HISTORY OF PIEDMONT FORESTS: IMPLICATIONS FOR CURRENT PINE MANAGEMENT

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Abstract—Piedmont forests were maintained for millennia in an open condition by anthropogenic- and lightning-ignited fires. After European settlement, row-crop agriculture caused serious soil erosion, making Piedmont soils less capable of supplying moisture and nutrients during drought periods. Dense stands of pine, both naturally and artificially regenerated over the past 70 years, are severely stressed on these soils and become highly susceptible to infestations of the southern pine beetle (SBP). The current SPB epidemic and depressed smallwood markets serve as a disincentive to invest in expensive reforestation. Prescribed burning, or herbicide applications where burning is not feasible, along with thinnings and timely harvests, should be used to maintain relatively open stands and encourage herbaceous vegetation. A Piedmont forest landscape consisting of a shifting mosaic of low-density pine stands in all seral stages, intermixed with hardwood and pine-hardwood stands, should reduce the intensity of SPB attacks and provide many commodity and noncommodity values desired by landowners and society.

INTRODUCTION

Loblolly pine (*Pinus taeda* L.) has been planted in the Piedmont physiographic region for more than 70 years. The species has been used to reclaim much of the severely eroded soils that were abused during the corn and cotton farming era from 1700 – 1930s. Reclamation of the worn-out farmland to productive forest land throughout large areas of the Piedmont has proven to be a major conservation success story. However, there is concern for pine plantation management, as now practiced, in the Piedmont. Recent southern pine beetle (SPB) epidemics, combined with depressed pine stumpage prices, have devastated many pine plantations in the region causing millions of dollars in damage (www.srs.fs.fed.us/research/4501/). These huge losses have become a disincentive to landowners considering investing in pine plantation management. The recent drought has exacerbated SPB damage. Landowners and forest managers must anticipate periodic droughts and avoid dense pine plantations on eroded soils in the Piedmont.

Because of the extensive damage done by SPB in recent years, it is timely to examine the land-use history of the Piedmont and determine if the past could provide insight to develop new management scenarios for this region. In this paper, we examined the effects of man's historical activities on the Piedmont landscape, from the early Native Americans to the European/African agricultural influence to the modern period of rapid population growth, pine plantation management, and landscape fragmentation. We report how land-use history can be used to suggest alternatives to contemporary pine management to enhance forest health and sustainability.

HISTORICAL LAND-USE IN THE PIEDMONT

Native Americans

Native Americans have been in the southern Piedmont for at least 12,000 years (Carroll and others 2002). They used fire extensively to manipulate and manage the landscape. Because of frequent burning by Native Americans and lightning-ignited fires, the Piedmont landscape, as well as much of the South's forests, was probably open and park-like with prairies, savannahs, and woodlands commonly occurring throughout the landscape. At the time of Columbus, it is believed that as many as two million Native Americans occupied the South (Dobyns 1983), more than enough people to make a significant impact on the landscape through their burning and farming activities.

Natural lightning fire complemented the frequent burning regime of Native Americans. Unlike today's closed forests with dense underbrush, lightning strikes in open forests with grassy understories would have started many fires that would have burned vast acreages. Without Native American burning and lightning-ignited fires, it is unlikely that oak-hickory-pine forests would have dominated the Piedmont for thousands of years (Carroll and others 2002). Although oaks, hickories, and pines still dominate the Piedmont today, it is important to emphasize that the horizontal and vertical structure, as well as the understory composition, of historical forests were much different than forests of today. Those earlier forests were lightly stocked in the overstory, generally open in the midstory, and probably had a rich layer of herbaceous species (both grasses and forbs) that readily carried fire and benefited foraging by many wildlife species.

Post-European Discovery Until 1930

With the introduction of European diseases, the Native American population collapsed by 90 to 95 percent, and the southern forest encroached and gradually became the romanticized forest primeval of 18th century writers (Carroll and others 2002, Dobyns 1983). This was the forest that had to be cleared by early European settlers and their African slaves (Edgar 1998). The Piedmont was first cleared and settled in Virginia in the mid-1700s, and agriculture progressed steadily southward through North Carolina, South Carolina, and into Georgia (Trimble 1974).

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Erosion of the loamy topsoil from the relatively steep Piedmont slopes gradually increased as agriculture intensified. Corn, not cotton, was the major agricultural crop although cotton became the primary cash crop in the mid-1800s. After the Civil War, cotton production proliferated and, by 1929, had exceeded the land area in corn production (Healy 1985). Row-crop agriculture accelerated soil erosion over two centuries, washing away the fertility and moisture-supplying capacity of the Piedmont soils (Trimble 1974). By the late 1920s, crop agriculture was in rapid decline in the Piedmont. The loss of the soil's productive capability due to erosion, losses to the boll weevil, and development of synthetic fibers all contributed to the decline of cotton agriculture (Healy 1985). Although the productive capacity of the land had been markedly reduced by row-crop agriculture, economically viable forestry could still be practiced in most of the region. However, in the early decades of the 20th century, the primary goal was to reduce erosion and restore the productivity of the land (Healy 1985).

Forestry in the Piedmont

As agriculture became unproductive on the worn-out soils, people left the farms for the cities (Healy 1985). It was Franklin Roosevelt's administration dealing with the Great Depression of the 1930s that began public works projects to put people to work. The Civilian Conservation Corps (CCC) was created to reduce soil erosion and restore productivity to the land. Tree planting became a major conservation activity (fig. 1); early plantations were planted at 6- by 6-foot spacing by the CCC. Two other government programs have made a significant impact on landscape restoration and forest productivity. In the late 1950s and early 1960s, the Soil Bank Program produced a dramatic spike in numbers of seedlings planted (fig. 1). Later, the Conservation Reserve Program in the late 1980s caused another major increase in tree planting. Today, the average density of plantations is about 700 seedlings per acre (Schultz 1997).

Loblolly pine, shortleaf pine (*Pinus echinata*), and Virginia pine (*P. virginiana*) occur naturally throughout most of the Piedmont. After farms were abandoned, much of the Piedmont seeded in naturally on old agricultural fields and home sites from residual pine trees scattered throughout the region. Loblolly pine, in fact, was known as "old field pine" because of its propensity to occupy abandoned fields (Schultz 1997). Loblolly pine grows faster than other pines on all but the driest of sites. Faster growth and its greater resistance to littleleaf disease (a root rot associated with eroded, heavy clay soils and a fungus (*Phytophora cinnamoni*)) made loblolly preferable for plantations in the Piedmont (Belanger and others 1986). The earliest plantations were planted on old fields and represented only a small portion of the loblolly pine ecosystem (Boyce and others 1975). Over the past 50 years, increases in plantation acreage have generally mirrored declines in natural pine acreage. Today, plantations occupy a similar acreage in the Piedmont and Coastal Plain to that occupied by natural pine stands (Conner and Hartsell 2002).

The loss of topsoil during decades of row-crop agriculture greatly lessened the capacity of Piedmont soils to produce biomass. Coile (1948) noted that site index for shortleaf and loblolly pine declined markedly with decreases in topsoil thickness in the Piedmont. We suspect that site quality for loblolly pine may have decreased by as much as 20 points where 10 or more inches of topsoil were lost to

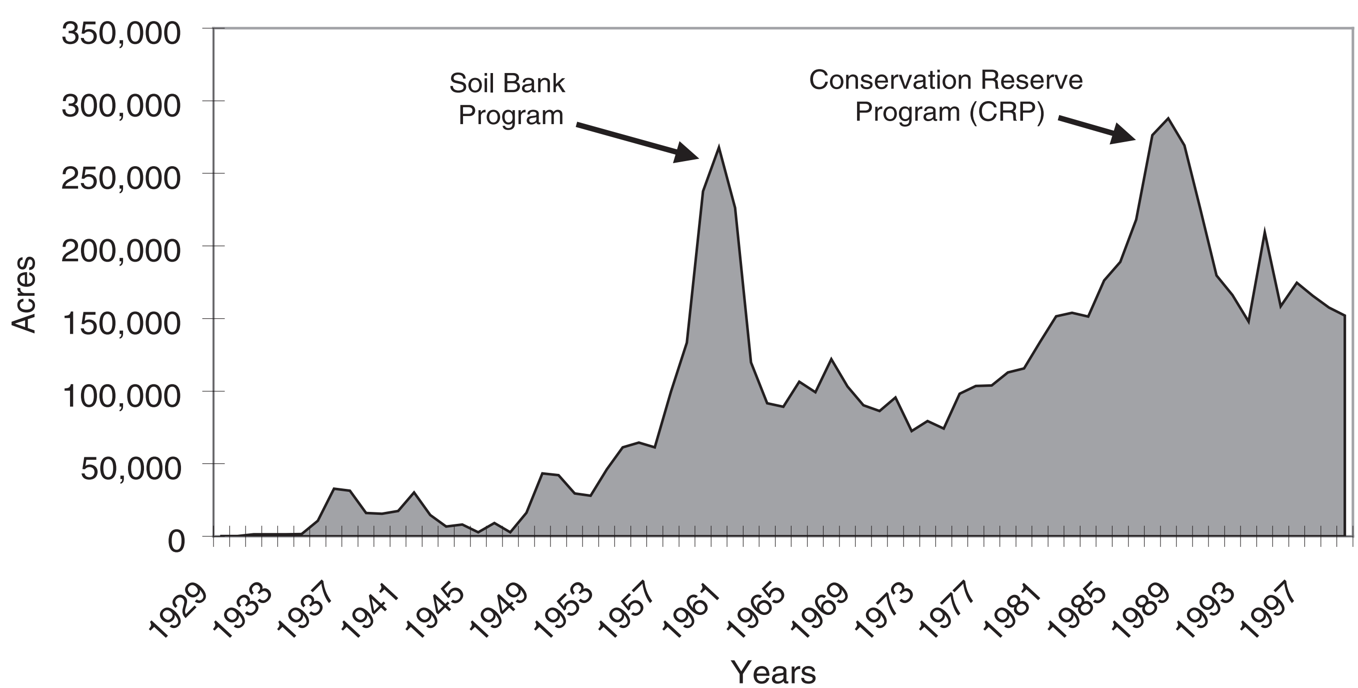

Figure 1—Acreage of planted seedlings per year in South Carolina from 1929 –to 2001.

erosion. Forestry also changed the Piedmont landscape through its fire suppression activities (Healy 1985). From the early decades of the 20th century, the USDA Forest Service and State forestry commissions sought to exclude wildfire from the landscape. They were quite successful, and the removal of fire allowed hardwood understories to encroach into both natural and plantation pine stands on lands not being farmed. Thus, open, fire-maintained stands (of both pines and hardwoods) became only a memory as fire exclusion became the dominant policy for forestry agencies. Forest management in the Piedmont is now challenged by the rapid urban growth and associated sprawl of the region. According to Wear (2002), the human population in the Piedmont grew rapidly from 1990 to 1999 and already has a population density along the I-85 corridor exceeding that which is compatible with forestry. When population density approaches 75 people per square mile, there is a 50:50 chance of practicing forestry. When population density exceeds 150 per square mile, the chance approaches zero. Because of the area's high population density, it is certain that a different kind of forestry will have to be practiced in many parts of the Piedmont if forestry is to be practiced at all.

The Southern Pine Beetle

Although there have been a number of SPB outbreaks in the Piedmont over the past 60 years, the recent epidemic that began in the late 1990s is by far the worst. In South Carolina, North Carolina, and Georgia, millions of dollars of damage have occurred as the beetles worked their way through drought-stressed pines growing in generally dense stands. Pine plantations have increased dramatically over the decades, adding to the acreage of pine stands that become increasingly susceptible to SPB infestations as they age and become stressed under droughty conditions. As often the case with serious outbreaks of SPB, the current outbreak is associated with a severe drought that has affected the entire South for the past 5 years, especially the upper Piedmont of the Carolinas and Georgia. Drought intensifies the stress that dense plantations already face on eroded Piedmont soils. Forest entomologists have known for decades that stressed trees are more prone to beetle attacks (Thatcher and Conner 1985), and foresters have long known that poor sites should support lower stocking to help alleviate this stress (Belanger 1980).

Oleoresin (sap) production is a primary defense mechanism of pine trees against SPB attack. SPBs are attracted to stressed pine trees, which are poor oleoresin producers (Hodges and Lorio 1975, Matson and others 1987). Beetles disproportionately attack and overcome over-mature trees of low vigor, although in epidemic populations they will attack dense stands of young trees (Hedden and Belanger 1985). During periods of drought, dense stands of pine trees are more stressed, and the probability of epidemic infestations by southern pine beetles is increased.

Both natural stands and plantations have been hit hard by SPB during the recent drought. In South Carolina alone, damage from the current beetle outbreak exceeded 75 million dollars in 2001 (http://www.state.sc.us/forest/). Few stands of any pine species are immune from attack when the SPB reaches epidemic populations. Beetle outbreaks in loblolly, shortleaf, Virginia, and white pine (*P. strobus*) have been witnessed on the Clemson Experimental Forest in the South Carolina Piedmont during the recent epidemic.

Management Implications

The land-use history of the Piedmont and current knowledge about the SPB provide insights concerning future management options to restore health to Piedmont pine forests. It is evident that present forest stands and landscapes are drastically different from those of previous millennia. Because of frequent fire, stand densities would have been much lower, understories would have been open, and soil moisture and nutrients would have been supplied in greater quantities to individual trees because there were fewer of them. The obvious implication of the Piedmont's land-use history and our current knowledge about SPB is that today's pine plantations are much too densely stocked. The dense stocking of pine trees increases moisture and nutrient stress on sites abused by agricultural practices for over 100 years and far exceeds stand densities during previous millennia of Native American occupancy. The increased probability that SPBs will damage or destroy pine stands, coupled with currently depressed smallwood markets, serves as a disincentive for landowners to invest in expensive reforestation. Restoring the health of Piedmont pine forests will require active management and greater consideration given to relations between stand stocking levels and soil capability. Current growth and yield models used to maximize wood production are counter productive if they encourage beetle outbreaks at some point during the rotation. A new model based on a balance between restoring forest health (encouraging plant/animal diversity and reducing susceptibility to damage from forest pests) and sustaining production of high-value wood products is needed. Enhanced aesthetic quality would be an associated value with this new vision of forestry.

Tree Spacing and Intermediate Treatments

Newly established plantations should either be planted at much wider spacing, e.g., 12 by 12 feet, or planted at current spacings and thinned early (by age 15 to 18) and frequently (every 5 to 7 years) thereafter. The latter alternative is probably best, because widely spaced trees develop rapid bole taper and are poor pruners, which degrades log quality (Schultz 1997). Burton (1982) showed that early, heavy thinnings combined with pruning of green limbs and understory control could produce good quality sawlogs in a much shorter time than conventional thinning regimes.

Where prescribed fire can be used, burning should be conducted at about 3-to 5- year intervals after trees are large enough to be safely burned (Van Lear and Waldrop 1991). Burning should precede a thinning by 1 or 2 years to reduce the risk of damage to crop trees from intense fire in the downed tops of thinned trees. During periods of drought, burning should be conducted with great care, if at all, to avoid stressing trees even more. If burning is not feasible, herbicides can be used to control understory encroachment of hardwoods; this can also improve habitat for some wildlife species (Wigley and others 2002). In certain cases, herbicides and fire can be used together to accomplish management objectives. The goal should be to favor vigorous, high-quality trees in relatively open stands as the rotation proceeds. Such stands would not only be more resistant to SPBs, but would also be aesthetically attractive and excellent wildlife habitat for those species that prefer open woodland conditions. The property value of such sites should far exceed that of land supporting dense plantations.

To restore forest health, residual basal areas following thinnings should be lower than those currently recommended for maximum timber production for both even and uneven-aged stands. Depending on site quality, target basal areas for even-aged stands should be in the range of 50 to 70 square feet per acre late in the rotation, although early thinnings should not remove more than about 40 percent of the stand's basal area to minimize damage from potential ice or wind storms or both. For uneven-aged management, stand density should be maintained at levels that allow regeneration to occur in openings created by periodic removal of small groups of trees. Actively managed, fully stocked uneven-aged stands of loblolly pine will have considerably less basal area than fully stocked even-aged stands (Schultz 1997).

First thinnings have recently become a management problem because of lack of markets for small wood. However, as engineered wood technology emerges and wood energy becomes more cost effective, small wood markets should improve. A diversity of competitive markets is necessary to allow forest landowners to keep their stands healthy and reduce the likelihood of SPB infestations. Pruning of crop trees should be considered, especially on good quality sites where rapid volume growth will help offset costs of pruning. Pruning increases diameter growth at the base of the crown, making the stem more cylindrical and increasing its volume (Schultz 1997).

Harvesting/Site Quality Relationships

The length of time that trees can be grown and remain vigorous and healthy depends on site quality. Over-mature stands of pines should be avoided. Stands should be harvested when they reach financial maturity, which will vary with the type of product being produced and site quality. On eroded Piedmont sites, loblolly pine trees over 50 years grow slowly and become susceptible to SPB attack. Pine trees will remain vigorous on better quality sites at older ages and may be more resistant to SPB attack, although when the beetles are in epidemic populations they can overcome the defense mechanisms of younger stands (Personal communication. Steve Perry and Knight Cox, Forest Managers, Clemson Experimental Forest). Even-aged stands of loblolly pine must be thinned on schedule and harvested prior to the loss of tree vigor.

Uneven-aged management of loblolly pine is rarely used in the Piedmont today but perhaps should be given another look in light of recent SPB outbreaks. A stand's vulnerability to complete destruction by fire, bad weather, or biotic agents is less than with uneven-age management (Schultz 1997). In fully stocked, uneven-aged stands, about two-thirds to three-fourths of the basal area will be in sawlogs (Farrar 1981). Thus, managed uneven-aged stands have higher lumber yields in large, valuable stems because a greater proportion of the stand is in sawtimber. A major concern with uneven-age management is ensuring that regeneration develops following harvesting of small groups of trees. Regeneration normally develops following selection harvest if pine overstory density is less than 50 square feet per acre and site conditions are favorable (Schultz 1997). Prescribed burning must be used carefully with uneven-aged management because the fire regime that controls understory hardwoods and maintains open-stand conditions can destroy vulnerable age classes of pine. In many cases, herbicides may have to be used to control aggressive hardwoods where fire cannot be used.

Foresters and landowners should consider the larger landscape when they are deciding how to manage their forests. A healthy landscape composed of a range of seral stages in both pine and hardwood types, with generally lower densities in all stages, would theoretically enhance tree and stand vigor and reduce infestations of SPBs. Active even-age and uneven-age management of pine stands using thinnings, frequent prescribed burns or herbicides where burning is not feasible, and timely harvests to remove over-mature trees or stands, would maintain open park-like conditions while producing high-quality timber for lumber, poles, veneer logs, etc. Stringers of hardwood stands or mixed pine-hardwood stands on more mesic sites would enhance environmental qualities of the landscape and break up the continuity of pine stands, thereby lessening potential outbreaks of the SPB.

CONCLUSIONS

1. Forests in the Piedmont were maintained for millennia in an open condition by anthropogenic- and lightning-ignited fires.
2. Piedmont soils were extensively eroded during the era of row-crop agriculture, making soils in the region less capable of supplying moisture and nutrients during drought periods.
3. Unmanaged, overstocked pine stands established either naturally or by planting over the past 70 years have fueled the current SPB epidemic and resulted in millions of dollars in damage.
4. Beetle-damaged stands and depressed smallwood markets currently serve as a disincentive to invest in expensive reforestation.
5. Prescribed burning or herbicide applications where burning is not feasible, along with frequent thinnings and timely harvests, should be used to maintain open stands and encourage herbaceous vegetation.
6. A Piedmont forest landscape consisting of a shifting mosaic of low-density pine stands in all seral stages, intermixed with hardwood and pine-hardwood stands, should reduce the intensity of future SPB outbreaks and provide the commodity and non-commodity values desired by landowners and society.

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