The Berry College Longleaf Management Plan

A proposal for the study and management of Mountain Longleaf Pine on Lavender Mountain

Submitted to the Educational Land Management Presidential Ta
Dr. Scott Colley, President of Berry College

Karen Vaughn, Eduardo Aguilar-Espinoza, Sofia Arce-Flores, Corey B
Melanie Barnett, Rebecca Bennett, Brooke Bowen, Rex Bowman, A
Clary, Janine Douglass, Kevin Eifell, Jason Farmer, Sally Hileman,
Alison Hydeman, Jeremy Jones, John Jones, Stacy Lindsey, Carrie
Marziliano, Kimberly Mink, Diane Mitchell, Meghan Nolan, Pennsyl
Pugliese, Kristen Palmer, Sonya Payne, Susan Roth, Anna Sanders, S
Sarah Williams, Shelby West, Kerri Wrinn, and Martin Ci

Berry College Department of Biology
Mount Berry, GA 30149, July 2002

Preface

In the spring of 1999, the Berry College Plant Ecology class and I initiated a long-term study of longleaf pine on Berry's Lavender Mountain, based partly on some work done by former Berry student Roger Birkhead several years earlier. The data collected by that group of students lead to the formation of a follow-up project by the Plant Ecology class of 2001. This class was tasked with contributing additional background data concerning Berry's longleaf, and then drafting a management plan that focused on conservation, education, research, and public outreach. Using the students' drafts as a starting point, Ms. Karen Vaughn and I drafted a formal management plan in the summer of 2001. After much advice and feedback from members of the Berry Longleaf Network (a group of interested outside professionals), I finalized the plan in the spring of 2002. So, what you have before you is the product of the work of a large number of dedicated students and professionals, and not simply the vision of one person. The project as presented here is purposefully constructed to address our institutional mission of "head, heart, and hands", and I think sends all the right messages to the outside world concerning Berry's interest in the stewardship of its natural resources and the education of its students. The students and I could not have pulled this work together were it not for the help of the various members of the Berry Network (most notably Dr. John McGuire of the Longleaf Alliance), and we thank everyone who has contributed even the smallest amount of feedback to us. We will be leaning on these same individuals in the future, and for the most part their only reward is seeing to it that the longleaf pine, a true example of southern heritage, remains a part of these Georgia hills. We dedicate this proposed management plan to those individuals and their shared vision.

Martin Cipollini, Project Coordinator
July 2002

Table of Contents

I) Introduction and Overview of Project Goals:

The Natural Role of Fire in Ecosystem Processes

The human species has profoundly changed the landscape of the earth in a relatively short period of time. In recent decades, people have become increasingly aware of the negative impacts of such large-scale ecosystem disruption. Public opinion, often based on emotional response, greatly influences land management policies. In some cases, the public outcry for environmental preservation has contributed to the elimination of even natural disturbances. An important example of this phenomenon is the widespread fire suppression effort that began in the United States in the 1920s (Gilliam and Platt, 1999). The elimination of fire allows for the build-up of leaf litter and other debris. As this debris dries and decays, it becomes fuel for even greater fires in the future, fires that often cannot be extinguished in time to prevent massive damage to forests and homes. The destructive results of this fuel accumulation became very apparent in the summer of 2000, when the United States experienced 40,000 fires, which burned a total of 7.5 million acres (Wilkinson, 2001). According to Jerilyn Levi of the U.S. Forest Service, "the kind of fire season we had last year is destined to keep repeating itself unless we restore fire-adapted ecosystems at a landscape scale" (Wilkinson, 2001). These fires, along with a devastating wildfire in Yellowstone National Park in 1988, have helped to change the public attitude about fire. The U.S. government has taken action by making fire management a "top federal environmental priority for years to come," (Wilkinson, 2001) and the Forest service is changing the motto of its beloved mascot, Smokey the Bear (Figure 1), from "Only you can prevent forest fires" to "Only you can prevent wildfires" (Fahys, 2001).

Figure 1. Former U.S.D.A. Forest Service "Smokey the Bear" poster.

The Berry College campus, like much of the nation, has been shaped by decades of fire suppression. Fuel has accumulated to dangerous levels, and the rugged terrain of the mountains also makes it difficult to put out a fire once it has begun. A single unattended campfire or discarded cigarette has the potential to burn our forests to the ground. However, within this brush-choked landscape, there is a monument to fires of the past. On the slopes of Lavender Mountain, there is a population of mountain longleaf pine (*Pinus palustris*). This population is all that remains at Berry of a fire-adapted ecosystem that once dominated the landscape of the entire southeast. These trees, some hundreds of years old, have survived harsh conditions, and have even managed to bear some seedlings. Their presence offers us a starting point to rethink our view of fire and become a part of the national movement for restoring and managing fire adapted ecosystems. Berry also has the opportunity to become a site for ground-breaking research on the management of mountain longleaf.

Purpose Statement

The purpose of this document is to propose the initiation of the Berry College Longleaf Management Plan. The goal of the plan is to restore a portion of Berry's Lavender Mountain to a diverse, fire-managed longleaf pine ecosystem. To work towards this goal, a Longleaf Pine Management Area will be designated in which experimental management and research will be carried out. Management plans will include a number of practices designed to maintain and expand the existing longleaf population, and to restore other components of the ecosystem typically associated with mountain longleaf. These practices may include prescribed burning, hardwood removal, leaf litter removal, and planting of longleaf seedlings in clear-cuts, among others. Ancillary goals of the project are to educate the public about longleaf pine and fire ecology, and to provide research opportunities for Berry students and faculty, as well as for outside researchers. It is our hope that the project will serve as a model for the wise management of mountain longleaf on private landholdings. This project will include the formation of a Longleaf Network made up of groups or individuals interested in the restoration of Berry's longleaf ecosystem. A Longleaf Resource Center and website will be created and maintained to make information about longleaf pine available to interested persons. A student Longleaf Team will be formed to conduct research and to help organize and publicize the project. Donations, grants, and partnerships will be sought to fund the project and to supply equipment and expertise.

This paper discusses the natural history of longleaf and the longleaf ecosystem, the decline of the ecosystem, the unique situation of mountain longleaf, the history and current research of longleaf at Berry College, a plan for the restoration and continued study of Berry's longleaf, personnel and funding for the project, and possibilities for the future.

Project Justification

At first glance, it seems absurd to burn a forest or cut down large, beautiful trees in the name of conservation. However, if you look closer, you will find that the forests we see today were created relatively recently from the intensive manipulations of humans. The landscape has been altered at the ecosystem level. Sometimes it becomes necessary for people to go beyond simple preservation, and to take concerted action to fix our mistakes.

Any type of forest management practice involves some level of risk, especially if fire is involved. However, the greatest risk to the longleaf pines is to do nothing. Studies that we report in this document will show that our longleaf population risks extinction in the near future if current conditions remain the same. Unless the canopy is opened up to allow light to reach the ground, and litter and hardwoods are removed, new seedlings will not grow and the seedlings present are unlikely to reach adulthood. A heavy windstorm or an uncontrolled wildfire from a lightning strike or a cigarette could quickly kill all of the adult longleaf pines. Without a younger generation to replace them, another population of mountain longleaf may follow its predecessors to extinction.

The significance of focused management of Berry's longleaf forest tracts has been summed up as follows by Dr. John McGuire, Outreach Coordinator of The Longleaf Alliance:

1) The longleaf forests of the Berry campus represent an ecologically significant landscape type with a paucity of knowledge about it. Most information on longleaf forests comes from rolling hills or coastal plain landscape types, i.e., wiregrass country. Wiregrass, gopher tortoises, and many of the scrub oaks considered characteristic of the better-known longleaf ecosystems are far outside the range of Berry's longleaf stands.

2) Berry's campus has a number of very old trees, some in excess of 200 years old. These trees are significant for ecological, historical, and social reasons. There are very few tracts of old longleaf left in the south, and almost none left within mountainous areas.

3) Much of the steep hillsides at Berry have never seen a plow and thus (through seed banking) have the potential of benchmark groundcover species found on fire maintained mountain longleaf sites. In 1917 F.F. Andrews first conducted a general survey of the plant communities on the Berry Campus (Andrews 1917). In 1940, H.C. Jones conducted a more detailed survey of the plant ecology of the property (Jones, 1940). These references may serve as sources for determining potential or "target" plant communities of the restored longleaf system.

4) By establishing a model management plan that includes the research on the use of controlled burning, information generated by the plan will have important implications for fire re-introduction programs in other mountain longleaf sites within the south, and in other ecological analogs such as most Ponderosa Pine stands found out west.

5) As the management plan would be administered within an educational context, the project has extremely high potential to serve as an outdoor classroom for Berry students and for local school children, and as a demonstration forest for regional land managers.

6) The plan has the potential of generating funding from various agencies interested in conserving biodiversity and in determining how best to manage private forests for multiple uses.

II) Natural and Sociological History of Longleaf Pine

Historical and Current Distribution

Longleaf pine once covered most of the southeastern United States, and it dominated as much as 92 million acres when the first European settlers arrived (Landers et.al. 1995). Harper (1928) suggested that it was once the most abundant species of tree in the entire U.S. -- if any tree species represents national and southern U.S. heritage, it is the longleaf. Its natural range covers most of the Atlantic and Gulf Coastal Plains from southeastern Virginia to eastern Texas and south through the northern two-thirds of Florida (Landers et.al. 1995). This area includes parts of northeastern Alabama and northwestern Georgia (ridges associated with the Coosa Valley that transgresses these regions); these areas also represent the upper elevational limits of the longleaf pine. Its wide range is due partly to the fact that the species can occur on a wide variety of sites, from wet, poorly drained flatwoods of sandy soil near the coast to dry, rocky mountain ridges (Boyer 1990). Within the hilly and mountainous regions, longleaf often occupies the poorest of soils (cf., Harper 1913). Longleaf is a long-living species and can survive up to 500 years in undisturbed conditions, growing as large as 2 meters or more in circumference (Boyer 1993). Nevertheless, few of these pines live this long because of natural hazard

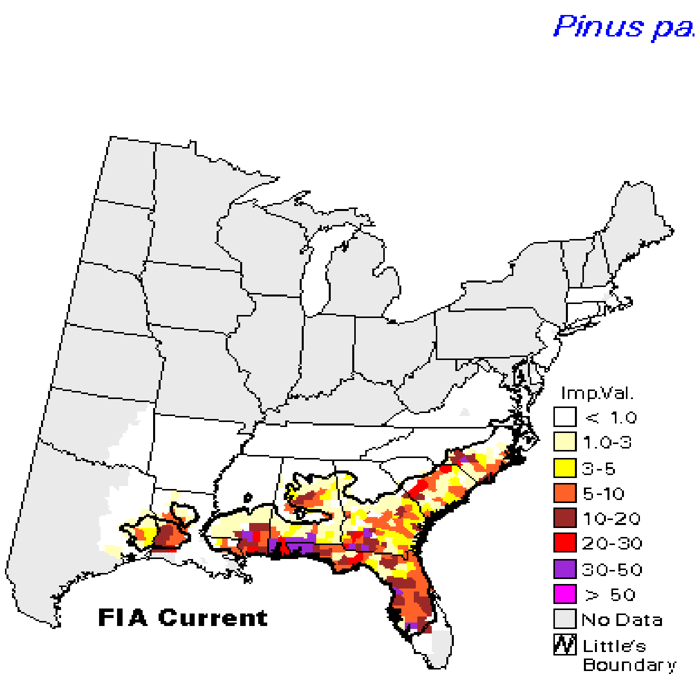


Figure 2. Distribution of longleaf pine in the Southeast US. Areas in color represent current distribution based upon importance values, and the black line represents the boundary of the historical distribution (Little's Boundary; *in loc cite*).

The Life Cycle and Fire Resistance of Longleaf

Much of what is known about the longleaf life cycle and dependence upon fire has been gained through numerous studies on coastal plain populations. In these regions, longleaf pine is known a shade-intolerant pioneer species because it is a poor seed producer with a limited dispersal range due to the large size of the seeds (Landers et.al. 1995). The seeds require exposed mineral soil and a large amount of sunlight to germinate, so they typically do well in newly formed gaps or after a fire has occurred. Longleaf is the most fire-adapted species in the region (this includes mountain habitats), and the trees have many characteristics that enable them to combat fire and even use it to their advantage. For example, they exist in what is known as the "grass stage" for 3 to 15 years depending on conditions (Figure 3). During this stage, longleaf is very resistant to fire because most of their growth efforts are put into the development of a long taproot, the length of which depends upon the depth of the local water table (Platt et.al., 1988). Because of this well-developed taproot, the grass stage needles can be burned off during a fire without long-term harm to the plant. The grass stage is also protected from fire by a dense tuft of long needles that surround the terminal bud (Means 1996). In fact, periodic fires may help to control brown leaf spot disease (*Scirrhia acicola* fungus) common to young longleaf (USDA Forest Service 1989).

Its long residence in the grass stage has given longleaf a reputation as "slow growing." However, once the pine has passed the grass stage, it enters into a stage known as the "juvenile stage" that is characterized by very quick height gain (Figure 3). It is during this stage that the longleaf is most vulnerable to fire damage. This is because it is not yet high enough to be above the hottest zones of a typical surface fire, and because most of the stored resources are being moved from the taproot to above-ground tissues. Loss of above-ground tissues in a surface fire can thus result in death. The pine remains vulnerable to fire until it reaches about 2 meters in height (surface fires are typically not very hot, and the most intense heat does not usually rise much above about 1 meter in height).

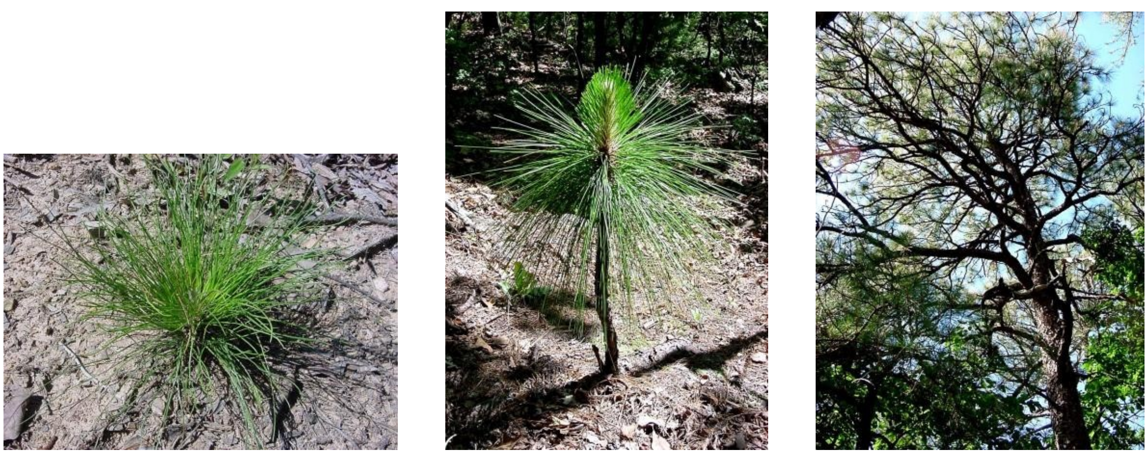


Figure 3. Three stages of the longleaf life cycle, the "grass", "juvenile", and "reproductive adult" stages from left to right.

In the our own studies, we consider longleaf pine to be a "non-reproductive adult" when there is at least one horizontal limb present, because this shows that the individual is no longer putting all of its efforts into height gain. The final stage, which we call the "reproductive adult" stage, is recognized by the production of cones and seeds (Figure 3). During the mature phase – when the pines are considered adults – the trees have very high fire resistance, are very resistant to fungal and insect diseases, show slow but steady growth, and produce hard durable wood (Landers et al. 1995). Thick, corky bark at the base of the tree (Figure 4) and the large diameter of the stems of young trees and branches can protect the stems and base of the tree from overheating from fires (Means 1996c). In fact, longleaf pine and many of the groundcover species found in fire-maintained longleaf ecosystems are considered pyrogenic in that they actually facilitate fire (Means1996c). Longleaf pine needle litter and the leaves of various groundcover plants, such as wiregrass (*Aristida stricta*) and bluestem (*Andropogon* spp.) burn more readily and hotter than the leaf litter of similar plants in other ecosystems (Platt et.al. 1988). In this way, longleaf and those species associated with it not only survive fires, but also increase the likelihood of frequent low intensity fires. This reduces fuel buildup and limits competition from non-fire-adapted hardwoods and other species (hardwood trees include broadleaf, usually deciduous trees such as oaks, maples, ashes, and elms).

Figure 4. Charred base of a mountain longleaf, showing thick, corky, layered bark. This bark may protect trees from low-temperature surface fires, but cannot protect the trees from intense ground or crown fires.

The litter (dead material) of forest soils can be divided into three layers: a top layer of newly deposited litter, a middle layer of partially decomposed duff, and a bottom layer of fully decomposed humus. It is important that the fuel buildup due to litter be low because longleaf adults and grass stages, while extremely resistant to fire, are not completely immune to its effects, and can be damaged if a fire is too hot or becomes a crown fire. A crown fire is one that burns high enough to destroy the canopy of the trees, and usually results in the death of most trees, including longleaf. Death may be due to the direct consequence of the destruction of the living tissues of the tree, or it may result from heat damage that causes the trees to subsequently become less resistant to drought, disease, and pests (e.g., by affecting resin production). Minimal competition from hardwoods is important to the longleaf because it is a poor competitor when faced with fast growing, shade tolerant hardwoods.

Components of the Longleaf Ecosystem

The decline of longleaf in the south threatens not only this tree species, but also the numerous plants and animals that make up the fire-adapted ecosystem associated with longleaf. An ecosystem consists of living organisms, their surroundings, and the natural cycles that sustain them. It is believed that the longleaf pine is the keystone species in the coastal longleaf ecosystem (Figure 5; Landers et.al.1995). This means that the survival of many other species is dependent upon it. For example, there are numerous other plant species within the coastal plain longleaf pine ecosystem that have adapted to fire. These include two species of runner oaks (*Quercus pumila*, *Q. minima*), turkey oak (*Q. laevis*), bluejack oak (*Q. incana*), and sand post oak (*Q. margaretta*). Each of these species will produce acorns on two-year old shoots after fire. They seem to be in an intermediate evolutionary stage of losing the tree habit, which is a fire adaptation (Means 1996c). Frequent fires, in turn, are a direct result of the litter buildup of longleaf, which promotes spread of low-temperature surface fires. As a keystone species, the longleaf exhibits features such as fire tolerance, longevity, and nutrient-water retention that can reinforce their dominance and moderate vegetation change following fire disturbances (Landers et.al., 1995.

Figure 5. Typical view of coastal plain longleaf-wiregrass habitat, showing open canopy and continuous herbaceous and low shrub groundcover. Numerous species in addition to longleaf are adapted to high fire frequencies in such habitats.

Mountain Longleaf

Within the southeastern United States, there are small populations of mountain longleaf pine present in northeastern Alabama and northwestern Georgia (Varner, 1999). The longleaf at Berry College represent one of these "mountain" or "montane" longleaf populations (Figure 6). The mountain longleaf pine forest is loosely defined, but it has been suggested that less than 40,000 hectares remained in 1995 (Varner, 2000). This number has most likely declined since that time. Fire has been absent over most of the mountain areas, and if this continues, then the mountain pine forests will succeed to a closed-canopy, mixed hardwood forest known as the Southern Mixed Hardwood Forest (Varner 2000). Some of the overstory species in the mountains that are replacing longleaf include sourwood (*Oxydendron arboreum*), red maple (*Acer rubrum*), several hickory (*Carya* spp.) and oak (*Quercus* spp) species, other pines (e.g., *Pinus taeda, P. echinata,* and *P. virginiana*), and black gum (*Nyssa sylvatica*) (Varner 2000). Approximations of "pristine" conditions are difficult to identify for mountain longleaf because land use and past management practices have created isolated patches of infrequently burned areas within a large fire-suppressed mosaic (Varner 2000). While intensive research has been done on coastal longleaf forests, very little has been done on mountain longleaf forests. For example, we know little about the degree to which genetic or environmentally-induced differences exist between coastal and mountain longleaf populations, and we have a poor understanding of the other plant and animal species that are associated with mountain stands. While the component species of typical mountain longleaf systems are not well known, the presence of relict longleaf stands among scattered populations of fire-adapted herbaceous plants suggests the historical presence frequent fires in mountain habitats. The "death" of longleaf ecosystems may be slow and progressive in fire-suppressed habitats. This suggests that recovery is possible with a return to a frequent fire regime, even after some years of fire suppression.

Figure 6. A mountain longleaf site on the southern slopes of Lavender Mountain, Berry College campus, Floyd County, Georgia.

The Decline of Longleaf: Mechanisms and Consequences

Unfortunately, the longleaf pine population throughout the south has been drastically reduced to about 3 million acres, which is approximately 2% of the land it originally occupied (Landers et al., 1995; Outcalt and Sheffield, 1997). In fact, the loss of the longleaf ecosystem is considered equal to or greater than the loss of the North American tall-grass prairie, the coastal rainforests of southeastern Brazil, or the dry forests along the Pacific Coast of Central America (Means, 1996c). This loss has occurred largely due to the high value of longleaf pine timber, in combination with fire suppression and the favoring of tree species (e.g., Improved Loblolly) with faster early growth rates. Longleaf has been cut for timber, cropland, and pasture, and because it is a poor colonizer within highly vegetated landscapes, it has not been able to compete with more aggressive species such as hardwoods (Landers et al., 1995). Just about the only time longleaf can succeed other tree species is after sweeping surface fires that provide a seedbed and control hardwood competition. Due to the influx of people across the south, and because of our building of homes, fields, and roads within the forests, fire has been continually suppressed (Figure 7). Fire suppression was exacerbated through the establishment of the "Smokey the Bear" campaign by the U.S. Forest Service in the mid-1900's.

In coastal plain sites, many birds and mammals have come to depend upon cavities made by the red-cockaded woodpecker (*Picoides borealis*) in mature longleaf, and at least 60 vertebrate species and 302 invertebrate species use gopher tortoise (*Gopherus polyphemus*) burrows for homes (Jackson, 1989). These two species are reliant upon coastal longleaf ecosystems, and they, like the longleaf ecosystem upon which they depend, are now considered to be endangered. While these particular species are unlikely to be associated with mountain longleaf ecosystems, it is likely that a similar loss of associated species has occurred by the reduction in the mountain longleaf habitat in the last century. We do not know this for certain, which is one reason why the Berry campus is a particularly ideal site for study. Concerning longleaf itself, the World Conservation Monitoring Center has classified it as a "vulnerable species" because it is "likely to move into the endangered category in the near future if the causal factors [for its decline] continue operating" (IUCN, 2002). The management plan we propose in this document is an attempt at mitigation of these factors, albeit on a local scale.

Figure 7. Application of prescribed burning in a coastal longleaf habitat. Prescribed burning serves as a substitute for natural fires, and thus is a management tool to help maintain a healthy longleaf-wiregrass community and to help prevent harmful wildfires.

While a lot of attention has been paid to red-cockaded woodpeckers, gopher tortoises, and other endangered animal species in coastal longleaf systems, less attention has been paid to the enormous diversity of other plant species within these areas, and much less is known about mountain longleaf systems. The diversity of groundcover plants is extremely high in coastal longleaf ecosystems, which makes them one of the most species-rich communities outside the tropics (Peet and Allard, 1993). These groundcover plants increase in diversity each time a fire is present, so the suppression of fires can decrease this diversity. In fact, the reduction of coastal longleaf forest habitats is the main cause for the precarious state of at least 191 taxa of higher plants (Landers et al., 1995). Georgia's forests are particularly vulnerable because only a very small percentage of the longleaf ecosystem in on public lands (Outcalt and Sheffield, 1997). This is of great concern if the biodiversity within the remaining longleaf pine ecosystems is to be preserved. Again, much less is known about species diversity within mountain longleaf ecosystems, making the Berry College site an ideal spot upon which to focus future research. There are reasonably good records of the flora on campus from the early part of this century (e.g., Andrews, 1917; Jones, 1940), and there have been a number of recent formal and informal studies conducted to identify and catalog current species (e.g., Dr. John Graham's "Biodiversity of the Berry College Campus" project [Graham, 2002]; Richard Ware's collection of plant species records [R. Ware, personal communication]). Taking advantage of this head start, research on plant species diversity patterns will be an explicit part of our management plan. The location of longleaf stands within a protected area on a college campus makes the system ideal for research on the physical features, biological components, and management of this rare ecosystem type.

The History of Berry's Longleaf Pines

The longleaf pine population at Berry College was first studied in 1917 by E.F. Andrews after she noted its ability to inhabit burned areas on the northern slopes of Lavender Mountain. Her descriptions of the expansive longleaf forests on Lavender Mountain are quite impressive and insightful. For example, she wrote:

> "The southern slopes [of Lavender Mountain] are covered with the remains of great forests of this valuable timber…[which] have repeatedly been cut for timber and burned over by "ground fires" started in the spring by farmers…but the longleafs continue to reproduce themselves with a pertinacity which, if not too diligently thwarted by blundering incompetence of county officials and the short sighted greed of ignorant cattle farmers, will in the course of a generation or two repopulate the southern mountain slopes with a new forest grown up from the old stock." (Andrews, 1917).

Andrews was probably correct in her prediction, but it is the conditional part of his statement that seems to ring more true. In fact, fire suppression starting about the time of his writing, coupled with continued exploitation of longleaf as a favored timber tree, steadily reduced the area covered by this forest type. For instance, in 1913, R. M. Harper noted that great longleaf forests once blanketed the entire mountainous areas surrounding the Coosa Valley:

> "Near the Coosa River all the way through the regions of chert ridges and even some of the more level areas were once covered with splendid forests of longleaf pine, intermingled with various oaks and a small proportion of shortleaf pine [*P. taeda*: loblolly]." (Harper, 1913).

At the time of Harper's 1913 observations, he noted that continued exploitation of longleaf, coupled with fire suppression, had already started to take its toll on these forests. In fact, by the time Harper followed up with reassessments of these forests in 1928 and again in 1942, the much less fire-tolerant loblolly pine (*P. taeda*) had progressively become dominant over longleaf in this region (Harper, 1928; Harper, 1942). As a result, much of the current longleaf population on Lavender Mountain is found not in the expansive areas described by Andrews and Harper, but instead almost entirely within small hillside patches that were already present at the time Berry College was established in 1902. In fact, Jones (1940) did not mention longleaf at all in his study of the plant ecology of the Berry campus, suggesting that the trees were already restricted to small patches that he presumably missed during his studies in 1936-1940. Berry's longleaf stands are the only notable patches of this tree species left in the region – trees that were present in Marshall Forest in nearby Rome, Georgia have largely succumbed to recent hurricane and ice storm damage since Lipps first studied them in the 1950s (Lipps, 1966). The patchiness of the distribution on Lavender Mountain suggests that these stands represent regeneration in gaps created by past fires. Not only are these patches remnants of once great forests, the populations are important because they are close to the elevation limit of longleaf pines (most are found on Lavender Mountain at elevation ranges from 750 to 1295 feet above sea level; Birkhead 1995) and very close to the northwesterly limit of the species. Additionally, the longleaf on Lavender Mountain are in the midst of the 28,000 acre Berry College property. This is important because the area is considered a Wildlife Management Area, which can be studied and managed without the interference of croplands, pastures, or harvesting of timber for profit.

Andrews (1917) and Jones (1940) indicate that the relatively open understory on Lavender Mountain was at one time covered with herbaceous plants including Goat's Rue (*Tephrosia virginiana*), Bracken Fern (*Pteridium aquilinum*), various broom sedges (*Andropogon furcatus, A. virginicus, and A. scoparius*) and sedges (*Scleria triglomerata*, *Cyperus retrrofactus*). This ground cover supported frequent surface fires that would sweep up the slopes of the mountain from the adjacent lowlands. Additionally, longleaf trees of various age classes were present, indicating sporadic but frequent regeneration from seeds. This situation contrasts greatly with the current situation, which is dominated by larger size classes of longleaf mixed with other tree species, and has an understory that largely lacks herbaceous cover. The sparse herbaceous cover is currently dominated by various heaths (*Vaccinium* spp.) and Catbriar (*Smilax* spp.)(Birkhead and McGuire 1998).

As of 2001, at least six tree species other than longleaf have been found to be dominant within the areas of highest longleaf density. Dominant species include loblolly pine (*P. taeda*), shortleaf pine (*P. echinata*), chestnut oak (*Quercus prinus (montana)*), red oak (*Q. rubra*), red maple (*Acer rubrum*), and sourwood (*Oxydendron arboreum*)(Birkhead and McGuire 1998; see also data in the section entitled "Current Research on Berry's Longleaf" below). According to Birkhead (1995), 50% of the mountain longleaf pine population on Lavender Mountain was destroyed in 1960 by an ice storm and by a snowstorm in 1993. In 1995 a windstorm from hurricane Opal damaged the populations again (Birkhead, 1995). An accidental fire in 1999 made a number of the remaining longleaf susceptible to insect attack (they are generally highly resistant to insects because their thick resinous sap normally blocks the entry of such pests). Due to the damage from the fire, coupled with intense drought conditions, a number of fire-damaged trees did not have enough internal pressure to force beetles out and consequently died (Figure 8). Despite these disturbances, many of the longleaf that have survived on Lavender Mountain are well over 150 years old, with the oldest trees around 200 years old (Birkhead, 1995). These trees indicate that parts of the forest predate the white settlement of Rome in 1832 and therefore qualify as "old growth forest". These sites therefore represent a rare opportunity to study virgin patches of longleaf forest.

Figure 8. Effects of the 1999 wildfire on Lavender Mountain. The large fallen trees in the foreground are various pines, including longleaf, that were attacked by beetles subsequent to damage from the wildfire.

Berry Longleaf Advocacy and Initial Research Efforts

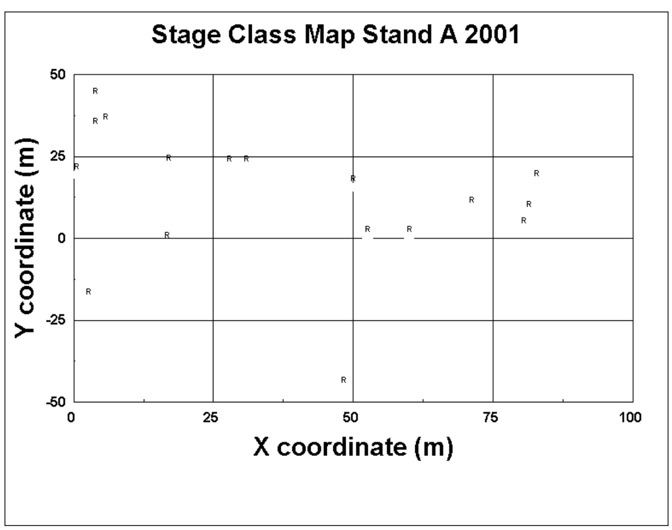
Interest in longleaf pine has been growing at Berry in recent years. As described above, in 1994-95 Berry student Roger Birkhead did a preliminary study of Berry's longleaf stands which included the coring of a number of trees (Birkhead and McGuire, 1998). In 1999, Dr. Martin Cipollini began a long-term demographic study with his Plant Ecology class in which five longleaf stands were studied along permanent transects. The primary purpose of the latter study was to create a demographic model to project future population change, and thus to determine whether the population is currently self-sustaining. In reaction to clear-cutting of some forest tracts as a means of controlling southern pine beetle, Students Against Violating Earth (SAVE; Berry's environmental club), began advocating longleaf restoration in 2000. The club also invited author Janisse Ray to Berry to speak about her novel *Ecology of a Cracker Childhood*, which depicts her experiences growing up in a longleaf pine ecosystem. Roger Birkhead returned to Berry from his research at the Joseph W. Jones Ecological Center at Ichauway Plantation in Newton, GA to give a talk on longleaf for the Biology Seminar Series in the Spring of 2000. Another seminar that year was given by Dr. John McGuire, outreach coordinator of the Longleaf Alliance, who also toured the forests and made management recommendations. In fall of 2000 and spring of 2002, Dr. Chris Mowry's Conservation Biology classes took field trips to the J. W. Jones Ecological Research Center (Ichauway Plantation) to see first hand a well-managed longleaf savanna and some of the current research associated with it. The Coosa River Basin Initiative sponsored a tour of Berry's longleaf pine led by student Karen Vaughn in fall 2000; its current director, former Berry student Mitch Lawson, remains supportive of the project and hopes to contribute assistance with management help, public education, and advice. In January of 2001, SAVE organized the planting of 2,000 longleaf seedlings on land that was cleared due to a pine beetle infestation. The land included a four-acre site just north of Friendship Hall and a two-acre site further west. That same spring, Dr. Martin Cipollini's Plant Ecology class worked to collect additional data from the existing longleaf stands and initiated the development of this draft management plan. In April of 2001, Karen Vaughn gave a presentation about the status and potential future management of Berry's longleaf pine at the Association of Southeastern Biologists meeting in New Orleans (Vaughn et al., 2001), the Berry College Poster Session and the Berry College Symposium on Student Scholarship. In May of 2001, Johnny Stowe, a Heritage Preserve Manager for the South Carolina Department of Natural Resources and mountain longleaf enthusiast, visited Berry's longleaf population and made management suggestions. He commented that our longleaf seedlings and juveniles are unlikely to survive without more light, and noted the extreme litter build-up, the presence of invasive species, and the growth of longleaf feeder roots into the duff layer. In the spring of 2002, a team of fire management experts (Neal Edmundson, Georgia Forestry Commission, Jimmy Rickard, U.S. Fish and Wildlife Service, John McGuire, Longleaf Alliance) visited Berry's longleaf stands with the intent of helping to devise a restorative burn plan. Coincidental with their visit, Dr. Lindsay Boring of the J. W. Jones Ecological Research Center visited to present a seminar on the management of longleaf pine ecosystem for multiple purposes, including education, recreation, conservation, and research. Dr. Boring also helped advise in the development of our management plan. Numerous members of the Berry Longleaf Network (Appendix II) graciously commented on a draft of this management plan in the spring of 2002, and extended offers for continued assistance and future advice. In summary, steam has been building for at least the last seven years toward the generation of a well-developed plan with the help and interest of numerous parties.

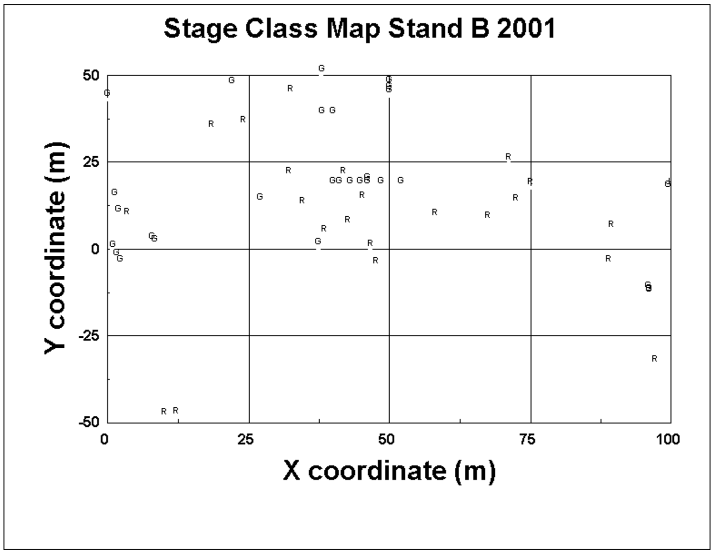
III) Current Research on Berry's Longleaf: A Technical Summary

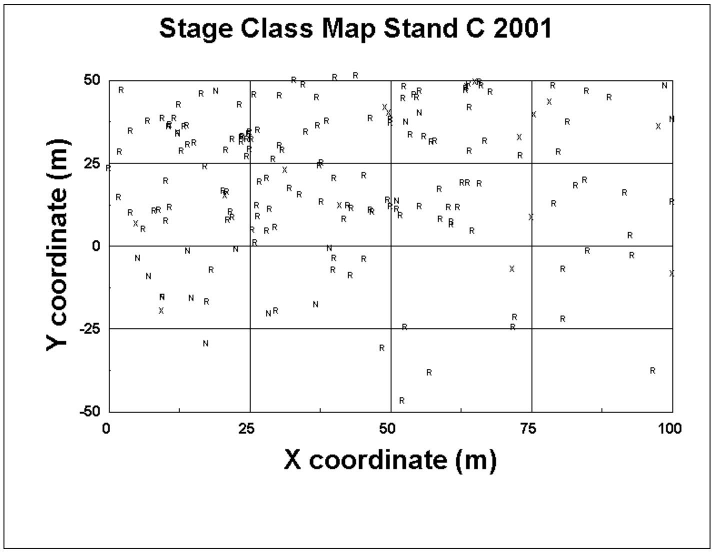
The following section gives a detailed description of the data that has been collected to date by Dr. Martin Cipollini's Plant Ecology class and by his student workers (who have been paid through the Berry College work program). This section is written for a technical audience in order to describe to professionals the current state of our knowledge about the existing stands. Most of the conclusions of this research are referred to in other sections of this plan in a more general manner. Less technically oriented readers may want to skip this section.

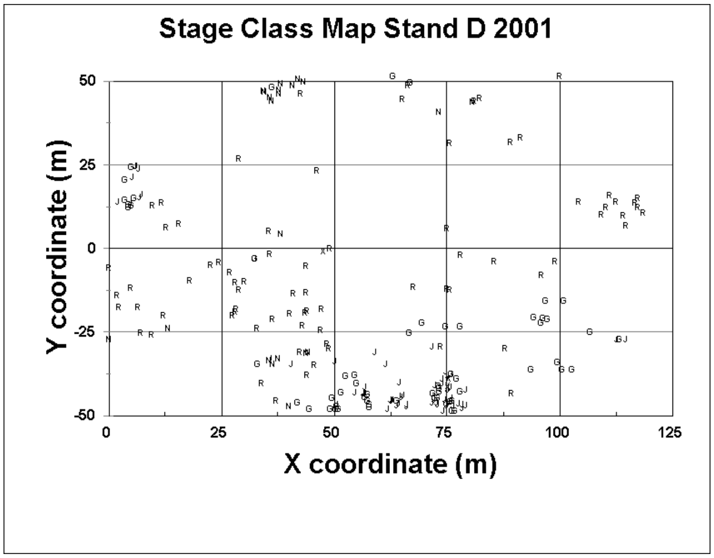
Census and Mapping

A census of several longleaf pine stands on Lavender Mountain was started in the spring of 1999. Trees were located along 100-125 m transects placed within four different stands (stands A-D; Figure 9). Study sites were chosen because they were known locations of longleaf pine stands that were reasonably accessible. During the initial census, all longleaf pines within 50 m of the transect line were identified, mapped, marked with aluminum numbered tags, and notes were taken concerning their condition (healthy, fire damage, fungal damage, insect damage, etc). Individuals were classified according to the following stage classes: grass (no visible stem), juvenile (single stem, leaves missing from lower portion of stem), non-reproductive adult (at least one lateral branch, no evidence of cone production), and reproductive adult (at least one branch, evidence of current or past cone production). For each adult tree, the circumference at breast height (CBH in cm) was measured. The CBH was used to determine basal area (an estimate of the area covered by canopy). In 1999, grass and juvenile stages were mapped, but were not measured in any way. In the spring of 2001, a re-census of all existing transects was completed, new individuals were added to the data set, and all juveniles were measured for height (m). A fifth transect (E) was added, and maps of all marked individuals were prepared in 2001 (Figure 9).




Stage Class Map Stand B 2001
Y coordinate (m)
X coordinate (m)


Stage Class Map Stand C 2001
Y coordinate (m)
X coordinate (m)



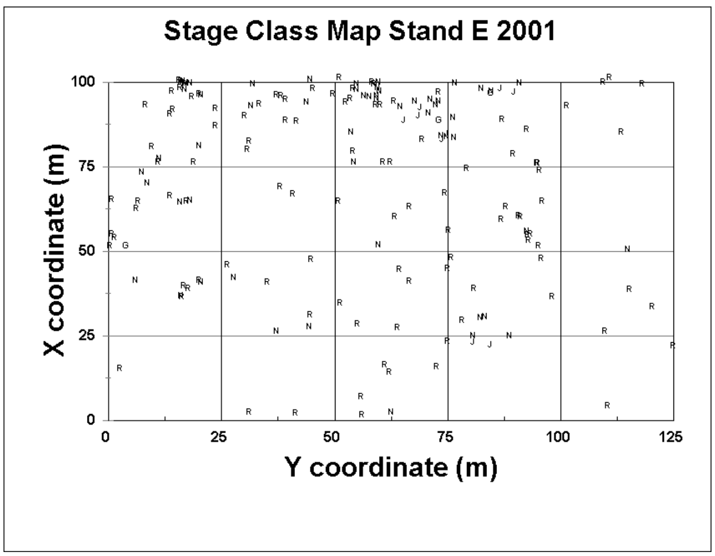


Figure 9. Stage class maps showing the positions and stage of all marked individuals following the 2001 census in stands A-E. G = grass, J = juvenile, N = non-reproductive adult, and R = reproductive adult.

Stage class distributions showed that in 2001 most individuals were in the adult stage classes (Figure 10). The only stand with significant numbers of grass and juvenile stages was stand D, where a majority of regeneration appeared to be taking place on a steep, open portion of the lower slope of the population (Figure 9). Stands C, D, and E had the greatest densities of adult trees, whereas lower slope stands A and B have relatively few individuals in any of the stage classes.

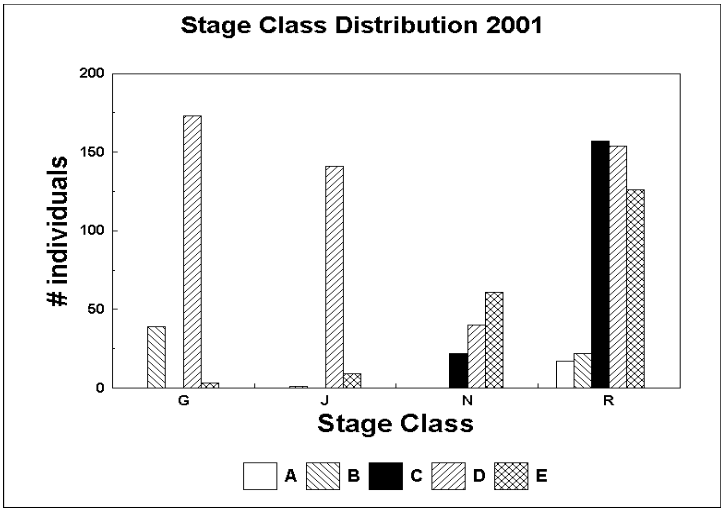
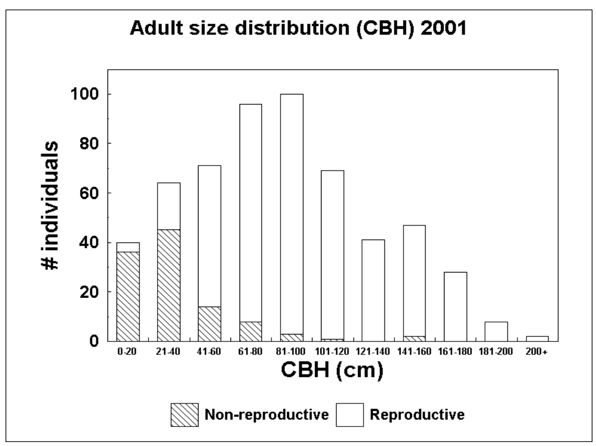


Figure 10. Stage class distribution for all marked individuals following the 2001 census in stands A-E. G = grass, J = juveniles, N = non-reproductive adults, and R = reproductive adults.

Among adult trees, most have a CBH greater than 60 cm, and mature (reproductive) adults vastly outnumber immature (non-reproductive) adults (Figure 11).



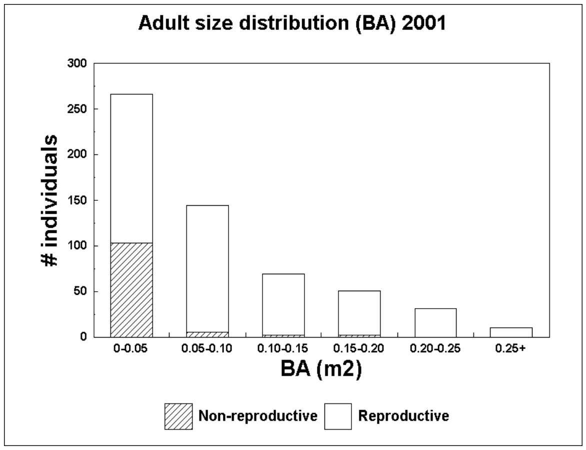


Figure 11. Size distribution of adults based upon circumference-at-breast-height (CBH; top) and basal area (BA; bottom) following the 2001 census in stands A-E.

Seed Production Estimate

An estimate of the seed production of reproductive adults was done in 1999 by gathering all cones within 10 randomly located 5 x 10 m plots within the stands, and counting the number of cone scales within each cone. Cones (n = 600) were only collected that were thought to be shed in 1999, based upon their position within the leaf litter and the lack of significant cone degradation. Using the assumption that each fully formed cone scale contained two seeds, we estimated the average number of seeds per cone to be 191.5 +/- 160.7. Based upon the number of cones per plot and the total area sampled, we estimated the total number of seeds produced within the stands. Dividing the total number of seeds produced by the total number of reproductive adults gave us an estimate of seed production per individual.

The results showed the average number of seeds per reproductive adult to be 19,900 +/- 16,700 seeds. This number could be biased because the data were collected in the spring instead of in October through November when the seeds are normally dispersed (Boyer, 1990). Additionally, it was difficult to tell for certain which scales had held viable seeds and which had not. It is possible that this number is an over-estimate, since Snyder et al. (1977) reported a range of 15-60 seeds/cone for mountain longleaf (compared with our estimate of over 190 seeds/cone). As these results were used in the population projection analysis that follows, the results of that analysis may be interpreted as an over-estimate as well.

Population Matrix Model Analysis

The census information gathered from the field research was compiled into a master data set for all five stands containing each individual's CBH, stage, map coordinates, and notes concerning condition. Using data on stage class transitions for stands A-D from 1999 to 2001, a matrix model was constructed to project future population growth. Stage class transitions are changes from one stage class to another (e.g., grass to juvenile stage, reproductive to non-reproductive adult stage) or reproduction (which contributes to early stage classes) over the census interval (in this case, 2 years). For example, out of 166 grass stages marked in 1999, 126 were recorded as still being in the grass stage in 2001. This gave a grass-to-grass stage transition of 126/166 = 0.759. Similarly, of the grass stages marked in 1999, 19 had become juveniles by 2001, so the grass-to-juvenile transition was 19/166 = 0.114. This was done for all possible transitions, except for the non-reproductive-to-reproductive transition, which was not observed. We thus estimated this single parameter at 2% per year. Seed production in 1999 was assumed to give rise to all new grass and juvenile stages recorded in 2001. Thus, we used our estimate of total seed production to estimate reproductive adult-to-grass, and reproductive adult-to-juvenile transitions. To do this, we divided the total number of new grass and juvenile stages found in 2001, respectively, by the total number of seeds produced in 1999. The full transition matrix is shown in Table 1.

Table 1. Overall stage class transition matrix for longleaf population in stands A-D (1999-2001). Elements are transitions from one stage class to another over the two-year census interval.

Stage	Grass	Juvenile	Non-reproductive	Reproductive
Grass	0.759	--	--	9.9×10^{-6}
Juvenile	0.114	0.895	--	8.7×10^{-6}
Non-reproductive	--	0.053	0.822	0.021
Reproductive	--	--	0.020	0.916

Matrix models are either solved analytically or by iteration; in either case, results can generate predictions about future population growth based upon census data (Tuljapurkar and Caswell, 1997). The model applied here assumes that population growth patterns do not change over time (e.g., the model predicts future population behavior in absence of changes in environmental conditions). The current results reported here are based upon only a single census, and must be interpreted in that light. To solve the matrix model, a computer program written in MATLAB (Appendix II; The Mathworks, Inc., 1994) was used to generate estimates of the following parameters: lambda (an estimate of long-term population growth rate), the vector of reproductive values (an estimate of how much an individual in each stage class contributes to population growth), the sensitivity and elasticity matrices (an estimate of how much each transition contributes to population growth; de Kroon, et al., 1986), and the stable population distribution (an estimate of the relative frequencies of individuals within each of the stage classes at equilibrium). Together, these results can be used to determine whether the longleaf population is currently decreasing, stable, or increasing, and to identify which stages or stage transitions are most critical for long-term growth (and hence worthy of management focus). As stated above, the model is a linear model (assumes that current conditions will not change), but gives a general idea of what the future population may look like should current conditions remain unchanged.

The population demographic analysis gave a lambda value of 0.92, and a vector of reproductive values showing grass, juveniles, non-reproductive adults, and reproductive adults at -0.32, -0.45, -0.22, and -0.98, respectively. These results can be interpreted to mean that the current population is declining (lambda < 1.0), and that the stages contributing most to population growth (in this case, population decline) are the juvenile and reproductive adult stages. The sensitivity matrix (Table 2) indicates that stasis (survival) of adult stages, and reproduction of new grass stages (via adult seed production) are the most critical elements for long-term population growth. Sensitivities for these elements were much higher than those for other stage class transitions. This analysis, however, shows large values for some transitions which are not possible (e.g., direct production of juveniles from reproductive adults (row 2, column 4). The elasticity matrix (Table 3), which describes the effects of proportional changes in transition elements, supports the sensitivity analysis regarding the importance of the survival of adults. The elasticity of this single element (reproductive adult-to-reproductive adult survivorship) had a much higher effect on population growth than any other parameter.

Table 2. Sensitivity matrix for longleaf stands A-D (1999-2001). Elements represent the relative contribution of an absolute change in each transition to population growth, thus values are present that are impossible in reality (e.g. the grass-to-reproductive adult transition).

Stage class	Grass	Juvenile	Non-reproductive	Reproductive
Grass	0.0000	0.0002	0.0678	0.3147
Juvenile	0.0000	0.0003	0.0955	0.4435
Non-reproductive	0.0000	0.0001	0.0465	0.2159
Reproductive	0.0001	0.0006	0.2053	0.9532

The predicted stable population distribution at equilibrium was 0.01% grass, 0.05% juvenile, 17.71% non-reproductive adult, and 82.23% reproductive adult stages. This distribution differs from the observed distribution of 22.2%, 15.6%, 12.7%, and 49.6% for the same four classes, respectively. In other words, the model predicts that the population is heading toward a distribution of nearly all adults, with little regeneration of

Table 3. Elasticity matrix for longleaf stands A-D (1999-2001). Elements represent the relative contribution of a proportional change in each transition to population growth, thus values are possible only for transitions that were actually observed (e.g. the grass-to-reproductive adult transition).

Stage class	Grass	Juvenile	Non-reproductive	Reproductive
Grass	<0.0001	--	--	<0.0001
Juvenile	<0.0001	0.0003	--	<0.0001
Non-reproductive	--	<0.0001	0.0415	0.0050
Reproductive	--	--	0.0050	0.9482

grass and juvenile plants, and from that point on will decline at a rate of about 8% every two years. Again, this prediction assumes that the two-year census period was representative of average conditions. So, the results suggest that, with no active management or other dramatic changes in future conditions, the population will be in a steady decline.

Noting that seed production was likely over-estimated (see Seed Production Estimate, above), and that the non-reproductive-to-reproductive adult transition was also possibly a high estimate (this section, above), the matrix model results probably represent a somewhat optimistic view of future population growth. The short story is that the existing populations are very much in trouble unless steps are taken to manage the stands. The results further suggest that protection and management of the adult stage class is the area most worthy of focusing management (as the death of reproductive adults contributed most to current population decline). In fact, most of the observed decline was due to the effects of the wildfire that swept through stands B and C in the summer of 1999. Our interpretation is that protection of these stands from potentially damaging wildfire is critical, as is management of wildfire risk via prescribed burning (Saveland, 1987; Omi and Martinson, 2002). This interpretation should help focus and guide management practices, as current regeneration is not apparently capable of keeping up with such potentially devastating events.

Leaf Litter and Available Fuel Load Estimation

To estimate fuel load, a total of 32 leaf litter samples were taken randomly from the five stands (approximately 6 samples per stand) in 2001 using sampling frames of 0.07-0.08 square meters. Each litter sample was oven-dried at 60°C to constant mass, and weighed. This information is important because it provides data that can be used to evaluate the potential for controlled burns to be used in these stands.

The average sample mass was 187.2 g. Conversion of this figure gives about 11.5 ton/acre dry mass. Litter masses are usually reported in wet mass along with percent moisture content (e.g., Hough, 1968; Hough, 1978). Moisture contents typically range from about 10 to about 250% of dry mass in Southern pine forests. Using a median moisture content value (130%) to convert our dry mass data into wet mass data suggests that typical litter layer wet masses are about 12.8 ton/acre. Regardless, the estimated litter load in the stands is quite high. Of 28 experimental burns in southern pine forests reported by Hough (1968), pre-burn total litter weights ranged from 1 to 16 ton/acre, putting our experimental plots in the upper range. For mountain longleaf sites, Varner et al. (2000) classified areas with about 3 tons/acre of leaf litter as low fire risk areas, and those with about 9 tons/acre as high fire risk areas. Based upon this classification the average litter mass of the five stands is also well within the high fire risk category. The question of available dry fuel prior to a prescribed burn is thus an issue. Hough uses the following regression to predict available dry fuel from total litter dry weight:

(1) $W_{AL} = 3.4958 + 0.3833(W_{TL}) - 0.0237\,(M_{TL}) - 5.6075(1/W_{TL})$

Where: W_{AL} = available litter fuel dry weight (tons/acre)
W_{TL} = total litter layer dry weight (tons/acre)
M_{TL} = moisture content of total litter layer (% dry mass)

Using Hough's (1968) equation, we can estimate available litter dry fuel as a function of moisture content. Unfortunately, this method does not take into account fuel load due to standing live vegetation. McNab and Edwards (1976) give methods of estimating litter and understory fuel weights from easily measured stand characteristics. While the understory in Sites A-E is currently quite sparse, in the future, the approach of McNab and Edwards will be used to obtain better estimates of available fuel load that include standing live vegetation. In the meantime, the data presented here can be used to predict the intensity of prescribed fires as a function of days since rain using the following formulae from Hough (1968). First, the moisture content of the litter layer is predicted based upon rainfall duration:

(2) $M_{TL} = 100.2261\ (RD^{0.3027})$
Where: M_{TL} = maximum total litter layer moisture content
RD = rainfall duration (hrs)

Second, litter moisture content is predicted based upon the time since the rainfall.

(3) $M_A = (e - t/\gamma \qquad _Q - M_E)) + M_E$
Where: M_A = % moisture at end of drying period
M_E = equilibrium % moisture = 25%
M_Q = % moisture at start of drying period
t = time (hrs)
γ = timelag constant = 100 hrs (for 100 hr fuels)

Finally, total available fuel is estimated using the calculated moisture content and litter dry mass using equation (1) above. Following Hough (1968), we estimated M_E to be 25%, which is consistent for stands having heavy fuel accumulations (about 12 tons/acre). For moderate loadings an M_E value of 15 %, and for light loadings an M_E value of 5% would be more appropriate. In combination, these formulae may be used to predict days that available fuel loads will fall within a range acceptable for prescribed burning, and thus to allow advanced planning. Predicted available fuel loads as a function of rainfall duration and days since rain are seen in Figure 12 (calculations are done using a spreadsheet program titled: "Estimating Available Fuel Load").

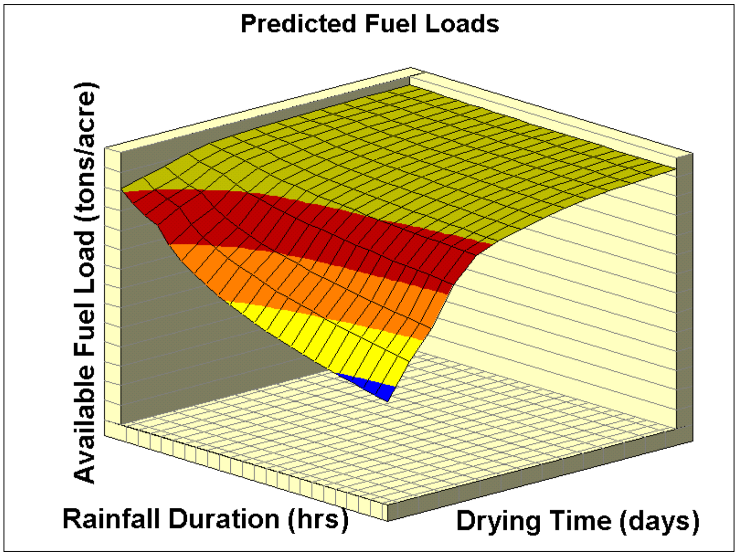


Figure 12. Predicted fuel loads for stands A-E based upon rainfall duration and drying time. Depending upon the desired fuel consumption and local weather data, this analysis can help determine when a prescribed burn might best be conducted.

Based upon these analyses, available fuel loads should rise to near equilibrium levels within 1 to 6 days, depending upon initial rainfall duration. Using these results, one can predict available fuel loads immediately following a given rain event, and base decisions concerning prescribed burning on fuel loads. These site-specific results can be used in conjunction with Georgia Forestry Commission daily burn reports for North Rome when making final decisions concerning prescribed burns within Sites A-E.

Forest Community Analysis

In spring of 2001, a point-centered quarter (PCQ) technique was used to obtain an estimate of the current tree species community composition of the five longleaf stands (A-E). Data were collected at 10 m intervals along the existing transects within each stand. At each sample point a line was established perpendicular to the main transect, marking off four quadrants at each point. Within each quadrant, the distance to the nearest individual was determined, its species identity was recorded, and its circumference-at-breast height (CBH) was measured. Basal area (BA) for each individual was calculated from the CBH. Using these data, we calculated the total density of trees within each stand, as well as the absolute and relative density cover, and frequency of each tree species within each stand as follows.

(4) Total density/ha = 10,000/average distance (m) from transect

(5) $D = \text{Density}_{\text{species A}}$ = (# of trees of spp. A / total # of trees) x total density/ha

(6) C = Cover (basal area) = $\text{Density}_{\text{species A}}$ x average basal $\text{area}_{\text{species A}}$

(7) F = Frequency = # $points_{species\ A}$ / total points

(8) RD = Relative Density = $Density_{species\ A}$ / Total Density

(9) RC = Relative Cover = $Cover_{species\ A}$ / Total Cover

(10) RF = Relative Frequency = $Frequency_{species\ A}$ / Total Frequency

Relative density (RD), frequency (RF), and cover (RC) values were then calculated and summed to generate an overall importance value (IV) for each species within each stand. These data are important in determining the degree of current hardwood encroachment within the longleaf stands, and will serve as a benchmark for the assessment of future management practices.

The results of the PCQ analysis can be seen in Table 4. Stand C had the lowest total density, and stands B, D, and E had the highest total density. *Nyssa sylvatica*, *Quercus* spp., *Tilia americanum*, *Pinus palustris*, and *Quercus* spp. have the greatest importance values within stands A, B, C, D, and E, respectively. In other words, the only stand dominated by longleaf was stand D. Students inadvertently failed to count and measure *Pinus palustris* in stand C, so those results should be interpreted as showing only non-longleaf species. This stand is known to have a high density of longleaf. For this reason, and also because species identifications were done using relatively untrained students, these results must be considered tentative. Nevertheless, they do suggest dramatic hardwood encroachment in the longleaf stands.

Table 4. PCQ data for longleaf stands A-E in 2001. See text for definition of variables.
* *Pinus palustris* individuals were not counted in stand C.

Stand A	Species	D	C	F	RF	RD	RC	IV
	Nyssa sylvatica	1060.16	2236.90	0.800	0.280	0.400	0.571	1.251
	Quercus spp.	265.04	432.02	0.400	0.140	0.100	0.110	0.350
	Pinus palustris	265.04	402.86	0.400	0.140	0.100	0.103	0.343
	Quercus alba	265.04	326.00	0.300	0.100	0.100	0.083	0.283
	Pinus echinata	265.04	283.60	0.300	0.100	0.100	0.072	0.272
	Prunus caroliniana	198.78	69.57	0.300	0.100	0.075	0.018	0.193
	Acer spp.	198.78	112.70	0.200	0.070	0.075	0.029	0.174
	Carya spp.	132.52	51.68	0.200	0.070	0.050	0.013	0.133
	Total	2650.40	3915.33	2.900	1.000	1.000	0.999	2.999

Stand B	Species	D	C	F	RF	RD	RC	IV
	Quercus spp.	551.09	518.02	0.400	0.264	0.175	0.264	0.703
	Oxydendron arboreum	551.09	264.52	0.300	0.135	0.175	0.135	0.445
	Pinus palustris	236.18	236.18	0.200	0.120	0.075	0.120	0.316
	Pinus echinata	393.64	161.39	0.300	0.082	0.125	0.082	0.289
	Diosporos virginiana	236.18	164.15	0.200	0.084	0.075	0.084	0.242
	Quercus rubra	157.46	185.80	0.200	0.095	0.050	0.095	0.239
	Acer spp.	393.64	106.28	0.300	0.054	0.125	0.054	0.233
	Carya spp.	236.18	77.94	0.200	0.040	0.075	0.040	0.154
	Pinus spp.	78.73	102.35	0.100	0.052	0.025	0.052	0.129
	Prunus spp.	78.73	82.67	0.100	0.042	0.025	0.042	0.109
	Cornus florida	157.46	47.24	0.200	0.024	0.050	0.024	0.098
	Acer rubrum	78.73	15.75	0.100	0.008	0.025	0.008	0.041
	Total	3149.11	1962.29	2.600	1.000	1.000	1.000	3.000

Stand C*	Species	D	C	F	RF	RD	RC	IV
	Tilia americanum	416.08	203.88	0.583	0.297	0.296	0.280	0.873
	Quercus rubra	312.06	177.87	0.416	0.212	0.222	0.244	0.678
	Acer saccharum	156.03	96.74	0.160	0.082	0.111	0.133	0.325
	Pinus taeda	156.03	84.26	0.160	0.082	0.111	0.116	0.308
	Carya tomentosa	104.02	41.06	0.160	0.082	0.074	0.056	0.212
	Quercus marilandica	104.03	34.33	0.160	0.082	0.074	0.047	0.203
	Quercus nigra	52.01	13.00	0.160	0.082	0.037	0.018	0.136
	Quercus alba	52.01	41.61	0.080	0.041	0.037	0.057	0.135
	Quercus spp.	52.01	36.41	0.083	0.042	0.037	0.050	0.129
	Total	1404.28	729.16	1.962	1.000	1.000	1.000	3.000

Stand D	*Species*	D	C	F	RF	RD	RC	IV
	Pinus palustris	646.55	924.57	0.500	0.166	0.188	0.363	0.716
	Pinus echinata	754.31	565.73	0.625	0.210	0.219	0.222	0.651
	Carya spp.	862.07	189.66	0.750	0.250	0.250	0.074	0.574
	Quercus spp	323.28	198.17	0.250	0.083	0.094	0.078	0.254
	Oxydendron arboreum	215.52	232.76	0.250	0.083	0.062	0.091	0.237
	Acer spp.	215.52	174.57	0.250	0.083	0.062	0.068	0.214
	Pinus taeda	215.52	145.47	0.250	0.083	0.062	0.057	0.203
	Nyssa sylvatica	215.52	118.53	0.125	0.043	0.062	0.046	0.152
Total		3448.28	2549.46	3.000	1.001	1.000	1.000	3.001

Stand E	Species	D	C	F	RF	RD	RC	IV
	Quercus spp.	1301.92	766.50	1.000	0.333	0.400	0.367	1.100
	Pinus palustris	569.63	760.05	0.500	0.170	0.175	0.364	0.709
	Acer spp.	325.48	134.27	0.400	0.133	0.100	0.064	0.297
	Acer rubrum	325.48	151.36	0.300	0.100	0.100	0.073	0.273
	Pinus echinata	325.48	130.20	0.300	0.100	0.100	0.062	0.262
	Nyssa sylvatica	244.13	63.47	0.300	0.100	0.075	0.030	0.205
	Pinus taeda	81.38	50.45	0.100	0.033	0.025	0.024	0.082
	Oxydendron arboreum	81.38	30.92	0.100	0.033	0.025	0.015	0.073
	Total	3254.86	2087.22	3.000	1.000	1.000	1.000	3.000

Interpretation of Current Results

The results gathered thus far reveal a great deal about the current status of the population of mountain longleaf on Lavender Mountain. A lambda value of about 0.92 suggests that, providing conditions remain the same, the population is in decline by about 8% every two years. This is due to the fact that the longleaf population is being succeeded by hardwoods because of the suppression of fire in the area, coupled with the loss of adults from the wildfire fire that swept through stands B and C in 1999. The vector of reproductive values suggests that the adult stages are the most important for long-term population growth. This is also seen in the elasticity matrix where the survival of reproductive adults contributes most strongly to population stability. This latter result is not unusual for woody plants in general. Most tree species show similar patterns, in which the survival of adults is the most critical aspect of long-term population growth (Silvertowne et al., 1993). This suggests that efforts to conserve adults would be the first place to focus management. Because of high mortality, efforts to encourage or plant seedling and/or juveniles within the current stands would have little impact on the long-term population growth. Efforts to plant longleaf seedlings to other areas of campus, or within or near the stands after changes in conditions (e.g., after burning) remain viable options, which must be evaluated as a separate issue.

The results concerning the projected stable population distribution suggest that the population is heading toward a distribution comprised mostly of non-reproductive and reproductive adults. The results suggest that the population will steadily age and occasional wildfire and other events will gradually drive the population to extinction. Because the adult stages are the most important, it might be concluded that management efforts should be focused primarily in Stands C, D, and E because they have the greatest number of viable reproductive adults. Nevertheless, since stands A and B have the fewest trees at risk (lowest densities), it may be wise to focus initial (trial) management practices in those stands, while continuing to protect and study stands D and E. Since stand C has also experienced a recent fire, and has a reasonable start on the re-establishment of a groundcover (see Site Descriptions below), early trial management experiments might also be conducted there.

The forest community data suggest that longleaf has the third highest or greater importance values within each stand. This suggests that the removal of a few of the more dominant species within each stand may help reestablish dominance by longleaf. One of the objectives of this management plan will be to return the stands on Lavender Mountain to something akin to a pre-European development mountain longleaf pine ecosystem. This set of baseline data may be used as an initial benchmark to track the success of the program in returning the sites to longleaf dominated stands, with lower overall tree density, and fewer hardwoods.

The amount of leaf litter present in the stands appears to be high and likely dangerous if burns were to be prescribed without careful consideration of this factor. Although the data show some variation among leaf litter samples, it is important to remember that because of the mountainous conditions, the leaf litter samples are expected to vary somewhat due to differences in slope. For example, a sample taken on a steep slope would have a lower amount of leaf litter than a sample taken at the bottom of a steep slope. In fact, most current regeneration within existing stands is taking place on particularly steep sites where litter is physically swept away, thus exposing mineral soil.

The salient conclusions of the current data analysis are that the existing stands are declining, probably due to hardwood encroachment and sporadic un-planned wildfires and weather events. Leaf litter has accumulated to dangerous levels in most areas, thus making fire management difficult. The control of hardwoods and the reintroduction of fire into existing stands that contain healthy adult seed trees should be the primary focus of a management plan. This, coupled with planting longleaf seedlings in distant areas clear-cut to control southern pine beetle, will therefore be the central focus of our plans.

IV) The Berry College Longleaf Management Plan

Principle Goals

The results of the field studies done to date indicate the need for restoration of the Berry's longleaf pine population, and a need for additional study into other aspects of this habitat type (e.g., associated herbaceous plant, bird, mammal, amphibian, arthropod, and fungal communities). A preliminary plan for restoration and future study is provided here in the form of the Berry College Longleaf Management Plan. The primary goal of the plan will be to restore an area designated as the Longleaf Pine Management Area to a functioning mountain longleaf ecosystem. The progress of the restoration effort will be monitored by comparing population and community data within the management area with data derived from existing healthy mountain longleaf ecosystems, with data derived from past surveys of the Lavender Mountain area, and with historical data from nearby mountains. An ancillary goal of the plan will be to foster research, education, and community outreach, as a means of making the plan beneficial to not only the Berry campus community, but also to the local and regional community. Within the south, the management of fire suppressed mountain habitats is still in experimental phases, and Berry has an opportunity to be a part of this research.

The Longleaf Pine Management Area

Though much of Berry's mountain campus was once covered in longleaf pine forest (Andrews, 1917), current efforts will be focused primarily within the general area where existing longleaf populations are found. This site will be designated as the Longleaf Pine Management Area (Figure 13). The Management Area is approximately 173 acres (70 hectares), and is located within existing firebreaks as much as possible. It encompasses all five study stands as well as the area recently planted to mountain longleaf by the Berry SAVE Club in 2001. The southern border is formed primarily by the Old Mill road, and the western border is the stream that runs into the Old Mill Pond. The northern border is the road connecting the reservoir to the House of Dreams, and the Management Area extends past this road on the east to include the seedlings planted by the SAVE club. To the east of this area, a streambed roughly marks a potential firebreak. Burns will be carefully planned and advertised, and firebreaks will be created to protect

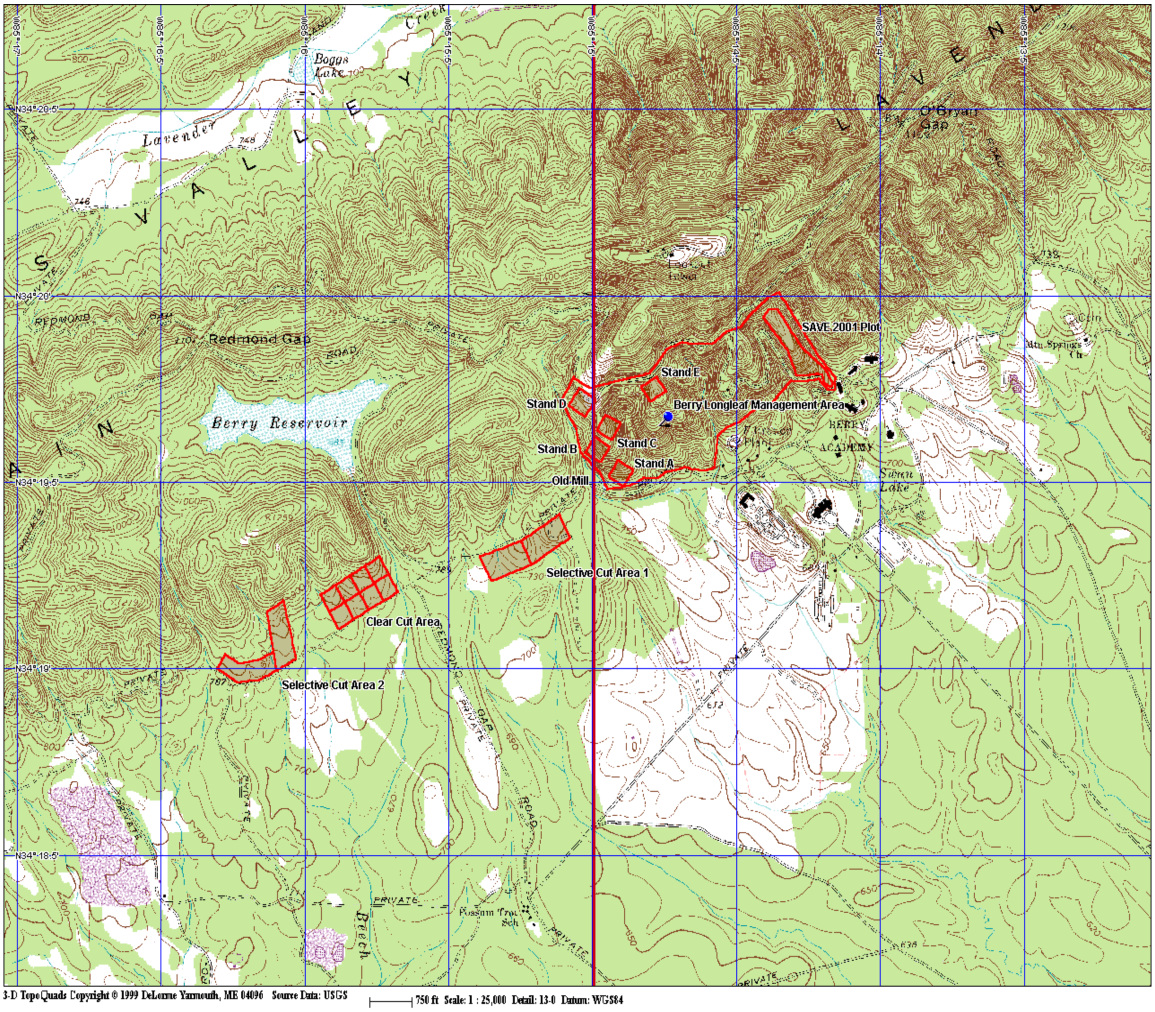


Figure 13. The Berry Longleaf Management Area. Overview of entire area.

the water treatment plant and residential areas. The boundaries of the Management Area will be marked with permanent signs with a brief description of the Longleaf Project. The area will remain open to public access unless burning or other potentially hazardous management activities are taking place. Aside from emergency situations, it will not be subjected to land management activities that are incompatible with the overall goals of the Longleaf Management Plan. All activities within the Management Area, including research and management, will first be reviewed by the Berry Longleaf Network (Appendix I). The network is a group of interested professional advisors who have stated a willingness to serve as an advisory panel. Planned management practices will be submitted for approval by the Berry's Educational Land Management (ELM) Presidential Task Force. A specific burn plan will be prepared according to recommended guidelines (e.g., Wade and Dixon, 1988; U.S. Fish and Wildlife Service, 2002) by an Interagency Burn Team (Appendix I). This team is a group of highly qualified professionals with experience in developing and implementing fire management in longleaf and other ecosystems. The goal of involving these groups is to facilitate the development of a solid management plan, and to assure that research at Berry can serve as a model for the management of mountain longleaf on private properties elsewhere.

Specific Management Objectives

The restoration of a longleaf pine ecosystem on the Berry College campus is clearly a long-term project. Decades of fire suppression have removed conditions favorable to longleaf growth and reproduction, and have allowed these areas to begin succeeding towards a mixed hardwood forest. The return of favorable conditions must be done gradually and cautiously, and everyone involved with the project must be patient because the desired results may not be seen until years after the project begins. Because of potential risks to adult longleaf, management activities involving existing stands will begin on a small scale. Experimental plots will be set up with the areas of the five study stands. Each site will be subjected to somewhat different management regimes, each either involving fire or simulating the benefits brought to the ecosystem by fire, such as elimination of hardwoods and litter removal. Management activities will follow closely the general recommendations of Stanturf et al. (2002) and other USDA Forest Service and Georgia Forestry Commission resources for longleaf, and those of Varner et al. (2000) for mountain longleaf specifically.

None of the sites are currently in pristine condition. All have heavy fuel loads, which can cause prescribed burns to reach fatal heat. Longleaf feeder roots have grown into the duff layer, where they can be damaged by fire and cause the death of the tree. A closed hardwood canopy is blocking light and preventing most seedlings from germinating and/or leaving the grass stage. The long-term goal for all the sites is to eventually reintroduce fire and begin a regular burning schedule, and to achieve a target community structure resembling that of mountain longleaf sites in nearby management areas. A specific site for comparison will be the "healthy" mountain longleaf system at Ft. McClelland, Alabama (Maceina, 1997; Varner, 2000; Varner et al., 2000). An important part of the plan will be to generate a network of interested professionals, faculty, student groups, and volunteers, such that the project can carry on in the absence of a permanent director. During the early stages of the project, Dr. Martin Cipollini will serve as the Project Coordinator.

V) Site-by-Site Descriptions and Tentative Management Plans

Stand A

Site Description: Stand A is a 1 hectare (2.47 acre) study area located across the ridge northeast of the Old Mill, with a transect on the eastern side of the trail called The Chute (Figure 14). In 2001 it contained only adult longleaf pines, with no seedlings or juveniles. The tree community is dominated by hardwoods, and longleaf pine has a low relative cover. The slope of the ground is much less severe than in the other sites.

Figure 14. Stand A in the spring of 2002. Note the extensive hardwood encroachment and deep litter layer.

Management Prescription: Site A will initially be the most intensely managed of all the sites because it has the least number of longleaf present. It therefore has a high need for restoration, and fewer trees will be put at risk. It is also more easily accessible to the public by way of the Old Mill road, allowing Berry to showcase this restoration effort and demonstrate the positive effects of prescribed fire. In this site, adult hardwoods will be cut, litter will be removed, and a small-scale prescribed burn will be performed.

- Caution signs will be posted at all major access points to prevent injury to hikers or bikers.
- In the fall of 2002, all hardwoods larger than 3 inches (7.62cm) in diameter will be cut with chainsaws (to prevent damage from heavy machinery), and a crew of sawyers will be required that are experienced in cutting with minimal disturbance. The stumps will be painted with the herbicide Arsenal to prevent re-sprouting. Sprouting may also be prevented by frequent burns that kill hardwood root systems, but this would not give longleaf seedlings a chance to germinate and reach fire resistant size.
- Fallen trees will be cut into logs and rolled out of the study area. Because this site is just upslope from the Old Mill Road, the logs can be transported to pickup trucks, such as

those used by the Berry Physical Plant. These logs will be split mechanically and sold as firewood.

- In the Spring of 2003, an area approximately 2 m in radius around each longleaf tree will have litter removed nearly to the mineral soil to prevent fire from directly affecting the base of the tree. This will be done using a portable leaf blower. Trees will be monitored for the effects of leaf litter removal in the summer and fall of 2003.

- In the Fall of 2003, a firebreak will be constructed by blowing leaf material away to expose bare mineral soil from an 8-10 foot strip around the entire site. For this site, the Old Mill Road will also function as a firebreak.

- In late fall or winter 2003-2004, a burn crew of 6-8 people, including at least one experienced crew leader, will perform a controlled burn in winter when conditions are appropriate as determined by the burn crew leader. This burn will be conducted by members of the Interagency Burn Team, the staff of the Land Resources department, and volunteer trainees.

- Before the burn begins, leaf material will again be blown away from the bases of all longleaf trees, and water will be sprayed liberally around the base of each longleaf using 5 gallon backpack sprayers to prevent the fire from destroying feeder roots or girdling the tree at the base.

- The burn crew will be posted at regular intervals around the site, and each crew member will have a tool, such as a rake or shovel. There should be several backpack sprayers and barrels of water placed around the perimeter, and a mechanical pump placed at the Old Mill pond will provide a plentiful water source.

- The site will be subjected to a low surface fire using a driptorch with fuel consisting of 60% diesel and 40% gasoline.

- Once the area has been burned and the fire extinguished, the base of each longleaf will again be sprayed with water to prevent smoldering.

- If data collected after the burn shows that management positively affected the site, the methods used can be repeated in the other sites containing mature longleaf. Cool season, low surface fires will be repeated on an annual basis using the above methods, until analysis of fuel loads indicate that it is safe to conduct growing season burns. Thereafter, fire management will continue at a frequency of every 3-5 years.

Stand B

Site Description: This site is located on the slope directly behind the Old Mill, on the western side of the Chute trail (Figures 15-16). It is a 1 hectare (2.47 acre) study area, with the transect to the west of the trail. In 1999, a wildfire came through the area, killing a number of adult trees. The site is dominated by hardwoods, but currently contains a small group of seedlings that emerged following the 1999 fire.

Figure 15. Stand B in the spring of 2002. This site was heavily affected by a wildfire in 1999 (see below).

Figure 16. Stand B in the spring of 2002, showing area heavily damaged by wildfire, with subsequent beetle damage.

Management Prescription: As this stand has already been affected by a wildfire, it will be treated identically to site A, but the first burn will not take place until after the burn on site A has been conducted and the early results assessed.

Stand C

Site Description: This site is north of sites A and B, and stretches across a level ridgeline area with slopes on either side (Figures 17-19). The study area is 1 hectare (2.47m), and the permanent transect is located east of the trail. Longleaf is currently the dominant species, but no seedlings or juveniles are present. A number of adults in this site were killed in the 1999 wildfire that swept up from site B. This site has a much thicker herbaceous community than any other site, probably due to the 1999 wildfire.

Figure 17. Stand C in the spring of 2002. This part of the stand was affected by the 1999 wildfire.

Figure 18. Stand C in the spring of 2002. This is a part of the stand that was affected by the 1999 wildfire. An herbaceous ground cover of bracken fern and broomsedge, coupled with *Vaccinium* spp. was establishing at this time.

Figure 19. Stand C in the spring of 2002. This area was heavily affected by the 1999 wildfire. Note that virtually the only adult trees to survive this fire were longleaf.

Management Prescription: In 2003-2004, stand C will undergo a cool season burn after litter has been blown away from the base of each longleaf. Methods will follow that of site A and B, except that mechanical hardwood removal will not be performed. Because Stand C is less accessible from the main road, Stand A will be burned first to foresee any potential problems. Information gained from the prescribed burn in Stand A will be used to alter the methods employed in Stand C.

Stand D

Site Description: This 1.25 hectare (3.09 acre) site is north of Stand C, and the transect is to the west of the trail (Figures 20-22). A major forestry road runs through the study area. Most of the site is on a steep slope, and the western-most, downslope edge contains the most populated patch of seedlings currently known. The area where seedlings are found has lower litter build-up and a more open canopy than the rest of the site, most of which has dangerously thick litter. Stand D has the most stable population structure, with individuals from each stage class represented.

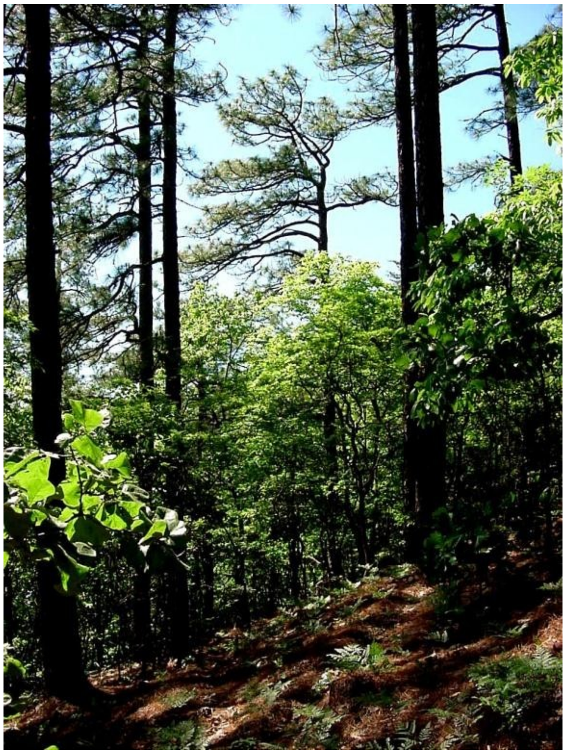


Figure 20. Stand D in the spring of 2002, showing large adults and a predominantly hardwood understory. This part of the stand shows little regeneration, in contrast to the area down slope (below).

Figure 21. Base of a very large longleaf tree in stand D in 2002. Note the heavy buildup of leaf litter that surrounds the base of the tree.

Figure 22. Regeneration site in stand D in 2002. This is one of the few small known spots of active regeneration in any of the five stands studied.

Management Prescription: Assuming that planned burns go well in sites A, B, and C, a specific burn plan will be developed for this site and surrounding areas to take place in 2004-2005. This site is located on the steepest slope, and contains the most natural regeneration of any of the sites, so it will be the last of the five stands to be subjected to fire management. Some mechanical hardwood removal will be undertaken in 2002-2003, as in Stand E (see below).

Stand E

Site Description: This site is located on the ridge northwest of the water filtration plant. It can be reached from the Water Works trail near the Old Mill road gate (Figures 23-25). This site contains both a level ridgeline area and steep slopes. Very few seedlings or juveniles are present. This site contains some of the largest and oldest trees in any of the five stands. Several trees cored by Roger Birkhead showed them to be nearly 200 years old in 1995 (Birkhead and McGuire, 1998). This site has extensive hardwood encroachment and an extremely thick litter layer. It was the site added to the census project in 2001. It is unlikely that this site has had significant fire activity for many years.

Figure 23. Entrance to the area where stand E is located in the spring of 2002. Note the extensive hardwood overstory and dark conditions of the understory.

Figure 24. Stand E in the spring of 2002. Again, note the extensive hardwood overstory and dark understory conditions.

Figure 25. View of the crown of a mountain longleaf in stand E in 2002. Note the somewhat twisted and flattened crown that is characteristic of mature mountain longleaf. This tree is likely in excess of 150 years old.

Management Prescription: As for stand D, this site will not be burned until techniques have been further refined and early results interpreted; most likely not until 2004-2005. Stand E may contain some old growth trees (in excess of 200 years), and caution should be taken to ensure that these remain for years to come.

In the latter two sites (D and E) some hardwood removal will be undertaken in 2002-2003 to open up canopy gaps to sizes that can meet the light requirements of longleaf seedlings. In the first year of management (2002), only about 1/3 of adult hardwoods will be removed to limit the trauma to the site from fallen trees. They will be cut using the methods described for Stand A. Both sites are accessible by a forestry road, which will allow for removal of the fallen trees by a tow-line. Another round of hardwood removal will occur in 2003. If longleaf regeneration increases significantly, then the removal of the last of the hardwoods may not be necessary.

For these two stands to thrive, and for the area in general to move toward a true mountain longleaf ecosystem, fire will eventually be needed for these stand and throughout the Management Area. However, hardwood removal may improve the germination and survival of longleaf seedlings in the short-term, allowing the stands to begin regenerating while they wait to be burned. Fire will be introduced into these sites no earlier than the 2004-2005 season, and only after other sites have been burned and enough time has passed for an assessment of delayed mortality and a review of the techniques used. The long-term goal of fire management will be to expand the longleaf ecosystem from its existing nucleus of five stands to a much broader area across the southern slope of Lavender Mountain.

SAVE 2001 Planting Site

Site Description: This site is an area that extends from the parking lot behind Friendship Hall up the south-facing slope of Lavender Mountain (Figures 26-27). The site is bounded to the north and west by the road to the House of Dreams, and to the east by an intermittent stream. In 2000, this site was clear-cut for Southern Pine Beetle (SPB) control. With no further site preparation, this area (approximately nine acres total) was planted in January 2001 with 2000 containerized mountain longleaf seedlings.

Figure 26. Site where the SAVE group planted 2000 mountain longleaf seedlings in January of 2001. This photo was made in the spring of 2002, and shows the beginning of herbaceous cover development and hardwood re-sprouting.

Figure 27. Containerized mountain longleaf seedling 1 ½ years after planting by the SAVE organization in 2001. While most seedlings were still healthy in the spring of 2002, herbaceous and hardwood competition will need to be controlled by fire if these seedlings are to survive to adulthood.

Management Prescription: A permanent firebreak will be pulled around the eastern edge of this area prior to a prescribed burn in 2003-2004. Prescribed burning will be thereafter undertaken every 3-5 years. The timing of the initial burn will be made based upon state of the grass stage individuals and the need to reduce competing vegetation. The burn plan will be designed to control hardwoods and to foster dominance by an open canopy of longleaf, with an understory and herbaceous layer typical of mountain longleaf sites (Maceina 1997; Varner 2000).

Stands Salvage-Cut for Southern Pine Beetle Control

Site Description: For the past few years, a number of small 1-6+ acre sites have been clear- or selective-cut in salvage operations as a means of containing SPB outbreaks. This practice is likely to continue as long as SPB remains a serious problem. When sites are clear-cut, all standing timber is removed, whereas when sites are selective-cut, all pines and some hardwoods (particularly "soft" hardwoods such as sweetgum and maples) are removed, leaving a scattered overstory of mostly young oaks and hickories. A number of these sites lie on the interface between the southern slopes of Lavender Mountain (where longleaf was formerly abundant), and loblolly-dominated flatwoods and plantations (Figure 28). As these sites contained a small percentage of longleaf prior to cutting, and fall within the historical range of longleaf-dominated sites, they are good sites for the establishment of controlled studies on the use of longleaf seedlings in a specific management plan designed to establish areas of open canopy dominated by longleaf (which is highly resistant to SPB). Most sites are easily accessible, readily isolated by firebreaks, and do not suffer the problem of being close to inhabited buildings (as do the areas planted by SAVE in 2001). Their size and proximity to roads make the sites ideal for the establishment of controlled studies, and for providing educational tours to interested land managers and others.

Figure 28. Selective Cut site in the spring of 2002. This area had all pines and some hardwoods removed during a southern pine beetle control, leaving a very open canopy.

Private landowners in mountainous areas of GA, AL, and SC, when faced with variably sized clear-cuts or selective-cuts due to SPB damage, might consider using mountain longleaf coupled with fire management, as a means of encouraging longleaf-dominated, mixed pine-hardwood stands. In making a decision to involve mountain longleaf in a regeneration program, a private landowner might ask the following questions (paraphrased from Ron Stephens, IDT Forest Silviculturalist):

1. What are the economic tradeoffs ?
   A. What is the cost and availability of containerized seedlings and how does that cost compare to loblolly?
   B. What is the cost of contract planting (if needed) for each and are they different?
   C. What revenue stream might I expect from longleaf as compared to loblolly?
   D. Is any revenue likely to accrue to me, my children, or my grandchildren?

2. If longleaf has a poorer revenue stream, what other objectives might I have that it meets better than loblolly (e.g., wildlife habitat, aesthetics, SPB resistance, being a partner in a South-wide restoration effort, etc.)?

As such, our research design for SPB clear-cuts and selective-cuts will be centered on these questions.

<u>Management Prescription</u>:

<u>Clear-cut areas</u>: One of the largest clear-cut areas (Figures 13 and 29) will be divided into eight plots of equal size. Following a summer or fall 2002 light burn designed to reduce deadwood buildup left behind from previous logging operations, containerized mountain longleaf will be planted in four of the plots (two longleaf timber and two longleaf biodiversity plots) and bare-root improved loblolly seedlings will be planted in the other four plots (two loblolly timber and two loblolly biodiversity plots). This experimental design will compare the most common approach of private land managers, which is to replant bare-root loblolly and manage with the intent of generating short-term income, with the alternatives of : 1) using mountain longleaf instead of loblolly for timber production, or 2) using either loblolly or longleaf and managing for multiple purposes, including biodiversity and game management. Planting of timber plots will be on a 4 x 4 grid in January or February of 2003, and fire management and thinning regimes of those plots will follow that normally used for loblolly timber production in this region. Planting of biodiversity plots will be on an 8 x 8 grid, and those plots will be managed with a combination of thinning and more intense fire management that fosters an open-canopy, mixed pine-hardwood forest. We expect the biodiversity plots to form an understory and herbaceous layer typical of mountain longleaf stands (Maceina 1997; Varner 2000).

Figure 29. Area clear-cut for control of southern pine beetle in the spring of 2002.

In particular, the first thinning will differ between the plot types. For timber plots, the first thinning will be typical of those designed to produce saw timber. For loblolly biodiversity plots, undersized loblolly and some naturally regenerated "inferior" hardwoods will be removed, leaving a mixed canopy of pines, oaks, and hickories. For longleaf biodiversity plots, the first thinning be similar to that of loblolly biodiversity plots, but will also involve the removal of other pines and hardwoods within 10 m of established longleaf pines, so as to favor longleaf specifically. Over the course of the experiment, growth rates, survivorship, and vitality of the trees within the plots will be quantified every two years in five permanent 10 x 10 m subplots per plot. The understory and herbaceous communities will be assessed every two years for percent cover in 10 permanent 1 x 2 m subplots per plot. The understory and herbaceous communities will also be assessed qualitatively with respect to potential use by wildlife each year. Actual use by wildlife (birds, mammals) will be assessed every two years via direct observation and live-trapping methods.

<u>Selective-cut Areas</u>: Within two selective-cut areas (Figures 13 and 30), a study will be established to compare the survivorship and growth rates of mountain longleaf planted in areas with and without total timber removal. Each area will be divided up into two plots of equal size. In one of the plots within each area, all hardwoods will be removed mechanically in the summer of 2002 and stumps will be subjected to an herbicide treatment immediately afterward to prevent re-sprouting. This will result in a complete clear-cut treatment in those plots. In the other plot within each area, the existing open canopy of hardwoods (mostly oaks, hickories) will be left standing. In all of the plots, containerized mountain longleaf seedlings will be planted in an 8 x 8 grid in areas at least 10 m away from the canopies of existing hardwoods in January or February of 2003. Thereafter, fire management and data collection will be identical to the longleaf biodiversity plots in the clear-cut area study (above).

Figure 30. Area selective cut for control of southern pine beetle in early 2002.

As with most aspects of this project, close cooperation between researchers and the Berry Land Management department will be essential. Personnel from that department will be responsible for site preparation, establishment and maintenance of firebreaks, assistance with acquisition of appropriate seedling stock, thinning cuts, and fire management. Biology department faculty, students, and student volunteers will be responsible for marking the plots, planting seedlings, and collecting and analyzing data.

The Greater Longleaf Pine Management Area and Long-term Plans

Site Description: The area within the Longleaf Pine Management Area that will not be under any current direct study of management contains both ridgelines and steep slopes. Locations for planned activities within the greater area are noted on the map in Figure 13 (nine total research areas). Longleaf pine is concentrated in a few stands (mostly those under direct study), and is completely absent in many areas. Litter build-up is generally high throughout the area, as it has been a long-standing management practice to exclude fire from the slopes. While burning has taken place in flatland fields and forests on the Berry campus, these areas have probably not seen significant fire activity since the early 1900's.

Management Prescription: With the experience and knowledge gained from managing the nine existing research sites, it may be possible to establish an expanded plan that favors mountain longleaf throughout the Management Area. While smaller burn plots in our currently planned studies will be mostly created with temporary, raked or blown firebreaks (at least within established longleaf stands A-E), the boundaries of the Management Area will be provided with permanent firebreaks created with a small bulldozer, and maintained thereafter when necessary. Most of the area is already circumscribed by existing firebreaks, although the east and west sides are less well established. The long-term goal will be to conduct a series of cool-season burns, but less caution will be needed to protect existing longleaf, since the areas immediately around existing stands will have already been involved in a fire regime. Once fuel has been reduced to safe levels throughout the management area, then growing season burns could begin. The entire Management Area will then be incorporated into a permanent prescribed burning schedule, in which the land is burned in the spring every 3 to 5 years (Maceina, 1997). The plan would be for natural regeneration from existing longleaf stands to spread to adjacent fire managed areas, thus slowly enlarging the area occupied by longleaf, and decreasing the likelihood that a wildfire or other natural catastrophe might destroy the population. The main concern is that this process be undertaken slowly enough to prevent possible soil erosion on the steep slopes. The gradual replacement of deep litter with an extensive herbaceous groundcover will help ameliorate potential problems of erosion. If necessary, seed stock from mountain longleaf stands outside of Berry College, may need to be introduced as a means of restoring herbaceous groundcover.

Collection and Use of Berry Mountain Longleaf Seed Stock

Though management of existing stands should improve conditions for longleaf establishment throughout the area, some sites may not have enough adult longleaf to provide a seed source for regeneration. These areas may require reseeding or planting of containerized seedlings. While current plans using planted seedlings will use certified mountain longleaf from outside sources, ideally reseeding and/or replanting should be done using seed from our own longleaf pines. A partnership between Berry and a seed company would be mutually beneficial, allowing Berry to get seed for the project at no cost. The Creekside Consulting Corporation in Alabama is interested in obtaining seed from mountain sites, and has developed a proposal to provide seed collection and processing services at a discounted rate.

The ideal would be to generate containerized seedlings using our own seeds. To do this, the seeds will need to be collected, processed, and stored at subfreezing temperatures until they are needed, and sown into pots designed to produce containerized seedlings (Barnett et al. 1989). Seedlings can be grown within the Biology Department’s Research Greenhouse, and then transplanted to either the larger outdoor enclosure associated with that facility or the outdoor area associated with the Animal and Horticultural Sciences Department greenhouses. Because uniform spacing of trees is not desired, the seedlings can be planted in open, burned areas by volunteers. Seedlings should be sown in February or March (Barnett, 1989). The amount of seedlings that need to be generated and planted will be determined as the project develops.

Long-range Plans for Areas Clear-cut for Pine Beetle Control

As discussed above, numerous times in recent years the Berry Land Resource department has supervised small clear-cut (salvage-cut) operations as a means of controlling SPB, which mostly attacks species of pines other than longleaf (e.g., loblolly, short-leaf). Thus, in addition to our experimental plantings, we plan to plant mountain longleaf seedlings in any new clear-cuts on mountain areas within the historical distribution of longleaf (southern slopes of Lavender Mountain). Ideally, this will wait until a seedling source can be generated from Berry's own seed sources (as above). One of the objectives will be to establish longleaf pines in place of the loblolly, shortleaf, and other pines that are much more susceptible to insect damage. Recent salvage timber operations will be re-evaluated for application within the management area (Karpinski, et al., 1984; Swain, and Remion, 2002). For example, the cut-and-leave method will be applied when and where possible. In areas where salvage cuts are necessary, efforts will be made to remove as many of the hardwoods as possible, and tree limbs and other debris will be moved to the center of the clear-cut for immediate burning. A firebreak will be pulled around the entire clear-cut area, and the area will be designated a code number so that future management practices can be tracked. In January or February of the year following the salvage cut, containerized mountain longleaf seedlings will be planted by groups of volunteers, at densities of about 500 per acre. After seedlings have established and advanced to a solid clumped grass stage, firebreaks will be established around each site. Prescribed burns every 3 to 5 years will be conducted to reduce competition from fire-intolerant species and to foster the establishment of not only the longleaf seedlings, but also other fire-adapted plant species.

Measuring the Success of the Restoration Aspect of the Project

<u>The Target Ecosystem:</u> The success of restoration efforts will be based on the progression of the Management Area toward the conditions present in a fire managed mountain longleaf ecosystem. For Berry's Longleaf Project, the target sites are "old growth, frequently burned longleaf pine stands" at Fort McClellan, Alabama (Varner, et al., 2000; Maceina 1997). Varner et al. (2000) suggests that these sites should represent the goal of future forest management of the mountain region. These stands generally have open canopies, and consist of uneven-aged trees in even-aged patches. They are dominated by longleaf pine, and most of the longleaf are in the smaller size classes, particularly 2-3 cm in diameter. A few of these stands at Ft. McClellan have limited regeneration, but Berry will refer to those stands with more successful reproduction, such as the Mt. Tylo stand. The herbaceous layer is very diverse, with as many as 50-60 species within a 15.5 ft^2 (4.72 m^2) sampling area. Varner et al. (2000) identified 40 species that can serve as indicators of pristine mountain longleaf forest (Table 5).

Table 5. Plant species which may serve as indicators of pristine mountain longleaf stands (Varner et al., 2000).

Andropogon spp. (A. ternarius, A. scoparius, A. virginicus)
Asclepias spp. (A. amplexicaulis, A. tuberosa)
Aster spp. (A. dumosus, A. patens, A. undulatus, etc.)
Carya pallida
Chrysopsis graminifolia
Clitoria mariana
Coreopsis major
Galactia volubilis
Helianthus spp. (H. microcephallus, H. mollis)

Hypericum spp. (H. gentianoides, H. hypericoides, H. punctatum)
Hypoxis hirsute
Krigia biflora
Kuhnia eupatorioides
Lespedeza spp. (L. intermedia, L. procumbens, L. virginiana)
Panicum spp. (P. commutatum, P. virgatum, etc.)
Pinus palustris
Pteridium aquilimum
Quercus marilandica
Rhus copallina
Rhyncosia tomentosa
Salvia urticifolia
Senna marilandica
Sisyrhyncium angustifolium
Smilax glauca
Solidago spp. (S. erecta, S. odora)
Tephrosia virginica
Vaccinium arboreum

These characteristic species are usually present in healthy mountain longleaf stands at Ft. McClelland, and are mostly absent in fire-suppressed stands. Likewise, Harper (1905) reported the following species to be associated with mountain longleaf in natural stands within this region: *Aletris farinose, Andropogon scoparius, Andropogon virginicus, Ceonothus americanus, Chrysopis graminifolia, Coeropsis major Oemleri, Dasystoma pectinata, Cracca virginiana, Eupatorium album, Helianthus divaricatus, Pteridium aquilinum, Pinus echinata, Quercus marilandica, Q. prinus, Seriocarpus linifolius, Silphium compositum, Solidago odora, Viola pedata*, most of which also occur with longleaf in coastal sites. Together, these reports give us some general sense of what the target plant community composition should be.

VI) Opportunities and Challenges

Research

A longleaf restoration project presents countless opportunities for research, both for students and professional scientists. Almost any aspect of the ecosystem can be studied to look at the effects of various management practices, and the project on Lavender Mountain will thus be a natural laboratory for studying the restoration of a healthy mountain longleaf ecosystem. Specific studies will be conducted alongside management in order to quantify the progression of Berry's longleaf stands towards the target ecosystem. Several long-term research projects will be initiated, and sampling conducted before and after management efforts will be compared to estimate their effectiveness.

1) The demographic study will continue to be performed every two years by the Plant Ecology class to calculate the population growth rate and effects of management practices on the size structure of the longleaf population. The matrix analysis will be performed separately for each stand to help determine which management techniques positively affect population growth. Berry's population is currently dominated by large individuals from about 7-12 inches DBH (60-100 cm CBH), while old-growth stands at Ft. McClellan are dominated by individuals in the 2-3 inch diameter classes (Figure 2). Effective management should increase the proportion of smaller sized longleaf. The census will also be used to determine the mortality of longleaf from prescribed burns, and to locate and tag new seedlings. Some managers have experienced high mortality of adult longleaf upon the reintroduction of fire, which may not become evident for months or years after burning (J. Stowe, personal communication, 2001). The demographic study will look for evidence (e.g., post-burn beetle damage) that might explain any tree mortality (Price, 2001).

2) The point-centered quarter (PCQ) analysis will also be repeated biennially within Stands A-E by the Plant Ecology Class to examine the effects of management on tree community composition. Restoration efforts should increase the dominance of longleaf in the community, which indicates movement towards the longleaf pine ecosystem. The relative dominance of longleaf will, obviously, instantly increase with hardwood removal. But, a site cannot be considered fully restored until longleaf pine is not only the dominant tree species, but shows a fully mixed-age population that is potentially self-sustaining. PCQ analysis will provide a way to estimate hardwood mortality from burning in areas where direct hardwood removal is not done.

3) Litter sampling will be repeated biennially by the General Biology (BIO103) and Principles of Biology II (BIO112) classes, but in the future will be performed separately for each management site (starting with sites A-E in 2003). Coordinates within each site will be randomly selected, and litter will be collected to bare soil within a standardized frame. The litter will be dried and weighed to determine weight of litter per unit area. Prescribed burning should reduce the fuel load over time, and litter sampling will be

conducted before and after any winter burn. Once the leaf litter approaches the low-risk category, below about 7,000 lbs/acre, it will be safe to begin spring burns.

4) The herbaceous layer will be sampled to look for an increase in diversity expected from management (Varner et al., 2000). The seeds of fire-adapted plants can remain dormant in the soil for years, only reappearing after a fire. The data will be used to assess the effects of management on the herbaceous layer, differences in recovery between the sites, and similarity to old-growth stands at Ft. McClellan. Ten 1 x 2 m permanent understory plots will be sampled in each managed site. All species within each quadrat will be identified and the percent cover of each species will be estimated visually. A sample of each newly encountered species will be collected for the herbarium. An herbarium is a collection of dried plant specimens that are mounted, labeled by species, and systematically arranged for use in scientific study. These specimens will allow species identities to be verified, and will be a reference for future identification. The presence or absence of indicator species will also be noted. The data will be analyzed both for species richness (total number of species) and for diversity (a measure of both richness and the evenness with which species are represented). Diversity will be measured with the Shannon-Weaver diversity index, which quantifies the heterogeneity of a community (Krohne, 1998). Each species will also be assigned a form class (woody or non-woody). As the ecosystem recovers, it is expected that the number of woody species will decrease, and non-woody species, especially grasses and legumes, will increase. The plots can be sampled yearly in spring, summer, and fall to account for seasonal variation. If fire adapted species are no longer present in the soil, they may be reintroduced using seed from similar habitats. Johnny Stowe has volunteered to provide this seed from Talladega National Forest in Alabama.

6) Studies focusing on other taxa will be conducted by undergraduate researchers working within the Biology or Animal and Horticultural Sciences departments. Faculty within these programs will work with the project coordinator to develop research projects commensurate with the goals of the management plan. For example, students in various courses (e.g., Conservation Biology, General Botany, Ecology, Advanced Ecology) may participate in specific research projects focusing on not only plant diversity, but also on diversity other taxa (e.g., mammals, birds, insects, reptiles, fungi, etc).

7) Seedlings planted by student and volunteers will be monitored annually by student workers within the Biology department to determine when areas are ready for a controlled burn. While grass stages are relatively fire resistant, juveniles (those in the transition stage) become fire resistant at a height of about 2 meters. So, fires must be suppressed during the time that most of the trees are in the juvenile stage and below 2 meters in height. The individuals will be surveyed by measuring the heights of a representative sample of individuals, and determining the percentage of individuals that are 2 meters or taller. If at least 75% of the trees have reached this height, controlled burns can be resumed and the area incorporated into a routine burning schedule. The surveyed grass stages will also be checked for infection with brown spot fungus. If more than 20% are infected, a cool season burn will be performed regardless of tree height (Boyer, 1990).

The Longleaf Resource Center

A Resource Center is being created and will be maintained to make longleaf information available to researchers and to the public. It currently consists mostly of journal and newspaper articles about longleaf pine, fire, conservation and related issues, and forest management. It also includes data from recent studies and topographic maps of Berry's Campus. It will be continually expanded to include data from future studies, a longleaf ecosystem herbarium, and additional references. These resources are being kept in the care of the Project Coordinator, and made available to anyone interested upon request. A listing of the current materials in the Resource Center can be found in the bibliography section of this report.

Project Personnel

Faculty and other Non-student Personnel:

The Project Coordinator will oversee all aspects of the management plan. Where possible, we have tried in previous sections to indicate personnel responsible for various specific activities. However, as the management plan will be an evolving project, the personnel responsible for management and other activities will differ depending on the development of new projects and the availability and source of funding. Hired personnel may include loggers for hardwood removal and professional seed collectors. The local fire management crew will include Dean Wilson (Berry Land Resources), who will supervise student workers and volunteers. Scott Layfield of the US Forest Service will also offer free training to volunteers. For short-term labor-intensive management or research projects, student workers will form temporary longleaf management crews that are supervised by the Project Coordinator. With good publicity, adult volunteers can also be found through Berry's Volunteer Services program. For example, Alumni Work Day may be a great opportunity for returning alumni and local residents to participate in planned management tasks. Multiple groups will be needed to conduct research, and as suggested above, much of the research can be achieved with the participation of Berry's faculty. Biology and environmental science classes can use longleaf research as laboratory exercises. For example, because of its non-technical nature, litter sampling will be performed by students in majors and non-majors introductory classes (BIO112, BIO103). Faculty can also develop specific research projects (Directed Studies, class projects, independent faculty/student research) that are commensurate with the goals of the management plan. For example, the understory study of herbaceous plants would be an excellent opportunity for biology, environmental science, and agriculture students to gain experience in plant ecology and taxonomy. The Project Coordinator will assist the various groups working on the Longleaf Project to identify and plan projects, and will assist with most aspects of research and data management.

This project is not limited to science faculty and students, thus the project will be advertised to other Berry departments and constituencies outside of the sciences, as a means of encouraging cross-disciplinary research and education. An important aspect of this project will be the generation of high quality public relations materials designed to advertise the project and educate the community.

Finally, we hope to attract the attention of outside researchers as a potential site for either short- or long-term research. We would be particularly interested in supporting the completion of PhD dissertation research by students from regional universities, or researchers from the various state and federal agencies interested in forests and wildlife.

The Berry College Longleaf Network:

Because of the large scale of the Berry College Longleaf Project, it will require the cooperation of multiple groups and individuals. The project will also not survive if it is dependent solely upon a single faculty member and his/her students. Therefore, the establishment of a formal plan, and the involvement of multiple groups and individuals are essential. Effective communication between funding agencies, researchers, professors, students, and the public will help the project to run more smoothly and be well understood. To facilitate communication, the Berry Longleaf Network has been formed (Appendix I). The Longleaf Network is a group of people who have been involved or expressed interest in the project, or who have expertise that will be needed. The Interagency Burn Team, which will assist in preparing specific burn plan recommendations, currently consists of Jimmy Rickard (U.S.D.A. Fish and Wildlife Service), Neal Edmundson (Georgia Forestry Commission), and John McGuire (The Longleaf Alliance). The network will expand with the project, and will hopefully include members from the Rome community as information about Berry's longleaf becomes more widely available. Our primary contact is Dr. John McGuire of the Longleaf Alliance, which is a non-profit organization formed in 1995 to provide information and advice to landowners who wish to plant or restore longleaf pine. The Project Coordinator will keep the Longleaf Network group informed about developments in the project via an e-mail distribution list.

Berry Students:

A "Longleaf Team" will be made up of 3-4 students hired as part of Berry's student work program. Under the direction of the Project Coordinator, these students will have a variety of duties. One student will be in charge of publicity, primarily through the creation and maintenance of a website and related hardcopy materials. The website will include information on longleaf pine, a description of Berry's Longleaf Project, data from related research projects, a bibliography of resources, and contact information for anyone interested in volunteering time or financial support. The other students will focus on research and management. They will assure that the Longleaf Project stays organized and that all necessary data are collected. They will also be student spokespeople for Berry's longleaf, and will share information at events such as the biennial Longleaf Alliance conference. New students will be hired every few years and trained by the Project Coordinator and the older students to take over their work. The Longleaf Team will provide an opportunity for students to gain knowledge, practical experience, and a conservation ethic, which satisfies the threefold mission of Berry College to educate the head, heart, and hands. Annually, these students will be involved in summer research activities associated with the project.

A small "Student Burn Crew" will be needed, with a leader experienced in burning fire-suppressed areas. This leader can be found through the Longleaf Alliance, and the Interagency Burn Team. Students will be trained, certified, and prepared to respond when needed either for prescribed burn activities or for response to wildfires. These students need not be science majors.

SAVE, the Biology Club, and other student groups will be invited annually to participate in various management activities, most notably the planting of mountain longleaf seedlings.

Berry Administration:

Depending on the kinds of funding awarded for the project, Berry College may be required to cover some of the management costs or to provide matching funds. Expenses should be kept to a minimum, and the school might find that spending on fire management could save money in the long run (e.g., by helping to prevent damaging wildfire). Research done by ecologists from the U.S. Forest service shows that for every dollar spent on prescribed burning, forest thinning, and the training of fire management personnel, $7 worth of savings are realized in the costs of having to extinguish big fires (Wilkinson, 2001). Prescribed burning as a means of preventing wildfire has been demonstrated to be highly effective by various cost-benefit analyses (e.g., Saveland, 1987; Outcalt and Sheffield, 1997). Students hired for the Longleaf Team would be a part of the student work program, and their income would constitute an expense, although one already borne by the college. The project has a greater chance of being successful if some investment was made in advertising. Information sent to alumni could elicit further donations, and adding the project to current Berry literature would encourage research oriented students to attend Berry. Permanent educational signs posted along trails and roads near the Management Area would help to curb public skepticism about burning and cutting for restoration. Assistance with the creation of promotional and educational publications and presentations should be made available via the publications office. In general, full and enthusiastic support for the management plans is all that is required to encourage redistribution of some of our existing resources to the project.

Funding the Longleaf Project

A crucial component of the Longleaf Project will be to seek funding, and one of the reasons for developing this plan was so parts of it can be used to apply for funding. There are several potential sources of funds for this project. Interest in longleaf restoration has been growing over the past several years, which is reflected in the number of restoration projects going on all over the southeast. Many landowners are at a loss for how to restore their fire-suppressed longleaf stands, and federal, state, and non-governmental groups are willing to fund research that will help solve this difficult problem. Among the opportunities are:

1) **Global ReLeaf** supports longleaf planting efforts in almost every state in the southeast.

2) **The Old-Growth Forest and Wilderness Protection Program of the Pew Charitable Trusts** provides grants for non-profit organizations for the protection of forests and the adoption of beneficial forest management practices. Berry College has the potential to qualify for a grant from this organization.

3) **The USDA, US Forest Service** offers funding through the **Joint Fire Science Program**. This program is a partnership of six federal wildland management and research agencies with a need to address problems associated with accumulating wildland fuels on lands administered by the partners. Clearly the problem of long-term accumulation of fuels applies to Berry's longleaf stands. To apply for such funding, evidence of cooperation with a Federal cooperator must be provided.

4) **The Nature Conservancy** is interested in working with Berry on this project. According to Malcolm Hodges, Lavender Mountain has already caught the attention of the Nature Conservancy, and they are interested in helping us find funding for the project (M. Hodges, personal communication, 2001).

5) **The U.S. Fish and Wildlife Service** has a program called **Partners of Fish and Wildlife** that helps to fund restoration projects, and this program has worked on several longleaf projects. James Bates, an advocate for longleaf within the Service, has expressed interest in working with Berry on this project (James Bates, personal communication, 2001). The Partners program requires a 50% cost share arrangement with the landowner. The funding program is designed to provide cost reimbursement, but advance payments can often be arranged. Representatives from the Fish and Wildlife service would need to come to Berry for a site assessment, and their report would be used to rank Berry among other potential projects to determine which qualify for the program. Site visits should be arranged in the summer of 2002. Berry would then be notified in the fall of 2002 whether the project qualifies, and money would be allocated in early spring. This will be coordinated through Debbie Harris, the program coordinator for this area. The Fish and Wildlife service also offers grants for restoration projects. This would also require a site visit, but grants are given on a non-competitive basis, and the money would be available more quickly than through the Partners program.

6) **The Laird Norton Endowment Foundation** funds "distinctive programs in conservation and forestry education". Their focus through 2004 is on sustainable forestry. While this foundation does not provide multi-year funding, it may be a source of initial funding to set up long-term projects.

7) **The Georgia Native Plant Society** offers small $100-$500 grants that can be used to support minor aspects of the larger project.

Current Needed Resources

Summer Research Stipends for Faculty/Invited Researchers: $10,000 per year

While much research can be done in association with courses and/or independent research during the academic year, the bulk of research and management activities must be conducted during the summer period, when Berry faculty are not on salary. To encourage and reward participation in the project, faculty participants should receive compensation equal to 1/9 of their academic salary per month of full-time participation. This amount would also apply to outside researchers seeking to participate in the project.

We will seek support for the Project Coordinator and one additional senior collaborator (two positions) for one month of summer research each year. Estimated cost = $45,000 x 1/9 x 2 = $10,000 per year.

Graduate or Postdoctoral Research Assistant. $26,000 per year

Because the Project Coordinator will have additional teaching responsibilities throughout the academic year, it will be important to have one person dedicated to the basic research aspects of the program. Ideally, this person will be a graduate or post-doctoral research assistant attracted from nearby universities with forestry or forest ecology programs (e.g., UGA, Auburn). As the project is by nature long-term, we will seek to award flat research stipends for periods of three years at a rate of $26,000 per year.

Research Technician. $25,200 per year

If the research aspects of the project are to be carried out in timely fashion, it will be necessary to collect data at times when student researchers and volunteers are unavailable or unable to provide assistance. Therefore, it will be necessary to hire a full-time research technician to assist the Project Coordinator and Graduate/Postdoctoral Research Assistant in data collection, entry, management, and analysis, and in the preparation of the finding for presentation and publication. We anticipate hiring former Berry College students at a rate of $10 per hr for 50 weeks, or approximately $25,200 per year including benefits.

Burn Management Equipment: $4500 year 1 only

While some equipment is on-hand to conduct management activities, the following items are essential to carry out all aspects currently within the project design.

Backpack firefighting tanks: 5 @ $150 = $750
Drip torches: 5 @ $125 = $625
Fuel containers: 5 @ $15 = $75
Large portable (truck-bed) water tank: $500
Fire rakes: 10 @ $25 = $250
Personal fire safety gear: 5 @ $400 = $2000
Portable water pump: $300

Field Vehicle leasing: $4800 per year

Most areas where management and research activities will take place are located on remote unpaved roads. It is imperative that we have access to a vehicle capable of transporting researchers, managers, volunteers, and equipment to and from field sites quickly and safely. Therefore, we are in need of access to an off-road type large truck, that is at least capable of carrying the portable (truck-bed) water tank listed above. We estimate the cost of leasing this vehicle at $400 per month or $4800 per year. This vehicle will also be made available to support other aspects of the School of MNS field-based programs (e.g., Animal Science, Environmental Science).

Seedling Project Development: $5,440 year 1; $140 per year thereafter

For the projects currently planned, we will need to purchase mountain longleaf and loblolly seedlings at a rate of 500 per acre. In order to collect and prepare seeds, we will need to arrange for collection and processing of seed, and purchase containerized seedling trays and inserts, soil, fertilizer, and planting tools. Thereafter, only annual soil and fertilizer purchases will need to be made.

Purchases of Mountain Longleaf and loblolly seedlings (30 acres x 500/acre x $0.20 per seedling): $3,000 year 1
Collection and preparation of Berry Mountain Longleaf seeds (Mr. Robert Gandy: $2000) year 1
Planting trays and inserts: $100 per year
Soil: $30 per year
Fertilizer: $10 per year
Planting tools: 10 x $30 each = $300 year 1

Marking Plots and Trees for Biennial Plant Censuses: $920 year 1; $70 per year

In order to mark plots and trees we will need the following items:
100 meter tape measures: 10 @ $80 each = $800 year 1
Day-glo marking tape: 10 rolls x $ 2 per roll = $20 per year
Permanent plot markers (cut re-bar): $50 year 1
Aluminum Tree tags: 200 x $ 50 per 1000 = $10 per year
Batteries for GPS Unit: 10 x $4 per pack = $40 per year

Other Biennial Censuses: $5702 year 1 only

Vertebrates:

Avifauna:

Mist nets: 10 @ $90 each = $900
Mist net poles: 10 sets @ $155 each = $1550
Bands: 1000 x $0.30 each = $300
Bird bags: 3 @ $4 each = $12
Pescola (spring) scales: 2 @ $55 each = $110
Cornell Lab of Ornithology "Birding by Ear" CD: $25
Landbird Census techniques book: $55

Herpetofauna:

Snake bagger: $70

Mammals:

Live Traps:
Sherman small: 30 x $15 each = $450

Sherman large: 10 x $18 each = $180
Tomahawk collapsible small: 10 x $40 each = $400
Tomahawk collapsible medium: 10 x $48 each = $480
Tomahawk collapsible large: 10 x $97 = $970

Terrestrial Invertebrates:

Berlese funnels: 10 @ $20 each = $200

Aquatic Invertebrates:

No additional equipment needed.

Scientific Conference Travel Costs: $4500 per year starting year 2

Annually, the Project Coordinator would attend a regional or national scientific conference to speak about research activities associated with the project or to network with professionals in the field. Additionally, the Berry Land Manager, and students/faculty conducting research will need to travel to conferences for education or to present research results.

We estimate three trips per year at a cost of $1500 per trip = $4500 per year.

Publication Costs: $2500 year 1; $400 per year thereafter

High quality materials for dissemination to the public and to interested professionals will need to be developed. We will also need to place permanent educational signs near public entrances to the management area. We estimate the following charges initially, with costs for annual printing.

Management Plan: $1200 year 1
Permanent Signage: $1000 year 1
Pamphlets: $300 per year
Journal Page Charges: $100 per year

Initial project start up costs (year 1): $85,262
Operating budget (year 2): $71,310
Operating budget (year 3): $71,310
Total three-year project cost: $227,882

VII) Conclusions and Possibilities for the Future

The Berry College Longleaf Project has the potential to expand, especially if publicity brings more attention and assistance to the project in the future. Opportunities to improve and enlarge the project are many and include such things as:

1) Gradually increasing the size of the Longleaf Pine Management Area.

2) Reintroducing populations of locally extinct longleaf-associated plant and animal species to Berry. For example, bringing in seed sources for herbaceous plants from existing mountain longleaf sites elsewhere, and using these in a program designed to foster the restoration of the associated herbaceous flora.

3) Initiating a genetic analysis of our mountain longleaf populations, focusing on genetic differences and degree of cross-breeding with coastal plain longleaf and other mountain longleaf populations.

4) Conducting an analysis of effects of various management practices on soil and surface water quality.

5) Creating a self-guided, educational tour of the longleaf management area.

6) Creating a program of educational workshops/symposia designed to showcase Berry's restoration efforts while providing advice and working examples for land managers.

This document has presented a history of longleaf pine in the southeast and at Berry, data from past and ongoing studies of Berry's longleaf, a management plan for the restoration of Berry's longleaf, potential sources of funding, the roles of various personnel in the project, and ways the project could be expanded in both the short and long term.

Lavender Mountain's longleaf pines represent both an opportunity and a responsibility. The Longleaf Management Plan has the potential to be very rewarding for Berry College. It will demonstrate the school's commitment to protecting the environment, which is becoming increasingly important to students and alumni. Because so little is known about mountain longleaf, Berry could become a prominent research site for students and scientists from all over the country. The project will provide yet another chance for students to receive training as research scientists. Berry College has already been mentioned in several longleaf publications, and the initiation of a restoration project could bring considerable positive media attention, and consequent support from alumni and potential donors.

The responsibility lies in the ability and willingness of humans to change their environment for the better. Because of mistakes made in the past, we may cause harm even by refraining from action. Risks associated with implementing the management plan will need to be weighed against the risks of doing nothing. Odds are that the forest will burn at sometime in the future – the question is, can we do anything to prevent or ameliorate negative consequences of future fires? The forest fires running rampant in the western states this very year should be evidence that continued fire suppression can lead to devastating effects. Berry College could lose irrevocably the natural beauty and potential diversity of its longleaf pine forest, and Berry's stewardship of its natural resources would be questioned if inaction led to its demise. While care must be undertaken in all aspects of the project to minimize risks, it may be much better to try and fail (and learn from it), than to not try at all.

IX) Cited and Consulted References

After planting dichotomous key for herbaceous release. Longleaf Alliance Note #5.

Andrews, F. F. 1917. Agency of fire in propagation of longleaf pines. *Botanical Gazette*. 64: 497-508.

Anonymous. 1998. Saving Longleaf. *American Forests*. 104:19.

Askey, L.C. Kissed by fire. *Southern Living*: 66.

Barnett, J.P., D.K. Lauer, and J.C. Brisette. 1989. Regenerating longleaf pine with artificial methods. In Proceedings of the symposium on the management of longleaf pine. General Technical Report SO-75. USDA Forest Service, Southern Forest Experiment Station, Long Beach, MS.

Barnett, J.P. 1978. Alternative methods for extracting southern pine seeds. In "Proceedings: 1978 Southern Nursery Conferences: Western Session, Hot Springs, Arkansas, July 24-27, 1978, Eastern Session, Colonial Williamsburg, Virginia, August 7-10.

Barnett, J.P. 1976. Collecting and processing methods affect pine seed germinability. In "Proceedings: 1976 Southeatern Area Nuserymen's Conferences, Eastern Session-Charleston, S.C.-Aug. 3-5, 1976; western session-Mobile Ala.-Aug 17-19, 1976.

Barnett, J.P. and T.C. Pesacreta. 1993. Handling longleaf pine seeds for optimal nursery performance. *Southern Journal of Applied Forestry.* 17(4):180-187.

Barnett, J.P. 1999. Longleaf pine ecosystem restoration: the role of fire. *J. Sustainable Forestry.* 9:89-96.

Before Planting Dichotomous Key for site preparation on agricultural lands. Longleaf Alliance Note #4.

Bibliography of Proceedings: 18th Tall Timbers Fire Ecology Conference. The longleaf pine ecosystem: Ecology, restoration and Management. May 30-June 2, 1991.

Birkhead, R. Longleaf pine management recommendations for Berry College.

Birkhead, R. 1995. Longleaf Pine (*Pinus palustris*) on Lavender Mountain. Berry College.

Birkhead, R. and J.P. McGuire. 1998. Lavender Mountain – the forgotten longleaf pine of Georgia. Poster presentation at 1st Longleaf Alliance Conference. Hcarleston, SC 1998.

Birkhead, R. 2001. Personal communication.

Boyce, S.G. and H.A Knight. Prospective ingrowth of southern pine beyond 1980. US Dept. of Agriculture, Forest Service. Research Paper SE-200.

Boyer, W.D. 1990. Growing-season burns for control of hardwoods in longleaf pine stands. Research Paper SO-256. USDA Forest Service, Southern Research Station New Orleans.

Boyer, W.D. Regenerating longleaf pine with natural seeding. In Proceedings: 18 th Tall Timbers Fire Ecology Conference: 299-309.

Boyer, W.D. 1979. Regenerating the natural longleaf pine forest. *Journal of Forestry.* Sept: 572-575.

Boyer, W.D. and R.M. Farrar. Thirty years of management on a small longleaf pine forest. *Southern Journal of Applied Forestry.*

Brissette, J.C., M. Elliot, and J.P. Barnett. Producing container longleaf pine seedlings. In Proceedings of the symposium on the management of longleaf pine. General Technical Report SO-75. USDA Forest Service, Southern Forest Experiment Station. Long Beach, MS. April 4-6, 1989.

Brockway, D.G. and K.W. Outcalt. 2000. Restoring longleaf pine wiregrass ecosystems: Hexazinone application enhances effects of prescribed fire. *Forest Ecology and Management*. 137:121-138.

Brockway, D.G. and K.W. Outcalt. 1998. Gap-phase regeneration in longleaf pine wiregrass ecosystems. *Forest Ecology and Management*. 106:125-139.

Bugwood Network. 1999. Practical guidelines for producing longleaf pine seedlings in containers. The BugwoodNetwork – The University of Georgia College of Agricultural and Environmental Sciences and Warnell School of Forest

Bugwood Network. 2002. Forest Pests of North America. The BugwoodNetwork – The University of Georgia College of Agricultural and Environmental Sciences and Warnell School of Forest Resources. http://www.forestpests.org/

Cipollini, M.L., D.A. Wallace-Senft and D.G. Whigham. 1994. A model of patch dynamics, seed disperal, and sex ratio in the dioecious shrub *Lindera benzoin* (Lauraceae). *Journal of Ecology.* 86:621-633.

Cipollini, M.L. 2001. Devil's advocate questions: Draft proposal for the study and management of Berry College's longleaf pines.

Croker, T.C. Jr. and W.D. Boyer. 1975. Regenerating longleaf pine naturally. Research Paper SO-105. USDA Forest Service, Southern Forest Experiment Station.

Croker, T.C. Seedbed preparation aids in natural regeneration of longleaf pine.

Cordell, C.E., G.E. Hatchell, and D.H. Marx. Nursery culture of bare-root longleaf pine seedlings. In Proceedings of the symposium on the management of longleaf pine. General Technical Report SO-75. USDA Forest Service, Southern Forest Experiment Station. Long Beach, MS. April 4-6, 1989.

De Kroon, H., A. Plaisier, J. van Groenendael, and H. Caswell. 1986. Elasticity: the relative contribution of demographic parameters to population growth rate. Ecology 67: 1427-1431.

Ecotones. Joseph W. Jones Ecological Research Center, Ichauway. Vol. 1 Num. 5. March 3, 2000.

Ezzard, M. Lament for the longleaf pine. *Atlanta Journal Constitution*.

Fahys, J. April 18, 2001. Smokey's new line: Not all forest fires are bad. Atlanta Journal Constitution.

Farrar, R.M. and W.D. Boyer. 1990. Managing longleaf pine under the selection system – promises and problems. Paper presented at the Sixth Biennial Southern Silvicultural Research Conference, Memphis, TN, October 30, 1990.

Fiedler, C.E., et al. 2001. Overcoming America's wood deficit: An overlooked option. *BioScience*. 51(1):53-58.

Forestry History Society. 2002. U.S. Forest Service History. http://www.lib.duke.edu/forest/usfscoll/

Franklin, R.M. 1997. Stewardship of longleaf pine forests: A guide for landowners. Longleaf Alliance Report No. 2, The Longleaf Alliance, Andalusia, AL.

Frelich, L.E., R.R. Calcote, and M.B. Davis. 1993. Patch formation and maintenance in an old-growth hemlock-hardwood forest. *Ecology*. 74:513-527.

Georgia Forestry Commission. Reforestation and other services for landowners.

Georgia Forestry Commission. 2002. Georgia Forestry Commission homepage. www.GFC.State.Ga.US

Georgia Forestry Commission and the Longleaf Alliance. 2002. Keys to successfully planting longleaf pine. The Georgia Forestry Commission, Macon, GA, and the Longleaf Alliance, Andalusia, AL.

Georgia Wildlife Federation. 2002. Georgia Wildlife Federation homepage. www.gwf.org

Georgia Wildlife Federation. 2002. The Fire Forest: Longleaf Pine-Wiregrass Ecosystem. Georgia Wildlife Federation, Covington, GA.

Gilliam, F.S., B.M. Yurish and L.M. Goodwin. 1993. Community composition of an old growth longleaf pine forest: relationship to soil texture. *Bulletin of the Torrey Botanical Club*. 120(3):287-294.

Gilliam, F.S. and W.J. Platt. 1999. Effects of long-term fire exclusion on tree species composition and stand structure in an old-growth *Pinus palustris* (longleaf pine) forest. *Plant Ecology.* 140:15-26.

Glitzenstein, J. S., W. J. Platt, and D. R. Streng. 1995. Effects of fire regime and habitat in tree dynamics in north Florida longleaf pine savannas. *Ecological Monographs*. 65:441-476.

Grace, S.L. and W.J. Platt. 1995. Effects of adult tree density and fire on the demography of pregrass stage juvenile longleaf pine (*Pinus Palustris Mill*.). *The Journal of Ecology.* 83:75-86.

Groenendael, J. van, H. de Kroon, and H. Caswell. 1988. Projection matrices in population biology. *Tree*. 3:264-269.

Hamrick, J.L., W.J. Platt, and M. Hessing. Genetic Variation in Longleaf Pine. In Proceedings: 18th Tall Timbers Fire Ecology Conference: 193-203.

Harper, R.M. 1905. Some noteworthy stations for *Pinus palustris*. *Torreya*. 5(4):55-60.

Harper, R. M. 1913. Economic botany of Alabama. Part I. Geographical Report. Geological Survey of Alabama. Press Brown Printing Co., Montgomery, Alabama.

Harper, R. M. 1928. Economic botany of Alabama. Monograph 9, Part 2. Catalogue of the trees, shrubs and vines of Alabama, with their economic properties and local distribution. Geological Survey of Alabama/State Commission of Forestry. Birmingham Printing Co., Birmingham, Alabama.

Harper, R. M. 1942. Forests of Alabama. Geological Survey of Alabama. Wetumpka Printing Co., Wetumpka, Alabama.

Hartshorn, G.S., 1975. A matrix model of tree population dynamics. Springer-Verlag New York Inc.

Horn, H.S. Succession. In: May, R.M. ed. 1981. Theoretical Ecology: Principles and Applications. Blackwell Scientific, Oxford. 253-271.

Horton, T. 1998. Longleaf redux. *American Forests*. 104:16-18+.

Horton, T. Mar. 1995. Longleaf Pine: A Southern revival. *Audubon*. 97:74-80+.

Howe, H.F. and L.C. Westley. Ecology of pollination and seed dispersal. In: Crawley, M. ed. 1986. Plant Ecology. Blackwell Scientific, Oxford. 185-215.

Hough, W. A. 1968. Fuel consumption and fire behavior of hazard reduction burns. USDA Forest Service, Southeastern Forest Experiment Station. Forest Research Paper SE-36, 7 pp.

Hough, Walter A. 1978. Estimating available fuel weight consumed by prescribed fires in the South. USDA Forest Service, Southeastern Forest Experiment Station. Forest Research Paper SE-187, 12 p.

Hough, W.A. Fuel consumption and fire behavior of hazard reduction burns.

IUCN/World Conservation Union. 2002. IUCN/World Conservation Union homepage. http://www.iucn.org/

Jacqmain, E.I., R.H. Jones, and R.J. Mitchell. Jan. 1999. Influences of frequent cool-season burning across a soil moisture gradient on oak community structure in longleaf pine ecosystems. *American Midland Naturalist*. 141:85-100.

James, A., K.J. Gaston and A. Balmford. 2001. Can we afford to preserve biodiversity? *BioScience*. 51(1):43-52.

Johnson, R. 1996. Longleaf pine: A southern legacy. *Alabama's Treasured Forests*.

Jones, H. C. 1940. Plant ecology of the Berry Schools property, Floyd County, Georgia. PhD. Dissertation, George Peobody College, Nashville, TN.

Joseph W. Jones Ecological Research Center. 1996. Development report, 1991-1996: Joseph W. Jones Ecological Research Center, Newton, GA.

Joseph W. Jones Ecological Research Center. 1999. Research, education, conservation, and administration staff. Joseph W. Jones Ecological Research Center, Newton, GA.

Joseph W. Jones Ecological Research Center. 1999. Research and education report: Staff publications and presentations (1993-1999). Joseph W. Jones Ecological Research Center, Newton, GA.

Joseph W. Jones Ecological Research Center. 1999. Flora of Ichauway, Baker Co., Georgia. Herbarium Records. Joseph W. Jones Ecological Research Center, Newton, GA.

Joseph W. Jones Ecological Research Center. 2002. Site Description. Joseph W. Jones

Karpinski, C. Jr., R. L. Hedden, R. P. Belanger, and T. S. Price. 1984. Guidelines for managing pine bark beetles in Georgia. Georgia Forestry Commission, Macon, GA.

Kelly, L.A., T.R. Wentworth and C. Brownie. 2000. Short-term effects of pine straw raking on plant species richness and composition of longleaf pine communities. *Forest Ecology and Management*. 127:233-247.

Kush, J.S. and R.S. Meldahl. 2000. Composition of a virgin stand of longleaf pine in south Alabama. *Castanea*. 65(1):56-63.

Krohne, D.T. 1998. General Ecology. Wadsworth Publishing Co. Belmont, CA.

Landers, J.L., N.A. Byrd, and R. Komarek. 1989. A holistic approach to managing longleaf pine communities. In Proceedings of the symposium on the management of longleaf pine. General Technical Report SO-75. USDA Forest Service, Southern Forest Experiment Station. Long Beach, MS

Landers, J.L., D.H. van Lear, and W.D. Boyer. 1995. The longleaf pine forests of the Southeast: Requiem or renaissance? *Journal of Forestry* Nov 1995: 39-44.

Lipps, E.L. 1966. Plant communities of a portion of Floyd County, Georgia – Especially the Marshall Forest. PhD Thesis, University of Tennessee, Knoxville, TN.

Longleaf Alliance. 2000. *Longleaf Alliance Newsletter* 4(2).

Longleaf Alliance. 2000. Publication listing. Longleaf Alliance, Andalusia, AL.

Longleaf Alliance. 2000. Staff Activities. Longleaf Alliance, Andalusia, AL.

Longleaf Alliance. 2000. Longleaf pine: A southern legacy. Longleaf Alliance, Andalusia, AL.

Mann, W.F. Jr. 1969. At last - longleaf pine can be planted successfully. *Forest Farmer.* March: 6-19.

Manous, C. 1999. Population Structure of *Pinus Palustris* on Lavender Mountain, Berry College Campus, Rome, Georgia. Unpublished manuscript.

Maple, W.R. Mortality of longleaf pine seedlings following a winter burn against brown-spot needle blight. Research Note SO-195. USDA Forest Service, Southern Forest Experiment Station.

Maple, W.R. 1969. Shaded longleaf seedlings can survive prescribed burns. *Forest Farmer.* v29 n3:13.

Mathworks, Inc. 1994. MATLAB ™ for Windows, Version 4.2c.1. Mathworks, Inc., Natick, Massachusetts.

McGee, A. 1999. Out on a limb. *Science and Stewardship*. Winter/Spring. 4-10.

McLemore, B.F. 1975. Cone and seed characteristics of fertilized and unfertilized longleaf pines. Southern Forest Experiment Station, USDA Forest Service, Research Paper SO-109.

McMahon, C.K. et al. 1997. Longleaf pine ecosystem restoration: The role of the USDA forest service. In: Kush, J.S., comp proceedings of the longleaf pine ecosystem Restoration Symposium, presented at the Society of Ecological Restoration 9th Annual International Conference – Ecological Restoration and Regional Strategies. 1997 November 12-15. Longleaf Alliance Report No. 3. Fort Lauderdale, FL. 20-31.

McNab, W. H. and M. B. Edwards, Jr. 1976. Estimating forest fuel buildup. Forest Farmer 35(5): 6-7.

Means, B.D. 1996. Longleaf pine forest, going, going, . . . Pp. 210-229 in M. B. Davis (ed.) In *Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery.* Island Press.

Meldahl, R.S., et al. Dendrochronological investigations of climate and competitive effects on longleaf pine growth. In Tree Ring Analysis: Biological, Methodological and Environmental Aspects. Eds. Wimmer, R. and R.E. Vetter. CABI Publishing, 1999:265-285.

Minor, E. 1999. Seed shortage is root of the problem for South's pine trees. The Atlanta Journal-Constitution. June 27, 1999: H6.

Mitchell, S. 1999. The Natural Communities of Georgia: Longleaf pine – wiregrass community. Ichauway, Joseph W. Jones Ecological Research Center.

Nature Conservancy. 2002. The Nature Conservancy homepage. http://nature.org/

Nature Conservancy. 2002. Fire Management Program. www.tncfiremanual.org

Nelson, C.D., et al. 1994. A genetic linkage map of longleaf pine (*Pinus palustris* Mill.) based on random amplified polymorphic DNAs. *Journal of Heredity*. 85:433-439.

Noel, J.M., W.J. Platt, and Barry E. Moser. June 1998. Structural characteristics of old- and second-growth stands of longleaf pine (*Pinus palustris*) in the Gulf Coastal region of the U.S.A. (LA, MS, GA, and FL). *Conservation Biology*. 12:533-548.

Omi, P. and E. J. Martinson. 2002. Final report: effects of fuels treatment on wildfire severity. Western Forest Fire Research Center, Colorado State University. Submitted to the Joint Fire Science Governing Board, March 25, 2002.

Outcalt, K.W. and R.M. Sheffield. 1997. The longleaf pine forest: trends and current conditions. Resource Bulletin SRS-9. USDA Forest Service, Southern Research Station.

Palik, B.J., et al. 1997. Effects of canopy structure on resource availiability and seedling responses in a longleaf pine ecosystem. *Canadian J. of Forest Research*. 27:1458-1464.

Pawuk, W.H. and J.P. Barnett. 1979. Seed handling practices for southern pines grown in containers. *Southern Journal of Applied Forestry*. 19-22.

Pecot, S. and C. Helton eds. Legumes of Ichauway. Joseph W. Jones Ecological Research Center.

Phillips, D.L. and D. J. Shure. 1990. Patch-size effects on early succession in Southern

Appalachian forests. *Ecology*. 71:204-212.

Platt, W.J. and S.L. Rathbun. Dynamics of an Old-Growth Longleaf Pine Population. In Proceedings: 18th Tall Timbers Fire Ecology Conference: 275-297.

Platt, W.J., G.W. Evans, and Stephen L. Rathbun. Apr. 1988. The population dynamics of a long-lived conifer *(Pinus Palustr*is). *The American Naturali*st 31:491-525.

Plocher, A.E. 1999. Plant population dynamics in response to fire in longleaf pine-turkey oak barrens and adjacent wetter communities in southeast Virginia. *J. of the Torrey Botanical Society*. 126(3):213-225.

Poage, N.J. and D.R. Peart. 1993. The radial growth response of American beech *(Fagus grandifolia*) to small canopy gaps in a northern hardwood forest *Bulletin of the Torrey Botanical Clu*b. 120:45-48.

Price, T. S. 2001. Forest health for Georgia foresters. Georgia Forestry Commission, Macon, GA.

Rebertus, A.J., G.B. Williamson, and W.J. Platt. Impact of temporal variation in fire regimes on savanna oaks and pines. In Proceedings: 18th Tall Timbers Fire Ecology Conference: 215-225.

Schmidtling, R.C. and V. Hipkins. 1998. Genetic diversity in longleaf pine (*Pinus Palustris*): influence of historical and prehistorical events. Canadian J. of Forest Research. 28:1135-1145.

Silvertowne, J., Franco, M., Pisanty, I., and A. Mendoza. 1993. Comparative plant demography: relative importance of life cycle components to the finite rate of increase in woody and herbaceous perennials. Journal of Ecology 81: 465-476.

Saveland, J. M. 1987. Using prescribed fire to reduce the risk of large wildfires: a break-even analysis. pp. 119-122 in Ninth Conference on Fire and Forest Meteorology, April 21-24, 1987. San Diego, CA. American Meteorological Society.

Snow, G.A. et al. 1989. Pest management in longleaf pine stands. In Proceedings of the symposium on the management of longleaf pine. General Technical Report SO-75. USDA Forest Service, Southern Forest Experiment Station. Long Beach,

Snyder, B.E., R.J. Dinus, and H.J. Derr. 1977. Genetics of longleaf pine. USDA, Forest Service. Research Paper WO-33.

Stanton, W.M. and R.A. Hamilton. 1987. Producing longleaf pine straw. Woodland Owner Notes, NC Cooperative Extension Service.

South Carolina Dept. of Natural Resources. 2001. *South Carolina Wildlife*. 48(1).

Southern Research Station. 2002. Southern Research Station hompage. www.srs.fs.usda.gov/index.php

Sierra Club. 2002. Sierra Club homepage. http://www.sierraclub.org/

Sierra Club. 2002. Sierra Club Georgia Chapter homepage. http://www.sierraclub.org/ga/

Stanturf, J. A., D. W. Wade, T. A. Waldrop. D. K. Kennard, and G. L. Achtemeier. 2002. Background paper fire: fire in southern forest landscapes. Southern Forestry Resource Assessment Draft Report, Southern Research Station, USDA Forest Service. www.srs.fs.fed.us/sustain

Stephens, R. 2001. Personal Communication.

Streng, D.R., J.S. Glitzenstein, and W.J. Platt. 1993. Evaluating effects of season of burn in longleaf pine forests: a critical literature review and some results from an ongoing long-term study. In Proceedings: 18th Tall Timbers Fire Ecology Conference: 227-263.

Stowe, J. 1998. Longleaf Pine Heritage Preserve Management Plan. Heritage Trust Program, South Carolina Department of Natural Resources.

Stowe, J. and J. Leidner. 1998. Longleaf pine's tall comeback. *Progressive Farmer.*

Stowe, J. 1998. Longleaf pine on South Carolina's Heritage Preserves. Presented at: The Longleaf Alliance's 2nd Biennial Conference. Charleston, SC. November 1998.

Stowe, J. 1999. Fat lighter. *South Carolina Wildlife*.

Swain, K. M., and M. C. Remion. 2002. Direct control methods for the Southern Pine Beetle. Online Format USDA Agricultural Handbook 575.

Tall Timbers Research, Inc. 1993. Table of Contents for The Longleaf Pine Ecosystem: Ecology, Restoration, and Management. Proceedings: 18th Tall Timbers Fire Ecology Conference. Tall Timbers Research, Inc. Tallahassee.

Tilman, D. 1997. Community invasibility, recruitment limitation, and grassland biodiversity. *Ecology* 78(1):81-92.

Tuljapurkar, S., and H. Caswell. 1997. Structured-population models in marine, terrestrial, and freshwater systems. Population and Community Biology Series 18. Chapman & Hall, New York.

Uhl, C., and A. Anderson. 2001. Green destiny: Universities leading the way to a sustainable future. *BioScience*. 51(1):36-42.

USDA Forest Service. 1981. Forest management practices to prevent insect and disease damage to southern pine. Forestry Report SA-FR 9. USDA Forest Service, Southeastern Area.

USDA Forest Service. 1989. Insects and Diseases of Trees in the South, USDA Forest Service - Southern Region, Protection Report R8-PR 16, June 1989.

USDA Forest Service. 2000. Southern Research Station employees honored for longleaf pine ecosystem restoration research. USDA Forest Service. News Release. June 5, 2000.

USDA Forest Service. 2002. Southern Research Station publications online. USDA Forest Service. http://www.srs.fs.usda.gov/pubs/publist_srs.php

US Fish and Wildlife Service. Restoration of longleaf pine – wiregrass ecosystems. St. Marks Wildlife Refuge. US Fish and Wildlife Service

US Fish and Wildlife Service. 2001. The longleaf pine/wiregrass ecosystem. Carolina Sandhills NWR, US Fish and Wildlife Service. http://carolinasandhills.fws.gov/index.html

US Fish and Wildlife Service. 2002. Fire Management. http://fire.fws.gov/

US Fish and Wildlife Service. 2002. US Fish and Wildlife Service homepage. http://www.fws.gov/

US Fish and Wildlife Service. 2002. Partners for Fish and Wildlife. Voluntary Habitat Restoration in Cooperation with Private Landowners. http://partners.fws.gov

Varner, J. M. 1999. Longleaf pine forests…in the mountains? Alabama's Treasured Forests Fall 1999: 30-31.

Varner, J.M. 2000. Plant species composition of two old-growth mountain longleaf pine (*Pinus palustris* Mill.) stands at Fort McClellan, Alabama: Evidence for frequent fire regimes? PhD thesis, University of Florida, Gainesville, FL.

Varner, J.M., J.S. Kush and R.S. Meldahl. 2000. The mountain longleaf pine resources of Fort McClellan, Alabama: Final report on their status, ecology, and management needs. Longleaf Pine Stand Dynamics Laboratory, Auburn University School of Forestry and Wildlife Sciences, Auburn, AL.

Vaughn, K. 2001. Proposal for the study and management of Berry College's Longleaf

Pines, Devil's advocate questions and answers.

Wade, D.D. and M.J. Dixon. 1988. A guide for prescribed fire in southern forests. www.fs.fed.us/rm/pubs/rmrs_gtr292/1989_wade.pdf

Ware, S., C. Frost, and P.D. Doerr. 1993. Southern Mixed Hardwood Forest: The former longleaf pine forest. Pp. 447-493 In Biodiversity of the Southeastern United States: Lowland Terrestrial Communities. Ed. William H. Martin et al. John Wiley & Sons Inc.

Wells, O.O. and P.C. Wakely. 1970. Variation in longleaf pine from several geographic sources. *Forest Science* 16:28-42.

Wahlenberg, W.G. 1946. Longleaf Pine: Its use, ecology, regeneration, protection, growth, and management. Charles Lathrop Pack Forestry Foundation.

Wilkinson, T. 2001. Prometheus unbound. *Nature Conservancy*. 51(3):12-20.

Wilson, M.E. 1995. The Heyday of Georgia's longleaf pine lumber industry: Two Dodge County companies in the late nineteenth century. *The Georgia Historical Quarterly*. 69(3):685-693.

Appendix I. Matrix model for the analysis of population demographics of Berry Longleaf pine in stands A-D (1999-2001).

```
% File = c:\matlab\longleaf.m (MATLAB)  M. Cipollini
% This MATLAB program computes lambda, w1, v1, S and E.
! copy c:\matlab\longleaf.wpd c:\matlab\longleaf.bak
! del c:\matlab\longleaf.wpd
diary longleaf.wpd
format short
format compact

fprintf('File = c:\matlab\longleaf.wpd               M. Cipollini\n')
fprintf('Output of c:\matlab\longleaf.m (MATLAB) program\n')

Today = date

% Column 1 = grass
% Column 2 = juveniles
% Column 3 = nonreproductive adults
% Column 4 = reproductive adults

fprintf('Initial matrix')

A = [0.7590361 0 0 0.0000099
0.1144578 0.8947368 0 0.0000087
0 0.0526316 0.8222222 0.0211082
0 0 0.0222222 0.9155673]

     [w,d]=eig(A);
     lambda=diag(d)
% lambda is the vector of eigenvalues of A

     imax=find(lambda==max(lambda));
% imax is the index of the maximum eigenvalue of A.

     lambda1=lambda(imax)
% lambda1 is the maximum eigenvalue, equal to the population
% multiplication rate for A. (n t+1) = (n t)*lambda1.
% Note that the time step for this population is 2 years.

fprintf('Check to see if lambda1 is the largest positive eigenvalue in
lambda vector')

     w1=w(:,imax);
% w1 is the maximum right eigenvector, which is proportional
% to the stable population distribution for A.

     v=inv(conj(w));
% v is the array of left eigenvectors
% Note: the left eigenvectors of a matrix A are the right
% eigenvectors of the transpose of matrix A

fprintf('Vector of reproductive values')

    v1=real(v(imax,:))'
```

```
% v1 is the vector of reproductive values for A.
% Note: the scalar product of w1 and v1 is automatically 1, so
% these eigenvectors can be used directly in sensitivity
% analysis.  For each element in matrix A, sensitivity is
% equal to the multiplication of the corresponding elements of
% v1 and w1.  For instance, the sensitivity of A(1,2) is
% v1(1)*w1(2).

     s1=v1*w1(1);
     s2=v1*w1(2);
     s3=v1*w1(3);
     s4=v1*w1(4);
     Sen=[s1 s2 s3 s4]

% Sen is the matrix of sensitivities of the elements of A
% Each element sij of Sen is the corresponding sensitivity of
% element aij of A.  Sensitivities estimate the absolute
% effect on lambda of absolute changes in the elements of A.

     B=A/lambda1;
     E=Sen.*B

% This last step divides each value of A by lambda to create
% a new matrix B, and multiplies each element of Sen by its
% corresponding element in B (element by element multiplication).
% The elasticity of an element mij of A is equal to:
% eij = (aij/lambda)*sij; where sij is the sensitivity of element aij.
% So, E is the matrix of elasticities of the elements of A.
% Elasticities give the proportional effect on lambda of a
% proportional change in the elements of A.  Elasticities are
% more useful than sensitivities for comparisons among population
% models (or among submatrices).

Sen = Sen.^2;
lambda1 = lambda1

% The above variables are estimates of the variance, standard
% error, and 95 % confidence limits on lambda.

w1 = abs(w1/sum(w1));

fprintf('Population distribution:\n')
fprintf('  Grass Juveniles NonReproductiveAdults ReproductiveAdults\n')
grass = w1(1);
juveniles = w1(2);
nonreproductiveadults = w1(3);
reproductiveadults = w1(4);
StableDist = [grass juveniles nonreproductiveadults reproductiveadults]

check = sum(E)

T = E(1,1)+E(2,2)+E(3,3)+E(4,4)+E(2,3)+E(2,4)+E(3,4)
C = E(2,1)+E(3,1)+E(4,1)+E(3,2)+E(4,2)+E(4,3)
R = E(1,2)+E(1,3)+E(1,4)

check2 = sum(T)+sum(C)+sum(R)
```

Appendix II. The Berry College Longleaf Network

Jim Bates
Partners of Fish and Wildlife
706-544-6422

Roger Birkhead
Department of Zoology and Wildlife
331 Funchess Hall
Auburn University, AL 36849-5414
birkhrd@mail.auburn.edu

Robert Brooks
Partners of Fish and Wildlife – Georgia Coordinator
4270 Norwich St. Extension
Brunswick, GA 31520-2523
912-265-1061
Fax: 912-265-1061
Robert_Brooks@fws.gov

Lindsay Boring, Director
J.W. Jones Ecological Research Center
Ichauway Plantation
Newton, GA
lboring@jonesctr.org

Dr. Bill Boyer
US Forest Service (retired)
Talladega National Forest
bboyer@fs.fed.us

Rene Carleton
Lecturer in Biology
430 Berry College
Mt. Berry, GA 30149
706-238-5892
rcarleton@berry.edu

Dr. Steven Castleberry
Wildlife/Forestry
University of Georgia
scastle@smokey.forestry.uga.edu

Dr. Martin Cipollini
Associate Professor of Biology
430 Berry College
Mt. Berry, GA 30161
706-290-2149
Fax: 706-238-7855
mcipollini@berry.edu

Dr. Scott Colley
President, Berry College
Campus Box 39
Mount Berry, GA 30149
706-236-2211
scolley@berry.edu

Dr. D. Bruce Conn
Dean, School of Mathematics and Natural Science
Campus Box 5036
Berry College
Mount Berry, GA 30149
706-236-1756
bconn@berry.edu

Dr. William Davin
Biology Department
Campus Box 430
Berry College
Mount Berry, GA 30149
706-290-2663
bdavin@berry.edu

Katherine Eddins
Chattowah Open Land Trust
310 Shorter Ave.
Suite B
Rome, GA 30165
706-802-1544

Neal Edmondson
Georgia Forestry Commission
Interagency Burn Team
Macon, GA
478-751-3332
nedmondson@gfc.state.ga.us

Chris Faulkner
Campus Box 968
Berry College
Mount Berry, GA 30149
706-235-0237
WarEagleX@aol.com

Robert Gandy
Creekside Consulting, Inc.
67 Creekside Dr.
Harpersville, AL 35078
205-672-8587
Fax: 205-672-8264

James Golden Goss
Berry College
Mount Berry, GA 30149
jgoss@students.berry.edu

Dr. John Graham
Professor of Biology
Department of Biology
P.O. Box 430, Berry College
Mount Berry, GA 30149
jgraham@berry.edu

Debbie Harris
Partners of Fish and Wildlife – Athens
706-613-9493 ext. 24

Susan Haymore
Agnes Scott College
Atlanta, GA
shaymore@agnesscott.edu

Malcolm Hodges
The Nature Conservancy
404-873-6946
Cell: 404-234-3903

Matt Jones
SAVE Co-President
P.O. Box 1995
Mt. Berry, GA 30149
mjones@students.berry.edu

Mitch Lawson, Director
Coosa River Basin Initiative
Broad Street
Rome, GA 30161
crbi@roman.net

Scott Layfield
USDA Forest Service
NEPA/ Silviculturist
P.O Box 465
806 East Villanow Street
LaFayette, GA 30728
706-638-1085
Fax: 706-638-4276
slayfield@fs.fed.us

John McGuire
Longleaf Alliance, Outreach Coordinator
School of Forestry and Wildlife Sciences,
109 M. White Smith Hall
Auburn University, AL 36849-5418
Office: 334-844-1032
Home: 334-742-0887
Fax: 334-844-1084
mcguijo@auburn.edu

Dr. Christopher Mowry
Biology Department
Campus Box 430
Berry College
Mount Berry, GA 30149
706-236-1712
cmowry@berry.edu

C. Joseph Nairn
Assistant Professor, Forest Genomics
Warnell School of Forest Resources
University of Georgia, Athens, GA
+1 (706) 542-1885
jnairn@smokey.forestry.uga.edu

Heather Montanye
The Nature Conservancy
National Fire Management Program
13093 Henry Baedel Dr.
Tallahassee, FL 32312
850-668-0827
Fax: 850-668-7781
www.tncfiremanual.org

Janisse Ray
Contact Susan Doerr, Publicist
612-332-3192 ext. 116

Dr. Jeff Reynolds
Faculty Sponsor
Berry SAVE Club
Campus Box 550
Mount Berry, GA 30149
706-290-2694
jreynolds@berry.edu

Stephen C. Richter
Sam Noble Oklahoma Museum of Natural History
University of Oklahoma
2401 Chautauqua
Norman, OK 73072
+1 (405) 325-3332
+1 (405) 325-7699 (FAX)
richter@ou.edu

Jimmy Rickard
U.S. Fish and Wildlife Service
Georgia Ecological Services
237 S. Milledge Ave.
Athens, GA 30605
+1 (706) 613-9493 ex 23
+1 (706) 613-6059 (FAX)
+1 (706) 255-1606 (cell)
james_rickard@fws.gov

Dan Roper
Forester/Attorney
ropersfive@aol.com

Glenda Smith
430 Berry College
Mt. Berry, GA 30161
gsmith@berry.edu

Ron Stephens
Plan IDT, Forest Silviculturalist
Hours 0730-1600 M-F EST
770-297-3020
Switchboard: 770-297-3000
rstephens@fs.fed.us

Johnny Stowe
Wildlife Biologist/Heritage Preserve Manager
SC Registered Forester #1584
Wildlife Diversity Section
South Carolina Dept. of Natural Resources
P.O. Box 167
Columbia, SC 29202
803-734-4037
jstowe@scdnr.state.sc.us

Jonathan Streich
Stewardship Director
The Nature Conservancy
Georgia Field Office
1401 Peachtree NE
Atlanta, GA 30309
404-873-6946
FAX 404-873-6984

Dr. Patricia Tomlinson
Biology Department
Campus Box 430
Berry College
Mount Berry, GA 30149
706-368-6742
ptomlinson@berry.edu

Leah Updegrave
SAVE Co-President
P.O. Box 3418
Mt. Berry, GA 30149
lupdegrave@students.berry.edu

J. Morgan Varner III
Interdisciplinary Ecology Program
University of Florida
Box 118526
Gainesville, FL 32611-8526
352-392-7165
Fax: 352-392-3993
Buttahatchee@yahoo.com

Karen Vaughn
5364 Pounds Dr. N
Stone MTN, GA 30087
Home: 770-469-6612
extrapair@yahoo.com

Dale Wade
Southern Research Station
320 Green Street
Athens, GA 30602
706/559-4307
706/559-4317 (FAX)
rxfire@ix.netcom.com

Rachel Wallace
Student Involvement
Georgia Chapter Sierra Club
1447 Peachtree Street NE Suite 305
Atlanta, GA 30309-3034
+1 (404) 299-7973
RayRayRoogaloo@hotmail.com

Joseph Walton
Vice President for Finance
Berry College
Campus Box 129
Mount Berry, GA 30149
706-236-2234
jwalton@berry.edu

Richard Ware, President
Georgia Botanical Society
2 Idlewood Court NW
Rome, GA 30165-1210
+1 (706) 232-3435
ware@wavegate.com

Dean Wilson
Forestry and Land Management
Land Resources Office
Campus Box 146
Berry College
Mount Berry, GA 30149
706-236-1723
706-238-9041
landmanagement@berry.edu
wilsdean@bellsouth.net

Brent Womack
Wildlife/Forestry
University of Georgia
Athens, GA
Blw7037@owl.forestry.uga.edu