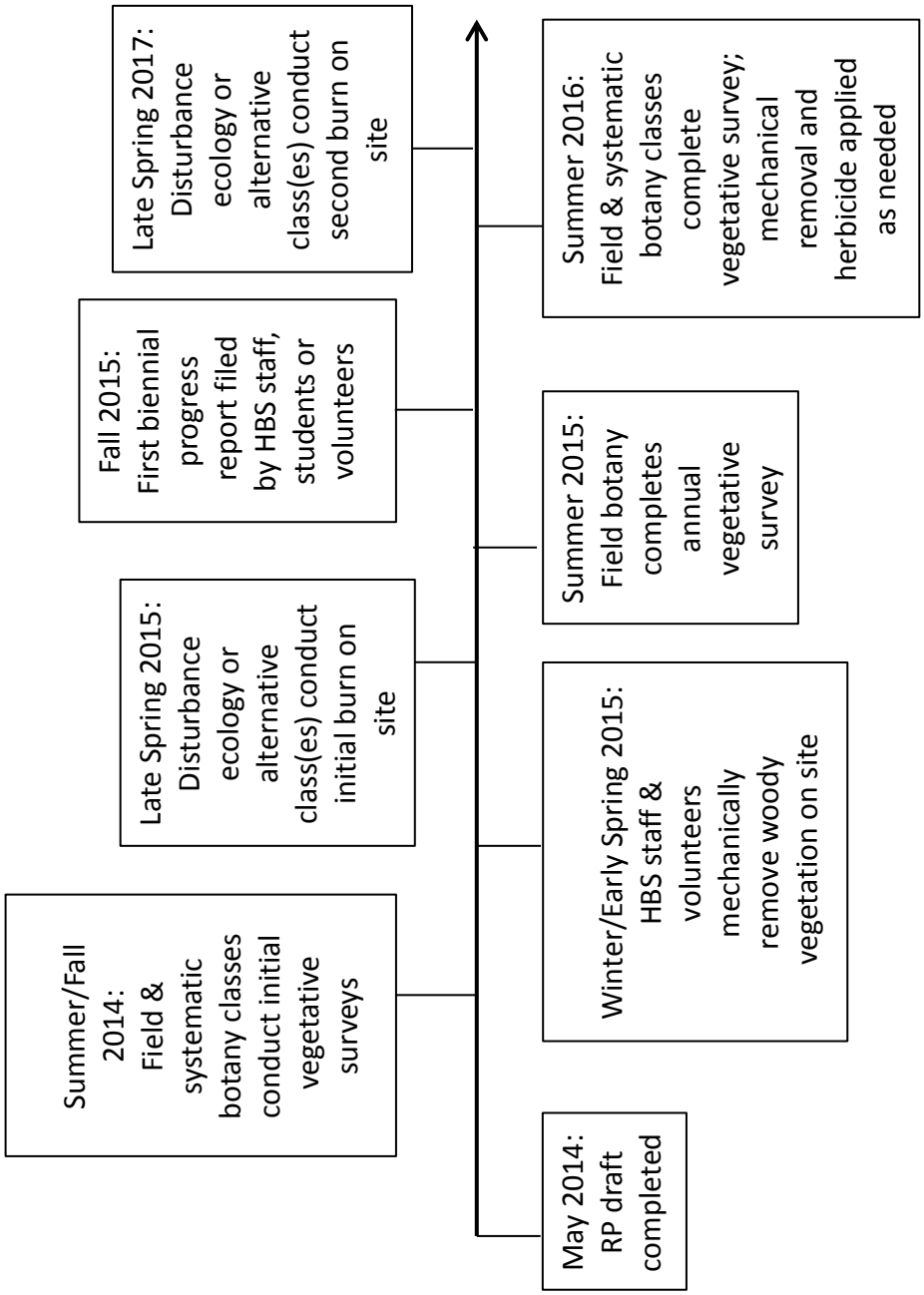
- Completed by: MSU's Disturbance Ecology (BIO 590/690), Wildlife Management (BIO 580/680), or Conservation Biology (BIO 578/678) class(es)
- Outputs: Completed prescribed burn plan; documented post-burn description of burn activities, nature, and overall success

- Data Maintenance & Progress Reports
  - Purpose:
    - To provide a documented record of restoration activities and results
    - To allow evaluation of restoration methodology, strategy, and success
    - To allow for adaptive management
    - To help identify the ways in which the restoration effort can be modified or improved for increased efficacy or success
  - Methods:
    - All data collected from surveys checked for quality and then added to the project's electronic spreadsheet or database.
    - Any documented descriptions of restoration activities saved in electronic form.
    - Hard copies of the data collected and documentation from restoration activities filed chronologically with previous restoration documents.
    - Biennial report drafted (See Appendix VIII)
    - Electronic and hard copies of the biennial report stored or filed accordingly.
  - Proposed frequency of completion: biennially
  - Completed by: HBS staff, students, or volunteers
  - Outputs: organized record of restoration data and documentation; series of biennial reports by which restoration progress may be traced or evaluated

C. Murray State University Class Involvement

As detailed above, Murray State University classes, such as disturbance ecology (BIO 590/690), systematic botany (BIO 350), and field botany (BIO 553), will play critical roles in the implementation and prolonged success of the HBS barrens restoration effort. The subjects that these classes cover and the intervals at which these classes are offered correspond well to the needs of the project (e.g., annual field botany classes requiring plant species identification occur to complete annual vegetative monitoring; disturbance ecology or conservation biology classes that cover prescribed fire as a disturbance or management technique occur every two years to apply biennial prescribed burns to the site). Involvement of these classes in restoration efforts will ensure that management activities are adequately staffed, completed in a regular, timely manner, and performed at little to no additional cost to the university. Additionally, class involvement in restoration activities provides students with an invaluable hands-on learning experience and the opportunity to observe the first-hand application of skills acquired in class. Concurrently, class involvement increases student awareness of HBS, native habitat types, and ecological restoration. Overall, class involvement promises to greatly benefit MSU's students, enhance the university's curriculum, and promote MSU's continued commitment to the environment and conservation.

D. Tentative Timeline of Restoration Activities



E. Additional Management Considerations

- *Native plantings*
    - Many restorations have seeded or planted native species to promote the rapid establishment, required composition, or desired structure of native communities. Should initial or post-fire vegetative surveys indicate the absence or low relative abundance of barrens to non-native species, native plantings might be considered as a potential supplemental management activity. As many as ten nurseries offer native seeds, mixes, and/or plugs throughout the state of Kentucky (see Appendix II). The cost of species can vary widely, and the cost-effectiveness of the species purchased and planted should be evaluated before plantings are performed. A source of funds to complete plantings remains to be identified.

- *Adaptive management*
    - The complexity and unpredictable nature of ecological systems pose a major challenge to ecological restoration. This challenge is made greater by unavoidable human error, limited understanding of ecosystem function or dynamics, and incomplete control over the repercussions of management actions (Williams et al. 2009). As a result, restorations sometimes struggle to identify or apply the most effective management strategies to achieve their goals and objectives. Often the most appropriate strategy depends upon the current condition of a system that is likely to change through time.

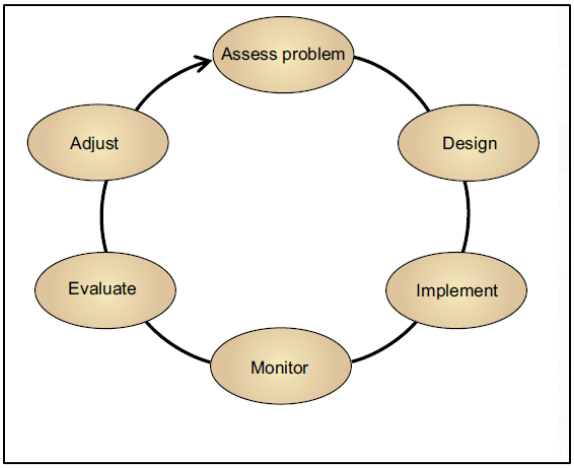


Figure 14: A general diagram of the adaptive management process (Williams et al. 2009)

Adaptive management is a systematic approach to restoration or land management that helps to overcome the above challenges (Fig. 14)(Williams et al. 2009) . The goal of adaptive management is to improve ongoing and future management by learning from previous management outcomes. It involves consideration of alternative strategies to meet restoration objectives, the implementation of one or more of these strategies, monitoring of the strategies' outcomes, and using the results to modify or adjust future management decisions (Williams et al. 2009).

Adaptive management should be applied to the HBS barrens restoration project. As management activities are completed and biennial reports filed, the plan detailed in this document should be assessed for cost-effectiveness, feasibility, and effectiveness. When necessary, this plan should be modified to improve project success. Modifications should be documented in updated editions of the HBS barrens restoration plan.

References

Anderson, R., Schwegman, J., & Anderson, M. R. (2000). Micro-scale restoration: A 25-year history of a Southern Illionois barrens. *Restor Ecol, 8*(3), 296-306.

Barnes, T. (2002). *Kentucky's last great places*. Lexington, KY: University Press of Kentucky.

Baskin, J.M., and Baskin, C.C. (1981). The Big Barrens of Kentucky not part of Transeau's Prairie Peninsula. In *The Prairie Peninsula – In the "Shadow" of Transeau*, ed. R.L. Stuckey and K.J. Reese, pp. 43-48. Proceedings of the Sixth North American Prairie Conference, The Ohio State University, Columbus. Ohio Biological Survey Biological Notes Number 15.

Baskin, J., Baskin, C., & Chester, E. (1994). The Big Barrens Region of Kentucky and Tennessee: Further observations and considerations. *Castanea, 59*(3), 226-254.

Baskin, J., Baskin, C., & Chester, E. (1999). The Big Barrens Region of Kentucky and Tennessee. In R. Anderson, J. Fralish, & J. Baskin (Eds.), *Savannas, barrens, and rock outcrop communities of North America* (pp. 190-205). Cambridge University Press.

Bourne, A. (1820). On the prairies and barrens of the west. *Am. J. Sci., 2*, 30-34.

Bryant, W.S., and Martin, W.H. (1988). Vegetation of the Jackson Purchase of Kentucky based on 1820 General Land Office Survey. In Snyder, D.H. (ed.) *Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys* (pp. 264-276). Clarksville, TN: The Center for Field Biology of Land Between the Lakes, Austin Peay State University.

Copeland, T., Sluis, W. I., & Howe, H. (2002). Fire season and dominance in an Illinois tallgrass prairie restoration. *Restor Ecol, 10*(2), 315-323.

Davidson, Rev. R. (1840). *An excursion to the Mammoth Cave and the Barrens of Kentucky*. Lexington, KY: A.T. Skillman and Son.

Davis, D. (1923). *Kentucky Geological Survey Series 6: Vol. 9. The geography of the Jackson Purchase of Kentucky*.

Douglas, T. (2002). *Ecological restoration guidelines for British Columbia*. Terrestrial Ecosystem Restoration Program of British Columbia, Biodiversity Branch, Ministry of Water, Land, and Air Protection, Victoria, BC.

Fenneman, N. M. (1938). *Physiography of eastern United States*. New York, NY: McGraw-Hill Co.

Gibson, D. (2009). *Grasses and grassland ecology*. New York, NY: Oxford University Press.

Guyette, R., Dey, D., & Stambaugh, M. (2003). Fire and human history of a barren-forest mosaic in Southern Indiana. *Am Midl Nat, 149*, 21-34.

Heikens, A., West, K. A., & Robertson, P. (1994). Short-term response of chert and shale barrens vegetation to fire in Southwestern Illinois. *Castanea, 59*(3), 274-285.

Howe, H. (1994). Managing species diversity in tallgrass prairie: Assumptions and implications. *Conserv Biol, 8*(3), 691-704.

Keith, J. H. (1983). Presettlement barrens of Harrison and Washington counties, Indiana. In C. L. Kucera (Ed.), *Proceedings of the Seventh North American Prairie Conference* (pp. 17-25). Springfield, MO: Southwest MIssouri State University.

Keys, Jr., J., Carpenter, J., Hooks, S., Lienig, F., McNab, W.H., Russel, W.E., and Smith, M.L. (1995) Ecological units of eastern United States – first approximation. United States Department of Agriculture, Forest Service, Southern Region Geometronics, Atlanta, GA.

Kite, T. (1847). Journal of a trip through Kentucky and visit to Mammoth Cave, May and June 1847, by Thomas Kite, Cincinnati, Ohio. Typewritten copy of manuscript ["Cincinnati, Ohio, 1943"] housed at Manuscripts and Folklife Archives, Kentucky Building, Western Kentucky University.

Kuchler, A. W. (1964). *Potential natural vegetation of the conterminous United States* (Vol. 36). American Geographical Society.

Loughridge, R. N. (1888). *2. Report on the geological and economic features of the Jackson Purchase Region, embracing the counties of Ballard, Calloway, Fulton, Graves, Hickman, McCracken, and Marshall* (Vol. 6F). Kentucky Geological Survey Reports of Special Subjects.

Louis-Phillipe, Duke of Orleans. (1797). Diary of my travels in America. Reprinted by S. Becker (1977). Delacorte Press, New York.

Michaux, A. (1904). Journal of Andre Michaux [translated from French]. In R. G. Thwaites (Ed.), *Early western travels, 1748-1846* (Vol. 3). Cleveland, OH: Arthur Clark Co.

Michaux, A. (1904). Travels to the west of the Allegheny Mountains in the states of Ohio, Kentucky, and Tennessee [reprint]. In R. G. Thwaites (Ed.), *Early western travels, 1748-1846* (Vol. 3). Cleveland, OH: Arthur Clark Co.

Owen, D. D. (1856). *1. [First] Report of the geological survey of Kentucky, made during the years 1854 and 1855* (Vol. 1). Frankfurt, KY: A.G. Hodges, State Printer.

Rhoades, C., Barnes, T., & Washburn, B. (2002). Prescribed fire and herbicide effects on soil processes during barrens restoration. *Restor Ecol, 10*(4), 656-664.

Ross, J. (1882). *Life and tImes of Elder Reuben Ross [1776-1860]*. Philadelphia, PA: Grant, Faires, and Rodgers.

Samson, F., & Knopf, F. (1994). Prairie conservation in North America. *BioScience, 44*(6), 418-421.

Sargent, C. S. (1884). *Report on the forests of North America (exclusive of Mexico)*. Washington, D.C.: Department of the Interior Census Office, Government Printing Office.

Society for Ecological Restoration International Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration*. www.ser.org & Tucson: Society for Ecological Restoration International.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/15/2014]

Thompson, R. (2007). The vascular flora of the Hancock Biological Station, Murray State University, Calloway County, Kentucky. *J. Bot. Res. Inst. Texas, 1*(1), 609–630.

Thompson, R., & Poindexter, D. (2006). Vascular flora of the Elk and Bison Prairie, Land Between the Lakes National Recreation Area, Trigg County, Kentucky. *Castanea, 71*(2), 105-123.

Towne, E. G., & Kemp, K. (2003). Vegetation dynamics from annually burning tallgrass prairie in different seasons. *J Range Manage, 56*, 185-192.

Transeau, E. N. (1935). The Prairie Peninsula. *Ecology, 16*, 423-437.

Williams, B., Szaro, R., and Shapiro, C. (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Woods, A.J., Omernik, J.M., Martin, W.H., Pond, G.J., Andrews, W.M., Call, S.M., Comstock, J.A., and Taylor, D.D. (2002). Ecoregions of Kentucky (color poster with map, text, summary tables, and photographs): US Geological Survey, Reston, VA.

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Deiter C. Ullrich – Murray State University, Pogue Library – Assistant Professor, Archivist and Special Collections Librarian

Dr. David White – Murray State University, Hancock Biological Station - Professor of Biological Sciences, Director of Hancock Biological Station

Dr. Howard Whiteman – Murray State University, Watershed Studies Institute – Professor of Biological Sciences, Director of the Watershed Studies Institute

Appendices

I. Resource Contact Information

Murray State University

- Dr. David White - Hancock Biological Station - Professor of Biological Sciences, Director of Hancock Biological Station
  561 Emma Drive
  Murray , KY 42071
  # (270) 474-2272
  david.white@murraystate.edu
  HBS site information, equipment inventory, site access, etc.

- Deiter C. Ullrich – Pogue Library – Assistant Professor, Archivist and Special Collections Librarian
  Pogue Library - Office 207
  # (270) 809-4295
  dullrich@murraystate.edu
  Jackson Purchase regional history

The Nature Conservancy

- Shelly Morris – Western KY Project Director, MSU Alumna
  Benton, KY
  # (270) 748-0259
  mmorris@tnc.org
  TNC barrens restorations information, Livingston Co. restoration projects information

UDSA US Forest Service – Land Between the Lakes National Recreation Area

- Elizabeth Raikes – Wildlife Biologist, Openlands Coordinator
  # (270) 924-2062
  eraikes@fs.fed.us
  Elk/Bison prairie restoration and management information

- Chad Ingle – Natural Resource Specialist
  # (270) 924-2028
  cgingle@fs.fed.us
  Fire management information

KY State Nature Preserves Commission

- Joyce Bender – Nature Preserves & Natural Areas Program Branch Manager
  # (502) 573-2886 ext. 101
  Joyce.Bender@ky.gov
  Barrens restorations throughout the state (Eastview Barrens, Springhouse Barrens, Thompson Creek Glades, Bouteloua Barrens, Raymond Athey Barrens SNPS)

- Deborah White – Botanist, Natural Heritage Program Branch Manager
  # (502) 573-2886 ext. 119
  Deborah.White@ky.gov
  Barrens restorations throughout the state (Eastview Barrens, Springhouse Barrens, Thompson Creek Glades, Bouteloua Barrens, Raymond Athey Barrens SNPS)

II. Native Plant Nursery Contact Information

Dropseed Nursery
1205 S. Buckeye Lane
Goshen, KY 40026
(502) 439-9033
margaret@dropseednursery.com
www.dropseednursery.com

Roundstone Native Seed & Nursery
9764 Raider Hollow Rd.
Upton, KY 42784
#(270) 531-5853 or (270) 531-3034

Shooting Star Nursery
160 Soards Road
Geogetown, KY 40324
(502)-867-7979
shootingstarnursery@msn.com

Salato Native Plant Program
Mary Carol Cooper
1 Sportsman's Lane
Frankfort, KY 40601
(502) 564-5280

Gardenside Natives
Lexington, KY
Patricia Hartman
gardensidenatives@gmail.com
http://www.facebook.com/GardensideNatives

Chrysalis Natural Landscapes
680 Mt. Vernon Ridge Road
Frankfort, KY 40601
(502) 682-8279
connie@chrysalisnaturallandscapes.com

Habitats Native Plant Nursery, LLC
PO Box 265
Silver Grove, KY 41085
(859) 442-9414
native@habitatnursery.org

Highland Moore
226 Shady Lane
Midway, KY 40347
(859) 509-2719
info@highlandmoor.com
http://www.highlandmoor.com/

Kentucky Division of Forestry
627 Comanche Trail
Frankfort, KY 40601
(502) 564-4496
diana.olszowy@ky.gov
http://www.forestry.ky.gov/seedling/

Keystone Flora
P. O. Box 20109
Cincinnati, OH 45220
(513) 961-2727
nativeplants@keystoneflora.com
http://www.keystoneflora.com/

* List assembled by the KY Native Plant Society 2010
(http://www.knps.org/native%20plant%20resources.html)

III. Sample Vegetative Monitoring Data Sheet

Date: _07/20/2014___ Sampled by: _W. Wallett, M. Moore,B. Richardson, B. Tumolo_____
Transect: __D___ Quadrat #: __2__

	Species No. & Code									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cell #	**ANGE**	**SONU**	**POPR**	**SMGL**	**LIST**	**EUCO**	**COMA**	**RUHI**	**SCSC**	**POSA**
1	1	2	1	4	5	2	1	1	1	1
2	0	1	0	0	2	4	7	1	2	0
3	1	0	0	2	5	6	3	1	1	1
4	2	4	0	0	0	2	7	3	3	4
5	0	0	0	5	1	1	1	1	1	2
6	1	2	1	4	5	2	1	1	1	1
7	0	1	0	0	2	4	7	1	2	0
8	1	0	0	2	5	6	3	1	1	1
9	2	4	0	0	0	2	7	3	3	4
10	0	0	0	5	1	1	1	1	1	2
11	1	2	1	4	5	2	1	1	1	1
12	0	1	0	0	2	4	7	1	2	0
13	1	0	0	2	5	6	3	1	1	1
14	2	4	0	0	0	2	7	3	3	4
15	0	0	0	5	1	1	1	1	1	2
16	1	2	1	4	5	2	1	1	1	1
17	0	1	0	0	2	4	7	1	2	0
18	1	0	0	2	5	6	3	1	1	1
19	2	4	0	0	0	2	7	3	3	4
20	0	0	0	5	1	1	1	1	1	2
21	1	2	1	4	5	2	1	1	1	1
22	0	1	0	0	2	4	7	1	2	0
23	1	0	0	2	5	6	3	1	1	1
24	2	4	0	0	0	2	7	3	3	4
25	0	0	0	5	1	1	1	1	1	2
Total	20	35	5	55	65	75	95	35	40	40
Relative Abundance	4.3	7.5	1.1	11.8	14.0	16.1	20.4	7.5	8.6	8.6

Total number of individuals observed: ___465___
Total number of species observed: _____10___

Barrens indicator species observed: ____*Andropogon gerardii, Sorghastrum nutans, Euphorbia corollata, Coreopsis major, Rudbeckia hirta, Schizachyrium scopariu, Polygala sanguinea*_____
_____

Invasive species observed: __*Poa pratensis*_____
_____
_____

IV. Applicable KY Fire Legislation

Kentucky Revised Statutes – Chapter 149:

149.36 Public policy declared:

The General Assembly of the Commonwealth of Kentucky declares as a public policy of the commonwealth the prevention and control of forest fires on or threatening the forest land within the Commonwealth in order to preserve forest and other natural resources, enhance the growth and maintenance of forests, conserve forest cover on watersheds, protect recreational, wildlife and other values, promote stability of forest-using industries, and prevent loss of life and damage to property from wildfires and other conflagrations.
History: Created 1964 Ky. Acts ch. 158, sec. 1.

149.365 Definitions for KRS 149.360 to 149.430 and 149.991:

As used in KRS 149.360 to 149.430 and 149.991, unless the context requires otherwise:

(1) "Secretary" means the secretary for energy and environment.
(2) "Cabinet" means the Energy and Environment Cabinet.
(3) "Person" means an individual, corporation, partnership, association, municipality, state and federal government, or other public body or other legal entity, or any officer, employee or agent of any of the foregoing.
(4) "Timberland" means any land which has enough timber or woody brush, standing or down, to constitute a fire menace to itself or adjoining lands, but does not include lands under cultivation or entirely in grass, nor land that is an isolated fire risk unless a fire on it would imperil the lands of an adjoining landowner.
(5) "Flammable material" shall include but is not limited to refuse, debris, waste forest material, brush, stumps, logs, rubbish, fallen timber, grass, stubble, leaves, slash, and grain.

Effective: July 15, 2010
History: Amended 2010 Ky. Acts ch. 24, sec. 159, effective July 15, 2010. -- Amended 1974 Ky. Acts ch. 74 Art. III, sec. 13(3). -- Created 1964 Ky. Acts ch. 158, sec. 2.

149.375 Setting fire on own land regulated:

It shall be unlawful, within or adjacent to timberland, for any person to set fire to, or to procure another to set fire to, any flammable material upon land owned or leased by him unless he previously shall have taken all reasonable care and precaution, by carefully clearing around the flammable material as necessary to prevent the escape or spread of fire to lands other than those owned or leased by him. It shall also be unlawful for any employee of any such owner or lessee of land to set fire to any flammable material, upon such land unless he shall have taken similar precautions to prevent the spread of such fire to any other land. All fires shall be attended until extinguished.

Effective: July 15, 1998
History: Amended 1998 Ky. Acts ch. 169, sec. 2, effective July 15, 1998. -- Amended 1982 Ky. Acts ch. 142, sec. 6, effective July 15, 1982. – Amended 1966 Ky. Acts ch. 23, sec. 44. -- Created 1964 Ky. Acts ch. 158, sec. 4.

149.400 Fire hazard seasons -- Fires prohibited – Exceptions:

(1) The periods commencing on February 15 and ending on April 30 and commencing on October 1 and ending on December 15 of each year are hereby declared to be and established as the fire hazard seasons. During the fire hazard seasons, even though the precautions required by KRS 149.375 shall have been taken, it shall be unlawful for any person to set fire to, or to procure another to set fire to, any flammable material capable of spreading fire, located in or within one hundred fifty feet (150') of any woodland or brushland, except between the hours of 6:00 p.m. and 6:00 a.m., prevailing local time, or when the ground is covered with snow.

(2) This section shall not apply to fires which may be set for the purpose of burning plant beds.

(3) This section shall not apply to fires which may be set by competent and qualified employees of railroad, utility, or pipeline companies in connection with the construction, operation, or maintenance of railroads, pipelines, powerlines, or other projects in the public interest on rights-of-way used for such railroads, pipelines, powerlines, or other projects, and such fires shall be attended at all times and be extinguished before the employees of such railroad, utility, or pipeline companies leave the vicinity of the fire.

(4) This section shall not apply to fires set by trained and qualified employees of a state government agency on land owned by the state or leased or managed by the state under a written agreement with the landowner and set for the specific purpose of wildlife or plant habitat improvement, ecological site restoration, site preparation for natural or artificial regeneration or fuel reduction. Nongovernmental organizations and other governmental agencies may apply to the Division of Forestry for written approval to set fires under this subsection. Fires set under this subsection shall be in accordance with KRS 149.375. Persons who set such fires shall give written notification of the burn to the local Division of Forestry district office at least twenty-four (24) hours in advance and obtain the approval of the district office.

Effective:June 24, 2003
History: Amended 2003 Ky. Acts ch. 47, sec. 1, effective June 24, 2003. -- Amended 1998 Ky. Acts ch. 169, sec. 3, effective July 15, 1998. – Amended 1982 Ky. Acts ch. 142, sec. 8, effective July 15, 1982. -- Amended 1966 Ky. Acts ch. 23, sec. 48. -- Created 1964 Ky. Acts ch. 158, sec.9.

149.401 City or county ordinance banning open burning during fire hazard periods:

(1) Without limiting the general authority granted to a county by KRS 67.083 and the general authority granted to a city by KRS 82.082, a city or county may enact an ordinance banning all open burning during periods of extraordinary forest fire hazard or fire occurrence. Such ordinance may authorize the implementation of such a ban by executive order of the chief executive officer upon notice by the division of forestry that a period of extraordinary forest fire hazard or fire occurrence exists.

(2) Any ordinance promulgated by a city or county pursuant to subsection (1) of this section may establish penalties for violation of the ordinance not to exceed the penalties set forth in KRS 149.990(2).

(3) Any ordinance promulgated by a city or county pursuant to subsection (1) of this section may be enforced by the promulgating body, or by the cabinet, and referred to the appropriate county or Commonwealth attorney for prosecution.

Effective: July 15, 1986
History: Created 1986 Ky. Acts ch. 17, sec. 1, effective July 15, 1986.

149.415 Energy and Environment Cabinet to administer law – Investigations:

The Energy and Environment Cabinet shall administer KRS 149.360 to 149.430 and shall have power to issue, amend and revise such rules and regulations as may be authorized hereby or as may reasonably be necessary to implement the same. The cabinet is authorized to make, conduct or participate in any investigations and surveys designed to establish the cause of and responsibility for a particular forest fire or forest fire conditions generally and to cooperate with any and all law enforcement officers of or in this state in the apprehension and prosecution of persons violating this law. Nothing contained in KRS 149.360 to 149.430 shall be construed to limit or otherwise impair the jurisdiction or powers of any other department, agency or officer of or in this state to investigate, apprehend, prosecute or punish violations of law.

Effective: July 15, 2010
History: Amended 2010 Ky. Acts ch. 24, sec. 162, effective July 15, 2010. -- Created 1964 Ky. Acts ch. 158, sec.

149.420 State inspection of premises:

In connection with the administration of KRS 149.360 to 149.430 and any rule or regulation pursuant hereto, any duly authorized officer, employee or agent of the cabinet and any law enforcement officer or fire protection officer having jurisdiction to enforce any provisions of KRS 149.360 to 149.430 shall have power to enter upon or into any premises at any time in order to inspect the same and to ascertain the degree of compliance with KRS 149.360 to 149.430, and with such rule or regulation promulgated hereunder.

History: Amended 1974 Ky. Acts ch. 74, Art. III, sec. 13(3). -- Created 1964 Ky. Acts ch. 158, sec. 13.

149.430 Liability of violator for state and private damages -- Disposition of damages:

(1) If any forest fire shall originate as a result of the violation by any person of any provision of KRS 149.360 to 149.430, such person shall be, in addition to the penalty prescribed under KRS 149.991, liable to the state and to each county for the full amount of all expenses incurred by the state and county respectively in suppressing each fire, such amounts to be recoverable by action brought by the secretary for energy and environment in the name of the Commonwealth on behalf of the Commonwealth and by the county attorney on behalf of the county.

(2) In addition to any penalty pursuant to KRS 149.991, any person violating any of the provisions of KRS 149.360 to 149.430 shall be answerable in damages to any persons suffering such damage for the cost incurred in the suppression of any fire resulting from such violation and for damage to property resulting from such fires.

(3) Damages assessed under this section shall be ordered to be paid directly to the Energy and Environment Cabinet or to any other injured person or organization specified by written order of the court. The court shall not direct that the damages be paid through the circuit clerk.

Effective: July 15, 2010

History: Amended 2010 Ky. Acts ch. 24, sec. 163, effective July 15, 2010. -- Amended 2002 Ky. Acts ch. 183, sec. 12, effective August 1, 2002. – Amended 1982 Ky. Acts ch. 142, sec. 9, effective July 15, 1982. -- Amended 1974 Ky. Acts ch. 74, Art. III, sec. 13(3). -- Created 1964 Ky. Acts ch. 158, sec. 17.

- A complete copy of the Kentucky Revised Statutes Ch. 149 can be found at http://www.lrc.ky.gov/ Statutes/chapter.aspx?id=37723

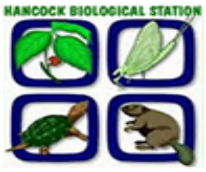
- In addition to forest fire hazard seasons and outdoor burning regulations enforced by the Kentucky Division of Forestry (KDF), the Kentucky Division for Air Quality and the Kentucky Division of Waste Management, further restrictions may be initiated at the local level through county burn bans and local ordinances. County burn bans are issued by the county judge/executive and are enforced with assistance from KDF. Violation of a burning ban is a misdemeanor punishable by law.

- The Current Wildland Fire Activity Report (available daily at http://forestry.ky.gov/wildlandfire management/pages/countyburnbans.aspx) details the counties with active burn bans.

- Local fire departments should be made aware of any burn activities in advance. These departments can be contacted using the following information:

Calloway County Fire-Rescue
Physical Address: 101 E Sycamore ST
Murray, KY 42071
Mailing Address: PO Box 612
Murray, KY 42071
Phone # (270) 753-4112
Fax # (270) 753-4117

Murray Fire Department
Physical Address: 207 S 5th St
Murray, KY 42071
Mailing Address: 207 S 5th St
Murray, KY 42071
Phone # (270) 762-0320
Fax # (270) 762-0338



Hancock Biological Station
Murray State University

Pre-Burn Checklist

Anticipated Burn Date: _____

Weather forecast:

_____
_____
_____

Individuals Involved:

_____
_____
_____
_____

Equipment Needed:

_____
_____
_____

- ☐ Neighbors contacted (approximately 2 weeks in advance)
- ☐ Minimum number of staff/volunteers required committed to burn date
- ☐ Required equipment checked to ensure working order and availability
- ☐ Fire lines mowed/cleared
- ☐ All staff/volunteers participating have signed waiver forms
- ☐ Local fire departments contacted (1-2 days before)
- ☐ Current Wildland Fire Activity Report consulted to ensure no local burn bans are active
- ☐ Burn plan completed and on file
- ☐ All staff/volunteers briefed on burn plan and procedures
- ☐ Forecast weather conditions confirmed (day of burn)
- ☐ Test ignition completed (day of burn)

Additional Notes:

Hancock Biological Station
Murray State University

PRESCRIBED BURN PLAN

General Location: Hancock Biological Station
561 Emma Drive
Murray, KY 42071

Site Contact Information: Dr. David White
Director of HBS
(270) 474-2272
david.white@murraystate.edu

Site Coordinates: 36°43'58.83" N, 88°07'07.03" W

Acres to burn: 0.25

Date of Burn: 4/25/2014

Previous Burn Date(s): March 2012

Notified parties: Calloway County Fire & Rescue, Murray Fire Dept., neighbors/surrounding community

Reason for burn: Ecological management with the goal of preventing woody encroachment and reducing the relative abundance of trees, shrubs, vines, and cool-season grasses, while promoting the relative abundance of native barrens/prairie vegetation.

Burn objectives:
Reduction of fuels/ground layers by 70%+

Site Description:
This site is an abandoned old field of predominantly warm-season grasses interspersed with saplings of numerous woody invaders including *Acer rubrum, Diospyros virginiana, Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipfera, Nyssa sylvatica, Rhus capillina, R. glabra, Rubus argutus, Smilax bona-max,* and *S. glauca.* The site sits at approximately 435 feet of elevation and its slope ranges from 3-20%. It's soils incluse Brandon silt loams and soils of the Pruitton-Riverby complex. This site is completely surrounded by a wide buffer zone of oak-hickory mixed forest and is not bordered by any major roadways or areas of human development. Prior burns on the sitehave been completed every two to three years since the early 1990s.

Vegetation Types: Old field warm-season grassland
Surrounding Fuels and Vegetation Types: Oak-hickory forest and associated leaf litter /fuels

Site Preparation Completed:
A fire line approximately 5' in width was cleared via mowing/weed eating around the perimeter of the site. All potential fuels (e.g., woody debris, leaves, etc.) were removed from this line via hand removal or raking.

Ignitions, Holding and Mop Up Strategy:
A back fire will be set on the upper side of the site to create approximately 6' of stable black line. Following black line establishment, ground ignitions will begin at the downslope side of the site, and fire will be allowed to run upslope until contact with the black line is made. Holding will be achieved by volunteers yielding flappers and shovels around the perimeter of the site, with these tools being used to extinguish any flames that extend beyond the cleared fire line or black line. Mop up will be completed by all volunteers following ignitions, with all smoking debris extinguished or removed from within 15' of the site perimeter. Monitoring and mop up will continue for as many days as necessary until the site is 100% extinguished.

Equipment Needs: torches (2), flappers (6), shovels (4), rakes (3), hoses (1), etc.
Crew Members: Whitney Wallett, Ben Tumolo, Brad Richardson, Mike Moore, Carla Rothenbuecher, Cory Groover, Kirk Raper, Kaylin Boeckman, Ann Gilmore, etc.
Special Precautions and Hazards to Crew: NA at this time
Contingencies and Safety Zones: Safety zones include the established fire and black lines surrounding the site, as well as the relatively moist oak-hickory forest on the downslope side of the site. Should fire escape the site but remain easily and safely extinguished, crew members should do so. If not, backup (Calloway Co. Fire & Rescue or Murray Fire Dept.) will be contacted and crews should retreat to appropriate safety zones.

Weather Factors:	**Minimum – Maximum Forecast**	**Actual (Pre-Burn)**
Surface Wind Speed	5-10	
20’ Wind Direction	N	
20’ Wind Speed	8-12	
Transport Wind Direction	N	
Transport Wind Speed	19	
Mixing Height	64	
Dispersion Index (DAY)	MOD UNSTBL	
Temperature (F)	69-73	
Relative Humidity	39-41	
Days since rain: 4		
Other:		
Exclusions: High wind speed with low RH; Red flag conditions; Local burn bans active		

Attached to plan: Site Map/Ignition Plan Schematic, NWS Paducah Fire Weather Report (day of burn)

Name of Fire Coordinator (printed): ____John Doe_____

Signature of Fire Coordinator: ___*John Doe*_____

Date: _4/25/2014_____

Site Map/ Ignition Plan Schematic:

NWS Paducah Fire Weather Report:

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000
FNUS53 KPAH 212035
FWFPAH

FIRE WEATHER PLANNING FORECAST FOR THE HEARTLAND
NATIONAL WEATHER SERVICE PADUCAH KY
335 PM CDT MON APR 21 2014

.DISCUSSION...
SCATTERED TO NUMEROUS SHOWERS AND STORMS WILL MOVE THROUGH THE REGION
TONIGHT. A COLD FRONT WILL ALSO MOVE THROUGH...WHICH WILL RESULT
IN GUSTY NORTH WINDS THROUGH THE REGION FOR TUESDAY. RELATIVE
HUMIDITY WILL BE RATHER DRY TUESDAY AND WEDNESDAY. SOUTH WINDS ARE
EXPECTED TO BECOME GUSTY THURSDAY...BUT ANOTHER COLD FRONT WILL
MOVE EASTWARD THROUGH THE AREA WITH A BAND OF SHOWERS AND
THUNDERSTORMS THURSDAY AFTERNOON AND EVENING. WINDS WILL BE RIGHT
BACK FROM THE SOUTHWEST ON FRIDAY. THE FORECAST FOR THE WEEKEND IS
QUITE MUDDLED AT THIS TIME.


KYZ001>009-221030-
FULTON-HICKMAN-CARLISLE-BALLARD-MCCRACKEN-GRAVES-LIVINGSTON-
MARSHALL-CALLOWAY-
335 PM CDT MON APR 21 2014
```

	TONIGHT	TUE	TUE NIGHT	WED
CLOUD COVER	CLOUDY	MCLEAR	CLEAR	MCLEAR
PRECIP TYPE	TSTMS	NONE	NONE	NONE
CHANCE PRECIP (%)	60	0	0	0
HIGH TEMPERATURE(F)		69-73		68-72
MINIMUM RH(%)		38-43		30-35
LOW TEMPERATURE(F)	54-58		41-45	
MAXIMUM RH(%)	90-95		77-82	
TEMP (24H TREND)	56 (+2)	72 (-5)	43	71
RH % (24H TREND)	93 (+11)	41 (-3)	80	33
20FTWND-AM(MPH)		N 8-12 G23		E 4-8
20FTWND-PM(MPH)	SW 4-8	N 11-15 G21	N 5-9	LGT/VAR
PRECIP AMOUNT	0.09	0.00	0.00	0.00
PRECIP DURATION	3			
PRECIP BEGIN	7 PM			
PRECIP END	7 AM			
1700`MIX HGT TEMP		64		59
MIXING HGT(FT-AGL)		5342		3948
TRANSPORT WND (KTS)		N 19		E 6
TRANSPORT WND (M/S)		N 10		E 3
VENT RATE (M/S-M)		16280		3609
DISPERSION INDEX		VERY GOOD		FAIR
LAL	2	1	1	1
HAINES INDEX	3	3	4	4
STABILITY(DSI)	N/A	MOD UNSTBL	N/A	SLGT UNSTBL

REMARKS...NONE.

.FORECAST FOR DAYS 3 THROUGH 7...

.WEDNESDAY NIGHT...MOSTLY CLEAR. LOWS IN THE UPPER 40S. SOUTHEAST WINDS 5 TO 10 MPH.
.THURSDAY...PARTLY SUNNY WITH A 50 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. HIGHS IN THE UPPER 70S. SOUTH WINDS 10 TO 15 MPH.
.THURSDAY NIGHT...MOSTLY CLOUDY WITH A 20 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. LOWS IN THE MID 50S. SOUTHWEST WINDS 5 TO 15 MPH.
.FRIDAY...SUNNY. HIGHS IN THE UPPER 70S. SOUTHWEST WINDS 5 TO 10 MPH.
.FRIDAY NIGHT...PARTLY CLOUDY. LOWS IN THE MID 50S. WEST WINDS 5 TO 10 MPH.
.SATURDAY...MOSTLY SUNNY. HIGHS IN THE LOWER 70S. NORTH WINDS 5 TO 10 MPH.
.SATURDAY NIGHT...PARTLY CLOUDY WITH A 20 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. LOWS IN THE MID 50S. EAST WINDS 10 TO 15 MPH.
.SUNDAY...PARTLY SUNNY WITH A 30 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. HIGHS IN THE LOWER 70S. SOUTHEAST WINDS 10 TO 15 MPH.
.SUNDAY NIGHT...MOSTLY CLOUDY WITH A 30 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. LOWS IN THE MID 50S. SOUTHEAST WINDS 10 TO 15 MPH.
.MONDAY...CLOUDY WITH A 50 PERCENT CHANCE OF SHOWERS AND THUNDERSTORMS. HIGHS IN THE MID 60S. SOUTHEAST WINDS 10 TO 15 MPH.

Hancock Biological Station
Murray State University

PRESCRIBED BURN PLAN

General Location: Hancock Biological Station
561 Emma Drive
Murray, KY 42071

Site Contact Information:

Site Coordinates: 36°43'58.83" N, 88°07'07.03" W

Acres to burn: 0.25

Date of Burn:

Previous Burn Date(s):

Notified parties:

Reason for burn:

Burn objectives:

Site Description:

Vegetation Types:

Surrounding Fuels and Vegetation Types:

Site Preparation Completed:

Ignitions, Holding and Mop Up Strategy:

Equipment Needs:

Crew Members:

Special Precautions and Hazards to Crew:
Contingencies and Safety Zones:

Weather Factors:	**Minimum – Maximum Forecast**	**Actual (Pre-Burn)**
Surface Wind Speed		
20’ Wind Direction		
20’ Wind Speed		
Transport Wind Direction		
Transport Wind Speed		
Mixing Height		
Dispersion Index (DAY)		
Temperature (F)		
Relative Humidity		
Days since rain:		
Other:		
Exclusions: High wind speed with low RH; Red flag conditions; Local burn bans active		

Attached to plan: Site Map/Ignition Plan Schematic, NWS Paducah Fire Weather Report (day of burn)

Name of Fire Coordinator (printed): _____

Signature of Fire Coordinator: _____

Date: _____

VIII. Biennial Progress Report Format

Date: _____
Prepared by: _____
Most recent previous report completed: _____

General Description of Current Site Conditions:

Photographs of Site:

Description of Site Management:

- Description of burn(s) completed – when, by whom, nature of burn, etc.
- Additional management activities completed – when, by whom, what (e.g. mechanical removal of cedars, herbicide application), methods, etc.
- Suggested or planned management activities in future or prior to next report

Restoration Project Monitoring:

- Description of vegetative surveying completed – when, by whom, methods, etc.
- Results of vegetative surveys – species composition/list, relative abundances, presence/absence of dominant prairie grasses, presence/absence of invasive species, etc.
- Comparison of results obtained from last report's vegetative surveys

Assessment of Overall Restoration Project Progress:

- Where do we stand in relation to project goals & objectives?

Adaptive Management:

- What about the restoration project is working or failing?
- Any adjustments to management or monitoring procedures
- Any adjustments to restoration plan goals, objectives, timelines, etc.

Projected Future Timeline (now through next report date):

References & Acknowledgements: