A DECISION TREE APPROACH USING SILVICS TO GUIDE PLANNING FOR FOREST RESTORATION

Sharon M. Hermann, John S. Kush, and John C. Gilbert[1]

Abstract—We created a decision tree based on silvics of longleaf pine (*Pinus palustris*) and historical descriptions to develop approaches for restoration management at Horseshoe Bend National Military Park located in central Alabama. A National Park Service goal is to promote structure and composition of a forest that likely surrounded the 1814 battlefield. We considered options for (1) stands currently supporting second-growth montane longleaf, (2) isolated trees, and (3) areas beyond dispersal range of longleaf seed. We estimate >50 percent of the property is appropriate for longleaf but <20 percent is within dispersal range of existing seed trees. There are three major areas with current densities sufficient to be classified as longleaf stands—in these high-priority stands, fuel reduction burns are being applied to maintain adult trees and create appropriate seedbeds. Criteria applied to isolated trees categorize them as medium priority. Areas beyond seed dispersal range of longleaf are low priority and require planting.

INTRODUCTION

Forest restoration efforts are largely focused on reestablishing trees. A current issue of concern in the Southeastern United States is how best to increase acreage of longleaf pine (*Pinus palustris*). With at least a 97-percent loss in this once-dominant ecosystem, there is interest in restoring both the species and the forest type. In some cases a primary interest is to regenerate existing stands (Croker and Boyer 1975) and in other cases a forester must decide which tree species is most appropriate to use to initiate a new stand (Moser and others 2003). Although there have been advances in restoration much of the effort has been limited to planting trees, especially in the Coastal Plain. Planting is critical to the ultimate goal of recovering the forest. However, there are additional approaches that could be pursued (where appropriate). There is growing interest in longleaf forest restoration that promotes ecological values that include forest composition and structure. In the current paper we review a traditional approach for planning forest restoration projects and we propose to augment previous efforts. The additions are designed, in part, to maximize benefits conferred by residual longleaf trees that are not dense enough to be of value in traditional stand regeneration efforts. In addition we propose factors to aid in prioritizing areas within the landscape for (1) relying on natural regeneration, (2) enhancing the value of residual longleaf, and (3) artificial regeneration (seedling planting). To make this approach useful, we apply information based on ecology of the species and incorporate knowledge derived from longleaf pine silvics.

OVERVIEW OF STEPS IN TRADITIONAL FOREST RESTORATION

Steps in forest restoration often include:

1. Articulation of goal or desired future condition for the site. When there is an emphasis on conservation values this often results in the need to understand what tree species dominated the landscape during some reference period (often representing pre-European settlement)
2. Determination of the existing conditions (restoration starting point)
3. Steps 1 and 2 set in motion application of a decision tree (ex. Johnson 1998) that includes such actions as
   a. removal of offsite trees
   b. site preparation (control of competing species, etc.) and, if necessary, remediation treatments such as subsoiling, etc.
   c. seedling selection
   d. planting technique
   e. release actions

Under a traditional, formulaic approach to forest restoration planting is the primary focus because it meets the primary goal of establishing a target tree species. When the primary goal is driven by conservation concerns and when there are residual components of the forest that are retained on the site then a broader range of actions may be warranted. In addition, when longleaf pine is the target of forest restoration there may need to be additional actions such as (1) reintroduction of fire and/or (2) reintroduction of ground-layer species.

Many recommendations included in the steps for forest restoration are most appropriate for homogeneous management units and/or where restoration goal is uniform across the landscape. Because the process is designed to produce an even-sized stand, any residual longleaf trees are eliminated before planting begins. The Longleaf Alliance developed an informal decision tree to guide successful creation of a longleaf pine plantation but also has options for making effective use of longleaf currently existing under undesirable conditions (Johnson 1998). If goals for a site include ecological values, then the additions to the process of forest restoration proposed by the Longleaf Alliance will promote those goals better than more traditional restoration options. In the current paper we propose additional

[1] Visiting Assistant Professor, Department of Biological Sciences and Longleaf Pine Stand Dynamics Laboratory, School of Forestry and Wildlife Science, Auburn, AL; Research Fellow and Research Associate, Longleaf Pine Stand Dynamics Laboratory, School of Forestry and Wildlife Sciences, Auburn, AL, respectively.

options that should enhance ecological goals even more. Specifically, we focus on enhancing the ecological value of residual longleaf pine trees rather than discarding them in favor of a more uniform landscape. In addition we propose a set of considerations to aid in prioritizing areas for different management actions including enhancing natural regeneration opportunities vs. reliance on planting.

EXPANDING TRADITIONAL APPROACHES TO LONGLEAF FOREST RESTORATION

There is no doubt that there is a vital role for tree planting in an effort to recover some of the 97 percent of the original longleaf forest lost to conversion and development. However, there are additional opportunities to maximize the potential of sites that support residual components of the forest. Sites that retain some longleaf trees, especially those of cone-bearing size may be relatively small in acreage but the small area is offset by having trees that are decades older (often 40 to 70 years older) than newly planted stands. One obvious expansion of traditional forest restoration is to promote efforts to recover fire excluded stands. Using Forest Inventory and Analysis plot data, Outcalt (2000) determined that approximately 50 percent of the existing stands of longleaf pine are inadequately burned as measured by presence of fire in the past 5 years. Reintroduction of fire requires effort but also may yield high benefits. Planted stands with young, even-aged trees will require decades to reach the ecological complexity offered by multiple-aged stands.

The decision tree offered by the Longleaf Alliance (Johnson 1998) appropriately stresses careful assessment of the starting point. This is the basis for selection of appropriate types of site prep techniques, planting methods, release actions, and subsequent management. Focus is on stands or management units where the restoration goal is uniform across the landscape and this is often highly appropriate for a small private landowner.

We propose ways to broaden the decision tree of the Longleaf Alliance. As interest in complex conservation values of longleaf restoration grows, the range of desired future conditions expands. Start points become more multifaceted and less homogeneous. This is especially true north of the fall line where topography is more complex and the natural landscape may not be as homogeneous as the Coastal Plains. Broader consideration of starting conditions provides additional opportunities for conservation efforts, especially for recovery of degraded sites. In the current paper we describe the initial phases of a case study of expanded planning for forest restoration at the landscape level.

THE SITE

The target area is Horseshoe Bend National Military Park (HOBE), Tallapoosa County in northcentral Alabama. This 2,000+-acre site is north of the fall line, in the montane region of longleaf. The National Park Service (NPS) acquired HOBE in the 1950s because it is the site of the final battle of the Creek War of 1813 to 1814. Across the region the majority of uplands were cutover prior to 1930s and HOBE appears to be no exception. The NPS is interested in restoring uplands surrounding the battlefield to a condition that represents the time of the battle. A battlefield letter provides some evidence for an open-canopy forest in 1814 (see Hermann and Kush 2006). Almost a century after the battle, there is documentation from a nearby county that confirms open-canopy forest structure as well as describes the composition of native longleaf forest (Reed 1905).

Hermann and Kush (2006, in press) provide an overview of HOBE uplands today that supports residual longleaf in a long (50+ years) fire-excluded landscape dominated by hardwoods and offsite pines. The number of mature longleaf is not insignificant. There are 1,000+ scattered longleaf that have 50 to 70 rings at breast height, with approximately half the trees with diameter at breast height (d.b.h.) of >6 inches. In addition, there are three dense stands, each approximately 5 acres in size. Hermann and Kush (2006) provide information on size-class distribution of HOBE residual longleaf pine compared to data from nearby uncut forest of 1905 as well as descriptions of the first attempts to reintroduce fire. Evaluation of the site provides the basis for establishing meaningful objectives appropriate for pursing the goal of longleaf forest restoration.

CASE STUDY OF AN EXPANDED DECISION TREE APPROACH TO RESTORATION

1. Information gathered on the site indicates substantial residual longleaf pine that is embedded in a matrix of a degraded forest structure. Based on this assessment, we developed two objectives. The first and immediate objective is to restore the look (structure) of the forest at the time of the battle. The second and more long-term objective is to restore species composition of the forest. The order was determined by ease and time required to tackle each objective.

2. Once the objective of restoring forest structure was established we considered the placement of residual longleaf across the HOBE landscape. Figure 1 displays the Global Positioning System's (GPS) locations of the large (>6 inches d.b.h.) longleaf.

Identification of Longleaf Positions Over the Landscape

1. Visual assessment of figure 1 reveals numerous scattered residual longleaf suggesting that maintaining these trees will be useful in a restoration effort with ecological and conservation values. It also illustrates that simple removal of offsite hardwoods and reintroduction of fire will not be sufficient to restore forest structure because the population of residual longleaf does not meet expectations of a native forest based on what is described in the literature.

   It should be noted that use of GPS technology permitted us to evaluate tree locations on a fine scale but application of the decision process and silvics-based restoration is not dependent on use of the technology. However, it does enhance the value of the graphical displays of this paper.

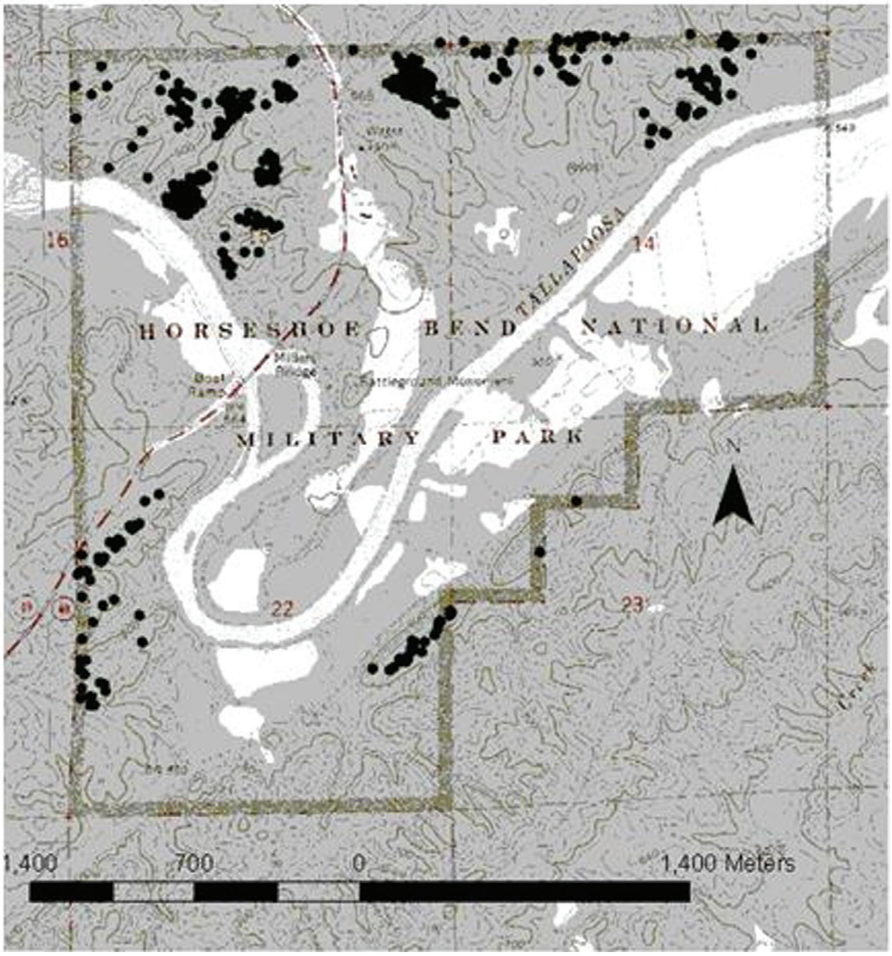


Figure 1—Map of longleaf pine stems (>15 cm d.b.h.) at Horseshoe Bend National Military Park in Tallapoosa County, AL. Map was created using ArcGIS version 9.2.

2. Figure 1 also reveals three dense stands of residual longleaf. This divides the property into areas of dense longleaf trees and no dense stands.

Assessment of Dense Stands of Longleaf

1. Assessment of these stands determined that basal area ranged from 35.6 to 50.7 square feet per acre. Croker and Boyer (1975) suggested that 30 square feet basal area per acre is required for successful natural regeneration of longleaf. This silvic information indicates that the three dense stands do not require supplemental planting in the near future.

2. These stands require reintroduction of fire to eliminate excessive litter and accumulated duff (Hermann and Kush 2010). In the future they may benefit from selective removal of offsite trees. Figure 2 provides a stem map of one of the three stands. Visual inspection as well as measurements of the polygons between longleaf suggests that there are opportunities for future small gap natural regeneration. Neither longleaf nor hardwoods are positioned in a uniform fashion over the stand. In figure 2, one natural gap is obvious and may be sufficient for natural regeneration once bare mineral soil is exposed; minimum gap size is estimated as 0.25 to 0.50 acre (McGuire and others 2001). Over the remainder of the stand selective offsite tree removal eventually may be required if stems have not been eliminated by fire.

Consideration of Hardwoods in the Uplands

1. Many hardwood species are correctly viewed as offsite in longleaf forests, however, Reed (1905) indicated that at sites near HOBE there were scattered hardwood trees prior to regionwide logging and exclusion of fire. To confirm that some hardwood individuals might be appropriate to leave, we cored selected trees.

2. Cores from hardwood trees revealed ages of 150+ for eight trees, primarily post oak (*Quercus stellata*). This information modified initial plans and scattered individual selective hardwoods will be retained. Although rare in 1905 upland forest, hardwoods should be part of a restored landscape.

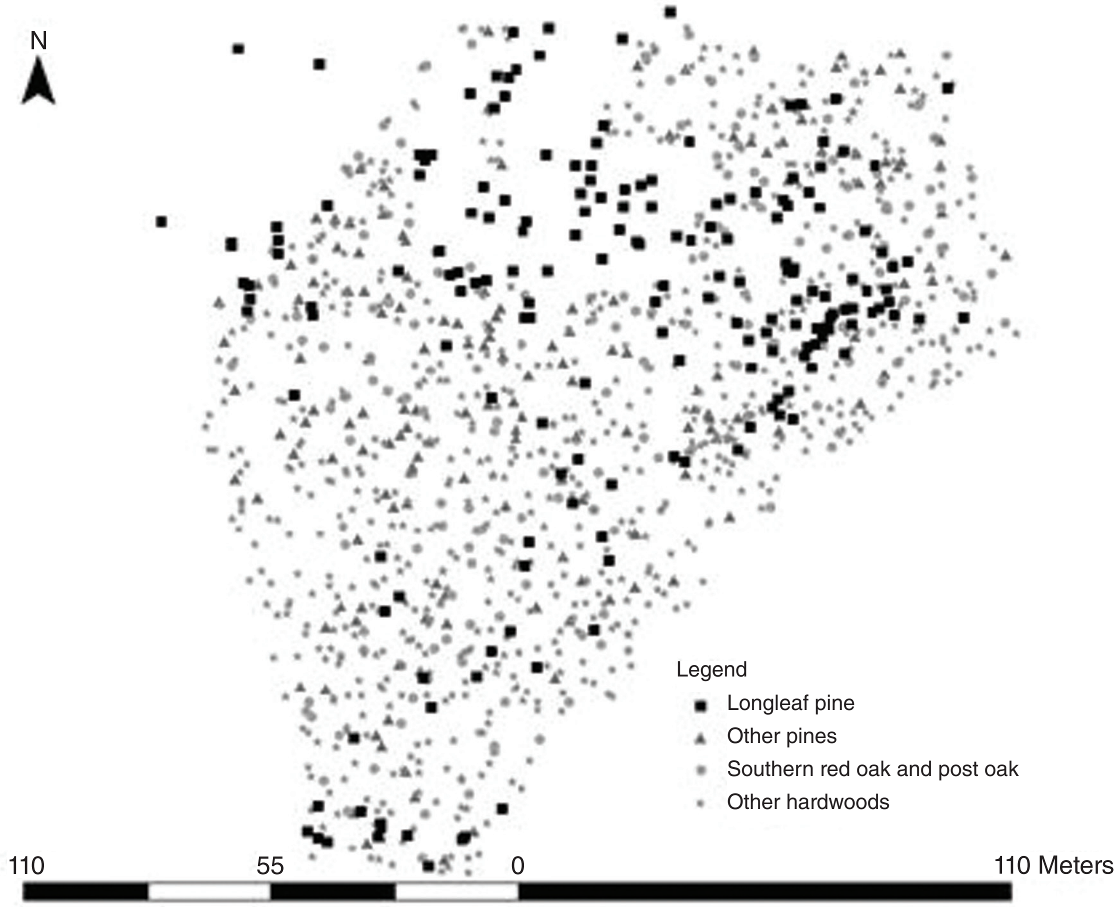


Figure 2—Stem map of a mixed pine hardwood stand that is one of three areas on Horseshoe Bend National Military Park with a dense coverage of longleaf pine. The perimeter of the stand was determined by the presence of longleaf pine.

Assessment of Longleaf Locations Based on Soil Series

1. The dense stands revealed in figure 1 suggest priority areas to target for maintaining residual longleaf on HOBE but it does not address a way to consider areas away from the dense stands. Examination of soil series currently occupied by HOBE longleaf is one way to address this issue. Longleaf is known to occupy a wide range of soil series (Craul and others 2005) but in an effort to target the most likely areas for restoration we determined what soils HOBE longleaf currently occupies. Figure 3 reveals that the HOBE soil landscape is complex with 21 soil series represented and provides no well-defined starting point for restoration. This level of complexity makes it difficult to assess possibilities and so we collapsed soil series into two simple categories: (a) those that currently support longleaf and (b) those that do not (fig. 4).

2. Figure 4 reveals that residual large longleaf are scattered over seven soil series types that occupy approximately 50 percent of HOBE uplands. Although it is very possible that some if not many of the soil types currently without longleaf once supported the tree, we use this distinction to prioritize efforts and elect to burn but not consider non-longleaf soil areas for further immediate consideration for restoration activities.

Do Isolated Longleaf Pines Have Value for Forest Restoration Efforts?

1. Isolated trees are rarely considered as contributing to landscape-level restoration efforts. Their isolation appears to add little to recreating forest structure and they may require time and effort to manage. To assess potential value of isolated longleaf pine trees we consider seed dispersal distance. Boyer (1963) determined that approximately 75 percent of seed would fall within approximately 60 feet of the cone tree and approximately 95 percent of seed was likely to fall within approximately 120 feet of the cone tree. This information serves as the basis for determining what areas are likely to benefit from natural regeneration.

2. Silvics information on longleaf seed dispersal distance permits estimation of areas that will benefit from isolated trees serving as seed sources. Figure 5 zooms in on a small area of residual longleaf. The largest circles surrounding trees illustrates the dispersal limit for 95

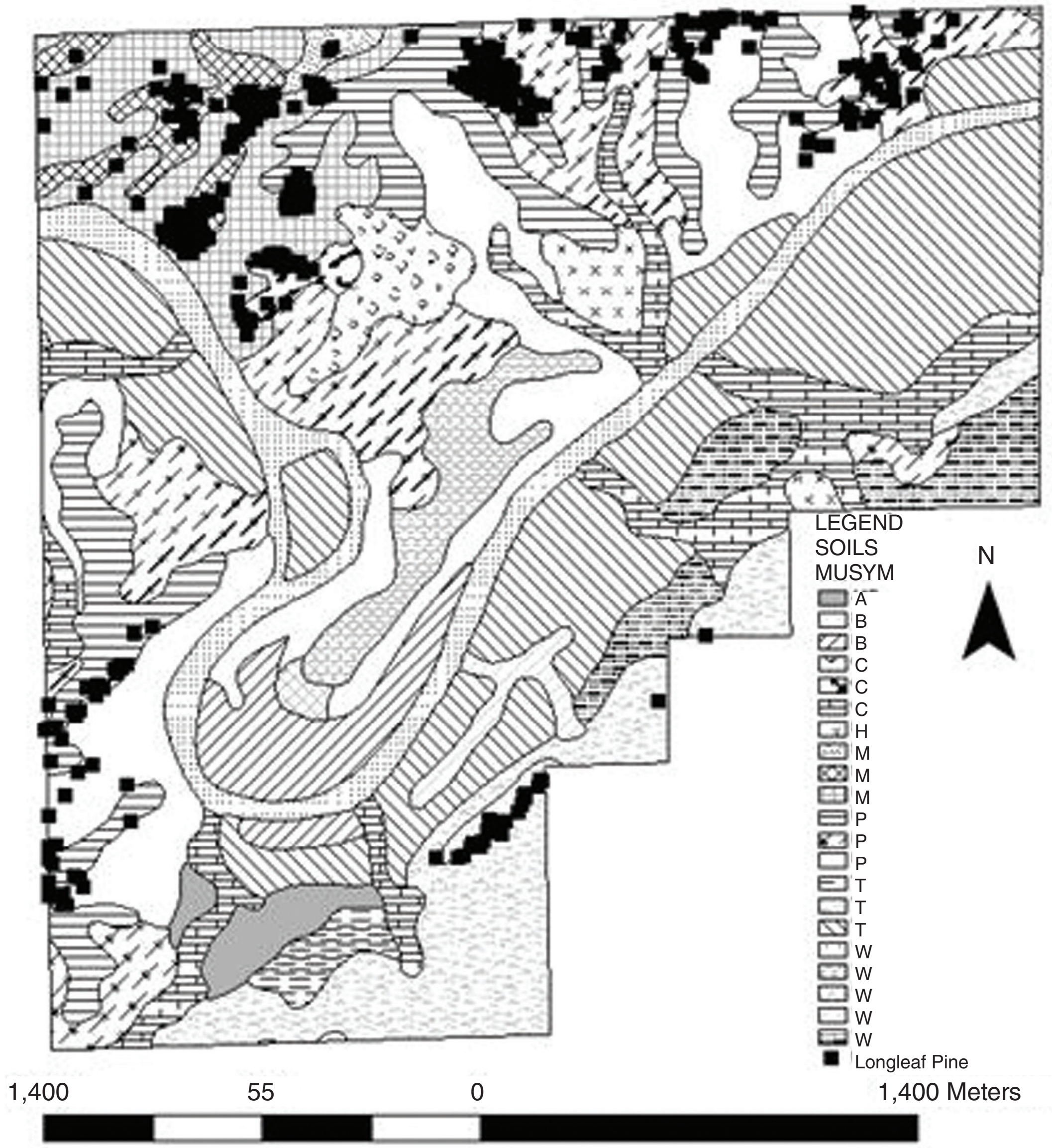
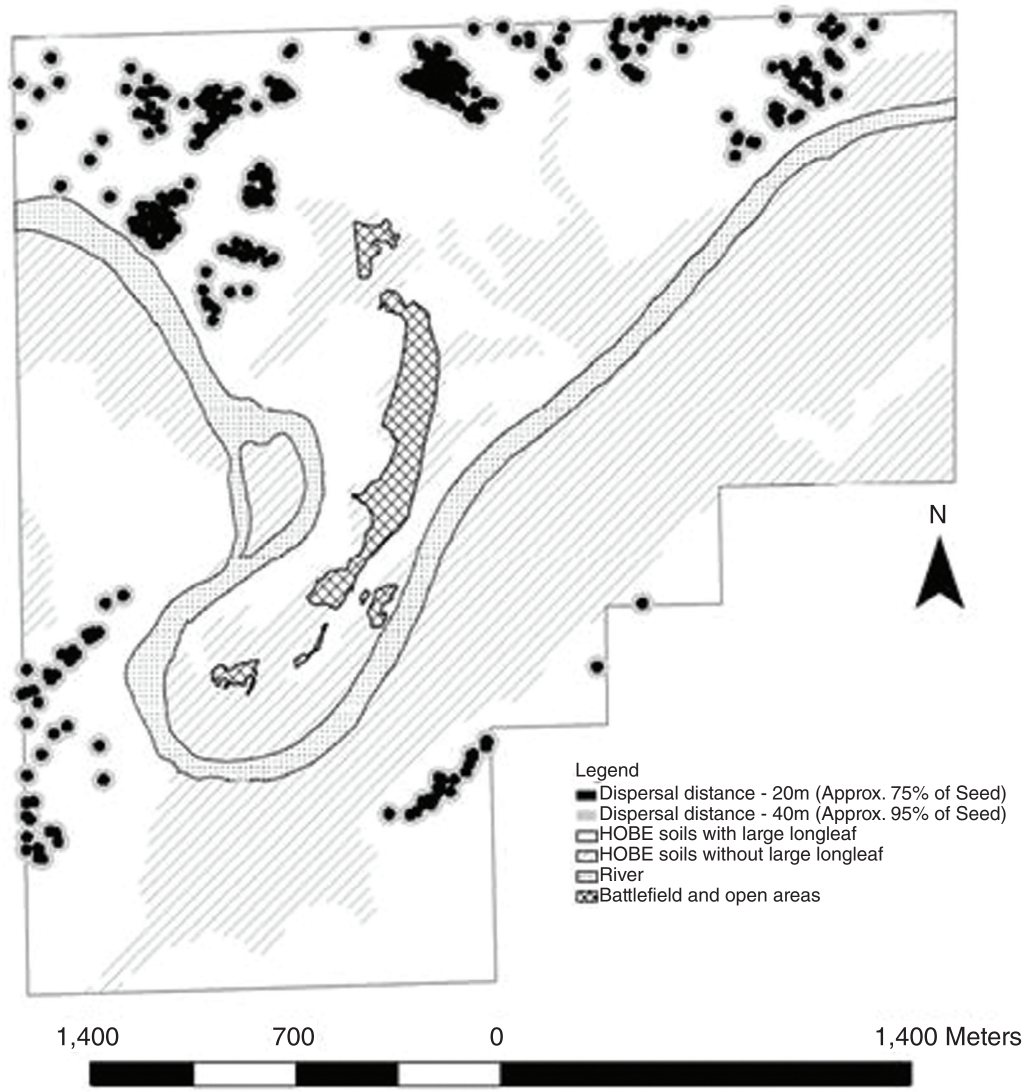


Figure 3—Longleaf pine (>15 cm d.b.h.) mapped with the soil series found at Horseshoe Bend National Military Park. Each dot represents a tree with the black center encompassing the stem plus 20 m (the expected distance of 75 percent of seedfall); the lighter gray circle represents a 40-m radius (the expected distance of 95 percent of seedfall). The soil component of the figure is derived from Web-based Natural Resources Conservation Service material. Map was created using ArcGIS version 9.2.

percent of the seed from each stem. The result is a map of small areas likely to benefit from natural regeneration imbedded in a mosaic of appropriate soils that have little or no possibility of getting seed. The areas outside of seed dispersal become potential areas for additional management effort and perhaps seedling planting. Figure 4 illustrates the entire site with areas likely to benefit from seed dispersal of residual trees. We estimate that slightly <20 percent of the appropriate area will benefit from natural regeneration over the next 40 years (approximate time until there are cone producers derived from natural regeneration). This apparently small benefit from isolated trees coupled with potential challenges of reintroduction of fire may generate concerns that isolated residual longleaf are more trouble than they are worth because they will be expensive to protect during the process of reintroducing fire. This could be true if heroic efforts were made. However, this need not be the case. If no extra effort is made to safeguard them as duff is reduced, any trees that survive are an extra bonus to restoration efforts. Even if only half of the 20 percent benefits from natural regeneration, the HOBE landscape is that much farther along in restoration of forest structure. It should be noted that although figures 5 and 4 are based on GPS data, this approach to assessment could be completed in a low-tech manner relying on trained eyes.



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CONCLUSIONS

Application of the decision tree proposed by the Longleaf Alliance (Johnson 1998) coupled with our recommendations for additional considerations provides a basis for identifying needs of areas within the landscape to be restored as well as a way to prioritize areas and associated actions. Our application of silvics information (seed dispersal distance) coupled with a conservative view of appropriate soils is expected to result in enhanced use of residual trees to meet conservation goals and a more efficient approach to forest restoration planning. Natural regeneration can benefit restoration at HOBE but will not be the primary means for meeting the goal of reestablishing a longleaf forest.

A decision tree approach that includes our additions will identify areas where (a) longleaf pine seedlings should eventually be planted and (b) restoration efforts (duff and litter consumption) coupled with offsite stem removal can create appropriate regeneration gaps with as little effort as possible. Future refinement of this landscape model for restoration could include slope and/or aspect. Reed (1905) noted few longleaf pines on north- or east-facing slopes.

Our additional considerations identified areas with potential to enhance conservation goals that would not have been included in a traditional forest restoration plan. Many plans do not confer value on isolated trees and this is understandable because goals for many sites are not driven by conservation values. In addition cost-effective site prep and planting are dependent on economy of scale. Generally if a major goal for property includes need for income, leaving isolated trees may not generate adequate benefit in the short term. However, if goals are driven in large part by conservation interests, value of isolated trees may be in creating uneven-aged stands as

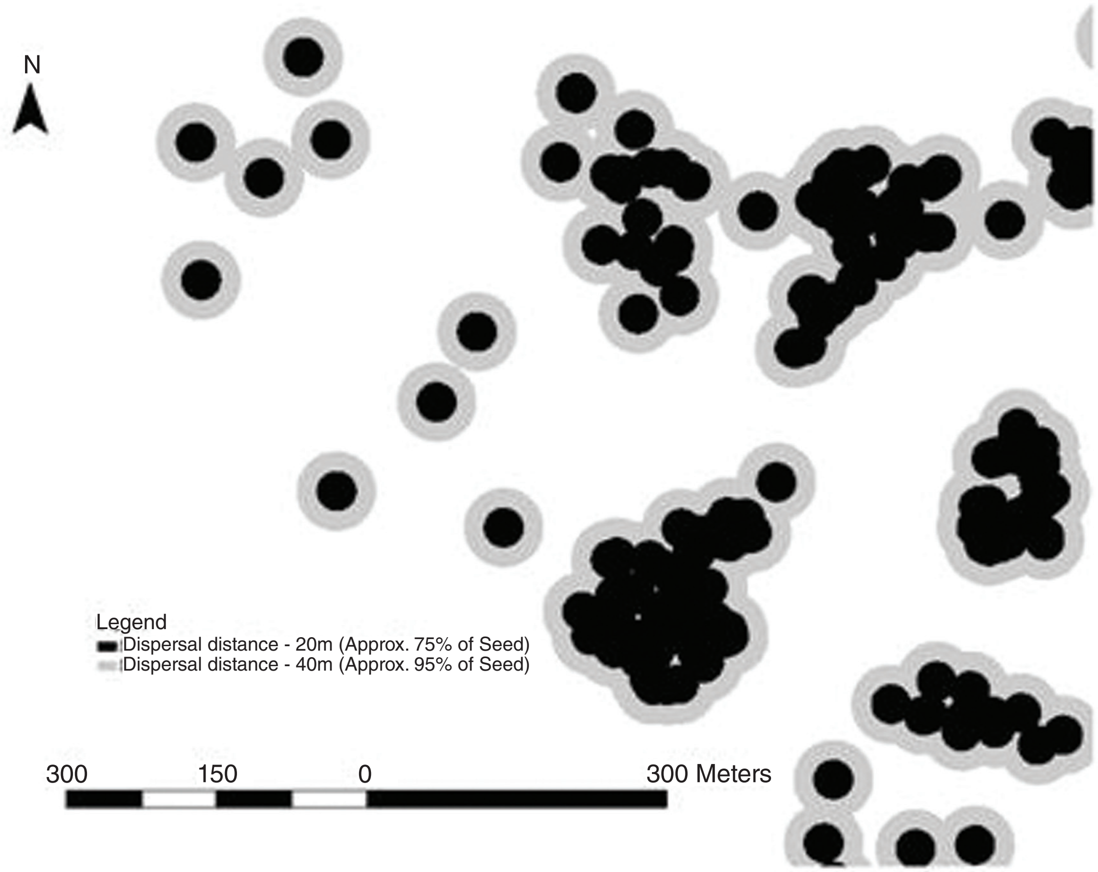

Figure 5—Longleaf pine (>15 cm d.b.h.) in a selected area of Horseshoe Bend National Military Park. Each dot represents a tree with the black center encompassing the stem plus 20 m (the expected distance of 75 percent of seedfall); the lighter gray circle represents a 40-m radius (the expected distance of 95 percent of seedfall).

well as creating potential of areas of natural regeneration. Retention and promotion of isolated trees will decrease time and potentially cost of restoration of a complex multiaged longleaf forest.

In the case of HOBE, discovery of residual dense stands identified areas of high priority for aggressive but careful reintroduction of fire to reduce litter and duff (Kush and others 1998), removing small woody stems and perhaps thinning canopy offsite stems is needed to produce small regeneration gaps. If offsite tree elimination does happen with fire, mechanical treatment should be considered. As a category, isolated longleaf have a moderate likelihood of contributing to forest appearance (structure) restoration. They may be difficult to protect during fire reintroduction but some have moderate potential for assisting in restoration of forest multiage structure, especially on edge of gaps.

Areas outside of dense longleaf stands and beyond dispersal distance of residual trees should be awarded relatively low priority for management actions because with frequent fire they are not likely to degrade further. However action necessary to plant some of them may be relatively easy to carry out, especially with a combination of mechanical and chemical treatments.

By considering the full range of start conditions across the HOBE landscape, we are better able to prioritize action for each condition, plan efficiently, and maximize restoration value of residual resources. In doing so we added a step (consideration) to decision tree developed by Longleaf Alliance (Johnson 1998). We followed their lead and (1) articulated desired future condition, and (2) determined starting points but we then considered how to make the best use of each starting point to achieve various components of the desired future condition. By pursuing this process we hope to restore longleaf pine forest structure to some areas of HOBE within the decade. Multiple states of starting points for restoration are also likely in other open-canopy forests; it may be useful to expand the evaluation and planning to species such as shortleaf (*P. echinata*) and slash pine (*P. elliottii*).

We urge consideration of recovery attempts for degraded stands where possible. This requires effort but may also have significant benefits. Our take-home message is that in mature fire-excluded stands, even if only some residual trees are retained after reintroduction of fire, stands can be multiaged in a few years. Planted stands with all trees young and the same age requires decades to reach complexity of multiple ages.

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