Berea College Forest Management Plan

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Author's Note: The bulk of this plan, and much of the inventory cited, was conducted by John Perry, former Berea College Forester whose dedicated service to the Berea College Forest spanned from 1991-2010. I have updated the plan myself on several occasions to reflect the current conditions, new property purchases and accomplishments such as the Carbon Project herein noted. Most recently, the harvesting recommendations have been expanded to allow for horse/mule logging, uneven-aged silviculture, and prescribed burning.

Mr. Perry's extensive 19 year experience on the College Forest, and literature cited for the plan need not be redone. Perhaps after I have been here for 20 years I will feel up to the task…and have the time to do it. Meanwhile, a hybrid plan is presented.

Summary

The goal of this plan is to provide a framework to guide the management of the Berea College Forest for multiple uses. Education provides the framework for managing water production, timber/wood production, recreation, and biodiversity within the Forest. This plan provides general guidance for specific management operations. Schedules, goals, silviculture, inventories, recommendations, and maps will be developed for these site specific operations based on this plan.

Location: 5 management units south and east of Berea, KY

Area: Total area – 9,122 acres

Management Use Allocation:

Stephenson State Nature Preserve	100 acres
Dogfoot Springs Preserve	50 acres
Lakes and Dams	200 acres
Wildlife Fields	60 acres
1988 Fire Area	300 acres
Recent regeneration harvests (clearcuts)	100 acres
Current Production Forest*	6,400 acres

*This is the area inventoried for this plan that can contribute to timber production for the life of this plan.

Education: Forest revenues can fund Forest needs and contribute to funding the general education mission of the College. Under production

	management, the Forest can serve as an active, real-world example of sustainable forest stewardship for the College and Appalachian region. The variation of stand conditions and habitats generated by silviculture increase the variety of opportunities for class, demonstration, and research use.
Silviculture Practice:	Use mainly an even-age system: 1 to 3 commercial thinnings per stand approximately 15 years apart followed by a regeneration harvest timed based on fitness of oak or other target advance regeneration. Oak regeneration site preparation ("oak shelterwood" or thinning from below) to precede final regeneration harvest approximately 5 to 10 years, depending on site quality. Two-aged and group selection (uneven-aged system) to be used sparingly where appropriate. Some pine regeneration silviculture recommended for economic enhancement and biological diversity. Silviculture is focused on producing large, high-quality trees, keeping high canopy forest on the majority of production area at any given time, and maintaining spatial variation of different stand age, physical, and compositional structures that support native biodiversity.
Regulation of Harvests:	Conduct one large harvest approximately every 3 years. Spacing allows time to prepare and oversee harvests and large sales have the opportunity to get a better price due to competition. Sales should be by sealed bids. Small harvests, such as those targeted primarily for research purposes, salvage, and as a means for obtaining wood for local use, can be conducted as necessary. These small harvests may be done through a shares contract if applicable.
Water:	Protect water quality through the use of reservoir buffers and use of Best Management Practices.
Recreation:	Manage the current hiking trail system with the addition of a trail around Owsley Lake and, if functional access can be acquired, expand the cross-country trails to Welch Mountain tract and Indian Fort. Hunting leases can provide both income and recreation.
Biodiversity	Utilize the course-filter management system recommended by the Nature Conservancy that relies on spatial heterogeneity of habitat conditions over the Forest. Production use area will have spatial variation due to different stand ages, physical structures and

compositions created by production silviculture. Field and forest preserve areas will contribute other habitat conditions. Special habitat features identified in preparing site specific harvest plans can be protected. Critical habitat components like pine stands or American chestnut composition can be restored when possible. The diversity of forests of this region developed due to fire and other disturbance factors. Production silviculture provides a way to imitate that disturbance while generating income.

Forward

Through its forest management, Berea College holds the distinction of being a pioneer in forestry and conservation in the United States. The Berea College Forest has been under management for over a century and is recognized on the National Register of Historic Places for sustained conservation practice and education. Berea College has made this effort for education of its students and in demonstrating forest stewardship to the Appalachian Region.

The 9,300 acre Berea College Forest is a rich and varied forest landscape. It was originally acquired to provide both economic (principally through timber production) and educational benefits to the College. Current educational, economic, ecologic, and social contexts of forest management require an updated assessment of the Forest and its management. The second century of management of the Forest offers new opportunities and challenges. The global economic system is changing rapidly. The need for education and example in sustainable natural resource management is greater than ever. Uncertainty in future energy supplies focuses attention on new sources. Human population and consumption threaten the function of ecosystems that sustain them throughout the world. Largely due to technology, there is a disconnect between humans and those ecosystems. Yet, appropriately used, technology offers a chance to better understand, protect and sustainably utilize the ecosystems.

Under focused management, the College Forest can continue to address economic resource needs of the College and community while simultaneously serving as an educational resource and regional example of forest stewardship. The goal of this management plan is to enhance the economic, educational, and conservation value of the Berea College Forest. The goal of the plan is to re-assess management needs based on the economic and educational needs of the College, the current condition of the forest resource, and the local and global factors that influence both. Management can adapt to both the dynamic ecological and social factors.

A principal failure of the environmental movement of the late 20th century in the United States was that it generally failed to connect human economics and conservation when addressing natural resource issues. The complex enmeshment of industrial age consumers and the ecosystems that enabled their consumption was rarely explored. The outdoor recreation boom, itself based on

consumption, did not help the disconnect, increasing the pressure to manage landscapes as postcards while the National Park Service lost more native biodiversity than any other Federal land management agency. A storm-surge of concrete rushed over the privately owned rural landscape while domestic economics and policy drove farmers from the land and shut down sawmills. Consumers, many who labeled themselves environmentalists, increasingly relied on distant ecosystems to meet their "out-of sight, out-of-mind" resource demands. Despite an abundance of productive forestland, United States is currently a net importer of wood products. Production has shifted to parts of the world where soil productivity, professional natural resource oversight, and environmental protection levels are lower. As large resource dependent communities, largely staffed with people with ample disposable income and travel time, colleges and universities taught the abstraction to a few, but rarely attempted to address it in concrete form. Their own consumption and land management was a usually net negative from a conservation standpoint.

A way to counter that trend at the academy is to utilize available "working landscapes" that meet both economic and ecological goals as teaching resources. Aldo Leopold, the parent of modern conservation (Leopold 1949), noted, "The evolution of a land ethic is an intellectual as well as emotional process. Conservation is paved with good intentions which prove to be futile, or even dangerous, because they are devoid of critical understanding of the land, or of economic land use." The highest and best use of the Berea College Forest is for it to continue to do what it has been doing for over a century by applying up to date forest/natural resource science and technology as guided by the current conservation issues facing the College, region, and world. It can do this with a focus on meeting the College's economic and resource needs locally, the benefit of advances in natural resource technology and ecosystem knowledge, and an urgent need for working examples of conservation. The Berea College Forest can serve the goals of conservation education by demonstrating that economic and ecological goals are not only compatible, but they are inseparable.

Historical Context

> *Perhaps there is not in the United States a more unique and characteristic piece of Forestry work being carried on. The adaption of this work to the general needs of the Appalachian region as an object lesson and basis for instruction has been commended to come for the best students and experts in Forestry matters in the United States.*
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> *-Prof. Silas C. Mason, 1907, The College Forest Preserve (1st Berea College Forest Management Plan)*

1897-1918. The basic policy framework for management of the Berea College forest (hereinafter Berea Forest or Forest) was established at the dawn of the American conservation movement in one of the pioneering efforts of forestry in the United States. A program in forestry education and

management was initiated by S. C. Mason in 1897. In that year, he began an effort to acquire forestland and taught a course in general forestry in 1898. Cornell University and the Biltmore School of Forestry had just begun the first college level degree programs in forestry at that time.

Mason purchased the initial tracts of the Forest out of his own funds and urged further acquisition of lands "as a means of insuring future supplies of timber and fuel" and "for purposes of instruction" (Mason 1907). Ms. Sarah Fay of Boston donated funds for forestland acquisition and the College owned several thousand acres by 1905. Most of the land acquired was abandoned agricultural land that had been abused. Cooperative projects with the fledgling US Forest Service were initiated early on. Mason wrote a management plan for the Forest in 1907 that was reviewed by most of the top foresters in the United States, including Bernhard Fernow, Carl Schenk, Filbert Roth, and Henry Graves. By that time, water supplying the College and town had begun via gravity feed from springs on the Forest. The principal management goals at that time were instruction, timber/wood production (for College use and income), water utilization, fire protection, research (the first paper from research on the Forest published in 1899), recreation (via Mountain Day and hiking), and management of tenant farmers. When Mason left in 1918, the College owned 5,400 acres.

1918-1945. Between 1918 and 1945, minimal timber was harvested (100,000 to 200,000 board feet per year, Whipple (1950) because the tree growth on most of the forest was in young stands that had regenerated on old agricultural lands. Most of that was natural regeneration, but College nurseries also grew seedlings for planting. Most sales were commercial thinnings that were labeled selective harvests. Two reservoirs were built on the Forest to increase water supply during this period. The cooperative relationship with the Forest Service grew to include research. College forest managers were not professional foresters during this period.

1945-1958. After World War II a professional forester was hired as both Forest manager and faculty. The tree growth on the Forest had matured considerably by this period and the post-war demand for wood products was great. The College Forester completed several "Management Plans" between 1945 and 1958 that were more policy directives than inventory based plans. Timber harvests increased (> 180,000 board feet per year plus additional wood products), logging roads were built, and an additional reservoir was built for the growing water demand (Whipple 1950, Rock 1959, Perry 2000). The College was assisted in logging road construction by the US Forest Service research station. Management policy involved culture and harvest of timber; soil protection and enhancement; water production and protection; wildlife management; recreation; demonstration and instruction; fire protection; management of boundaries and non-forest land use; and additional land acquisition. A survey of exterior boundaries begun in 1936 was completed in 1957 (Strunk 1957). There was considerable research activity, principally by the US Forest Service. A portion of the forest was developed as Indian Fort Theater for outdoor drama productions in this period and responsibility for construction and management fell on the Forestry Dept.

1958-1970. The most comprehensive management plan ever made on the forest was completed in 1959 by College Forester David Rock with inventory assistance from US Forest Service Berea research station staff. This plan was a sustained yield timber management plan designed to increase harvest production (Rock 1959). Accompanied by the donation of a sawmill to process logs, forest production rose to over 800,000 board feet per year. Harvests in this period (and those since 1945) were similar to the commercial thinning conducted on the Forest since the early years. Class use was high during the entire period from 1945 to 1970 and research activity continued. The sawmill was closed in 1970. Forest operations with sawmill and theater were not profitable. This ended the most active period of forest management to date.

1970-1992. Between 1970 and 1992, professional foresters continued to manage the forest on a part-time basis. Acquisition of property was made in the Owsley Fork watershed and a 151 acre reservoir was completed in 1974. Some 1,200 acres of forestland were acquired in this effort. Timber production was minimal during this period. Two timber harvests were completed in the 1980's, both silvicultural clearcuts. In 1981, the Daniel Boone National Forest built a District Ranger's office on the Forest. The facility also housed the US Forest Service Berea Research Station. The research unit had been in a College building in town up to that point. Class use fell and research activity on the Forest was minimal during this period.

1992-2010. In late 1991, a full-time forester assumed management of the College Forest. Regular timber sales resumed and production averaged over 200,000 board feet a year between 1993 and 2008. The Berea College Utilities Department was sold to the City of Berea in 2004 and the management of reservoirs and water infrastructure went to the City. The College retained ownership of all land and reservoirs and the City pays for raw water extracted. Research use increased with universities, principally the University of Kentucky, conducting most of the projects with help from Berea College Forestry. Class use also increased slightly over this period as the Agriculture Dept. (now Ag. & Natural Resources, hereinafter ANR) began to emphasize natural resource education and the Sustainability and Environmental Studies Department (hereinafter SENS) began. These changes began in the early 1990's as part of a College effort to address environmental issues. Recently, energy issues and a global economic collapse have caused the College to re-examine its financial support and natural resource dependency. The economic situation caused timber prices to drop and timber sales were suspended. This management plan stems from the need to examine the utility and management of the College Forest in the context of present challenges and opportunities.

2010-2019. In October, 2011, Clint Patterson was hired to fill the recently vacated College Forester position when John Perry retired. Perry's Forest Management Plan had been finished during his last year, and a consulting firm (Fountains Forestry) contracted to secure FSC certification. The new forester's first major task was to finish the certification requirements while obtaining certified wood for the Deep Green Residence Hall construction. Patterson enrolled at the University of Kentucky the next year and began his research project towards a Master's degree in Forestry on "Expanding Gap Harvest Systems". The next eight years saw this research project

and master's degree completed, around 700 acres of new properties purchased and added to the College Forest, a Carbon Project put into practice, EQIP funding regular utilized, a prescribed burning program initiated, and a horse logging program began. A new Forestry Outreach Center was constructed at Indian Fort and the old Forester's Cabin refurbished; which has transformed the face of the College Forest and created a "Visitor's Center for the Forest" experience. The new positions of Forest Technician and Forestry Outreach Center Coordinator have been created. The College Forest is slated to host a Field Tour for the upcoming Society of American Foresters Convention in Louisville in November, 2019.

Geography

Location and Physiography

The Berea College Forest is located south and east of the Berea College campus which is located approximately 40 miles southeast of Lexington. The Forest is arranged in 5 units of contiguous boundary. The majority of the land is in Madison County, and portions are also located in Jackson and Rockcastle Counties. The closest unit is adjacent to and immediately south of campus. The most distant is approximately 10 miles south east of campus.

The Forest is located on the western edge of the Cumberland Plateau. In the area of the Forest, three of Kentucky's physiographic regions, the Knobs, Mississippian Plateau, and Cumberland Plateau, essentially merge to touch the edge of the Bluegrass Region. Geology and soils from all four regions are found in parts of the Forest. The topography is mostly dissected plateau creating narrow stream bottoms below steep hillsides capped with cliffs of Pennsylvanian sandstone and/or Mississippian limestone (Weir, et. al 1967). Elevations range from just over 800 feet to 1,665 feet above sea-level.

Geology

The underlying rock ranges from Silurian dolomite (underlying alluvium at Brush Fork creek) through lower Pennsylvanian sandstone on the ridge tops. Acid Devonian shale underlies the slopes just above the major drainages (Brushy Fork and lower Cowbell). Most side slopes are underlain by Mississippian shales, siltstones and limestones (in order of ascending elevation). Lower Pennsylvanian sandstone, sometimes conglomeratic, caps the highest ridges (Weir, et. al 1967). Clifflines above Owsley Fork are of Mississippian limestone whereas clifflines on most of the main block of the forest are sandstone perched above the limestone. Cliffs may be over 100 feet in height. A small unnamed coal seam is present in the sandstone at Bear Knob and just below Windswept. These seams have been mined for local use in the past but are too small to be commercially utilized. Karst features are present due to the Mississippian limestone. Abundant springs, directly utilized for water during early college ownership, are present at the base of the limestone and small caves and sinkholes (usually on ridges where sandstone has collapsed) are present. Eroded sandstone creates "rock shelters" at the clifflines.

Soils

Soils are in the Colyer-Weikert-Captina association (Newton, et. al, 1973). Most of these soils lie on slopes, but a few level alluvial bands are present along the major creeks. Productivity for woodland is high in alluvial flats, hollows, and lower north/east facing slopes. South and west facing slopes, steep upper slopes, and ridge tops are moderate to poor in productivity due to excessive drainage, shallowness, and rapid evapo-transpiration. Woodland is the land use best suited to these soils. However, agriculture was practiced on a majority of the Forest resulting in degradation of soils due to erosion and organic matter loss. Soils are recovering under forest cover.

Vegetation

The Forest lies at the meeting of Braun's (1950) Mixed and Western Mesophytic forest regions and Fralish and Franklin's (2003) Plateaus and Appalachian Mountain sections of the Central Hardwood Forest region. These regions are characterized by diverse vegetation and with the physiographic/geologic, soil, and topographic diversity, there is considerable vegetation diversity across the Berea Forest. Thompson (2008) documented 821 vascular plants in the Forest.

Management Context

Berea College Forestry Department Mission Statement

Revised 9/2004

The purpose of the Forestry Department is to serve Berea College, in support of the Great Commitments that define the College's larger mission, as follows:

1) To manage the Berea College Forest based on up to date forest science, maintaining and improving physical facilities and records while enhancing, studying and utilizing varied resources: wood products, water, recreation and wildlife. This is to be accomplished with concern for the educational value and ecological health of the Forest as well as the financial well-being of the College.

2) To provide education and service to the Berea College community in forestry, natural resource and land management related matters.

Both purposes are stated given the significance that forestland management has to the southern Appalachian region and Berea College's commitment to that region. Both are to serve the purpose of the original endowment for forestland, management and education made to Berea College beginning in 1897.

Much of the context for making forest management decisions for the Berea Forest has not changed from the earliest years. Education is still the matrix that supports management goals. Resource

utilization that supports the College economically and materially is still important. A list of specific management goals and their justification follows in the next section. However, current forces and issues, both within and outside the College community, should be considered in choosing those goals. Some of those forces and issues are:

Education - The relevance of environmental sustainability education and practice has increased. The Forest is one of the oldest examples of the emphasis on sustainability at Berea. Its management for sustainability precedes the popular use of the term by almost a century. The value of the Forest as an academic resource and regional example of sustainable forest management is greater than ever. The service of the Forest as a conservation education resource was expressed by College Forester S. D. Whipple in 1957 as, "….an ideal program of forest management as a practical demonstration to students and woodlot owners". A working landscape that sustainably produces resource outputs while conserving ecosystem processes, structures, and components is an ideal resource for conservation education. Berea College's commitment to serve the Appalachian Region and the fact that forest is the land use best suited to the region gives special emphasis to the educational value on the Forest.

Economic - The crisis in the global economy that began in 2008 has had significant effect on Berea College. It has emphasized the importance of diversifying economic support for the College. It has made it apparent that it is important to diversify income streams. Economic use of the Forest not only offers financial support. If properly conducted it increases its educational value. Additionally, the security of the energy and raw resource needs of the College are likely to meet challenges in the next few decades. The Forest is a potential source of woody biomass for energy, or it could provide a source of revenue through sales of credits for carbon sequestration. These are in addition to the water, lumber, and financial support (from timber and water sales) it has provided for over a century.

Forests offer significant economic support to the Appalachian region through a variety of uses. The demands on the region's forests will increase in the coming decades while the importance of their ecological functions also increase ((Wear & Greis 2002). These demands make it likely that most of the region's forestlands will have to meet multiple demands while ecological functions are sustained. Berea College has the opportunity to demonstrate and research sustainable ways to meet those demands.

Berea College is committed to providing a positive local and regional socioeconomic impact. Berea College's longstanding commitment to Appalachia informs our decisions and policies and provides the framework for continued efforts to insure that forest products harvested and/or collected from the Berea College Forest provide benefits to this region. The Forest provides an "anchor" point for the promotion of forest certification, and example for carbon sequestration projects, and a role model for sustainable management and development.

Berea College is committed to supporting local development opportunities, and operates in a manner that provides local purchasing opportunities and seeks to promote conditions which provide economic opportunities and job creation and/or maintenance of quality jobs. Timber sales are offered in a manner which is conducive for local and regional buyers, sawmills, and loggers to purchase. Wood from the forest is utilized, where feasible, in our own building projects and Crafts enterprises to emphasize the importance of local use of resources and use of local workers.

Threats and Conservation - Forests in the southeastern United States are particularly threatened. Land conversion for development (urban sprawl, second homes, mineral extraction, agricultural, etc.) is the principal destructive force. Farm and forest land was lost at a rate exceeding a million acres per year in the southeast and Kentucky alone lost 700,000 acres of forestland between 1988 and 2004 (Wear & Greis 2002, Turner et al. 2004, USDA 2004). The loss of forest and farm land is apparent in the Berea area and Appalachian region. The loss of forestland increases the importance of good stewardship of the remaining lands to sustain both outputs and ecological function.

While forestland is being lost, the demand for wood, water, recreation and other forest outputs is expected to increase while a multitude of human, biotic and abiotic factors threaten both forest productivity and ecological function (Wear & Greis 2002). Logging in the Appalachian hardwood region, especially eastern Kentucky, is still focused primarily on extraction while the practice of production silviculture to insure the health, diversity, and productivity of the future stand is rare (Nyland 1992). Eastern Kentucky and southern West Virginia are the only areas of the United States that still have a significant incendiary fire problem that damages forests and local economies. Fire regimens have been altered throughout the Eastern United States in a way that threatens biodiversity (Fralish 2004, Nowaki & Abrams 2008). Production silviculture offers a way to imitate the disturbance factors that shaped the region's forest types. Nonnative plants, insects, and diseases threaten native biodiversity at unprecedented levels. Abiotic factors such as air pollution and climate change threaten forests. These threats increase the need for science based forest management and the educational value of well managed forests.

Management Goals

Education:

Education is the primary function of the Forest. For this plan, education on the Forest refers to formal academic use by Berea College and other academic institutions, as well as demonstration, research, and outreach. A working forest that is managed sustainably provides the most applicable educational model. A greater variety of research is possible due to the diversity of stand conditions available in a working forest. Demonstration value is also enhanced.

Economic Support:

Timber—Timber sales provide income to the College while supporting the stewardship of the Forest.

Water—Water provides income and its utilization alongside timber production provide a model of resource use integration that dates back to the early 1900's.

Energy—Woody biomass may become a valuable resource in the coming decades. Poor quality trees and waste products from timber harvest can be utilized in this way.

Hunting—Hunting leases can provide some income while discouraging illicit trespass.

Carbon Credit Sales—These sales can be explored for additional income.

Other non-timber—Sustainably produced/harvested forest herbs like ginseng and leeks may contribute to future income.

Recreation—The current hiking trail use and Owsley Lake boating will continue. Hunting leases can contribute a revenue-generating recreational use.

Conservation:

Soil/Water—Soil and water protection protects the productivity of the forest ecosystem. Best Management Practices (BMP's) for soil and water conservation have been and will continue to be employed during production silviculture. Road maintenance and construction need to be designed for slope stability.

Biodiversity—Silviculture offers the opportunity to maintain/restore forest diversity by managing disturbance, the factor that drives biodiversity at the landscape level, while supporting the funding necessary to manage for biodiversity.

Cultural Resources—Cultural resources need assessment and protection. Income streams generated in the Forest offer the opportunity for use in this area.

Land Assessment and Protection—Uncertain boundaries and trespass issues need continuous attention. They may be addressed as timber harvests in perimeter areas provide funding and incentives. Destructive trespass issues can be reduced by the active presence that silvicultural management requires. An active presence could also be enhanced by moving Forestry Department Offices and support areas to Indian Fort or nearby area on the Forest, possibly in conjunction with a new Nature Center at Indian Fort.

Certification of Sustainability—Berea College has sustainably managed its Forest for over a century. "Green" certification by a third party can bring greater recognition of that history, while increasing educational opportunities in the area of natural resource sustainability and increasing

the value of wood products sold from the Forest. The College achieved Forest Stewardship Council (FSC) certification in 2011.

Management Use Allocation

The uses and area allocation of the 8,500 forested acres of the Berea College Forest is broken down for this plan. Areas are approximate and based on map determination, and recently purchased tracts have not yet been inventoried or categorized in this account.

Non-Timber Production Use—1,600 acres: No timber inventory was conducted on any of these areas.

1) KY State Nature Preserves--100 acres: This is the John B. Stephenson State Nature Preserve ("Anglin Falls") in Rockcastle County. The management of this area is dictated by written agreement with The KY State Nature Preserves Commission (KSNP). A draft of a separate management plan is currently being reviewed by KNSP. The uses of the tract under this plan are as a nature preserve (to enhance biodiversity), for education, and for recreation (hiking). It is not open for resource extraction.

2) Dogfoot Springs—50 acres: The immediate hollow below the cliffline containing Dogfoot Springs is recommended as a nature preserve. It is not recommended as land open for public recreation. Its primary uses are biodiversity and education. Grant Hollow, immediately to the north, is recommended as a "legacy stand" (limited harvesting, see recommendations). This will give approximately 100 acres of contiguous mature/large tree habitat. The preserve area may receive non-commercial silviculture to benefit biodiversity. The two management approaches to maintain older/larger trees side by side offers educational value through contrast. This area could be designated a state nature preserve. Additional areas, designated as Special Use Areas, are featured in Figure 2 and total approximately 500 acres.

3) Hiking Trail Buffers—680 acres: This includes forest buffers around the hiking/cross-country trails on Indian Fort Mountain and the Fairchild tract. No buffer was designated for the area around trails in the West Pinnacle area. These trails have been used in the past to provide educational trail access to production silviculture areas. Exact boundaries to minimize visual impact in the non-production trail buffers can be determined in the field as harvests are prepared. The principal use of these areas is recreation, biodiversity, and education. Non-production silviculture to enhance those uses is permissible. The 30 acre Welch Mountain tract where a trail is proposed is included in this unit. The Owsley Lake trail proposed in this plan would lie within the water protection buffer described below.

4) Reservoir protection buffers—590 acres: This includes buffers around 3 water production reservoirs and major perennial streams that feed production reservoirs. The 3 production

reservoirs are B-Lake (located on Ballard branch of Silver Creek), Cowbell (Cowbell Creek), and Owsley Fork (Owsley Fork of Red Lick Creek). There are 3 other impoundments that are totally or partially on College Land. The Cowbell Flood Retarding (Cowbell Cr.) and Blue Lick (Blue Lick Cr.) Lakes are flood control structures managed by the Red Lick Conservancy Dist. The Blue Lick Lake is only partially on College land. Kale Lake (Ballard branch of Silver Creek) is above B-Lake and was formally a water production reservoir. These buffers are to give an added protection to reservoirs beyond BMP's. BMP's give protection to all streams on the Forest; especially perennial streams, regardless of protection. The Owsley buffer would contain the trail proposed for that area. These areas are for production water protection, biodiversity, education, and, in the case of Owsley, recreation. Future development of water resources for the City of Berea will likely include expansion of reservoirs and reservoir protection buffers within the Forest in the next ten years.

5) Lakes and Dams—200 acres: This includes all impounded waters (mentioned by name above) and their dams/spillways. These areas are for water production, biodiversity, education, and, in the case of Owsley, recreation. College staff (only) recreational use is proposed in this plan for the 4 lakes on the Fay-Mason south block. Current uses are water production (income), biodiversity, flood control, research, education, and recreation. Aquaculture research for paddlefish production has been proposed for some lakes. If that takes place, food production will be added to the management uses.

6) Wildlife Fields—60 acres: This involves areas that receive annual/biannual mowing to keep them in a field state for wildlife. They are located on the Fairchild tract, Silver Creek, Cowbell Creek, and Owsley Fork. They include area managed as savannah that could produce limited timber. Chestnut progeny orchards, a butternut progeny orchard, and a grafted nut tree plantation/agro-forestry area are included within this use area designation. Their uses are biodiversity, education, recreation (a trail runs through one of the areas on Fairchild), and food production.

7) Inaccessible Forest--20 acres: This includes areas that cannot be reached with logging equipment. They are areas isolated by clifflines. While there are slopes that might restrict equipment use due to steepness, trees felled can usually be reached from below or above with cable. The uses of these areas are biodiversity and education.

8) Other non-forest—30 acres: This involves areas like Indian Fort Theater/parking lot, houses & other buildings, the Forest Service Building, grounds surrounding these developments, and other non-forest uses located on College land within the Forest. The water plant and pump houses are not included in this because the building and surrounding land belong to the City of Berea.

These areas are not designated for timber production. All forested areas, except the Stephenson Nature Preserve, should be utilized for timber if they need salvage after a large scale damaging event—insects/disease, weather, fire, etc. There is no ecological reason not to use harvesting to

clean up after such events. Such harvesting can generate income and restore a healthy forest stand. Additionally, lake buffers can contribute to production if the entry is low impact. However, they are not included in the area where production is designated a primary use.

Timber Production Use—6,800 acres. Timber inventory was conducted on 6,400 acres of this area.

1) 1988 fire area—300 acres: This fire burned 837 acres, over 600 of which was College Forest. Much of it was a stand replacement fire, killing all or most canopy trees. Some of that land falls into the trail buffer use designation. This area was not included in the most recent inventory because volume is difficult to determine in the standing trees due to decay from fire damage. Merchantable timber was harvested from this area in 2012. This area is managed for timber, biodiversity, and education.

2) Recent regeneration harvests (clearcuts)—100 acres: These are young stands created by regeneration harvests (all merchantable trees harvested and the remaining residual stand eliminated in a site preparation operation). The oldest date from the mid-1980s, while the newest from 2008. The largest trees in the older stands are beginning to reach small saw-timber size. However, none of the trees in these areas will contribute to merchantable timber volume during the life of this management plan. This area was not included in the inventory. This area is managed for timber, biodiversity, education, and recreation (the latter for areas located along trails in the West Pinnacle area and deer hunting permits).

3) Current Production Forest—6,400 acres: This is the area inventoried for this plan. It can be managed for production under the silvicultural systems outlined in this plan. This area is managed for timber, biodiversity, education, and recreation (the latter for areas located along trails in the West Pinnacle area and deer hunting permits).

All of the areas mentioned above are managed for clean water, even if not in production watersheds. Best Management Practices (BMP's) are used for timber and recreational development.

Forest Units

The Forest is separated into five units.

1) Fairchild/Welch Mountain. This involves most of the Fairchild tract south of Brushy Fork Creek and the separate Welch Mountain tract. The portion of the Fairchild tract south of the ridge divide is designated for timber production. In the inventory it is included with the Fay-Mason North unit (below) because there is not enough area there to warrant a separate inventory unit. This unit is close to campus in Madison County.

2) Fay-Mason North. This is the portion of the main block of the Forest north of Hwy. 21. It contains the Indian Fort trail system. The entire unit is in Madison County.

3) Fay-Mason South. This is the portion of the main block of the Forest south of Hwy. 21. It contains the older, smaller water production lakes. The wooded portion of the Windswept tract is included in this unit because it is immediately adjacent. This unit is mostly in Madison County, with some area in Rockcastle County, and a small area behind Windswept in Jackson County.

4) Owsley. This is the area around Owsley Fork reservoir. It is mostly in Jackson County with some in Madison County.

5) Anglin Falls. This unit is the John B. Stephenson State Nature Preserve. It is in Rockcastle County.

For inventory purposes, the blocks were labeled Fay-Mason north/Fairchild, Fay-Mason south, and Owsley.

Inventory Stratification by Site Type

The inventory was stratified by site types. The site types used were based on Smalley's (1986) site classification system for the Northern Cumberland Plateau and Highland Rim/Pennyroyal area where Berea is located. The system uses physiography, climate, geology, soils, topography, and vegetation to break larger landscapes into particular land types. These land types have similar enough vegetation dynamics to guide forest management options. This is a superior ecological classification system to outdated methods like potential natural vegetation (Kuchler 1964) or the similar climax system (Braun 1950) that have not accounted for the long-term forest dynamics that have helped determine pre-settlement vegetation cover.

The Forest is at the meeting point of several of Smalley's ecoregions and Berea site classifications do not fit neatly into any one ecoregion, subregion or land type association. Using defining criteria, most of the Forest fits best into landtypes of the Northern Cumberland Plateau region, western escarpment sub-region (facing the Eastern Highland Rim &Pennyroyal and Bluegrass landtypes). However, the western landtypes of the Forest match the Eastern Highland Rim region, transition to Bluegrass subregion (E. KY knobs landtype).

For the purposes of this inventory and future management recommendations, using Smalley's landtypes is too complex to guide the inventory and future silviculture. On the Berea Forest there are too many of these landtypes. Six site types that combine several similar landtypes were used to stratify the inventory and general silviculture. Five of these were included in the timber inventory and one was not inventoried because it is only located in a non-production area. The

individual site types are based on similar forest cover and productivity (due to site factors). Given the uniform nature of past Berea management practices that generated similar tree stocking and size distribution, stand conditions within these site types are uniform enough to stratify the inventory and guide general silviculture. Where two site types interface, the transition can have forest cover and productivity resembling both types. These transition areas are minor and a forester (or other natural resource professional) with some familiarity with the Berea Forest will be able to recognize the site types in the field. The site type names are chosen for convenient reference and may not adequately describe all defining features of the site type. The inventory sample was distributed approximately proportional to a site type's prevalence on the landscape. The percent of inventory refers to the percentage of sample points that were collected in the site type and the approximate percent that site type occupies on the 6,400 acres sampled. Smalley's landtypes that fit into the site types used in this plan are listed in parenthesis with Northern Cumberland Plateau = NCP and Highland Rim = HR. The inventory breakdown by site type is included in the Appendix.

Site Type Description and General Silviculture

Site Type 1: Wide stream bottoms

6% of inventory (landtypes: NCP 23 & 24; HR 39). This is a relatively rare site type across the Forest and most of it that exists is either cleared (Silver Creek near the water plant), inundated by reservoirs, or in relatively young forest. The latter is true because these were some of the last sites where agriculture was practiced. Owsley has the most of this site and much of it was in fields when acquired in the 1970-80's. Some of that area was mowed for a period after college ownership. While scattered merchantable trees are present throughout this site type, most tree growth is small.

From a topographic standpoint, this site type is easy to recognize as the wider, relatively flat alluvial planes that lie along the perennial streams. They are not the relatively narrow flat areas lying along streams in the steeper "V" notch hollows. They generally have good drainage, but wet areas are present. Soils are alluvial. These are generally productive sites and important ecologically.

Cover—Tree cover on these sites is dictated more by recent agricultural disturbance than by long-term forest dynamics. Small red cedar and Virginia pine can be found throughout Owsley from old field succession. Older stands have yellow-poplar, sweetgum, sycamore, ash, black walnut, red maple, and sugar maple cover. Pin oak, swamp white oak, and northern red oak were observed in several areas of this site. Oaks may have been more prevalent prior to land clearing. These sites can contain some herbaceous vegetation, especially orchids that are rare in the Forest.

Many are wet meadow plants that require open conditions. The open field areas maintained on these sites in Silver Creek are important for these and other open area species. Beaver have flooded some of this area and provide important habitat for hydric species. Due to past disturbance, non-native plants are common on these sites. For the same reason, grape vines are also prevalent in these young stands where they can do considerable damage due to small tree size.

Dynamics—Heavy disturbance due to agriculture has played a role in the current cover of the majority this site type. Though infrequent on the landscape, their productivity and ecological value warrants management. In older stands, it appears that succession will lead to red maple dominance, with some beech and sugar maple, in the absence of disturbance. A single heavy disturbance event will be followed by sweetgum and yellow-poplar dominance, especially if maple sprouting is controlled.

Silviculture--Black walnut, northern red oak, and swamp white oak are the trees found on these sites that justify silvicultural focus due to economic and ecological value. Favoring these species in thinning or introducing them in enrichment plantings after harvest is desirable. If the area is sufficiently well drained to support yellow-poplar, black walnut is a good species choice to enrich stands. Its growth is not fast enough to allow it to compete on an equal basis, but is fast enough to require less help than the oaks and its value justifies the investment. Yellow-poplar, sweetgum, sycamore, the maples, and other species will perpetuate without much management focus. Ash is questionable at this time due to the emerald ash borer, otherwise it would warrant management emphasis. Sanitation operations to control invasive plants and grape vines are warranted in these areas. Loblolly pine was planted on some of these sites in the 1950's and should be harvested when possible, allowing for native trees to take over.

Site Type 2: Low slope, Bluegrass transition

0% of inventory (landtypes: HR 36 & 39). This site type is the least prevalent on the Forest and is only found on the gentle, low slopes of the Fairchild tract. It is all recent growth on former agricultural land. Because the cross-country trail runs through the area, it was not inventoried for timber. Slopes are gentle, soils have a calcium influence from Silurian and Ordovician calcite and dolomite, and woodland productivity is high.

Cover--Black cherry, red maple, shingle oak, and white ash are the dominant canopy cover. A variety of other species are scattered through the area including hackberry, mockernut hickory, Shumard's oak, red cedar, yellow poplar, sugar maple, and white oak. Some shrubs and herbs characteristic to the Bluegrass region are found on these sites. Grape vines are a considerable problem and can lead to tree mortality. A variety of non-native plants are prevalent in this area and bush honeysuckle dominates the understory, shading out all tree regeneration and herbs.

Dynamics—Invasive plants dominate the dynamic for this site. Tree succession in the absence of disturbance would likely be red and sugar maple, but they may have trouble establishing due to invasives.

Silviculture—Production silviculture is impractical here. Some invasive control is warranted, but resources are limited to target such a degraded forest environment. Asian bittersweet and tree of heaven can be controlled and should be targeted to prevent spread. Bush honeysuckle, burning bush, privet, and winter creeper can be controlled along trails or in areas where desirable subcanopy shrubs/small trees can hold their own. Winter creeper can be cut off trees to prevent seed production. Grape vines can be cut to save the current tree cover. The ecological health and trail aesthetics are degraded by the invasives. It would be a good area to utilize a research program focused on invasive control (e.g. goats), in addition to the invasive control activities begun in 2012.

Site Type 3: Knob toe slopes

22% of inventory (landtypes: HR 33,34,35,36, & 37). This site type is found in all areas of the Forest but it is most abundant in the Fay-Mason north unit. These are sites characteristic of the toe slopes of the Knobs region. Soils are relatively shallow, acid clays influenced by Devonian shale parent material. Woodland productivity is moderate to poor except for narrow strips located immediately along a drain. The site is gently sloping to steep and highly dissected with ephemeral drains that create the steepest slopes. Fertility and moisture availability are generally low and soil conditions have been degraded by past agricultural use.

Cover—The overstory on these sites is generally oak-hickory and oak-pine. White oak, black/southern red oak, chestnut oak, scarlet oak, pignut hickory, shagbark hickory, Virginia pine, and shortleaf pine are the most common crown dominants. The transition to Site Type 4 can be difficult to distinguish by tree cover at the interface, especially on dryer, south/west aspects. Several vegetative characteristics can be used to distinguish this type. Sourwood is common on this site type and nearly absent on type 4. The subcanopy trees on this site tend to be dominated by red maple, while red maple is not as common on 4. Low growing *Vaccinium* species (blueberry genus) can be common on this site and virtually absent on 4. While mountain laurel can be found on this site (though only locally abundant), it is absent on 4. Hemlock can be locally abundant on this site (Horse Cove, Baker Hollow, etc.), and is absent for site type 4 (scattered on site type 5 in Rockcastle County).

Dynamics—Fire and agricultural practices have influenced the current cover. Virginia pine that came in as fields were abandoned, begins to drop out of the stand (falls down, usually due to weather events) around age 60, and is mostly gone by 100. Down Virginia pine trees are common on this site type though standing trees are still common. Shortleaf pine needs regular disturbance, likely fire, to maintain the open conditions it needs to perpetuate itself because it is extremely shade intolerant. Succession will take this site type to red maple dominance in the absence of heavy disturbance, though some beech and sugar maple will occasionally dominate. Heavy disturbance will regenerate yellow-poplar and sweetgum, with some blackgum, aspen, and sassafras. Unless directly adjacent to an ephemeral (or larger) stream, yellow-poplar and

sweetgum will drop out of stands due to moisture stress prior to reaching large pole or small sawtimber size (8 to 14 inches DBH). They persist long enough to stifle oak and pine growth. Asian bittersweet and Japanese honeysuckle are aggressive invasive plants on this site, while bush honeysuckle is uncommon. Tree of heaven can be problematic on this site.

Silviculture—Oak and shortleaf pine perpetuation are the focus of silviculture on this site. Hickories, due to better shade tolerance and root sucker regeneration, are less difficult to regenerate. Oak-hickory/oak-pine cover represents the best management goal for biodiversity and production. Shortleaf pine, due to longer life and better timber quality, is the best species for pine management. Virginia pine has low timber quality, a relatively short life, and it fuel loads stands as it dies, making catastrophic fires a threat. Scarlet oak is the least desirable oak due to a shorter life and lower stem quality. These two species, along with red maple, blackgum, and sassafras, should be discriminated against in commercial thinning and improvement operations, especially as a stand nears regeneration.

Site Type 4: Side slopes and limestone ridges

40% of inventory (landtypes—NCP 17, 18, 19 & 22; HR 3 & 32). This is the most common site type, found on all units. It makes up the largest portion of the Owsley unit. It varies the most in productivity because it takes in both north and south facing aspects. It is lumped as one site type because vegetation cover and dynamics are similar enough to require similar silviculture. Soils are well drained, moderate to shallow in depth, and are influenced by calcium from Mississippian calcitic siltstones/shales and limestones. Calcium influence increases on an upslope gradient due to the presence of Mississippian limestone cliffs/outcrops at the top of this site. Assuming productivity on aspect alone can sometimes be deceiving due to seeps and springs present on these sites. These sites are usually steep but benches are common on the slopes. The combination of steepness and shallow soils make tree loss to weather events common in some areas as trees get older and larger.

Cover--The combination of site factors and past disturbance history make these sites the most diverse in dominant overstory. Due to slope and thin, rocky soils, these sites were less likely to have been used for row crops in the past. While they may have been cut, burned, and grazed, some trees likely remained. South and north slopes usually have similar forest cover. Such species as yellow-poplar, yellow buckeye, basswood, and black walnut, often associated with mesic sites, can be found on upper south slopes. The dominant canopy is made up of yellow-poplar, white oak, hickories, northern red oak, ash, sugar maple, and chestnut oak. Sugar maple is the dominant subcanopy tree with beech, followed by red maple, the next most common. Beech may form a small tree layer under larger subcanopy sugar maple. The sugar maple prevalence distinguishes this site type from type 3. At its interface, this site is similar to type 3 on south/west slopes and type 5 on north/east slopes. In addition to sugar maple prevalence, the presence of larger sawtimber yellow-poplar, northern red oak, and black walnut, distinguish it from site 3. Other

calcifiles such as hackberry and mockernut hickory also distinguish this site from types 3 and 6. Differences between this site and site 5 are listed below.

Dynamics—Sugar maple will eventually dominate in absence of heavy disturbance. Beech and red maple also will dominate with low disturbance. Yellow-poplar, basswood, sassafras, and elm will dominate after a single stand replacing disturbance. Bush honeysuckle and winter creeper do well on these sites because of calcium in the soil. Tree of heaven and princess tree can be problematic.

Silviculture—Prescriptions that perpetuate oak, black walnut, and hickories will help maintain diversity on these sites while enhancing economic value. Black cherry offers an opportunity to diversify some stands of higher productivity, enhancing value and biodiversity. A variety of shade tolerant and intolerant species will do well with a focus on these species. Shortleaf pine is occasionally present on these sites and can direct regeneration goals on southern aspects. Large ash are present on this site type but their future management is questionable due to the emerald ash borer. Care must be taken on steep slopes with commercial thinning to protect residual trees. They may be lost to weather events or harvesting activity due to shallow soils. This site grows high quality black walnut, northern red, white, southern red, chestnut, black, and chinquapin oaks. Management for these species benefits economic and biodiversity goals.

Site Type 5—Appalachian cove sites

21% of inventory (landtypes--NCP 15,17, & 23; HR 34). This site type is present on all units except Fairchild and most prevalent on Fay-Mason south. It is the mixed mesophytic forest (Braun 1950) site type. These sites are located in hollows and on north and east facing slopes. Soils are deep, productive, and well drained, but retain moisture due to topographic protection. On north/east facing slopes and areas protected from direct sun by clifflines, they may extend the entire slope up to the cliffline, but will definitely be present on lower slopes of these aspects. They best development of this site can be found below sandstone clifflines where colluvium from Mississippian limestone and Pennsylvanian sandstone form a rich sandy loam soil. In Owsley, where sandstone caprock is absent, soils are a rich loam.

Cover—Because these sites were used for row crop agriculture at acquisition, yellow-poplar dominates this site type. Northern red oak, basswood, sugar maple, and black walnut follow well behind in crown dominance. Subcanopy trees are mainly sugar maple, followed by red maple and beech. Spice bush is often thick in the shrub layer (though it may be found on Site 1 and the most productive areas of type 4). Wild *Hydrangea* in the shrub layer is not consistently present, but can be used to distinguish this site from site 4. The best way to distinguish this site type from type 4 is the cover of spring ephemeral wildflowers (though they may be present at the transition to 4). Species that prefer the richest sites like trout lily, *Hepatica*, twinleaf, Dutchman's breeches, spring phlox, Virginia bluebell, and dwarf larkspur can be abundant. If the site has not been disturbed in a while, this cover might be found on site 1, but it is distinguishable from site 5 by topography.

Tree of heaven and princess are the most common invasives on these sites, but any invasive present will respond vigorously to sunlight on these productive sites and must be controlled.

Dynamics—Yellow-poplar dominates because its rapid early growth as a pioneer species helped it establish on these abandoned field sites. It will dominate in the aftermath of a stand-replacing disturbance (with some basswood that has similar growth and pioneer strategy). In the absence of disturbance, these sites will go to sugar maple dominance, with some red maple and beech. Hemlock overstory or subcanopy is rare on these sites except in Rockcastle County, likely eliminated by past land use. While these sites are thought of as diverse, fire put the species mix in the mixed mesophytic cover in the pre-settlement forest. In its absence, silviculture is necessary to maintain tree diversity. These sites may be the most difficult to diversify, because yellow-poplar can dominate small openings and maples dominate in lower light situations.

Silviculture—There is a good economic argument to perpetuate yellow-poplar on these sites through even-aged silviculture and control of maples and beech at regeneration harvest. It is simple, requires low inputs and is highly productive. The best sites have a site index (age 50) for yellow-poplar that is 120 or more. However, that productivity is not being realized by yellow-poplar at this time due to overstocking. Some plots on cove sites showed a basal area of 220 ft^2/acre for the overstory alone. Thinning would help the growth and health of the residual trees. Even in an even-aged system, harvest related site preparation is desirable at regeneration to reduce maple (and other) sprout clumps that can produce low quality stems to dominate considerable areas on these productive sites (McGee 1970). In this case yellow-poplar should be regenerated by the seed bank and any stump sprouting from large stems (> 2 inch DBH) controlled

Diversifying the overstory is highly desirable for these sites for both biodiversity and economic reasons. Black walnut offers the best economic rewards and northern red oak is also important. (Due to the productivity, oak mast can be heavy in good years on these sites benefiting deer, turkey, and bear.) White oak regeneration poses a significant challenge because of its relatively slower growth. Site preparation, in the form of low thinnings well in advance of a regeneration harvest to develop vigorous advance regeneration, is necessary to compete with seedling poplar and basswood. For oaks this would have to precede harvest by 10 years or more, but walnut regeneration would likely develop more rapidly. The low thinning would benefit understory herbs and nesting conditions for some songbirds. Site preparation would be needed to control the remaining subcanopy after or just before the regeneration harvest. Enrichment plantings are difficult on these sites due to fast yellow-poplar growth.

Site Type 6: Sandstone ridges

2% of inventory (landtypes--NCP 1, 3, 4, 5, 7, 8, 15, & 16). These sites are easy to recognize in the field as lying at or above the prominent Pennsylvanian sandstone clifflines. This site type is found only on north and south Fay-Mason units. The sandstone cliffs are mostly contiguous around the ridges except where dissected by drains. The sites are mostly gently sloping with some

steep areas along drainages and small sinkholes. The small sinkholes develop where the underlying Mississippian limestone has collapsed and small cliffs may line their edge. Small caves and rockhouses can be found at the base of ridge and sinkhole cliffs. Soils are generally acid, moderately deep, and well-drained loams and sandy loams. They can be shallow and quite sandy in small strips along the cliff drop. These sites are moderately productive to very productive in sinks and drains, with poor productivity on cliff edge strips.

Cover—Forest cover is a mix of oaks with sugar maple, yellow-poplar, and hickories. Chestnut oak, yellow-poplar, black/southern red oak, sugar maple, hickories, and white oak are the dominant species. Chestnut oak can form nearly pure stands in some areas. Old red-heart pine stumps give evidence there was a greater pine component in the past. Virginia and shortleaf pine are scattered throughout the site, and scrubby pines dominate the shallow soils at the cliff edge. Mountain laurel can be quite abundant in some areas. The largest "skeletons" of dead American chestnut remaining on the Forest are found on or just below sandstone ridges. Invasive plants are invading from the edges created by Burnt Ridge Road and tree of heaven and princess tree readily invade openings. Exposed cliff edges can harbor some prairie/glade plants that are not found elsewhere on the Forest. Many of these plants began to show up in the East Pinnacle area after the 1988 fire, presumably from the seed bank.

Dynamics—Oak, earlier pine cover, and the presence of prairie/glade species in the seed bank indicate fire influenced cover. Many of the wider, more level ridge sites have been cleared for agriculture prior to acquisition. Succession in the absence of regular disturbance is sugar maple. It dominates the subcanopy trees. Red maple is also present, but beech is uncommon. A single disturbance would favor yellow-poplar. The presence of sawtimber yellow-poplar over most of the site attests that it can develop well on most of the area, but it may be lost to drought stress as it reaches sawtimber size on the driest portions. It will likely drop out before reaching sawtimber size in the driest areas.

Silviculture—Oak regeneration silviculture can maintain both productivity and diversity on the site. Maple, yellow-poplar, and hickory will continue to be present in regenerated stands because of their competitive strategies. Shortleaf pine should be encouraged. Pine regeneration openings will have to be smaller on ridge sites than on site types 3 and 4 because there is not as much room on the ridges. 2.5 to 5 acre units are adequate. Maintaining shortleaf pine on ridges assures seed rain on adjacent lower land that can help regenerate these areas if silviculture techniques for natural regeneration are available. These sites would be good locations to re-establish American chestnut in harvest openings as resistant seedlings become available.

Maps

A general forest map (Figure 1) and a map featuring special use management areas (Figure 2) are located in the Appendix. Because the goal of this plan is not to give site specific recommendations, stand and/or prescription boundaries, detailed maps are not included. As site specific operation

plans are developed, maps that detail those areas should be included. Additionally, the Site Types are not mapped. While they provide a good basis for inventory stratification and silvicultural prescriptions, their boundaries on the landscape would be arbitrary delineations for site specific management prescriptions. The site types can be recognized on the ground and may guide silviculture (for example timber marking), but prescriptions of practical size are likely to span several ecological site types. Digital maps may aid management records. Resources such as ArcMap and GPS units should be should be used, when practical, as an aid in forest management and for recordkeeping.

Inventory & Results

The inventory is based on 260 variable probability (3P) sample points randomly located in the inventory areas. They were horizontal point samples utilizing a 20 basal area factor prism, using slope correction where necessary. The sample points were stratified by the site types described earlier. The number of sample points allocated to each site type was wide stream bottoms 15; knob toe slopes 56; side slopes & limestone ridges 103; Appalachian cove sites 55; and sandstone ridges 31. This sample is not sufficient for making precise sustained volume yield calculations. It is designed to serve as a basis for decision making for smaller management units, especially harvests. It is always best to mark such harvest units unless timber value is low and the silviculture applied is simple.

Only trees falling into sample points that had reached sawtimber size, ≥10 inch diameter at breast height (DBH) class, and trees < 10 inch DBH class that were judged to have the potential to reach sawtimber size due to canopy position, crown character, and stem quality were included in the sample. The latter includes trees that have reached the canopy or trees below the main canopy that appear to have the potential to reach sawtimber size as a canopy dominant if released in the next decade or so. Trees < 10 inch DBH below the main canopy that had poor crowns ("flat-topped", low live crown ratio, etc.) or stem qualities (crooked, hollow, etc.) that indicate they are unlikely to make sawtimber, were not tallied. Therefore, reported basal area is not the total basal area. It is the basal area that can be managed as current or future healthy canopy. Trees determined to be "cull" for sawtimber purposes (hollow, etc.) were recorded for stocking data, but no volume is listed. Dead trees, standing or down, were not recorded.

The species, DBH class, and merchantable height to the nearest 8-foot log were recorded for each tree that fell in sample points. DBH classes are in even numbers (e.g. 10 inch DBH class = 9.0 inch DBH to 11.0 inch DBH). All volumes are listed in board feet as determined by the Doyle rule, Girard form class 78. Pine is normally determined by the International rule in this region. It was tallied using the Doyle rule in order to present volume tables using only one scale. The form class 78 should give a conservative volume figure for most yellow-poplar. Growth was collected in every 4th sample point for the 2 trees closest to the point center that met the size and future potential criteria mentioned above. Growth data was reported for those trees as inches of diameter growth in the past 10 years.

Reported inventory results are estimates based on the sample and should not be mistaken for a 100% inventory (marking). Inventory data is broken down by species or species groups (e.g. hickories). From the standpoint of data on the individual species, the precision of inventory data decreases as species prevalence decreases. The less common species are reported in the results individually to highlight the diversity for silvicultural reasons. The accuracy of the reported volumes is low. Species that were the least frequent in the sample are listed as miscellaneous. Total figures are based on the 6,400 acres of production forest; thus non-timber production use areas described on pages 14, 15 and 16 were excluded in the inventory.

Stock and Stand Tables

Trees per acre and by volume.

Table 1. Volume by species for all sawtimber sized trees (≥ 10 inches DBH).

Species	Total volume	% by volume
yellow-poplar	17,166,000	33.6%
white oak	5,935,000	11.6%
chestnut oak	4,754,000	9.3%
hickories	3,360,000	6.6%
northern red oak	2,811,000	5.5%
black & southern red oak	2,889,000	5.7%
sugar maple	2,921,000	5.7%
ash	1,628,000	3.2%
shortleaf pine	1,405,000	2.7%
basswood	1,104,000	2.2%
Virginia Pine	1,573,000	3.1%
beech	798,000	1.6%
black walnut	793,000	1.6%
red maple	593,000	1.2%
scarlet oak	623,000	1.2%
chinkapin oak	609,000	1.2%
Misc.*	2,129,000	4.2%
Totals	51,091,000	100.0%

Miscellaneous species are blackgum, sweetgum, sycamore, elm, buckeye , sassafras,
black cherry, black locust, KY coffee tree, swamp white oak, pin oak and sourwood.

Recommended Annual Harvest Next 10 years: 500,000 to 750,000 board feet per year

Sustainable Annual Harvest: 1.3 million board feet per year

Note: An inventory conducted by Fountains Forestry affirmed the above inventory; with a similar total board foot volume of 56,250,000 over the same area. My assumption is that, since then, the forest has grown past 60,000,000 bf. I prefer to use John's inventory as it is more straightforward and his plots were in more useful locations. His was done for utility, while theirs was done for efficiency.

A Carbon Inventory was also done, by New Forests, for the Carbon Project. It is not included here because the units and entire format are not compatible for forest management purposes. Nevertheless, the Carbon Inventory meets requirements for certification re-inventory purposes.

Another forest-wide inventory; now that nearly ten years have passed since John's inventory and sizeable new land purchases have been made, is advisable but not urgent. As with all former College Foresters, such an undertaking would require contractural services to achieve without largely ceasing regular operations. Substantial funding (Fountains Forestry was paid $40,000) would be necessary. I would recommend that before such an endeavor was embarked upon, whatever forest road and trail additions, and likely land purchases, be implemented first so that a subsequent inventory and subsequent management plan adjustments would reflect the current situation.

Table 2. Non-sawtimber (< 10 inch DBH) trees with potential to the next stand if released in the next 10 years (approximate).

Species	Trees per acre	% by # of trees
sugar maple	7.1	30.0%
yellow-poplar	3.8	15.8%
Virginia pine	2.5	10.8%
black walnut	2.1	8.7%
white oak	1.8	7.4%
chestnut oak	1.6	6.8%
northern red oak	0.8	3.5%
red maple	0.8	3.3%
ash	0.4	1.7%
beech	0.2	0.9%
black & southern red oak	0.2	0.9%
hickories	0.2	0.9%
Misc.*	2.2	9.2%
Totals	23.7	100.0%

*Miscellaneous species are black gum, elm, sycamore, sweetgum, persimmon, and red cedar.

Table 3. Small sawtimber trees (≥ 10 inch DBH < 16 inch DBH)

Species	Trees per acre	Volume per acre	Total volume	% by volume	Ave. vol. per tree
yellow-poplar	6.3	298	1,905,000	24.5%	47
sugar maple	6.7	173	1,106,000	14.2%	26
white oak	3.8	130	832,000	10.7%	34
Virginia Pine	2.5	123	784,000	10.1%	48
hickories	3.1	109	699,000	9.0%	36
chestnut oak	3.8	93	598,000	7.7%	24
ash	1.1	49	316,000	4.1%	44
shortleaf pine	0.9	37	239,000	3.1%	43
chinkapin oak	0.9	28	181,000	2.3%	32
northern red oak	0.8	24	152,000	2.0%	31
scarlet oak	0.8	23	144,000	1.8%	28
basswood	0.4	22	139,000	1.8%	50
black & southern red oak	0.4	14	92,000	1.2%	38
red maple	1.1	14	91,000	1.2%	13
black walnut	0.4	13	81,000	1.0%	33
beech	0.1	8	51,000	0.7%	55
Misc.*	2.3	58	374,000	4.8%	25
Totals	35.5	1,216	7,784,000	100.0%	34

*Miscellaneous species are blackgum, sweetgum, sycamore, elm, buckeye , sassafras, and sourwood.

Table 4. Medium and large sawtimber trees (≥ 16 inch DBH)

Species	Trees per acre	Volume per acre	Total volume	% by volume	Ave. vol. per tree
yellow-poplar	8.5	2385	15,261,000	35.2%	280
white oak	4.7	797	5,103,000	11.8%	170
chestnut oak	3.9	649	4,157,000	9.6%	166
hickories	2.7	416	2,661,000	6.1%	152
northern red oak	1.6	415	2,659,000	6.1%	260
black & southern red oak	2.0	437	2,797,000	6.5%	217
sugar maple	2.2	284	1,815,000	4.2%	127
ash	1.1	205	1,312,000	3.0%	185
shortleaf pine	1.0	182	1,166,000	2.7%	180
basswood	0.7	151	965,000	2.2%	224
Virginia Pine	0.9	123	789,000	1.8%	135
beech	0.7	117	747,000	1.7%	167
black walnut	0.7	111	712,000	1.6%	164
red maple	0.6	78	502,000	1.2%	135
scarlet oak	0.5	75	479,000	1.1%	143
chinkapin oak	0.4	67	428,000	1.0%	160
Misc.*	1.6	274	1,755,000	4.1%	169
	33.9	6,767	43,308,000	100.0%	200

*Miscellaneous species are blackgum, sweetgum, sycamore, elm, buckeye , sassafras, black cherry, black locust, KY coffee tree, swamp white oak, and pin oak.

Additional inventory tables are provided in the Appendix. They include inventory listed by site type and forest block

Growth 10 year growth. 121 trees sampled.

Mean growth = 2.2 inches per last 10 years (standard error 0.06 inches/3%)

Table 5. Growth by site type (number of trees sampled) in inches/past 10 years.2

Site Type	10 Year growth	Standard error
wide stream bottoms (6)	4.3	0.4
knob toe slopes (24)	2.0	0.2
side slopes & ridges, limestone influence (51)	1.9	0.1
cove (24)	2.6	0.2
sandstone ridges (16)	1.9	0.1

Stand Density

For the entire area sampled, mean basal area per acre was 105 ft^2 (std. error 2.5/2%).

Table 6. Basal area per acre in square feet by site type (# of sample points).

Site Type	Basal area	Standard error
wide stream bottoms (15)	96	15
knob toe slopes (56)	97	5
side slopes & ridges, limestone influence (103)	104	4
cove (55)	112	6
sandstone ridges (31)	114	7

The average DBH/sampled tree was 7.2 inches with 93.1 trees per acre indicated by the sample.

Subcanopy Composition

No inventory of subcanopy trees was made. Visual survey indicates tree dominance of the subcanopy by suppressed shade-tolerant species. Sugar maple is likely most common because it dominates the subcanopy on more site types. Red maple and beech, in that order, appear to follow. Advance oak regeneration is generally absent from all but the poorest sites.

Mortality

Mortality was not inventoried. Visual survey indicates mortality is high in most stands. Even-aged yellow-poplar stands offer the greatest exception. Due to age, Virginia pine shows the

highest, usually die to wind-throw/uprooting. Mortality appears high in the red oaks, predictably in scarlet oak (due to short biological life) but also in older black oak and northern red oaks on steep hillsides (uprooting). Locally prevalent mortality (top breakage, uprooting) due to the 2009 ice storm is present, but general mortality appears high in areas that had little or no ice. White oak mortality evident is mostly from the drought and insect complex that hit stand in 2003-2004.

Inventory Discussion

With estimated volume per acre at over 7,900 board feet and most prevalent species in commercially desirable species, the Forest offers both commercial and silvicultural promise. It is possible to use commercial value as incentive to accomplish silvicultural goals. While there are differences in the 1959 inventory methods and that inventory covered 4,900 acres of "commercial" forestland, species compositions are remarkably similar. The most notable difference is that yellow-poplar volume has increased while "other oaks" (includes mostly red oaks) and hickory have decreased (Table 7). Yellow-poplar has increased due to growth rate and, because they grow faster than white oaks in mixed oak stands, red oaks were likely harvested more frequently in the 1960-70 period when the College ran the sawmill. Additionally, higher mortality of red oaks also likely plays a part in that change. A comparison the 1959 inventory is included in the Table 7.

Table 7. Comparison of per acre volume and percent composition based on sawtimber volume by species between 1959 and 2010 inventory.

Species	Volume per acre 1959*	Volume per acre 2010	% by volume 1959	% by volume 2010
yellow-poplar	1,651	2,682	26%	34%
white oak	612	927	10%	12%
other oak	1,714	1826	27%	23%
hickories	745	525	12%	7%
pine	356	465	6%	6%
sugar maple	319	456	5%	6%
black walnut	151	124	2%	2%
Misc.	744	958	12%	12%
Totals	6,292	7,983	100%	100%

*Total estimated volumes from 1959 inventory were converted to volume per acre and rounding to nearest whole number.

Volume per acre has increased by approximately 27% (~1,700 board feet) since 1959. Some 8 million board feet was harvested 1960-1970 (~1,600/acre). Since only a small percent (estimate <

2%) of the area inventoried in this plan was been partially harvested since 1970 (all of that actually between 1994-2008), volume/acre might be expected to be higher at this point. However, due to growth and land acquisition, the estimated total volume available for harvest in 2010 has increased from 28.96 million feet to over 51 million feet. This increase offers economic and conservation opportunities. The 1959 inventory was much more intensive and accurate than the one conducted for this plan. However, the estimated increase in available volume is still substantial.

Growth is slow to moderate at this time. Based on applying mean 10 year diameter growth to the sawtimber size tree indicated by the sample, there would be an average 4.1% increase in volume per year and Pressler's growth percent (approximates the compound interest rate) at 3.4% over the next 10 years if this growth rate continues. Gross growth (does not include mortality loss) over the next 10 years would average 337 board feet per acre per year for the sawtimber trees sampled for this inventory. Actual net volume growth would be less due to generally slower growth in trees that have not achieved sawtimber size and due to mortality. Commercial thinning harvests could increase this growth while utilizing some trees that might be lost to mortality. Growth is faster on wide stream bottom sites not only because of high soil productivity, but because many of these sites contain younger stands that came into areas kept open for agriculture more recently than other areas. The relative small area of these sites keeps them from having greater impact on total growth. Knob toe slopes are more likely to have experienced commercial thinning than any other (in the Indian Fort block where hardwood stands were thinned as Virginia pine was salvaged) and show better growth relative to their productivity. Cove sites show conspicuously slow growth relative to productivity. This is due to dense even-aged yellow-poplar where competition reduces growth potential. Because the growth on all sites represents increment on trees that are mostly relatively large already, financial increment is better than wood growth increment indicates.

The 1959 inventory indicated a net growth of 200 board feet per acre per year. That inventory was more intensive. Depending on stand size, growth was collected on every 3rd to 5th plot with every tree in the plot that exceeded 4.6 inches DBH sampled. This growth sample would have included crown suppressed trees of very slow growth that would have little or no chance of achieving crown dominance. The inventory likely yielded a conservative value for volume increment but the inventory does not indicate that mortality was factored into the growth projection. Even with stand changes since 1959, the growth indicated by that inventory still represents a safe board foot growth standard for the Forest.

Stand density indicates that the Forest is 85-90% stocking percent (upper range of fully stocked, Gingrich and Roach, 1968). The high level of stocking indicates that growth is slowing due to competition.

Subcanopy composition is representative of the situation described in the eastern United States by Norwacki and Abrams (2008). This presents silvicultural problems in regenerating valuable oaks, black walnut, and shortleaf pine, as well as effects of reducing native biodiversity.

Mortality is high due to age, high stocking, and vigor (as indicated by growth). Weather and insect/disease events create more stress under these conditions.

Recommendations

Education

The management of the Berea Forest can meet education goals in these ways:

1) Economic Support: The management of the Forest should sustain its costs of oversight and stewardship while providing surplus to support the general education mission of the College. Water sale income also supports education as a forest product. The Forest can provide the College direct resource support in the form of timber/wood and woody biomass for energy use, and potentially through the sale of carbon offsets.

2) Sustainable Forest Management: The College's management of its forest should serve as an example of forest management that is widely applicable to private forestland owners of the Appalachian Region and beyond. Economic and ecological demands made on that ownership require the integration of multiple management goals. The integration requires the application of appropriate forest science and sound business principals. This provides an outdoor laboratory of a working forest landscape for Berea College classes, other academic institutions in the region, the community, natural resource professionals, and interest groups. Hands-on demonstrations through the addition of a portable sawmill and possibly limited logging capacity with horses and/or tractor could enhance the program. Addition of a Nature Center would broadcast the effect of our program much more widely and affect others outside our community. The integration of economic and ecological goals provides a real-world example for educational use.

3) Conservation: Conservation is the basis of modern forestry. It requires sustaining ecosystem functions, components, and structures while generating a variety of resource outputs and amenities. The landscape that results from that type of management will have considerable spatial variation that supports both forest biology and economic land use education. Human economic needs are met locally while ecosystem protection is maintained. It answers the most basic question relating to forestry education, "Given the demands we make on them, can we live with our forest landscapes in perpetuity?"

4) Research: Research conducted on the Forest both informs its management and enhances the reputation of the College. Research conducted by Berea Students and Faculty has been presented at the KY Academy of Sciences and beyond. Work on at least four projects conducted since 1995 have been published by Berea Faculty. University of Kentucky has conducted a variety of forestry research projects. Among others, Eastern Kentucky University, University of Tennessee, Purdue University, Central Missouri University, The American Chestnut Foundation, and the USDA

Forest Service have conducted research projects on the Forest. At least 25 graduate-level forest science research projects have been conducted on the Forest since 1992. Berea students, faculty, and staff have participated in these projects. Research partnerships should be encouraged. Current and future research areas need to be protected from alterations that can negatively affect the study. The working forest landscape, because of its dynamic nature and spatial variation, offers a greater variety of research projects than a single use forest area.

5) Partnerships and Outreach: Partnerships with other conservation entities offer the possibility to expand educational potential and access. The University of Kentucky senior forestry capstone class (FOR 480) has used the Forest for its field project in the recent past and returned in 2010 and 2011. Their work, provided by student foresters only months from the job market, has provided timber, wildlife, and water inventory data along with management recommendations for portions of the Forest. At least 28 UK forestry graduate projects have been conducted on the Forest since 1992.

As the closest university level forestry school, a formal agreement should be considered with UK that serves both schools and the region. Partnerships with government conservation agencies, other universities/colleges, and NGO's (e.g. Nature Conservancy, KY Woodland Owners Assoc.) can help educational access and exposure. An MOU between Berea College and the Kentucky Division of Wildlife was authorized in 2017 to facilitate mutual cooperation towards the initiation of a prescribed burning program on the Berea College Forest. The first burn was successfully implemented on the forest May 1, 2018, and was planned around the Shortleaf Pine Initiative in partnership with Sewanee College (University of the South) as part of a NFWF Grant.

Outreach to inform conservation choices in the region has always been an important mission of the Berea Forest. Partnerships help accomplish this education goal. The addition of the Forestry Outreach Center facility has greatly expanded the ability of Berea College to host natural resource events and conferences, and our ability to conduct our own educational outreach programs. The Society of American Foresters National Convention will be in Louisville, KY this year (2019) and will include a field tour to the Berea College Forest November 3rd. I believe this is the first time Berea College has attracted a National Forestry Convention tour.

Production Silviculture

Silvicultural prescriptions should be chosen to minimize management inputs necessary to maintain forest health, productivity, and diversity. While high input, intensive production silviculture might be conducted on limited scale for research or demonstration (education) purposes (e.g. high yield yellow-poplar culture), general silviculture that is less intensive will increase net returns and minimize impacts over the life of a given stand. Most management inputs should be aimed at moderate increases in productivity and maintaining forest diversity. Those goals may require some intensive operations, but will represent low intensity over the life of the stand.

That said; the forests of this region have developed through moderately intensive disturbance regimes that are characterized by periodic stand or partial stand replacement disturbance events. Centuries of pre-settlement oak, pine, and chestnut dominance on much of the landscape (Delcourt and Delcourt 1987) indicates open understories; likely generated by fire (Nowacki & Abrams 2008). Silviculture must imitate that while minimizing management regulation, cost inputs, and larger impacts. See site type descriptions for ecological justification and general silviculture prescriptions related to site type.

Finally, the Berea College forestry effort has its roots in a conservation based ethic that emphasizes multiple uses/outputs while protecting ecological components, processes, and structures to sustain ecosystem functions and production outputs. Because the forest ecosystem of this region is sufficiently disturbance influenced, production silviculture offers the opportunity to sustain the ecosystem while generating funds that support the College and Forestry Department conservation efforts. This is the most widely applicable conservation model for the region - ecological goals sustained by economic outputs of the ecosystem.

Components of this silviculture follow:

1) Even-aged management: Even-aged management that keeps high canopy cover on the majority of the Forest, except for the final regeneration release harvest, may be employed. This may be regarded as a shelterwood system to the extent it targets tree species for regeneration that require development under a canopy before release (e.g. oaks). This involves 2 to 4 commercial thinnings over the life of a stand that keeps a cover of quality overstory trees for future harvest until stand regeneration is planned.

Because the current age and tree size in the forest is advanced, stands may only support one commercial thinning prior to final regeneration harvest. The final regeneration harvest is a silvicultural clearcut (as opposed to a commercial clearcut that leaves the stand dominated by poor quality trees) that removes all canopy and subcanopy to release regeneration. The size of these should be kept small (2 to 5 acres) and scattered to minimize negative aesthetic impacts unless justification on the grounds of large scale salvage is warranted or exceptionally high chances for regeneration success is evident by large numbers of advance regeneration of oak and/or shortleaf pine is present across a large area. Silvicultural clearcuts, while often unpopular, should remain a management option and are indeed desirable if used strategically and sparingly to maintain the spatial variation necessary for biodiversity conservation and the creation and maintenance of early succession communities.

The commercial thinnings are not designed to open the stand to the point of releasing regeneration. The post-commercial stand should have enough shade so that shade intolerant regeneration (e.g. yellow-poplar) is not stimulated. The subcanopy will be left after the thinning harvest and, with the remaining overstory, should provide enough shade to suppress new regeneration. The exception to leaving the subcanopy is where there is already advanced regeneration of oaks

present…as sometimes occurs in the vicinity of naturally occurring canopy gaps created from tree fall or mortality.

These harvests should leave 50 to 85 ft^2 of basal area in sawtimber trees plus the majority of the subcanopy. The upper range of residual basal area is left on the most productive sites (> 80 site index for upland oaks) with less on the intermediate sites (65 to 80 site index), and the lowest on the poorest sites. Diameter limits should not be strictly used as the sole harvest criteria. The thinnings should be improvement cuttings, removing poor quality stems, while retaining quality trees that have potential to increase in value…sometimes referred to as "worst first" harvesting.

The trees retained in the harvests will be the best quality trees in the 16-24 inch DBH classes based on species, stem quality, and crown condition that indicate health and growth potential. Only sawtimber trees < 16 inches of exceptional quality should be retained. A few high quality trees > 24 inches DBH that are judged fit to survive until the next harvest can be retained...particulary high quality white oak such as has been successfully utilized for historic ship reconstruction. The large trees in that size class cut in a given harvest will drive the economic value and make the improvement of the stand by removal of smaller and lower quality trees economically feasible. Residual crown cover (including subcanopy that survives the harvest) will close between harvests. The method of flexible diameter limit cutting researched in West Virginia (Smith et al. 1997) is similar to the commercial thinning described, except more of the larger trees are retained and the prescription terminates in a regeneration harvest (clearcut) to insure stand diversity, make regulation easier, and provide habitat diversity (for wildlife). This type of harvest plan can be used as a starting point for laying out a harvest, but the unique conditions on each hillside should inform the forester more than any given literature.

For stands where it is desirable to regenerate oaks, black walnut, or other similar species, thinning from below will be necessary to develop advanced regeneration prior to regeneration harvest. This will need to be conducted 5-10 years in advance of the harvest. As of yet, planning this far ahead has not been the rule…but it should be…and this is the direction the current forester endeavors to make the rule. Enough subcanopy will need to be removed by herbicide injection or felling plus herbicide stump treatment of non-oaks to foster oak regeneration. An adaption of this technique will also help establish black walnut on good sites. Guidelines for this may be found in Stringer, (2006) Research conducted on oak shelterwood, as well as on expanding gap (with midstory removal) techniques on the Berea Forest should inform decisions on this method. A review of research and some experimentation will be required for low thinning to enhance oak and walnut on highly productive cove sites.

Final regeneration cuts will require removal of all or most overstory and remaining subcanopy for the release of regeneration. This may be done gradually via expanding gap harvests when the condition of the surrounding forest canopy is sufficiently robust to wait for multiple entries and the topography permits such an approach. Herbicide injection or felling and herbicide treatment will work best for subcanopy site preparation treatments to release new regeneration. Timber sale

contracts should specify felling of all merchantable stems, including culls. As pulpwood and fuel wood markets develop, clear fell site preparation will be made easier while generating income. The thinning from below and site preparation that accompanies a final harvest are the most intensive aspects of this method. Otherwise, canopy cover is maintained throughout the rotation.

When the prescription requires regenerating only yellow-poplar or other shade intolerant hardwoods, thinning from below can be eliminated. It still requires clear felling and treating subcanopy so low quality stands of stump sprouts do not result.

This method will serve for the life of this management plan. Stands created by regeneration harvests (clearcuts) will eventually grow to the size where they can be commercially thinned (30-50 years). The first commercial thinning should be a "worst-first" system where the harvest mainly targets the lowest value/quality trees. This can be made economically viable by providing higher quality trees for sale in an adjacent area where trees are older/larger. After this system is utilized for several decades, a patchwork of even-aged stands in size of varying ages/sizes will begin to develop. Where the expanding gap system is used, these stands will be of such small size that it could be described as uneven-aged management. Either way, older stands with larger trees will be adjacent to younger stands; indeed, within them in the case of gap management. Having harvests with larger, more valuable trees in stands adjacent to younger stands that need thinning provides economic incentives for loggers to utilize the smaller, less valuable trees in adjacent stands. That will increase growth and stand quality in the younger stands.

Commercial thinning and regeneration harvests can be accomplished with conventional chain-saw and skidder operations or with mechanical harvesters ("feller-bunchers") that are coming into use in the region. The large trees that are currently common in the Forest may exceed the size that feller-bunchers can handle. However, they would be an excellent tool for thinning some stands with minimal damage. Generally, equipment on tracks is far preferable to wheeled equipment since it spreads the weight over more area and minimizes spinning, ruts, and soil compaction. However, when dozers are used, operators can get carried away digging "roads" along hillsides…negating any benefits otherwise derived by their low compaction tracks.

Currently, the use of horses and mules is showing remarkable success in the forest and acceptance by the public. It is preferred over other means of harvest so long as skilled horse and mule loggers can be secured and relied upon to take the low grade trees. So long as the quality of the timber, overall, is high enough for the loggers to earn a decent wage while also cutting the low value trees, this can work. However, skidding distance with this method is restricted, and unless the old logging roads are re-opened and made usable for forwarding and/or truck hauling, the result of horse/mule logging as a preference will be that all the timber within a 500 yards of a road (downhill of the timber) will be gone through ,with the rest remaining. Probably, some combination of old abandoned road re-opening (which requires the use of dozers, as culverts are washed out) and use of dozers for forwarding logs on the old roads will be necessary. Regardless of logging technology,

timber sale contracts need to support logging that protects the residual stand and other environmental aspects.

Even-aged silviculture for Appalachian hardwoods has been advocated by the forestry profession on the grounds that it requires less regulation (monitoring stand progress and deciding where to harvest) and management inputs while maintaining a greater diversity of native trees (Roach and Gingrich 1968). The final regeneration cut is the high impact entry into the stand. "Clearcuts" have gained a bad reputation in popular press, but fit within the natural disturbance system under which the region's forests developed…that is, after European settlement. Most of the species that make up our forests do not develop well under shade. While the aesthetics of the final harvest may disturb some, it is still considered sound ecologically (Botkin 1990) in the literature. Regenerated stands grow quickly due to high sunlight conditions. The disturbance level over the life of the stand is less for an even-aged system than an uneven-aged one because of fewer required stand entries. However, as invasive species have come onto the scene and fire has mostly been off the scene for many years now, my view is that the advocacy in the forestry profession for even-aged management is on the wane and I foresee uneven-aged systems becoming more acceptable and eventually preferable as the research catches up to what many field foresters have been seeing and doing for quite some time already.

2) Even-aged shortleaf pine silviculture: Even-aged shortleaf pine silviculture requires the most intensive management of any needed on the Forest. It is appropriate on Knob toe slope sites, sandstone ridges, and some dry side slopes. Commercial thinnings may precede a final regeneration harvest as outlined above. Prescribed fire is now being utilized, and as this developes, the planting of seedlings may eventually give way to natural regeneration of this species in some places. A silvicultural clearcut (all merchantable stems and remaining stems through site preparation) is necessary before planting. Herbicide injection of the subcanopy applied the summer prior to harvest may be the safest method, but clear-felling subcanopy and herbicide treatment of stumps associated with the harvest is also acceptable. Harvest areas should be shaped to minimize edge to give the high-light interior that shortleaf need to grow well. Larger units are desirable if aesthetic considerations are not important in a given area. A singe operation that establishes 10 to 15 acres (a single or two units) of shortleaf pine regeneration every 5-6 years can maintain enough pine cover to meet economic and ecological goals. An alternative scenario is to use smaller units such as cluster plantings, over a longer period of time.

As the goal is only to bring 30-50 shortleaf pines per acre to crown dominant positions over a unit, it is not necessary to plant more than 75 trees per acre and no closer than 15 feet apart. Trees should be marked by flagging so they can be found the next 2 growing seasons. Eight to nine feet around those trees should be treated with a directed foliar herbicide application (glyphosate plus Garlon-3) in the growing season (protect pine seedling with a stovepipe) for the first two years to eliminate all competition. In addition, vigorous hardwood stump sprouts within 15 feet or so that may compete with pines in later years should be treated at this time. Seedlings that do not survive the

first growing season can be replaced the following year, but will only receive herbicide release for one year.

This method represents trying to reduce total costs (per acre) while cost per seedling is large. Careful attention should be paid to shortleaf pine regeneration silviculture on Daniel Boone National Forest lands to learn possible techniques. It is important, economically and ecologically, to maintain this species. Berea College took on an important role as a leader in this area via the NFWF grant and partnership with Sewanee College and the Forest Stewards Guild.

3) Two-aged silvicultural systems: Two-aged silvicultural systems may work for hardwood stands. Also called a retention system, this system maintains stands of two different ages on an area. It requires more management input and regulation than an even-aged system. Stands may be commercially thinned in the harvest prior to the establishment of the two-aged stand in a partial regeneration harvest. It is similar to the even-aged system except at regeneration harvest where some trees are left to be retained on the area for a long time, perhaps an entire rotation. Trees chosen to be left should be a species variety and of a size, vigor, age, and quality that indicates they may persist and grow on the area for many decades.

20 to 40 feet of basal area per acre can be retained at the regeneration harvest. The stand should be opened up considerably by the harvest. At regeneration harvest, subcanopy trees need to be eliminated to open harvested areas for new regeneration. This system retains some canopy so it has aesthetic advantages to one that ends in a regeneration harvest. However, its regulation and input requirements make it more difficult to manage. Additionally, when trees retained at an earlier time are harvested at a later time, they will be larger than the second age group of trees and the harvest may cause damage to that second group.

4) Uneven-aged silviculture: The uneven-aged silvicultural method most appropriate for the Berea Forest is group selection in its various constructs such as expanding gap "Femelschlag" systems and its use should be limited in scope so far as follow up management can be adequately implemented to insure success. These harvests are when all trees in small groups are cut; accompanied with site preparation to eliminate all subcanopy within those harvested groups. For the Berea Forest, groups should be ¾ to 1 acre in size. (A harvest opening more than twice the height of surrounding trees is considered a regeneration or clearcut.) If low thinnings precede the harvests to develop oak regeneration, adequate light is available in the center of openings for oaks. Yellow-poplar and other shade intolerant species may also successfully regenerate in the center of the opening. Shade tolerant species can grow at the edges.

This system is more difficult to plan, regulate, and maintain. Mapping of the many small openings can be complicated; making location difficult if subsequent management is needed. Regeneration in openings is likely to be damaged when merchantable trees around the edges are cut in later harvests unless the harvesting is done by skidding out individual log sections at a time, as is done with horses/mules, and skilled sawyers are used. The system would best for use to regenerate

"legacy stands" described following, and those areas laying within or adjacent to trail buffers, where aesthetics are particularly important unless all aspects of this type of management can be closely followed and finished.

The rest of this section is taken directly from the current forester's research project/thesis completed in 2017:

Gap-Based Harvest System: Tree species composition in eastern hardwood forests, in the absence of historic fire regimes, which promoted oak species, is trending toward shade tolerant species in the understory (Smith 2005). Trends toward smaller forest tract size are also leading to an increasing aversion by landowners to large visual impacts (Smith 2005). As the shade tolerant species eventually replace the mature oaks in our forests, serious economic and environmental impacts loom. In Kentucky, where 48 percent of the state is forested, 75% of this forest is oak-hickory, 299 million cubic feet of wood is harvested annually, and 88.5% of the forests are privately owned (USFS & KDF 2008) this issue is particularly important. Forest management objectives across the CHFR increasingly focus on oak (*Quercus*) ecosystem management priorities for both timber and non-timber objectives that rely on maintaining oak-dominated stands to promote understory plant diversity, game wildlife productivity, and neotropical songbird habitat (Groninger 2008). Additionally, invasive exotic species (many of which are promoted by disturbance), increasingly invade and adversely impact our forest lands (Aukema 2010). A harvest method that does not create such widespread disturbance, maintains understory plant diversity and aesthetics, but also promotes oak regeneration, is needed.

This project refers to the areas being harvested as "gaps". Research in the area of gap-based silvicultural systems sometimes refers to harvest openings of various sizes by different names according to gap size, placement, and purpose. Terms such as "group openings", or"patch cuts", "single-tree gaps", "regular shelterwood" and "irregular shelterwood" may all be used to describe gap-based silviculture systems (Kern et al. 2016). An edge environment with greater light availability for seedlings created around gaps has been shown to extent at least 10-30 m into the surrounding forest matrix (Gehlhausen et al. 2000; Matlack 1993; Tryon et al. 1992; Hamberg et al. 2009). *Femelschlag* systems utilize an expanding-gap irregular shelterwood to gradually expand harvest gaps into this edge environment; thus providing a continuous process of specific species regeneration around enlarging gaps until the forest is regenerated (Spurr 1956; Raymond et al. 2009).

The goal of this project is to develop gap-based silvicultural practices that address the oak regeneration problem present in mature oak dominated stands within the CHFR while providing a sustainable management approach that promotes forest health, structural complexity, and species diversity. Many variables influence regeneration dynamics in forest gaps; such as gap size, canopy and midstory structure and edge effects. Understanding these variables and their interaction is an important step towards developing gap-based methods that can be utilized in mature oak forests. These methods are commonly used in Europe, but are not widely documented in North American

oak forests. This study is designed to address the lack of research in the use of such gap-based harvest systems for mature oak forests.

Uneven-aged methods like group selection, even-aged methods which utilize patch cuts, and the irregular group shelterwood (*Femelschlag*) system of Central Europe, are all part of the framework being considered in the development of a more unified gap-based system for the CHFR. The study of these gap-based harvest methods, along with their associated edge effects, are important to the study of the use of gap-based harvest systems and their validity as a management method.

The use of gap-based regeneration methods as a forest management practice has to consider many aspects of forest management before a clear view of its validity for the CHFR can be attained. Difficulties in oak regeneration must be considered under existing gap studies before gap systems utilized in non-oak species can be transposed in any useful strategy. In order to research applicable literature in these areas in a comprehensive manner, this review has been organized into sections. Sections are, in order: difficulties in oak regeneration, gap-based harvest systems, midstory removal, edge effects and underplanting.

Difficulties in Oak Regeneration

Regenerating *Quercus* spp. on productive sites in eastern hardwood forests is challenge to forest managers (Merritt 1979). The lack of oak regeneration in oak stands after various methods of harvesting is a problem across much of eastern North America (Lorimer 1983, Smith 1993). This is of particular concern, as oaks are the most valuable hardwood species group in the eastern United States (Luppold and Bumgardner 2008). In addition to the economic importance of oak species, their value to wildlife cannot be overstated, as they provide the primary source of hard mast throughout their range (Goodrum et al., 1971; Pekins and Mautz, 1987).

Clearcutting and shelterwood regeneration methods, though extensively adopted and studied, have given mixed results (Loftis 1990, Van Sambeek 2003). Meant to promote oak regeneration, these even-aged methods are often successful on poor quality, xeric sites where advanced oak reproduction is present in high numbers but on intermediate to high quality sites, they are not reliable (Johnson et al., 2002). The light intensity needed for oak to reproduce adequately from seed has been considered to be at least 35 percent of full sunlight (Minckler, 1965). Another source indicated that oak seedlings (including red and white oak group) reach their maximum photosynthetic rate at about 30% of full light and this level was difficult to obtain through overstory manipulation alone because of pervasive understory competition (Sander, 1979). Even-aged management on higher quality sites tends to produce mostly shade intolerant species such as yellow poplar (*Liriodendron tulipifera* L.) (Kolb et al, 1990). Also, as the size of forestland tracts continues to decrease across the eastern United States, landowners are less willing to employ these harvest methods (Smith 2005).

Single tree and small group selection; which are more accepted by small private landowners and the public (Smith 2005), have been shown to convert oak dominated stands to shade tolerant species such as red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* L.) and American beech (*Gagus grandifolia* Ehrh.) (Dey et al. 2008, Jenkins and Parker 1998, Lorimer 1983). A study in Indiana suggested that canopy gaps do not significantly benefit subcanopy populations of oak, due to insufficient understory light levels (Cowell et al. 2009). Likewise, harvests which concentrate on the use of group openings to promote shade intolerant species have shown that small openings will result in regeneration of the stand to shade tolerant species (Walters and Nyland 1989). Meanwhile, the "super-generalist" red maple, able to thrive across a wide range of moisture and light availability, is increasingly becoming a main component of the understory in oak forests (Abrams, 1998). To maintain oak composition near historic levels, silvicultural strategies are needed that will result in an accumulation of advance oak regeneration instead of red maple and other shade tolerant species, before the canopy trees are replaced (Johnson *et. al*. 2002).

Gap-based harvest systems

Gap-based regeneration methods for mature upland oak forests could prove to be a beneficial management practice for regenerating oak; particularly where the maintenance of an overstory for an extended period is desired. Sometimes considered a "nature based" silviculture, (where managers try to emulate natural disturbance through creating small openings which approximate windthrow, natural mortality, etc.), gap dynamics has been used to successfully assist in regeneration (Emborg 1997). Harvest methods using gaps of various sizes can be a good fit for aesthetics, wildlife and water quality (LeDoux 1999; LeDoux et al. 1993) by retaining high canopy and large trees on much of the landscape. Property value on small tracts may also be maintained through using gap-based harvest methods by not diminishing aesthetics (Atwood et al. 2009; Miller 1993). Use of gap-based harvest methods, when properly implemented, may improve timber quality and promote intermediate shade tolerant species such as oaks and hickories (Atwood et al. 2009; Ward et al. 2005).

Various sizes of gaps have been suggested for promoting the regeneration of shade intolerant species. Size of opening affects light availability, temperature, and moisture; forming a microclimate (Bradshaw 1992; Dale et al. 1995; Lhotka 2012). Group selection, considered an uneven-aged method, is used for removing small clusters of trees distributed across the stand (LeDoux et al. 1993; Nyland 2002). Group openings generally do not exceed a diameter greater than twice the height of the surrounding trees (Dale et al. 1995; Lhotka 2012; Minckler et al. 2006). In one study, the minimum diameter of 150 feet (46 m) for a gap opening is considered necessary to regenerate large number of trees per acre (Dale et al., 1995). Similarly, a study by Lhotka (2013) suggests the density of overstory oak resulting from an opening was highest in an intermediate opening size (45.7 m), while maple increased in lower opening sizes and yellow-poplar increased in larger opening sizes.

As the harvest openings increase in size from 150 (46 m) to 250 ft (76 m) in diameter, various studies show more shade intolerant species like oak may be regenerated (Dale et al. 1995; Hill 1987; LeDoux 1999; Lhotka 2012). A study of gap size effects on oak regeneration in Indiana revealed that only openings which were two to three tree heights in width were sufficiently large to stimulate oak regeneration (Fischer 1979), while another study suggested a maximum gap size of two tree heights so as not to lose the site protection (Daniel, 1979) and another study suggested controlling light with cuttings not to exceed one acre (Marquis 1965). This study features a 60m (200 foot) diameter gap (0.72 ac) in a forest stand with trees 80 to 100 feet in height, so it falls within the range of gap sizes cited above.

Patch cutting, which combines group selection and clearcutting, produces the biological advantages of clearcutting; while maintaining large trees in the stand (Meadows and Stanturf 1997) and can provide the basis for an expanding gap management system in the CHFR. A patch clearcut is when all trees removed from a small area or cluster not large enough to be characterized as a clearcut (Nyland 2002). The cost of logging in smaller openings is greater than larger openings due to fixed logging costs (LeDoux, 1999), but patch cutting has been shown to be economical for forest landowners (Miller and Stringer, 2007). Studies of group selection and patch cutting in mature oak forests provide data and insights towards a broader gap-based system.

The irregular group shelterwood (*Femelschlag*) is a traditional reproduction method that has been used in Central Europe to address these issues in mixed-species mountain forests with silver fir (*Abies alba* Mill.) (Puettmann et al. 2008). While early forest management efforts developed by Cotta and Hartig in 1804 and others advocated even-aged, homogenous stands (Kovac 2016), methods developed by Gayer in 1898 and others promoted irregularly-structured mixed forest stands and introduced irregular shelterwood and close to nature practices (Kovac 2016). Under the *Femelschlag* system, trees are selected for harvest based on spatial and stand structural considerations; opening up gaps, removing trees for poor health reasons, etc., and utilizing flexible and variable harvest schedules; with the underlying approach to management focused on a small spatial scale rather than a stand-level scale (Puettmann et. al. 2008). In contrast to even-aged systems developed for intensifying wood production, irregular shelterwood practices are grounded on the principles of spatial order, regeneration and tending of forest stands (Diaci 2006) to provide addition ecosystem services such as water supply, retention capacity of soils, carbon storage, air filtering, erosion mitigation, recreation, and other attributes (Kovac 2016). Such an approach may prove to be useful across other forest types.

A study of such “nature-based” management in old-growth Oriental beech (*Fagus orientalis* Lipsky) forests in Iran concluded that such management may be best focused on utilizing a continuous cover approach adhering to *Femelschlag* principles (Zenner 2014). In North America, irregular shelterwood methods such as the expanding gap system may be effective in regenerating species such as oak, as well as the maintenance and restoration of irregular stand structure and other ecosystem-based objectives (Raymond et al. 2009). This study

is designed to help understand how *Femelschlag* principles could be employed in the CHFR to develop specific strategies for targeted outcomes in oak forests.

Midstory Removal

Creating a canopy structure and subsequent understory light environment where oak seedlings can compete forms the basis for many silvicultural treatments. Manipulation of light availability, in fact, is one of the few tools forest managers can employ, since soil conditions, climate, aspect, and other factors are fixed. However, overstory manipulation alone does not regenerate red oak (Crow 1998). Following a regeneration harvest, stump sprouts from small diameter oak stems can produce a viable source of regeneration but mature stands on productive sites in Appalachia (including the study site) exhibit very few small diameter stems (Loftis 1990). Successful oak regeneration thus depends on the presence of advanced reproduction prior to harvest (Dey et al. 2010) and it should be considered the primary source of future dominant oak trees (Carvell and Tryon 1961; Merritt 1979; Sander 1971). Even when advanced oak reproduction is present; however, its success can be hampered by competition. On productive sites, oaks tend to be outcompeted by both shade tolerant and shade intolerant species (Smith 1993). Once tulip poplar (*Liriodendron tulipifera*) overtops oak on productive sites, the oak does not catch up and thus recruitment of oak in the overstory is limited (Beck 1986; Olson 1959; Doolittle 1958).

Canopy opening and understory-species growth, combined, should be employed to understand gap dynamics (Ehrenfeld 1980; Van Couwenberghe et al. 2010). A study of understory response to gaps created by gypsy moth mortality in New Jersey, found no difference in vegetation response to small gaps ranging from the size of a single dead canopy tree to larger gaps consisting of at least five contiguous dead canopy trees (Ehrenfeld 1980). However, the Ehrenfeld (1980) study noted that individuals of understory species tend to occur in dense patches of various sizes and that variations in response to disturbance can be understood and possibly predicted by viewing the disturbance as an interaction between patches of destroyed canopy superimposed over patches of the varied composition in the patchwork of the lower stratum. Preharvest herbicide treatment of undesirable species improves regeneration (Loftis 1983) and could be integral to the success of oak regeneration methods (Spetich and Graney 2003). On higher quality sites, a limited shelterwood harvest, combined with removal of the subcanopy (midstory) has been shown to promote oak regeneration without overly stimulating growth of shade intolerant species (Lorimer et al. 1994; Lhotka and Loewenstein, 2006). Midstory removal is recommended when oak regeneration is already present, or timed when a large acorn crop has occurred, to insure adequate oak advance reproduction. The final harvest should not be performed to release the oaks until the reproduction has reached a competitive height; which could take up to ten years (Loftis 1990).

The purpose of the midstory removal in this study is to serve as a treatment for promoting oak regeneration within and around a forest gap prior to eventual expansion of the harvest gap.

The timing of the gap expansion harvest is intended to coincide with the successful establishment of oak advanced regeneration in adequate numbers and size to outcompete their rivals upon release. Midstory removal has been shown to be successful as a pre-treatment for shelterwood or clearcut harvest in promoting northern red oak (Loftis 1983; Lorimer et al. 1994; Miller et al. 2004) cherrybark oak (*Quercus pagoda* Raf.) (Lockhart et al. 2000; Lhotka and Loewenstein 2006; Lhotka and Loewenstein 2008; Lhotka and Loewenstein 2009) and both black and white oak (Parrott et al. 2012). According to the Lhotka and Loewenstein study (2009), only complete midstory removal appreciably modified the understory growth environment in their study, so this study utilizes complete midstory removal. Little research has been done however, using midstory removal as prepatory cutting to promote oak reproduction beyond gap margins in a gap-based system. This study seeks to help managers to better understand how to effectively use midstory removal in association with a gap harvest.

Edge Effects and Available Light

Forest canopy manipulation not only modifies growth conditions within a treatment area, but also influences forest microclimate in the adjacent forest area (Matlack 1993; Schmid et al. 2005; Lopez-Barrera et al. 2006). Studies have observed greater light availability and increased tree growth and seedling establishment on the forest edge compared to the forest interior (Matlack 1993; Gehlhausen et al. 2000). Oak seedling survival has been shown to be greater on the forest edge created by agricultural fields and pastures (Lopez-Barrera et al. 2006; Schulte et al. 2011), but little research has been done to assess oak seedling establishment or growth trends forest edge environments created by a harvest. One study, which looked at oak seedling response in the hard, or "acute" edge created by a clearcut, suggested that such an edge may influence oak reproduction growth up to 20m into the adjacent forest (Lhotka and Stringer 2013).

Light levels are not evenly distributed in gap openings, and these differences can be largely attributed to canopy height surrounding and shading the gap and latitude (Canham 1990). Studies measuring light in gaps demonstrate that in the northern hemisphere, the highest light levels occur in the northern portion of gaps (Canham 1990; Gendreau-Berthiaume and Kneeshaw 2009). A study in Quebec revealed light levels nearly twice as high in the northern position in (16-25 m diameter) gaps compared to the southern part; concluding that this could allow for the establishment of intolerant to mid-tolerant species in the northern portion of gaps and shade tolerant species in the southern portion due to the angle of the sun in the northern hemisphere (Gendreau-Berthiaume and Kneeshaw 2009). A study evaluating the expanding-gap silvicultural system in the Acadian Forest Region of Maine, concluded that more research is needed to understand how canopy gaps affect tree growth beyond gap margins (Arsenault et al. 2011). The Lhotka and Stringer (2013) study suggested that the dynamics between oak and edge environments be explored along with expanding-gap regeneration methods which utilize appropriate gap sizes (at least 30-50m wide) paired with manipulations of vertical and horizontal canopy structure beyond the gap margin (2013).

A single tree selection system is not a good method to perpetuate the forests of this region. While the early harvesting on Berea Forest and the region was often termed selection, from a silvicultural standpoint it was really commercial thinning or "intermediate" harvests. After a half century of use, researchers recognized that single tree and small group selection systems were not sufficient to maintain tree species diversity for central hardwood forests (Watt et al. 1973, Trimble 1973). Besides loss of tree diversity, there are concerns over the high input management necessary and wildlife diversity loss (Wood and Dewurst 1998). Uneven-aged silviculture of the Forest, as initiated in the early 1900's, assumed that trees of all tree size classes present in a stand were potentially vigorous crown dominants that could contribute to future sawtimber. The "balanced all-aged stand" that could be perpetuated by single tree selection turned out to be a myth that does not exist in nature (Smith et. al. 1997). By mid-century, research not only showed that certain species were not perpetuated by this method, but also that suppressed trees, even shade tolerant species most favored by selection (Smith et. al 1997), may not respond to crown release vigorously if they have been suppressed long enough. They may persist, however, leaving a stand dominated by slow-growing, low quality trees (Trimble 1973). A selection system is a high input system, with frequent stand/soil disturbance due to repeated stand entry. Single tree selection can be used sparingly for research as comparison to other systems.

5) Site-preparation for Hardwood Regeneration: All of the silvicultural recommendations above employ some site-preparation to enhance regeneration that will make up the next stand. The site preparation that is conducted immediately before or after the regeneration harvest (clearcut) is easy to plan with the harvest. Coupled with the harvest, it eliminates competition for the regeneration, imitating the occasional stand replacing disturbances (weather, insects, fire, etc.) that have shaped the forests of this region for millennium. For oak regeneration on sites that are too poor to support sawtimber yellow-poplar (upland oak site index < 60), the site-preparation in proximity to harvest is all that is worth investing in. Such areas are currently oak dominated and, due to poorer site quality, some oak stump sprout regeneration and regeneration that can compete on these poorer sites is likely. It may be less effective than an earlier treatment, but some oak component is likely. For these sites, if the site preparation can be applied 3-5 years in advance, better success can be expected. Herbicide treatment of non-oak species may or may not be necessary on these sites. The current research on the Berea Forest should determine this. In the meantime, herbicide should be used on stems > 1 inch DBH removed.

Thinnings from below in oak shelterwood treatments on intermediate productive sites also imitate a critical historic disturbance regime that allowed light to the forest floor. One of the difficulties of applying this is the time/resource constraints of applying the treatments well in advance of the harvest. For intermediate sites (upland oak SI ≤ 85 ≥ 60), the treatments should be applied 5 to 6 years in advance of the harvest on as much of the planned regeneration harvest area as time and resources permit. The 5-6 year advance scheduling is difficult, but does not require as much planning as required for highly productive sites. For both, it can be overcome with mapping

technology (GIS/GPS) already in place that can aid in harvest record keeping, regulation, and planning. This is the main bottleneck for increased production, properly done, on the Forest. With an additional forestry technician and GPS incorporated into our operations (both in the works in 2012), greater productivity is forthcoming, which will enable us to reach and maintain harvest levels recommended in this plan. Better record keeping will also aid in keeping up with what needs to be done.

This type of site preparation is dependent on having existing seedlings and/or a seed crop from oak (or walnut) that can benefit from the treatment. Such sites currently have adequate oak overstory and some established seedling regeneration is usually scattered over the site. The 5 to 6 years may not be adequate time for some seedlings to develop, but developing some advance oak regeneration is probable on sites of this quality. The site preparation in proximity to harvest will also need to be applied to release oaks. Some walnut may be present on the best of this productivity range and it will also benefit. Yellow-poplar will persist on the best sites in this range, but may have difficulty at the low end. Whether by injection or cutting, herbicide treatment of all non-oak stems > 1 inch DBH is necessary on these sites. Oaks (and walnuts) may be cut and allowed to sprout.

Site-preparation that must be applied well in advance of the harvest on highly productive sites (upland oak SI < 85) is much more difficult to schedule and apply because it may have to be applied as much 10 years or more prior to harvest. Given the impoverished state of oak and black walnut components on these productive sites on the Forest, selective application of low thinning will be the best investment. While black walnut has reliable seed crops, oaks are notoriously irregular. It is quite possible to invest in the site preparation where oak seedlings are few and the seed crop comes too late in a 10 year interval (or not at all) to benefit. The goal on these sites is not a strong oak/walnut component, but <u>some</u> oak walnut component—diversifying the stands. Areas around existing black walnuts and those that have actual oak seedlings, regardless of how few or small can be targeted. Areas in the vicinity of oaks where no seedlings are present may receive some treatment, with the possibility of a seed crop. However, significant investment in this activity may not justify returns. This selective method will involve treating areas of 1-3 acres around existing oak seedlings and existing walnut or oak trees. Herbicide use as describe above is required.

Low thinning and harvest associated site preparation will not eliminate other species from the new stands. It will only increase the oak or walnut component and reduce the amount of low quality stump sprout trees of all species. Other species in all levels of shade tolerance will still be present.

Large Tree Silviculture

The College Forest has been managed to produce quality timber since its acquisition. This means producing trees of relatively large size. Commercial thinnings leave sufficient trees of large size

to grow until the final regeneration harvest. Because regeneration harvests come infrequently, at any given time most of the landscape is covered by stands of high-canopy trees of large size (trees exceeding 20 inches DBH).

The current condition of the Forest offers the opportunity to continue this condition. The notoriety that Berea College obtained through the Mayflower II restoration project…and stands to achieve again through the currenWestern Flyer restoration project, is a testament to the value of retaining high quality, large white oak trees to their maximum potential. However, there are challenges due to the current age of many stands. Trees like shortleaf pine, scarlet, black, and southern red oak that have achieved large size at the ages currently found on much of the forest (> 100 years) may be risky to leave for many decades. This is especially true of scarlet oak. Virginia pine is difficult to thin without subsequent wind-throw loss after 60 years. Some steep hillsides have shallow soils (as do areas adjacent to some streams) and uprooting/wind-throw may result when large trees are retained after a harvest. The maximum biological life of a given tree species is well beyond the age of a reproductive population that can produce genetically diverse regeneration.

However, some trees over 24 inches DBH may be retained at harvest on most acres of the Forest. The anticipated period until the next (perhaps final regeneration) harvest may determine which trees may be left. Trees over 30 inches DBH can be left, but should be examined carefully if considered for retention. The presence of larger, high quality trees will help sale returns at regeneration harvest and maintain structural diversity to support biodiversity goals while standing. In any harvest, residual trees that are to be retained to a later harvest must be protected from logging damage. This has been done on the Forest for a century and requires proper harvest layout, oversight, and contract provisions (e.g. specifying skidding at no more than 32 feet in some cases). Directional felling and careful skidding are necessary to accomplish logging of this sort.

Legacy Trees and Stands

Even if recommended silviculture on Berea Forests continues to maintain a landscape that is characterized by large, high canopy trees, for a variety of biological diversity and aesthetic reasons, individual large trees and stands that contain trees characteristic of the largest trees represented in the Forest today should be maintained. Productivity is not a primary objective in these areas. Legacy stands can be thought of as extractive reserves where light thinning harvesting takes place as adjacent areas are harvested, while maintaining stands of large older trees. Large individual trees, that due to species, location, and vigor have a good chance of persisting, can be protected in harvests as legacy trees and may be left standing alone in regeneration harvest areas. Legacy stands (or trees) will not persist indefinitely and species loss in the overstory and understory may occur overtime. They can be monitored for management needs to help maintain diversity. The group selection method outlined above is a good way to create areas of regeneration that may increase diversity. Areas used for reservoir buffers and recreation areas where harvesting does not take place will contribute to legacy stands. Tree mortality and accumulation of standing and down deadwood (course woody debris and snags) will contribute to stand biodiversity features. However, there is a diminishing biodiversity benefit to deadwood after plenty is available, so

utilization is desirable at some level, especially salvage in instances of high stand mortality caused by weather events, fire, insects, disease, etc. Production silviculture can salvage mortality after such events. Seven Legacy Stands: Davis Hollow, Baker Hollow, Owsley, Silver Creek, Cowbell, Shearer Hollow, and Grant Hollow are recommended and are included in the Appendix (Figure 2). Other Special Use Management Areas used primarily for research: UK Research, UK Butternut, Horse Cove Research, and Webb Chestnut; Dogfoot Springs, already a Legacy Stand; and Anglin Falls Nature Preserve, are also featured on the map. These Special Use Management Areas, combined, comprise approximately 500 acres. Since these designations were made by the former forester, John Perry, over 700 more acres of forest land has been purchased, and recreational use of the forest has expanded. Thus, it may be advisable to consider increasing the number and/or size of our Legacy Stands. The Berea College Forest now being over 9,000 acres, it would seem to me appropriate to set aside at least 10%, or 900 acres, in Legacy Stands.

1988 Fire Area

The area burned in the 1988 fire was salvaged in a single harvest operation that removed virtually all merchantable trees from accessible areas in 2012. Post-harvest silviculture was being implemented until the right of way into this area was "taken over" by a new landowner who purchased the Croucher property that lies at the entrance of Baker Hollow and refuses to recognize the historic easement back to the Berea College Forest.

Early Successional Forest Stands

These stands that have been created since 1980 by planting, regeneration harvests (clearcuts), and old field succession will not contribute to harvestable volume for several decades. Intermediate silviculture in these areas includes killing exotic species, controlling grape vines, and pre-commercial thinning to favor desirable species and increase growth. The latter is not necessary, but can be applied if other stand work is conducted adjacently.

Harvest Site-preparation Silviculture

Non-commercial operations that enhance growth, value, species diversity, and target non-native species can be scheduled relative to planned harvest. Assessment of potential harvest areas is a good time for the forester to assess other stand needs. The silvicultural prescription of commercial thinning that maintains a canopy cover except for a final regeneration harvest is designed to minimize the need for intermediate silviculture by keeping a canopy over most of the forest for most of the time. Thinnings from below to enhance oak regeneration would be completed 5-10 years prior to harvest to develop healthy oak regeneration. This can also be utilized for enhancing black walnut regeneration. Grape vines should be cut and non-native species killed at this time. Oak regeneration can later be evaluated for readiness (adequate size) to determine exactly when the harvest should take place.

Treatment of residual subcanopy not removed in the thinning from below may be done just prior to or after harvest by herbicide injection or felling with herbicide stump treatments to prevent sprouting. Oak and walnuts would be spared from injection or cut-stump herbicide treatments, but

may be felled to just before/after harvest to encourage stump sprouting. The post-harvest stand should be checked for non-native species and grape vine problems.

Intermediate Silviculture

Noncommercial crown thinning to favor desirable trees and speed growth can be made if resources permit. Concentrating silvicultural operations in proximity of harvest is likely to consume time and funding available for such operations. However, noncommercial crown thinning may benefit favored species and productivity. NRCS cost share programs are being used beginning in 2012 to fund College forestry staff and operations

Minimum Tool

While some intensive silviculture for research purposes may be desirable, lower intensity methods reduce costs and management oversight…and, quite frankly, there is just not enough staffing on the forest to perform intensive silviculture on a large scale. Hiring consultants/contractors to implement thinning from below over large areas would be advisable, if the cost can be offset with NRCS funds. This has been attempted on numerous occasions, but little to no interest was found among Kentucky forestry consultants to do such labor-intensive work.

Thus, the method that accomplishes a silvicultural goal(s) with the minimum resource inputs and long-term site impact is thus desirable. This can be called minimum tool (a term used to describe firefighting procedures used in Wilderness Areas). The more disturbance-dependent a silviculture goal is, the higher the level of intensity of management required. Minimum tool may be found through consulting research or experimentation. That is one reason this plan recommends wider use of even-aged methods. Over the life of a stand, an interval of well over 100 years, it represents minimizing the inputs and impacts.

Small and Low Grade Trees

Currently, pulpwood or fuel wood markets and other markets for small, low grade trees do not exist in this area. The ability to harvest these trees, even if returns are small, offers the chance to improve stand quality and health while realizing some return. Pulp and fuel wood markets are likely to develop soon. They may be utilized for stand improvements. It is important to avoid over harvesting that depletes soil productivity by removing too much biomass. Research is needed to determine safe extraction levels. In addition to its value in nutrient cycling, down wood is necessary for biodiversity maintenance. A vast amount of firewood, if nothing else, could be obtained while accomplishing needed thinning operations…but due to the rough terrain, it would scarcely be feasible under current conditions.

Plantations

There are small tree plantations of varying ages scattered throughout the Forest. None of them represent large contiguous areas. They can be managed and utilized along with adjacent areas. Loblolly pine planted in the 1950's can be harvested as adjacent areas are cut. Younger plantations may require thinning to help growth.

There is no land that requires reforestation at this time. The openland habitat remaining is too valuable for landscape biodiversity. Shortleaf pine establishment as described above is the principal tree planting required in the future. Openland areas and forest edges can be lined with small flowering/wildlife trees to create better edge habitat and aesthetic enhancement. The Kentucky Division of Forestry now sells these species and they can be obtained at commercial nurseries. Enrichment plantings of oaks, black walnut, butternut, and American chestnut (when a resistant cross is available) can be considered for timber harvests. With oaks and black walnut, developing advance regeneration requires a lower level of inputs/costs, but requires action well in advance of harvests. Any plantations/tree planting should focus on native species.

Non-native Invasive Plant Species

Non-native species should be targeted for elimination on an ongoing basis. When stands are evaluated for harvest or site preparation before harvest, non-natives can be assessed. Problem areas can also be identified during marking when the stand is covered thoroughly. They can be treated prior to sale. Herbicide is usually necessary for control of invasives. Extensive labor is employed every year in this endeavor, but scarcely a dint is made in it without an army of invasive species wackers and sprayers. Again, little interest has been found among the private practitioners to engage in such labor-intensive work in this area and cost-share assistance is not enough to entice a wholesale effort against this scourge.

Grape Vines

Wild grape development is currently damaging much of the forest. Top breakage and tree mortality from grape is common. Areas of several acres have been reduced to scrub arbors due to grape. When not treated before regeneration harvests, they can smother regeneration. However, wild grape makes important biodiversity contributions in both food and cover. At this point, it has progressed to a damaging level and management is necessary.

Management of grapes forest-wide is needed. Grapes should be cut from high quality trees and the scrubby arbor areas. Herbicide treatment is not necessary where a high canopy exists, unless a harvest is planned for the area in the next 5 years. Herbicide treatment or repeated cutting is necessary for high light environments created by arbors that have suppressed tree growth or when a harvest is planned in the next 5 years (any harvest that significantly opens the canopy, especially a regeneration harvest). If the canopy keeps sunlight to a minimum, cut vines will lose strength to compete in about 5 years. If that is not possible, they can be controlled by injection (best) or cut surface herbicide, for vines too small to inject, just prior to harvest. Vines can be left for biodiversity in low quality trees in closed canopy stands and commercial thinnings. For closed canopy areas, a fewer number of large grape vines left in low quality trees is preferable to many small vines scattered through a stand. Grape vines should also be managed in legacy trees/stands and preserve area. They can be a factor in the loss of large trees.

Special Use areas

Three special use plantations are located in the Forest (Figure 2 in Appendix). There is a chestnut

progeny orchard managed in cooperation with the American Chestnut Foundation (ACF) on the Webb tract. The trees in the plantation belong to the ACF and may be removed by them at any time. As of January, 2019, only 22 surviving trees remained. However, due to a grant by a generous donor, this area is designated to be turned into a Mother Tree Orchard for growing Kentucky 100% American chestnut trees for breeding and nut production. This is to help develop resistant American chestnut trees and crosses for outplanting in the region.

A butternut progeny orchard is located behind the caretaker's house in Silver Creek hollow. The trees are from seed gathered in this region, mainly in the Berea area. They are to be managed to produce seed for outplanting. Additional seed should be located there as individual trees that show canker resistance are found and seed collected. A few individual pure American chestnut are located along the access road to the caretaker's house as a seed orchard.

A grafted nut tree orchard is located in the bottom of Brushy Fork creek south of the foot bridge. Pecan, hican, hickory, black walnut, butternut, persimmon, and paw paws are planted there. They are to be managed for food production and the area between the trees for hay as an agro- forestry demonstration area. Prescribed burning may also be an option for this area. All these areas are included in the field area use designation because growth is young.

Herbicides

The use of herbicides is recommended for both silviculture and invasive plant control. Proper herbicide use does not threaten the environment or applicator. In many cases, herbicide use may achieve a management goal with less fossil fuel input than mechanical methods. Still, herbicides are dependent on fossil fuels for manufacture and their use should be minimized. Herbicides that biodegrade relatively quickly, soil bind (so they do not easily move in water), and do not cause off target effects are recommended. Those include glyphosate and triclopyr. Herbicides such as 2,4-D, atrazine, and picloram should be avoided within the watershed, and limited elsewhere to uses associated with research. Herbicide use should be limited as much as management goals will allow for economic and environmental reasons.

Many uses of herbicides are aimed at creating stand conditions that were once fire dependent. Prescribed fire may substitute in some future time. At this time, the biodiversity loss is at a critical state and herbicides must substitute until prescribed fire research and capacity catch up.

Summary of Forest Silvicultural Goals

Silviculture goals are primarily to maintain forest cover that contains larger, high value trees until a stand is ready to be regenerated as an even-aged stand. Some 2-aged and group selection systems can be employed. Regulation of harvest levels and maintenance of forest overstory diversity is more difficult with these methods. Maintaining forest diversity at many levels is an important goal for the silviculture chosen. Perpetuation of fire dependent species (oaks, shortleaf pines, chestnut, etc.) and structures (open understory, young even-aged stands) is an important silvicultural goal to

insure ecological health and maintain timber values. Non-native species must be controlled for both ecological and economic reasons

Harvest Regulation and Organization

1) Soil productivity as determined by the 1959 inventory indicates that over 1.3 million board feet per year can be produced by the 6,800 acres available for harvest. However, to meet conservation/sustainability goals and insure a supply of large, high quality trees, annual mean harvests should be held to 500,000 to 750,000 board feet per year for at least the next 10 years, requiring increases in staffing and funding for forest operations. After that level of harvesting has been applied for the period, an evaluation should be made to determine if adjustments are necessary. Growth indicates that larger average annual harvests are possible. All sales of high quality timber should be conducted based on marking (100% tally of trees for sale) and sealed bid stumpage sales with upfront payment. This will insure the best price. Lower quality harvests; such as for salvage or research, could utilize cutting on shares, if warranted.

In assessing the capability of the Forest to sustain the suggested production, it is important to note that over 1.2 million board feet is a sustainable annual yield for the 6,400 acres inventoried for this plan. That is estimated to be just over 2% of current standing volume on that area. Commercial thinning will improve growth on areas not scheduled for final harvest (although growth is not expected to increase dramatically due to average tree age). Growth in young stands will increase as other areas mature. Areas that receive regeneration harvest in the early years will be approaching sizes eligible for commercial thinning by at least age 50. Additionally, the 6,400 acres is designed to be a conservative estimate for the area that can contribute to production the 300 acres in the 1988 burn area can contribute harvestable growth in the short run (although of poor quality) and healthy growth when regenerated. The 100 acres of young stands created by regeneration harvests (clearcuts) in the 1980's through 2008 will begin to contribute merchantable volume by 2040.

The growth of 200 board feet/acre/year determined by the 1959 inventory provides a safe increment as a basis for sustainable harvest limits. The limited inventory made for this plan indicates a higher possible harvest. However, the nature and intensity of the inventory make the growth values applicable only to the current sawtimber stand. Harvest levels based on the more extensive growth data of the 1959 inventory provide a safer increment to insure sustainability. The recent inventory data do indicate that individual large harvests that take advantage of peak timber markets can be conducted safely. That can be balanced with smaller harvests in poor timber market conditions. Additionally, low impact harvests can be conducted in reservoir buffers on occasion without danger to water quality. Even if they are very infrequent, they can supplement production. The conservative approach recommended in this plan can also insure that legacy stands can be maintained.

2) In order to establish harvest preparation and silvicultural management procedures, the first harvest should be held to 500 to 800 thousand board feet. That is a large enough harvest to generate market interest and help establish management protocols that will guide larger harvests in the future.

3) Harvest preparation and silviculture requirements will be better met by having larger harvests approximately every 3 years as opposed to annual harvests. The total cut should reflect the annual harvested volumes recommended (e.g. single sale 1.5 to 2.4 million board feet every 3 years). This gives several years between harvest preparation and site preparation or other silviculture required to insure diversity and productivity. Larger sales will draw better buyer competition. These large harvest areas may be separated into 2-3 units of known volume during the marking. Though bids should be solicited based on the total sale, upfront payments proportional to the percent of volume in the unit can be made as the harvest progresses. Upfront payment frees the forester from having to monitor harvested volume and gives leverage to help keep the logger within the contract. A separate performance bond, refundable to the buyer at harvest completion, is also desirable.

4) Revenues may not be annual, based on the recommended approach. However, an average annual return can be computed over a 10 year or similar period. Funding required by site preparation to regenerate stands can also be evaluated against revenues. Because the funding is set up on annual budgets, it is important that budgets used to insure healthy stewardship are appropriated relative to average annual revenues (based on harvests).

5) Fall and winter harvesting are best for biodiversity protection, but it is impossible that large harvests can be confined only to this period. Winter and spring offer difficult logging conditions that make soil and water protection difficult. Some disruption in habitat is inevitable (just as in a fire cycle). Contracts can be set up so that most harvesting activity occurs in late summer and fall and nesting/growing season impacts are minimized.

6) Setting a required annual harvest level is not necessary. As an educational forest, options for research and demonstration may dictate levels. Additionally, this will be market driven. Taking advantage of good markets and/or research/demonstration opportunities requires flexibility. Salvage requirements driven by disturbance by weather, fire, insects, or disease require flexibility. This plan gives a recommended harvest level for the next decade based on large sales every 3 years or so with possible upper limits of annual harvest levels. The flexibility necessary to manage an educational forest will determine actual harvest levels.

Soil and Water Conservation

Production forestry and quality water production has coexisted on the Berea College Forest for over 100 years and can continue. Best management practices (BMP's) for water and soil protection have been researched and mandated by Kentucky law to address this. This plan also allows for

500 acres over the entire forest as production reservoir and stream buffer. This may exceed actual needs. Karst features like caves, springs, and sinkholes should be protected using appropriate BMP's for both water quality and biodiversity reasons. Contracts should also specify cessation of logging in weather/soil conditions that are not conducive to soil and water protection.

Low impact harvests may be considered for reservoir buffer areas. Additionally, some silviculture to maintain diversity can be practiced in these areas. Large stand disturbances due to weather or fire should be assessed for salvage in these areas.

Biodiversity

Wildlife management has been a stated management goal for the Forest in the post-war period. Wildlife is often only associated with fauna, but includes all native wild fauna and flora (Hunter 1990). Biodiversity conservation is the goal of these recommendations.

Course-filter approach: A course-filter approach as outlined by the Nature Conservancy (The Nature Conservancy 1982) is the best approach for the Berea Forest. Rare, threatened, or endangered species that require a fine-filter approach over a wide area are not present. A course-filter approach involves maintaining a wide variety of stand conditions across the Forest to meet the needs of a variety of native species. A variety of stand ages, structures, compositions, and spatial heterogeneity should be maintained. These conditions will shift around on the Forest as stands age and new young stands are created. At this time, early successional habitat--young forest stands and fields-- necessary for many species is probably the habitat type most lacking. Increased harvesting will promote this type of habitat.

Spatial variation and heterogeneity: Spatial variation and heterogeneity are important in the coarse-filter approach for managing for biodiversity. Larger continuous units of habitat types offer the best approach. Edge is minimized and individual habitat interior maximized. Silviculture calls for most of the forest to be mostly in older, closed canopy, high forest (taller trees) at any given time. These areas will accommodate species that require this habitat. However, early successional forest habitat is important for some plants and animals. Spatial variation that is heterogeneous across the Forest, but that maximizes the size of older, closed canopy and young even-aged forest units is desirable. Group selection silviculture, while showing early indications of success, should be used sparingly until the many small openings it creates can be adequately researched and assessed against the suspicion that they can lead to too little interior for either early successional or mature forest species.

Shortleaf pine habitat: As noted, shortleaf pine composition has been lost on the forest. Only scattered remnant trees exist; yet, these are still better than can be found across much of its range in the east. Species like pine warblers and pink-lady's slippers need pine cover (on toe slope sites). Pine regeneration harvests as described earlier, should be at least 5 acres, and preferably 10-15

acres, to provide habitat interior (except smaller 2.5 acre units are permissible on sandstone ridges). Burning and gradual conversion of larger areas back to shortleaf pine is a worthy endeavor.

Oak habitat: The loss of American chestnut, some 70 years ago, increases the importance of maintaining oak mast production for a variety of species.

Chestnut restoration: Berea College has participated in work aimed at restoring American chestnuts to the region. The cross-bred chestnuts (at least 15/16's genetically American chestnuts) and probably genetically modified chestnuts too, will soon be available. Plantings should be made to establish the seed source for future natural spread. Research conducted on the Berea Forest shows high sunlight environments are necessary for chestnuts to develop and compete in timber harvests. Harvests in 2014 have proven this, as over 80 American chestnut sprouts have been found on this area and one tree that had to be present prior to the harvest was found that was 40 feet tall and seven inches diameter.

American chestnuts periodically sprout from old stumps in in clearcuts and open two-aged shelterwood harvests. Release by directed foliar herbicide treatments similar to methods described for shortleaf pine establishment (including stovepipe to protect chestnut), except radius of the area of spraying can likely be smaller due to better shade tolerance of chestnut. Some experimentation is necessary to determine this. Chestnut is best suited for well drained, but productive areas of site types 3, 4, and 6.

Butternut: Inventory conducted in 1950 shows butternut ("white walnut") to be as common as beech on the Forest. The butternut canker has eliminated that component. Scattered butternut can be found. A small butternut progeny orchard has been established just south of the water plant. Seed or seedlings from butternuts that have shown canker resistance should continue to be established for this seed orchard. Butternuts that have reached a size/age where they can produce nuts, especially if the trees show resistance to the canker, should be protected in timber harvests and favored in thinning. Work currently being conducted at University of Tennessee and Purdue University to conserve butternuts can be followed to help in this effort. Butternut is most commonly found on the most productive areas of site 4, but can also be established on well-drained areas of site types 1 and 5.

Neo-tropical songbirds: Many neo-tropical songbird populations are declining. These species make good indicators of habitat health because different species use a variety of habitat types. According to Biologist Chuck Hunter, formerly chair of Partners in Flight for the Southeastern United States, 70% of the species of concern are early successional species. Even-aged regeneration harvests can provide habitat for early successional "shrub nesters" that use young forests. "Fewer, larger clearcuts are desirable" because they increase interior habitat and decrease edge and do not fragment mature forest as much (Hunter1990, Thompson and Desseker 1997). The use of small gap harvests; when followed up with midstory removal, can also provide early succession habitat, and more research is needed in this area to assess their compatibility for this.

The thick low seedling/sapling layers that develop under a high canopy after oak site preparation treatments (applied 5-10 years prior to harvest) are good nesting habitat for some bird species. Maintaining a majority of the Forest in high canopy forest helps crown nesters. Wildlife open fields are important for species that use those areas.

Species of concern: While few, if any, species that have been listed as endangered or threatened are known for the Forest, there are many species of concern. Amphibians of many species make the retention of closed canopy forest with ample large, down wood important. Protection and establishment of small vernal pools located in shade or forest edge is important for this purpose. (Vernal pools/ponds have water in winter through early summer, but dry out for a time in late summer/fall in most years.) Building vernal ponds can be done cost efficiently (1 hour or less per pond) by paying logging machinery operators while they are closing down a logged area.

Many species of snakes are species of concern due to persecution and habitat loss. Timber rattlesnakes are among these. There is a 1950's record for a rare scarlet snake in the Cowbell area. Snakes like open, high sunlight areas and frequent recent regeneration harvests (clearcuts). Several bats are species of concern. Rafinesque big-eared bats have been found on the Forest and utilize cliffline rock houses. Transient black bear are regular summer visitors to the area. The Berea Forest is too small to support a resident breeding population. However, the Daniel Boone National Forest contains some large contiguous forested areas in nearby Jackson County that may support resident populations. This may mean that breeding sows have the potential of locating on or near the Forest. Maintaining oak components, chestnut restoration, and berry foraging areas provided by regeneration timber harvests support bear habitat. While bobcat appear to be doing well on the Forest (based on tracks and rare sightings), they should be protected from hunting and trapping.

Clifflines: Clifflines are critical habitat for many plant and animal species. Clifflines shaded by tree cover are important for some species while exposed clifflines benefit other species. A single cliffline management strategy fails to meet some biodiversity goals. Clifflines that have rock shelters or small caves that serve as maternity habitat for bats require shade to maintain proper summer temperatures. Silviculture that maintains some canopy cover is desirable in these areas. In other areas, harvests that expose clifflines benefit species (e.g. reptiles, glade plants, peregrine falcon, etc.) that utilize sunny cliff areas. Because the predominant silviculture recommended in this plan keeps high canopy forest on the majority of the landscape at any given time, most clifflines will be shaded most of the time, but regeneration harvests will expose some to sunlight.

Karst Features: The Berea forest has karst features from the Mississippian limestone strata. Springs and small caves provide important habitat. (Few extensive caves exist on the Forest). These features should be protected. Keeping a shade cover on them is important. BMP's directly address sinkholes and springs.

Forest Herbs: Forest herbs are important for both economic and ecological reasons. The recommended silviculture that maintains mature tree cover over most of the Forest at any given

time will help conserve forest herb diversity. The heavy cover of subcanopy, especially low woody cover like small trees and shrubs is detrimental to forest herb diversity. Low thinning for oak regeneration will also help herbs. However, that will only be used near the end of a harvest rotation and thick subcanopy can develop only a few decades after a regeneration harvest. Some stands may be enhanced for herb diversity by understory treatments or the use of prescribed fires that kill or knock back low woody cover. Invasive plant species are threats to herb diversity because many leaf out early in the spring (and hold leaves late into the fall) and narrow the window of vernal and/or autumnal forest floor light some herbs require.

Some forest herbs have economic value that can be utilized by the College or used for demonstration, class project, or research purposes. Ginseng, goldenseal, and wild leeks are some of the more noted species. Wild cultivation is preferable to foraging, but foraging is feasible if wild stocks are not utilized too heavily. Theft, especially ginseng poaching, is a problem for some forest herbs in this region. Those identified stealing should be prosecuted to set the example for sustainable non-timber forest product economies in the region.

Den trees and Dead Wood: Snags (standing dead trees), down dead wood, and den trees (contain hollow trunks or branches) are important habitat features. Some den trees should be left in commercial thinnings. Snags can be left in both thinning and clearcuts as long as they are not a threat to the loggers. When salvaging down trees as part of a harvest operation, some should be left to serve as habitat. Precise numbers of den trees, snags, or down logs/wood that should be left are difficult to prescribe. The availability will differ in various areas. The past (and recommended management) of the Forest has maintained tree ages and stand conditions that insure den trees and dead wood structure are present. Dead wood can be created by girdling (with & without herbicide) or herbicide injection in timber stand improvement/site preparation operations. Deadened trees will stand as snags for a while and fall to create down wood. At the regeneration harvest point of the cycle, den trees will be harvested, but standing and down dead wood will be available for many years after the harvest. While the opportunity to sell trees for pulpwood or energy markets can improve management options, it is not desirable to remove all dead wood from a harvest area.

Open land/field habitat: The Berea Forest ownership is mostly in tree cover. Open land (old fields) is an important habitat component for biodiversity (fauna and flora) in such a landscape. These areas are maintained by annual or biannual mowing at the end of the growing season. The early growing season is important for nesting for many species. However, because woody vegetation may gain advantage when mowing is annual or less frequent, some areas may be occasionally targeted for mowing twice a year with a growing season mowing (mid-summer so most nesting is over) to control woody plants. Where possible, these areas should be converted from cool season grass cover to native warm season forbs and grasses. Many areas have already been converted.

Fire is an alternative to mowing, but difficult for a private entity to use under Kentucky laws. Additional open land habitat…approximately 27 acres of poor, old pasture…exists on the Bree

Tract that was purchased in 2014. The open pasture area here affords the first opportunity on the Berea College Forest to create an appreciable large and remote native grassland habitat area that can be managed with fire. This will benefit biodiversity and provide the College with a showcase native grass/savannah area that could become another model for the region. The area has been signed up through NRCS for EQIP funding to convert to native grasses. Assuming it is approved, the Forestry Department's staff should be burn-boss certified by the time the grass is established, to begin managing it with fire.

Hunting: Deer hunting has been permitted on the Forest most years since the late 1990's. Because excessive deer populations can reduce vegetation diversity and damage tree regeneration, continued deer management through hunting is desirable. Illicit deer hunting is more likely to occur if a no hunting policy exists. Deer are a source of low energy input, healthy meat for the community and they may be utilized for that purpose.

Other game animal hunting, with the exception of wild turkey and squirrel, are not in sufficient numbers to consider for hunting. Turkey and squirrel hunting may be considered as a privilege for employees and earned by student forestry labor students, but should not be wholesale allowed.

Beaver: Beaver have dammed small streams in Silver Creek and Owsley. Except where their dams are located immediately adjacent to the water plant, or threaten essential roads, they should be allowed to persist. They kill trees in the area, but provide important wetland habitat for dependent fauna and flora. Trapping of beaver to control their numbers in problem areas should be allowed.

Preserves/Legacy Stands: The legacy tree/stand approach described above is the best way to retain old growth characteristics over an extended period of time and still maintain canopy tree diversity. Berea Forest currently maintains a KY State Nature Preserve at Anglin Falls and it fulfills the role of a preserve. Areas considered for preserves should have some very unique features that set them apart from areas that might be managed as legacy stands. Dogfoot springs qualifies as sufficiently unique to be managed as a preserve. This would include 50 or so acres of the immediate hollow. Some silviculture to treat invasive plants or maintain tree diversity may be necessary from time to time. The small hollow (50-70 acres) that lies just south and west of Dogfoot springs has a similar composition and can be managed as a legacy stand. This gives a good side by side management comparison for demonstration and research value. It may be desirable to have Dogfoot springs dedicated as a State Nature Preserve as long as the agreement allows for non-extractive management to address biodiversity maintenance. Five other legacy stands are proposed.

Biodiversity and Related Partnerships: Berea College is fortunate to have conserved forest in an area that has largely been compromised by development. From a biodiversity standpoint, this is a significant contribution to the public good. Partners should be sought that have an interest in conservation. The KY Department of Fish and Wildlife Resources, KY Division of Forestry, KY

State Nature Preserves Commission, Nature Conservancy, American Chestnut Council, Forest Stewards Guild, US Forest Service, Natural Resource Conservation Service, University of Kentucky, and EKU (the latter two for research) are logical partners. The need for prescribed fire may be addressed through partnerships. Funding, research, and technical assistance are available through agencies and public Universities. Where possible, written agreements to formalize these partnerships are desirable…the MOU with the Kentucky Division of Wildlife for burning for example. A forest landscape managed for production silviculture offers considerable opportunity for biodiversity management and research because of the habitat diversity that can be created and maintained.

Non-native threats: Non-native species offer a considerable threat to both biodiversity and forest productivity and health. Non-native, invasive plants threaten biodiversity and economic productivity of the region's forests. There are several species that have established in the Forest. While birds and wind deposit seeds throughout, problem areas spread around established individuals or groups. Production silviculture, while it may help invasive, non-natives thrive when exposed to light, can also be means of controlling them. Site preparation/timber stand improvement operations, timber sale preparation, and post-harvest regeneration assessment are times when non-native plants can be located and eradicated. Additionally, the stem exclusion phase that follows a regeneration harvest by several years is a great time to eliminate non-native plants. The tough competition for light that follows can eliminate non-natives that are cut back. Herbicide may not be necessary at that time, but is required for their control at most other stages of stand development. Where site preparation to develop advance oak or other species regeneration is applied, invasives can be located and treated. Timber marking requires a thorough cover of the stand on foot and non-natives can be located then. They should be eliminated with herbicide treatments prior to harvest.

A variety of non-native insects and diseases are infecting the forests of this region. Species like the emerald ash borer and hemlock adelgid may virtually eliminate those tree species from the region. Gypsy moth and sudden oak death (*Phytophera* sp.) threaten an oak population that is already declining due to changes in fire ecology. It is economically and physically impossible to treat the entire Forest for an infestation. Individual legacy trees may be targeted for treatment. Otherwise, the best method of maintaining forest health is to have a variety of physical, compositional, and age structures in the Forest. Production silviculture can be used to maintain those structures while salvaging infected trees that may harbor pests and maintaining stocking levels that promote tree vigor. It also encourages stand assessments that help in locating problem areas.

Native Threats: While non-native species pose by far the greatest threat to forest health, given the fragmented and stressed forests, native plants and animals can also be problems. Overstocked stands are vulnerable to high mortality rates from native insects and diseases. (e.g. Heavy white oak mortality due to defoliations/borer infestation and heavy southern pine loss to southern pine beetles 2000-2003). Maintaining diverse and properly stocked stands as described above is the

best defense for native insect and disease problems. High deer populations can eliminate plant species, destroy bird (and other species) nesting habitat, and impact healthy forest regeneration. Since deer lack natural predators, population control through hunting is necessary.

Native plants, especially given the change in fire ecology, can threaten biodiversity. The shift to heavy cover of shade-tolerant trees (maples, beech, etc.) caused by changes in fire regimens threatens diversity in both the overstory and herb layer. Tree species that spread by root suckers (blackgum, sassafras, aspen, etc.) may locally reduce overstory diversity. While it is a valuable, fast growing tree, yellow-poplar may establish pure stands in regeneration harvests, even on sites that are too poor to develop mature poplar. Production silviculture, especially an oak and black walnut natural regeneration focus, offer the economic goal and support to counter some of these successional trends and help forest diversity at several levels.

Grape vines have proliferated to the point they threaten tree health. This may be due to fire protection. However, they also offer biodiversity benefits. A recommendation for management is included in the silviculture section.

Urban Interface: The College Forest is surrounded on most sides by high and low density urban development. Neighboring working farms or forests are the rare exception even in Rockcastle and Jackson Counties. (A visit to any of the high-elevation look outs at night can reveal just how dense the residential development is.) Urban sprawl brings a variety of management challenges, especially threats to biodiversity. The list of problems is great: invasive plants escape from yards; dogs and cats, domestic and feral, kill wildlife; neighbors encroach and damage areas; tools like prescribed fire may be eliminated as choices in some areas, etc. Active management is important to counter the effects of habitat loss in adjacent areas and the harmful effects of development. The contrast of land management increases the educational value of a well-managed, multiple use, and healthy forest ecosystem next door.

Access

Haul Roads: The Berea Forest does not have adequate road frontage and easements to support active management, protection (e.g. fire), and production on all areas of the forest. Historic easements that were not been maintained or used for 50 years are now disputed by new landowners who occupy the entrance of these easements; thus rendering approximately 600 acres of critical College property virtually inaccessible for management …or even casual entry (due to threat of bodily harm. Another approximate 600 acres is inaccessible due to lack of maintenance of old roads; allowing creek crossings to wash out…while 200 more acres occupies the upper reaches of cliffline and the topography renders it inaccessible.

Current production has thus been based since 1970 when the Berea College-owned sawmill and logging operation was shut down, on tractor-trailer hauling and long-distance mechanical skidding that does not require extensive haul roads deep into the property.

Some easements, if access can be re-established, will need upgrading even to support management access. The Snake Hollow, Croucher (Hwy. 21 near Big Hill), Blue Lick, Shearer Hollow, and Bowman easements will all require some attention. Interior roads like those that serve water infrastructure or Horse Cove have all supported large truck traffic in the past few decades and can continue to do so. Harvests provide both the impetus and economic benefit of road maintenance.

The Welch Mountain tract has an easement that is unusable by even a small pick-up truck. While that tract is not included in the area open to production, management access is not possible. The tract may require salvage harvesting due to a fire or weather event at some point. Access can be obtained through the Wynn (United Church Homes) tract now that it is owned by the College, but access to the others side via the abandoned easement is needed for for both recreational and custodial management of the west half of the tract.

Skid Roads: Due to past engineering and construction, the main block of the Berea Forest (Fay-Mason block) still contains an excellent skid road infrastructure. While some culverts are washed out, the road beds are mostly stable and in good condition. The roads were developed to accommodate two-axle logging truck access. That is not necessary being used under current logging methods, but would need to be used to accommodate horse/mule logging if that practice is desired to continue for the long term.

Skidding and skid road construction/maintenance are considerably less expensive than hauling and related road expenses. In the original construction, some culverts were undersized and have washed out. Culverts for the smaller ephemeral drains may be unnecessary and can be turned into broad-based dips to accommodate skidding. Culvert replacement (with written size specifications) can be required in timber sale contracts, or they may be replaced with timber bridges. That is typical of many contracts, and while it may lower receipts a small percentage, the work is taken care of within the sale. Slippage of old logging roads has occurred in rare instances. Normally, these areas are repaired prior to logging by the operator. (See the following section on the best way to make sure slippage does not occur). Additionally, some roads have eroded below grade when the College abandoned them without proper closing and/or by ATV use. Such roads can be graded and vented with water bars. The most extreme of those may require some College investment, but most can be done in the normal course of logging. Most mechanical logging operators will be pleased with the skid road infrastructure already in place and the necessary upgrades will seem minimal. If horse/mule logging is preferred, dozers will still be necessary to dress the roads, fix crossings, and forward logs to an access point for hauling.

Where new skid trails are required, Forestry Dept. personnel should scout and lay those out in the harvest preparation to insure soil and water protection. Most hillsides contain benches that will

accommodate skid trails. Lower slopes may be dissected by small, steep ephemeral drains. In such case, upper benches can accommodate main skid trails with lower slope skidding confined to spur ridges between the drains. (See next section on slope protection).

Mechanical fellers ("feller-bunchers") are coming into wider use in the region. They can operate safely on slopes up to 60% grade. They are often used with skidders on steep slopes. While they may not be appropriate for all areas of the Forest, existing roads and natural benches should accommodate their use.

As logging jobs are closed down, grading, water bars, seeding and other applicable BMP's are applied. Skid roads provide fire and management access. Some can be kept permanently open (with water structures maintained) for fire protection and prescribed burning. Some would make excellent trail biking or horseback-riding trails. Care should be taken to prevent ATV trespass that damages cover crops, water structures, creates erosion, and aids illicit access for other purposes.

Slope Stability

Due to the thin soils, steepness, and underlying rock structure, unstable slopes are present in the Forest. Slippage and, rarely, small landslides occur. Almost none of the slippage viewed in the inventory is due to human activity (hiking trails, roads, harvests, etc.) Large tree growth can actually speed this due the weight of the large trees acting on the slopes. Mortality of large trees due to slope stability is common. Management must account for and protect slopes.

The most common type of slippage occurs on natural benches on the hillsides. Insloping that concentrates water (and water/soil weight) on the inside of benches is the primary cause. This is also the cause of slippage on several hiking trails and some roads. Use of roads and construction of roads on benches should assure that down slope drainage is included. Roads built on wide benches should be put on the outside of the slope with drainage and outsloping to send water down the hill. When closing down the logging jobs, drainage ditches can be placed in natural benches that have become insloped (caused by natural slipping of the bench) and that show signs of slippage. That operation may not be a normal BMP required of the logger if slippage was already taking place prior to logging. It will be necessary to pay the per/hour rate to the logger for time spent on these measures. However, addressing it while the equipment is available is important and will save money.

Silviculture offers challenges on the steepest slopes. Trees may be unstable on such slopes. Commercial thinning dispersed on such slopes may be impossible. Felled trees usually go downhill and may knock over shallowly rooted trees that were planned as residuals. Thinning on such slopes may have to be in strips. Directional felling will be especially important in such cases. In the past 160 years, logging has taken place on virtually all of the area that is now the Berea Forest (some with primitive technology). Clifflines offer the principal inoperable sites. However, careful use of existing benches, constructed skid roads, and cable technology already in common

use is necessary. Steep slopes located adjacent to the south side of Owsley Lake were not included in the area of the Forest designated for production.

Recreation

Hiking trails: Hiking trails are located on the Fairchild, Welch and Indian Fort areas of the Forest. None of the land surrounding the cross-country trails on the Fairchild tract, and little surrounding the Indian Fort Trails was included in the production area inventoried for this plan. This was estimated be some 550 acres. Some of the forest adjacent to trails in the West Pinnacle area was included. This area has been used as a multiple-use demonstration area. It provides trail access for classes and interest groups to view active silviculture. This section of trails must be closed during active harvests.

Hiking trails require a considerable maintenance and support infrastructure—security, parking, etc. They also allow chronic human impacts to the ecosystem. Those impacts may be as important for what they do not allow (prescribed fire, vegetation management, etc.) as for those they cause (erosion, chronic wildlife disturbance, trash, etc.). For that reason, wide expansion of the system is not advisable. A trail that goes all the way around Owsley Lake would be a good addition. It can be located on the lower slopes 50-100 feet from the lake (to minimize silt introduced from the trail) with occasional direct lake interface where slopes are minimal. The trespass, solid waste, erosion, security, and other problems currently associated with the Owsley Fork Road need to be addressed for this trail to provide the full and safe recreational benefits possible. However, construction of the trail (with ATV control measures) may change the user profile of the area and protection of the resource.

Management and hiking easements should be explored. A circuit trail (using both roads and cross-country trails on the Alumni fields) of considerable distance could be completed if easements are acquired.

Given the funding already devoted by the College (as a private entity whose principal mission is not public recreation) to hiking trails, expansion of trails beyond what is recommended or expansion of use beyond hiking is not advisable unless extensive volunteer efforts can be secured in advance of such an expansion. Horse, ATV, and mountain bikes are high impacts that increase trail maintenance costs by 15 times or more, and should only be considered if sponsors for such activities are willing to maintain these special use areas. Regular, year-around horse and ATV use is beyond practical consideration due to excessive damage inevitability during wet soil conditions. Recent completion of the foot/bike trail to Indian Fort Theater may increase pressure to open trails to bikes. In addition to increasing trail impacts, user conflicts increase with bikes. However, the Wynn Tract, now acquired, could support mountain bike trails. Trails could be constructed to the standards sustainable for bike use and separated to reduce conflicts and a ready sponsor of such trails may be had in Boone Trace Outfitters.

Owsley Reservoir: Owsley already offers non-motorized boating and fishing for recreation. It is a valuable community resource apart from the water supply. The small lake front park is managed for public use. The proposed trail should enhance the recreational utility and help discourage the dumping and destructive off-roading use now prevalent there. Local attitudes…especially in the Jackson and Rockcastle counties…toward land, wildlife, and water degrade the resource. Any opportunities that arise to improve environmental conditions around the lake should be examined.

Other expansions and recreation conflicts: Outdoor recreation management is resource intensive. As the National Parks have demonstrated, the chronic human presence and the management it precludes is a considerable threat to biological diversity. Expansion of daily recreational use into other areas of the Forest will be cost intensive and threatens the management for other values. However, occasional event-related recreation that is education related and enhances forest protection is desirable. Uses open to College employees by permit can help discourage damaging illicit uses. This might include permitted picnics or fishing at some of the lakes not open to the public. That will serve to discourage the illicit use that occurs presently. Periodic field events involving bird watching, wild flower walks, mushroom hunting, etc. are examples. Deer hunting helps control deer populations while providing recreation, good relations, and more "eyes on the ground". Other periodic uses for the Forest not open for public hiking should be examined. Camping and/or rentable rustic cabins would make a good addition to the Berea College Forest if closely managed by the College.

Other Recreation Considerations: Forest recreation often conflicts with production silviculture and biodiversity management. Both require disturbance that imitates the evolutionary factors that have shaped forest ecosystems of this region. This conflicts with the short-term aesthetic demands of many hikers or other recreational interests. Even the establishment of some habitat conditions (native grasslands) conflict with the suburban aesthetic of neighbors and forest users. These conflicts do offer the opportunity for passive education. People can be exposed to the dynamic nature of native ecosystems and sustainable production of the resources their lives depend on where recreation use is in proximity to active forest management.

Fire

As repeatedly mentioned, fire, mostly anthropogenic, has had a significant evolutionary influence on the development of forests of this region. Spurr and Barnes (1973), state in their Forestry Ecology text, "Fire is the dominant fact of forest history". The management of fire offers a complex challenge for a small private college. Incendiary fires will still need to be suppressed for property protection. Vehicle roads, skid roads, trails should be maintained for that purpose. The current relationship with the KY Div. of Forestry, where they are provided an office in exchange for fire line maintenance, benefits the College. It also helps KDF personnel become familiar with the terrain and conditions of the Forest.

Prescribed fire can benefit both silvicultural and biodiversity management goals. Periodic burning of native grassland communities is the most obvious example of the latter. Burning for oak and/or shortleaf pine management is promising and may reduce the need for herbicides. Berea College should be open to burning and the recent establishment of partnerships with agencies and organizations like the KY Dept. of Fish and Wildlife Resources, KY Division of Forestry, KY State Nature Preserves Commission, Nature Conservancy, U S Forest Service, Natural Resource Conservation Service, and the University of Kentucky Department of Forestry encouraged to continue. Research is needed to both evaluate the effectiveness of this burning program and to enable Berea College to have data necessary to adequately tell our story in achieving this level of management.

Energy Production

Woody biomass for energy is gaining wider use in the region. The future of cheap, available fossil fuels will focus more attention on forest biomass as an energy source. The Forest can provide wood energy as a byproduct of timber harvests. Low quality trees/logs can be utilized for this purpose. Fuel production can help improve forest quality, health, and habitat values if conducted properly. Note the cautions about nutrient drains and habitat degradation mentioned previously. High yield, intensively managed energy tree plantations are an option on converted farmland. Black locust is a good choice due to high BTU production, nitrogen fixation for soil improvement, and ease of regeneration by coppice methods. Such plantations are not a good option for hillsides where intensive harvesting may cause soil loss and where establishment destroys native biodiversity.

Carbon Sales

The opportunity to sell the carbon capture of the Forest in "climate exchanges" was seized in 2016 but funds from the sale of the credits has not yet come in. The project offers an income opportunity independent of timber harvesting. It requires an intensive inventory and long commitment (100 years) to participate. It can coexist with a limited timber production system and helps insure that future leaders do not liquidate the Berea College Forest timber resource.

Cultural Resources

The Forest has many valuable cultural resources. These include sites of important pre-historic origin and post-settlement homesteads. These sites need protection. The recognition of the Forest on the National Register of Historic Places is enhanced by these cultural resources. Some, like the Grant House and several 19th century log cabins, have been lost due to mismanagement and neglect. Thieves have looted some prehistoric sites and ruined research potential. They have educational value. Partnerships are valuable is assessing and protecting the resources.

Boundary, Encroachment, and Security

Problems with destructive trespass, boundary encroachment, and property destruction are evident in College Forest records going back to the 1930's. Records from the 1950's call for Administration support for boundary enforcement with neighboring landowners. The problem continues to this day. The College has a good survey for most of the Fay-Mason block and several other tracts. However, some boundaries have been blurred by encroachment. Other areas need surveying. Poor boundary knowledge and enforcement policy does not set an example for a region known nationally for trespass and ignorance in property record maintenance. Timber income can support surveys. However, policy and resolve to enforce boundaries depend on College Administration resolve. Current efforts to survey, and back up surveys with litigation if necessary, are pending.

Illegal activity from minor vandalism to major problems like dumping and destructive drug activity are common in eastern Kentucky and have grown worse as population has increased. Poaching (plants and "game"), tree theft, and theft from prehistoric sites are other College security problems. Absolute prevention of these activities is beyond the ability of the College. However, College housing available on the Forest can serve to support security better than current arrangements. Better focus of resources to support security can also support partnerships with local law enforcement, including Fish & Wildlife.

The important step to both boundary protection and security issues is to take appropriate action at the Administrative level when problems arise to resolve the problem. The College Foresters play a large part in relations with adjacent landowners, and many conflicts can be prevented or resolved through personal relationship-building. However, the College will need to continue to act when its interests in the Forest are at risk from these activities.

Acquisitions

There are a few key Forest acquisitions that can protect the Forest and College community if funds and willing sellers are available. A priority purchases list has been devised for such properties.

Government Cost-Share

Cost-sharing for forest and wildlife operations was emphasized in the last Farm Bill. Berea College is eligible. Most of these programs are administered through the NRCS. The College currently participates in such a program that funds invasive plant control. Funds for site preparation, timber stand improvement, grassland establishment and wildlife management are available, and will be sought as opportunities are presented.

Certification of Sustainability

The Berea College Forest has been sustainably managed for a century, and has been recognized by The American Tree Farm System. Further certification of sustainable forest management through the Forest Stewardship Council was achieved in 2011 as part of a successful effort to

provide Berea College certified wood for the LEEDS Platinum certified Deep Green Residence Hall. Berea should maintain its Tree Farm and FSC certification to remain compliant with its Carbon Project.

Prioritization

Berea College's mission is devoted to education of its students first, but does not offer a forestry degree. Given some of the management recommendations outlined above and limited staff and resources available for forest management, prioritization is a challenge. The shifting application of production silviculture across the Forest offers some solutions to that challenge. This effort will require focus on certain areas of the Forest for several-year periods. This offers the opportunity to assess and apply management in these areas while they receive focus. The focus will then shift to a distant area of the forest and it will receive attention. In this way, needs are thoroughly addressed across the Forest over time. Other needs in other areas are addressed in the time not devoted to the particular areas of production silviculture focus. Research activities and partnerships offer other opportunities to focus on priorities elsewhere.

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Appendixes

Scheduling for a Hypothetical Timber Sale Unit

This hypothetical management of a 350 acre sale unit is based on the current estimated average of 7,900 board feet per acre. This unit could be a contiguous unit or as many as 2-3 sub-units located in the same general area of the Forest. This scenario assumes starting in the near future with inadequate time for the recommended site preparation work to develop oak/walnut regeneration, killing of vines 5 years before harvest, or control of invasive species well in advance of the harvest. That type of work could begin for future harvest areas as the first harvests are applied. If the first areas targeted for regeneration harvests are poor sites, it will allow time to develop oak and walnut regeneration on good and intermediate sites through applying low thinning (oak shelterwood) 5-10 years in advance of regeneration harvests. If good sites are subject to regeneration harvests early in the application of this plan, they will develop productive yellow-poplar stands if site preparation to remove all subcanopy is applied just before or after the harvest.

Winter of year 1: A good walkover of the harvest unit for general timber assessment involves access/skid roads, invasive species, grape vines, biodiversity/habitat features, and other interests (involves only those that can be assessed in winter). Property boundaries in the area of the sale can be addressed/marked at this time. This involves one work day.

After that, begin preparing sale by marking timber. A commercial thinning of approximately 40% of the standing volume is marked over 290 acres of the unit. This yields 916,000 board feet of timber (about 3,200 bf/acre). The commercial thinning leaves a small percent of the volume in trees > 24 inches DBH, most of the good trees in the 16 to 24 inch DBH range, and only the best trees in the 10 to 16 inch DBH range after harvest. Some poorer trees may be left purely for stocking purposes. 60 acres of regeneration harvest is marked in two separate areas; one at 40 acres and one at 20 acres. All merchantable trees are marked in these areas; which yields 474,000 board feet, for a total of 1,390,000 board feet.

The marking will require a thorough walk-over of the site for marking that will stretch until early spring. Water protection buffers, problems with vines or invasives, and biodiversity/habitat features can be better assessed and accommodated for during this work. Regeneration harvest marking will involve 10-15 acres per day and commercial thinning 25-30 acres per day.

Spring/Summer of year 1: Grape vine and invasive species problems are addressed using herbicide-based methods to prevent sprouting. Usually, this step is done in advance for invasives, with herbicide; and 5 or more years in advance for grapevines, without herbicide, under closed canopy. This example assumes beginning the harvest program, in the near future, with no advance site preparation. Treatment of subcanopy, for site preparation in the regeneration harvest areas, can occur during this period prior to harvest. (It is possible to do the site preparation the year before harvest, with advance planning). *Subcanopy will not be treated in commercial thinning areas; to speed canopy closure to control the stimulation of shade intolerant regeneration*.

Mid to late summer, year 1: Advertise the sale (prospectus sent to timber buyers with scheduled trips to show the area and bid date), take sealed bids, and award contract. Payment may be made lump sum for the entire unit or contract may break the sale into two or more sub-units (even if unit is contiguous) with multiple payments made based on the percentage of volume in that unit (delineated and figured during marking). Payment is made prior to logging entry in each one of these units. The latter may help in boosting competition for these large sales. Life of the contract can be one to two years as negotiated; based on the buyer's situation. The shorter contract life is desirable, but it depends on how much standing inventory the buyer has under contract at the time of the sale.

It is not desirable to force a situation where the buyer is tempted to work in weather conditions that threaten soil or water conservation. A contract extension can be executed in the event of bad weather that slows the work. If this method is chosen, this should be stated in the sale advertisement along with map of sub-units and sub-unit volume. A letter of credit on the buyer

might be advisable at the contract execution if payment is extended. The buyer should post a performance bond to be held in escrow. The bond, plus interest, can be returned to the buyer at successful completion of the harvest and contract compliance.

Late summer, year 1 to early fall, year 2: Spot check the harvest for contract compliance and to maintain communication with the buyer. This is not a time of intensive activity but should be conducted regularly. Grape vines/invasive control can be carried out in areas where the harvesting has not begun in summer/early fall in year one and site preparation treatment of subcanopy in regeneration units can take place before or after active harvesting within the unit. Final BMP's can be applied by the logger after any unit is complete. Seasonal applicability of BMP required seeding and coordination with site preparation (so as not to block skid roads with felled trees prior to water bars and seeding) is necessary in final BMP application to close down the job.

Pre-planning and early application of vine/invasive control and site preparation, as recommended in the plan, can be taking place for a future harvest unit during and after harvest is complete.

Fall, year 2 to winter, year 3: Finish applying site-preparation if necessary. A contract extension may push harvest period into this period. It may be time devoted elsewhere if all is finished.

Winter year 5 to 7: Walk regeneration harvest areas and address invasive species problems. Young trees will be ten to twenty feet tall and interior stand is easily accessible in the winter.

Year 5-20: Site preparation by low thinning in areas commercially thinned five years ago to develop oak/walnut regeneration if a regeneration harvest is planned in the next step outlined below.

Winter, year 15-25 (variable): Crown closure has occurred in the commercial thinning areas and additional commercial thinning and/or regeneration harvests are possible in the unit (trees left in the last harvest have grown). 220 acres is commercially thinned, similar to year 1; while 70 acres is regenerated in one to several units. Regeneration harvests should be preceded by site preparation of low thinning in areas slated for oak/walnut regeneration (preceding step). These should precede final regeneration harvest by at least five years on moderate sites and ten years on productive sites. Poor sites will be OK with site preparation at harvest only. Regeneration harvests in the unit may be conducted in conjunction with commercial thinning or other harvesting in adjacent units. The amount of volume removed in a commercial thinning at this time can be assessed as the harvest is prepared for marking.

Five to seven years after regeneration harvests conducted above: survey young stands for invasives/grape vine problems.

Year 20-45 (?): Areas that have already received two commercial thinning in this unit should be regenerated in the next harvest. Site preparation should take place in the period to develop oak regeneration.

Year 30-50: Final regeneration of remaining 220 acres of commercially thinned areas of this unit. Regeneration units may be harvested with commercial thinning (or regeneration harvests) in adjacent units. As the activity is occurring across the Forest, units of high canopy forest created by commercial thinning or growth of regeneration harvests will be mixed with young forests from recent regeneration. These units can be mapped for organization of harvests and site preparation.

Figure 1:

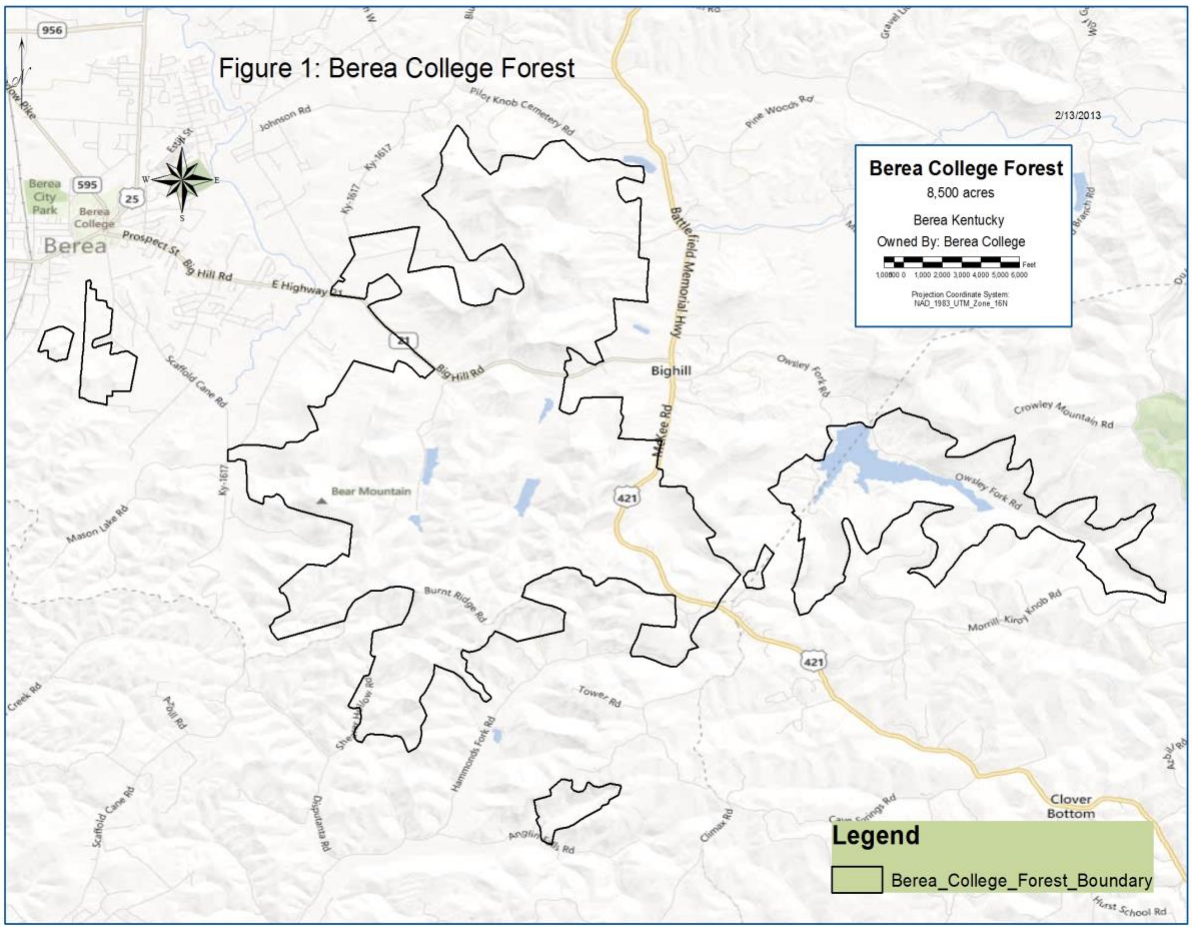
Figure 1: Berea College Forest
Berea College Forest
8,500 acres
Berea Kentucky
Owned By: Berea College
Projection Coordinate System:
NAD_1983_UTM_Zone_16N
2/13/2013
Legend
Berea_College_Forest_Boundary
Berea
Berea City Park
Berea College
Bighill
Bear Mountain
Clover Bottom
Prospect St
Big Hill Rd
E Highway 421
Scaffold Cane Rd
Mason Lake Rd
Burnt Ridge Rd
Tower Rd
Hammonds Fork Rd
Pilot Knob Cemetery Rd
Johnson Rd
Pine Woods Rd
Battlefield Memorial Hwy
Hackee Rd
Owsley Fork Rd
Crowley Mountain Rd
Morrill-Kiroy Knob Rd
Climax Rd
Hurst School Rd
956
595
25
421
Ky-1617

Figure 2:

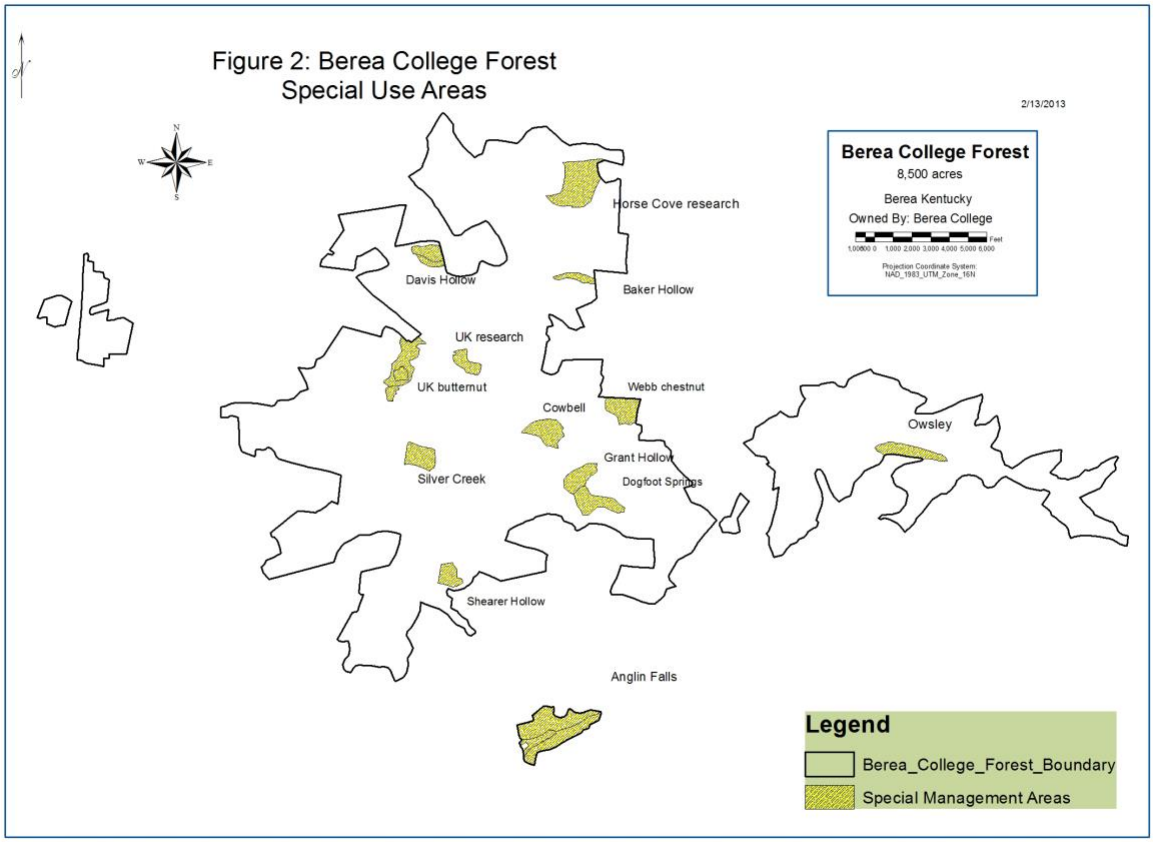
Figure 2: Berea College Forest
Special Use Areas
2/13/2013
Berea College Forest
8,500 acres
Berea Kentucky
Owned By: Berea College
Projection Coordinate System:
NAD_1983_UTM_Zone_16N
Horse Cove research
Davis Hollow
Baker Hollow
UK research
UK butternut
Webb chestnut
Cowbell
Owsley
Grant Hollow
Silver Creek
Dogfoot Springs
Shearer Hollow
Anglin Falls
Legend
Berea_College_Forest_Boundary
Special Management Areas