Site Preparation

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SITE PREPARATION TREATMENT IMPACT ON *PINUS TAEDA* AND *PINUS SEROTINA* VOLUME PRODUCTION IN A NORTH CAROLINA POCOSIN

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Abstract—Converting the pocosin landform to loblolly pine (*Pinus teada* L.) plantations has again received increased attention. However, the recent attention has not been geared toward the "wondrous yields of loblolly pine when planted on pocosin soils," but instead, what are the alternatives? Should we even be draining and converting this landform? One of the current difficulties in answering this question is our lack of information on pond pine (*Pinus serotina* Engelm.) productivity, whether grown naturally or in plantation. The results of this study show that maximum site preparation treatment (disk/burn and fertilization) yields the highest planted pine volume. However, this high volume is associated with pond pine and not loblolly pine, as might be expected. In almost all cases, loblolly pine produced higher average heights and diameters, and pond pine produced higher stocking levels. Fertilization increased planted pine diameter, height, and volume, as expected.

INTRODUCTION

Converting the pocosin landform to loblolly pine plantations has again received increased attention. However, recent attention has not been geared toward the high productivity of loblolly pine when planted on pocosin soils, but instead, what are the alternatives? Should we even be draining and converting this landform? One of the current difficulties in answering this question is our lack of information on pond pine productivity, whether grown naturally or in plantations.

Another difficulty in answering this question is that "model" pond pine stands, whether natural or planted, are rare if not nonexistent. However, it is accurate to say that a few isolated, suitable pond pine stands exist today. This study was conducted to determine the growth response and potential productivity of two pine species (loblolly and pond) growing in a low pocosin in eastern North Carolina.

METHODS

Three treatment combinations (site preparation, species, and fertilization) were allocated randomly by Teate (1967) in the original stand establishment. The block layout consists of five ditches dug east and west and two ditches dug north and south through the middle of a low, unaltered pocosin. The plantation of interest comprises a 25.91 hectare (ha) tract divided into four blocks.

The site preparation consists of four treatments: (1) control, (2) burn, (3) disk, and (4) disk/burn. Each of the four site preparation treatment plots was subdivided into four 0.4047-ha square subplots, and one-half of each subplot was randomly allocated to loblolly and pond pine plantings. The planting took place during March and April of 1963 on a 1.8 by 2.4 meter (m) spacing. Prior to planting, each 1-acre subplot was randomly selected for one of the following fertilizer treatments: (1) control—no fertilizer application; (2) lime at 12.35 tons per ha; (3) Calphos at 2.47 tons per ha; and (4) lime plus Calphos at the above rates. ("Calphos" is a mixture of calcium phosphate and kaolin, a colloidal phosphate.)

This study investigated the planted pine productivity and response to the nonfertilized (None) and Calphos or phosphate (P_2O_5) fertilization treatments across all four site preparation treatments.

Tree height and diameter were measured on trees in the two center rows in each control and phosphate 0.20 ha subplot. Data were tallied in each 6.47 ha block by species, fertilizer, and site preparation treatments.

ANALYSIS OF DATA

The loblolly and pond pines were analyzed for growth (volume, diameter, and height) by treatment combination. Three (inside bark and total height) volume equations are used in the planted pine analysis: (1) loblolly pine (volume = 0.11691 + 0.00185 x D^2Ht); (2) pond pine 12.7 - 22.6 centimeters (cm) (volume = - 0.301238 + 0.002452 x D^2Ht); and (3) pond pine $\geq$ 22.86 cm (volume = 0.088812 + 0.002374 x D^2Ht). The loblolly pine volume equation is designed for plantation grown wood (Burkhart 1977). The pond pine volume equations are designed for naturally grown wood[2], since no volume equation exists for pond pine grown in plantations. Pond pine volume for trees smaller than 12.7 cm was estimated using equation (2).

RESULTS AND DISCUSSION

The disk fertilized loblolly pine treatment yielded 38.21 cunits per ha (1 cunit = 100 cubic feet of solid wood). This volume is less than one-half that of a loblolly pine pocosin plantation receiving average silvicultural care (98.84 cunits per ha: author's experience after working 5 years in eastern North Carolina). The average height is only 57 percent of the expected value (28.32 m: author's experience), while the average diameter is slightly above that of the average pocosin loblolly pine plantation. These low values are due to loblolly pine's inability to compete and survive in an unbedded and unweeded environment. The low height is due to loblolly's inability to compete with the pocosin vegetation in an unweeded regime. The low volume is attributed to low height and stocking level.

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Of the four disk treatments, the disk fertilized pond pine treatment stands out significantly with 1,003 stems per ha and 74.84 cunits per ha. This volume is acceptable though not equal to what is expected of a loblolly pine plantation receiving average silvicultural care when grown on pocosin soils. On a positive side, this productivity is only 24 percent below expectation of 98.84 cunits per ha. The surviving stocking level of 1,003 stems per ha is high, and the relatively high volume is related to stocking. The association of pond pine and pocosin vegetation resulted in a detriment to this stocking value. That is, too many trees survived, creating smaller stems with an average diameter of 20.8 cm. This treatment had the second highest volume productivity found in this study and, based upon the treatment regimes employed in this study, one would choose this treatment combination second to the disk/burn fertilized pond pine treatment when wood production is of primary concern.

Clearly, the disk nonfertilized loblolly pine treatment is a commercial failure with just 7.84 cunits per ha. This low volume is attributed to the low survival of 96 stems per ha. The disk nonfertilized pond pine treatment also has a comparatively low survival rate (662 stems per ha), though not as low as its loblolly counterpart. In the absence of fertilization, the competing vegetation grew much faster and shaded out many of the planted pine seedlings. With fertilization, it is clear that the surviving trees grew compartively much larger.

Since no fertilizer was added to the disk nonfertilized pond pine treatment and pond pine is the planted species, volume per hectare is not expected to be high, based on previous results, even though the stocking level is comparatively high at 662 trees per ha. However, the volume level is three times higher than that of the disk nonfertilized loblolly pine treatment at 20.77 cunits per ha. Still, this is an unacceptable productivity level for commercial forestry. The low volume is due to low stocking, and small average height and diameter. The average height and diameter are 11 m and 14 cm less than the expected value, respectively.

When the burn treatment combinations are considered, the pond pine combinations stand out, though the results are not highly significant. The burn fertilized loblolly pine treatment's planted pine volume per ha, 39.32 cunits, is less than one-half that of a pocosin loblolly pine plantation receiving average silvicultural care. The low productivity is due to loblolly pine's inability to survive and grow in the burn fertilized treatment. The pocosin vegetation resprouted quickly following the burn treatment, and its growth was boosted by the added fertilizer. The average diameter of loblolly pine for this treatment equals the expected value, at 24.8 cm, but the average height is considerably lower than that of the average pocosin loblolly pine plantation, at 13.5 m. The low average height is due to loblolly pine's inability to compete with the pocosin vegetation in the absence of severe site disturbance and fertilization.

The burn fertilized pond pine treatment's volume is 36.19 cunits per ha. This value is only 37 percent of what might be expected of a pocosin loblolly pine plantation receiving average silvicultural care. This low productivity, even though trees per ha are relatively high for this study, is due to relatively low stocking and pond pine's stature, i. e., greater tapering and short trees.

The burn nonfertilized loblolly pine treatment's volume is a commercial failure at 8.29 cunits per ha. Since loblolly pine didn't survive well in this study, it is not surprising to see such a low value in the absence of fertilization. This low volume is due to low stocking and poor height and diameter. The average height is 41 percent of the expected value of a pocosin loblolly pine plantation, and the average diameter is slightly lower than the average. The low average height and diameter are attributed to the lack of fertilization.

Because the planted stems per ha are high in the burn nonfertilized pond pine treatment, one would expect volume productivity to also be high. However, planted pond pine without supplemental fertilization grew at a slow pace, producing only 25.98 cunits per ha at age 29 years. Again, pond pine does not produce high volumes due to its stature. The average height and diameter are quite low, and the stems per ha are only 75 percent of the expected value at 657. The low diameter, stocking, and height are a function of the species and the absence of fertilization.

It has been shown that loblolly pine does not survive well with the pocosin lesser vegetation; therefore, the control fertilized loblolly pine treatment's low planted pine volume, 34.12 cunits per ha, is not surprising. The low productivity is due to a small number of surviving trees (227 stems per ha) and poor height growth (60 percent of the expected value). However, average diameter exceeds the expected value which is a function of the fertilization and low stocking level, while the low height is a function of the species.

Since there are more than 900 stems per ha in the control fertilized pond pine treatment, one would expect productivity to be relatively high. The volume for this treatment is 55.43 cunits per ha, a value that is 44 percent less than that of the average loblolly pine pocosin plantation. Again, the stature of pond pine, even with fertilization, prevents it from attaining volume levels comparable to that of a pocosin loblolly pine plantation receiving average silvicultural care. The average height and diameter are 16 m and 4.5 cm, respectively, less than the expected value. The low diameter is attributed to the relatively high stem count and the low height is attributed to the species.

The planted seedlings in the control nonfertilized loblolly pine treatment did not survive well, and the volume per ha is low at 10.20 cunits. This treatment has the lowest productivity of the four control treatment combinations, at one-tenth the volume of an average managed loblolly pine pocosin plantation. The average height and diameter are

16 m and 5.5 cm, respectively, less than the expected value. This low volume is due to the low stocking level of 227 stems per ha, while the low diameter and height are due to the lack of fertilization and weed control.

When considering the control nonfertilized pond pine treatment, one finds 17.00 cunits per ha, still another commercial failure attributed to the lack of fertilization, slightly low stocking, and the stature of pond pine—i.e., small diameter and short stems. The average height is more than 300 percent less than the expected value, and the average diameter is 66 percent less than the expected value.

These outstanding results, high in the case of pond pine and low in the case of loblolly pine, are attributed to: (1) pond pine's association with pocosin vegetation, (2) pocosin environment, (3) lack of fertilization, (4) lack of severe site alteration, and (5) genetics.

The disk/burn fertilized loblolly pine treatment's volume productivity of 58.96 cunits per ha is 66 percent of a loblolly pine pocosin plantation receiving average silvicultural care. This relatively high volume, though lower than the expectation, is due to accelerated growth resulting from the application of fertilizer and the drainage effects. The low volume level is attributed to the low stocking level, 437 stems per ha, which is one-half the expected value. The maximum site preparation disturbance (disk/burn) is offset by the stocking level. The average height is low at 17.7 m and the average diameter is slightly below the expectation at 27.9 cm. The low height is attributed to competition from the pocosin vegetation.

Contrary to expectation, the disk/burn fertilized pond pine treatment has the highest planted pine volume of any observed in this study, at 78.92 cunits per ha. This high volume productivity is 75 percent of that expected of a loblolly pine pocosin plantation receiving average silvicultural care. The treatment's productivity is high due to high planted pine survival: 1,228 trees per ha. This stocking level is about 40-50 percent higher than optimum for a plantation 29 years old.

Caution is warranted here, as volume per hectare is just one measure of forest productivity. Perhaps the most meaningful measure is product, since the value difference between pulpwood and gradewood is quite high. Alternatively, one can argue that thinning can be used to reduce this treatment's stocking level and create a desired product, i.e., a large average diameter. This, assumes that pond pine's wood quality and property are comparable to those of loblolly pine. The average height and diameter are much lower than the expected values. The low diameter is due to high stocking, while the low height is attributed to the species.

When the disk/burn nonfertilized loblolly pine treatment is considered, one finds another commercial failure with a volume of 23.47 cunits per ha. This level is only 25 percent of the expected value of an average managed pocosin loblolly pine plantation. The low volume is due to a low stocking level of 373 trees per ha and relatively poor growth. This treatment's planted pine survival is the lowest of the disk/burn combinations. The average height and diameter are much lower than the expected value. The low volume, stocking, height, and diameter are attributed to the lack of fertilization.

Because the stocking level is high in the disk/burn nonfertilized pond pine treatment, one would expect relatively high-volume productivity. However, this treatment produced 35.20 cunits per ha, a value that is only 36 percent of a pocosin loblolly pine plantation receiving average silvicultural care. The low volume is due to pond pine's stature and the lack of fertilization. The average height and diameter are 17 m and 8 cm, respectively, below the expected value. The low volume, height, and diameter are attributed to the lack of fertilization and high stocking level.

CONCLUSIONS

1. The disk/burn fertilized pond pine treatment has the highest planted pine volume productivity, and is recommended when wood production is the overwhelming consideration.
2. Pond pine has a "harmony or association" effect with pocosin lesser vegetation.
3. Planted pine volume and stem count increase in association with pond pine.
4. Loblolly pine has higher average heights and diameters than pond pine.
5. Fertilization increases planted pine diameter, height, and volume.

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SITE PREPARATION TECHNIQUES FOR ESTABLISHING MIXED PINE-HARDWOOD STANDS IN THE SOUTHERN APPALACHIANS

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Abstract—Following commercial clearcutting of an upland hardwood stand, four site preparation treatments (control, silvicultural clearcut, fell-and-burn, and brown-and-burn) were tested for establishing a mixed pine-hardwood stand. Half of each treatment plot was planted (20 by 20 foot spacing) with 1-0 loblolly pine (*Pinus taeda* L.) and the other half with 2-0 white pine (*P. strobus* L.). After six growing seasons the resulting stands were composed of both natural regeneration (both hardwoods and pines) and planted pines. There were significant differences among the four site preparation treatments in numbers of naturally established stems per acre, and in the survival and growth of planted pines. Most of the differences were due to the use of fire, which reduced the number of hardwood stems, providing pines room to grow. Both the brown-and-burn and fell-and-burn treatments resulted in the establishment of a significant planted pine component, while the commercial and silvicultural clearcuts did not. The brown-and-burn treatment produced the best survival and growth of the planted pines and will likely develop into an understocked pine stand. At this time the fell-and-burn treatment has the best opportunity to develop into a mixed pine-hardwood stand.

INTRODUCTION

The inability to develop forest management strategies that are attractive to the nonindustrial, private forest landowner (NIPF) has been troublesome to forestry professionals for decades. Recurring reasons given by NIPF landowners for their failure to practice the more widely recommended forms of forest management are: (1) failure of these practices to maintain good wildlife habitat, (2) their dislike for the lack of diversity in pine plantation monocultures, and (3) their dislike of the clearcutting and conversion to short rotation management systems (pines) that are commonly recommended. Most NIPF landowners will not invest in forest regeneration (Alig and others 1990), yet would prefer to be growing a forest crop of some economic value. Failure to address these constraints is, to a large degree, the reason why the forestry profession has had little impact on NIPF landowners in Eastern North America.

These problems are most acute in upland forests that tend to be more droughty and less productive. Many of these sites are currently supporting low-quality forests due to repeated high grading, fires, and grazing. Pines are more marketable and tend to be more productive on these poorer, droughty sites than hardwoods. A strategy that will likely be attractive to NIPF landowners would be maintaining pines in mixtures with hardwoods to improve wildlife habitat with lower establishment inputs (planting with wider spacing, and less site preparation) than traditional monocultural procedures.

The initial problem that must be addressed in moving these forest lands toward some reasonable degree of productivity is the removal of low-quality trees from stands. In most cases this will be most effectively and efficiently done with a silvicultural clearcut. Once this low-quality material is removed, natural regeneration most often creates pure hardwood stands. Waldrop (1997) has found that a pine component can be introduced by planting pines with wide spacing after using various low-cost site preparation treatments.

METHODS

The study was conducted on the Oak Ridge Forestry Experiment Station, a unit of the University of Tennessee Agricultural Experiment Station. An upland hardwood stand on a south-facing slope was commercially clearcut; all sawtimber, pulpwood, and firewood [down to a diameter at breast height (d.b.h.) of 5 inches] was removed from the site. Twenty 1-acre, square plots were established within the harvest area. A randomized complete block design with five replications of the four site preparation treatments was used. The whole-plot treatments were: (1) control (commercial clearcut); (2) silvicultural clearcut; (3) brown-and-burn, (industry-type site-preparation method); and (4) fell-and-burn (Abercrombie and Sims 1986, Phillips and Abercrombie 1989).

In the spring following the commercial clearcut, all remaining trees taller than 6 feet were felled on plots receiving the silvicultural clearcut and the fell-and-burn treatments. The brown-and-burn plots were hand sprayed in midsummer (late July, early August), simulating a helicopter application of a tank mix consisting of 12 ounces Arsenal®, 2 quarts Roundup®, and 1 quart ionic surfactant in 10 gallons of water per acre.[2] The brown-and-burn and fell-and-burn treatment plots were burned on September 8 and 9, 1989. Each treatment plot was split in half with both loblolly pine (1-0 stock) and half to white pine (2-0 stock) planted to each subplot, respectively. The pines were planted in rows arranged perpendicular to the slope to eliminate a possible slope effect on species response. Each species subplot consisted of five rows 20 feet apart with trees in rows planted 20 feet apart. Pine seedlings were planted by hand using dibble bars.

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In September 1995, after six growing seasons, the following data were collected for all planted pines: (1) survival, (2) total height (nearest foot), and (3) d.b.h. (1/10 inch). For natural regeneration the data included the number of stems per acre by diameter class and species. Natural regeneration was sampled along two transects, 6.6 feet wide and 66 feet long (0.01 acre). Stems (the dominate stem in a clump) were tallied by species in 1-inch-diameter classes along the transect. Data were analyzed using a random block [split plot] model (Proc Mixed) (SAS 1996). Survival data were transformed using an arsin (SAS) transformation. Least square means were produced and compared using pairwise t-tests (P> .05).

RESULTS

Species Composition

Pre-harvest stand—The most abundant overstory trees in the preharvest stand were chestnut oak, white oak, yellow-poplar, and blackgum (see table 1 for scientific nomenclature). Sourwood, red maple, hickories, sugar maple, sassafras, southern red oak, post oak, black cherry, and shortleaf pine were minor overstory components (Andrews 1995). The understory consisted primarily of red maple, sourwood, blackgum, sassafras, and dogwood, (Andrews 1995). The preharvest stand was uniform in species mix and stocking across the study site.

Table 1—Species found on the study site seven growing seasons after harvest and site preparation

Common name	Scientific name[a]
Black cherry	*Prunus serotina* Ehrh.
Blackgum	*Nyssa sylvatica* Marsh
Black oak	*Quercus velutina* Lam.
Black walnut	*Juglans nigra* L.
Carolina buckthorn	*Rhamnus caroliniana* Walt.
Chestnut oak	*Quercus prinus* L.
Dogwood	*Cornus florida* L.
White ash	*Fraxinus americana* L.
Hickories[b]	*Carya* sp.
Eastern redcedar	*Juniperus virginiania* L.
Red maple	*Acer rubrum* L.
Sassafras	*Sassafras albidum* (Nutt.) Nees
Scarlet oak	*Quercus coccinea* Muenchh.
Sourwood	*Oxydendrum arboreum* (L.) DC.
Southern red oak	*Quercus falcata* Michx.
Sugar maple	*Acer saccharum* Marsh.
Shortleaf pine	*Pinus echinata* Mill
Serviceberry	*Amelanchier arborea* (Michx. f.) Fern.
Virginia pine	*Pinus virginiana* Mill.
White oak	*Quercus alba* l.
Yellow-poplar	*Liriodendron tulipifera* L.

Species with only one stem count per 40 plots; American chestnut, *Castanea dentata* Marsh; Cucumber magnolia, *Magnolia acuminata* L.; Eastern redbud, *Cercis canadensis* L.; Mimosa, *Albizia julibrissin* (Durazzini) Wild.; Paulownia, *Paulownia tomentosa* (Thunb.) Sieb.& Zucc. ex Steud.; Red mulberry, *Morus rubra* L.; Sweetgum, *Liquidambar styraciflua* L.
[a] Taxonomy follows Little(1988)
[b] Includes mockernut (*C. tomentosa* Nutt.), pignut (*C. glabra* (Mill.), and shagbark (*C. ovata* (Mill.) K. Koch.

Regenerating stand—Seven years after stand harvest, 27 hardwood and 3 conifer species were found regenerating naturally on the study site (table 1). The species mix was similar to that of the preharvest stand.

Treatment Effects

Seven years after treatment, stem counts of potential overstory species differed significantly among treatments (table 2). The plots that were not burned (commercial clearcut and silvicultural clearcut) had significantly higher stem counts (3,573 and 4,186, respectively) than plots that were burned (fell-and-burn, 2,195; and brown-and-burn, 1,361). Stem counts for understory species followed the same pattern but the differences were not significant. Total stem counts for all species differed significantly among treatments (table 2).

While differences were not significant, the stem counts for the natural yellow pines seeding into the study area increased with the intensity of the site preparation treatments (table 2). Smooth sumac, which was not found in the original stand, was abundant in all regeneration plots.

Planted Pines

Survival—Survival differences between loblolly pine (45 percent) and white pine (52 percent) were not significant. Pine survival for the commercial clearcut (27 percent) and silvicultural clearcut (26 percent) did not differ significantly. However, survival in both of these treatment areas was significantly lower than in the two treatment areas that were burned (fell-and-burn, 68 percent; brown-and-burn, 72 percent). Survival for both planted pine species was similar among all treatments (table 3). Mortality of pine seedlings between 1 and 6 years of age was approximately five times greater for treatments that were not burned than that for treatments that were burned.

Height and diameter—After 6 years, overall growth of loblolly pine was significantly greater for both height (13.7 feet) and d.b.h. (2.4 inches) than was that of white pine (6.8 feet, and 0.8 inches) (table 3). Other studies in this area indicate that white pine has slow early height growth. These trees should catch up with the loblolly pine around 16 years of age (Thor and others 1979, Miller 1982). Height and d.b.h. growth on the four site preparation treatments followed the same response pattern as did survival. Height and d.b.h. for both loblolly and white pines in the treatments involving fire were significantly greater than in the unburned treatments (table 3).

CONCLUSIONS

The silvicultural clearcut resulted in more hardwood stems per acre than did the commercial clearcut. Neither of the clearcut treatments contained a pine component. The stands developing on those plots will be hardwood stands similar in species makeup to the preharvest stand.

Table 2—Stem counts of natural regeneration, six growing seasons after different site preparation methods

Species groups	CC	SC	FnB	BnB
	Site preparation treatments[a]			
	- - - - - - - - Stem counts per acre - - - - - - - -			
Potential overstory				
Yellow-poplar	1630	1014	717	682
Chestnut oak	690	872	50	40
Red maple	500	965	150	110
Blackgum	223	665	680	369
Hickory[b]	180	140	278	30
Sugar maple	150	70	30	0
Black cherry	90	250	70	0
White oak	10	30	10	0
Upland red oaks[c]	30	100	60	0
Subtotal	3573 a[d]	4156 a	2045 b	1231 b
Pines[e]	0	30	150	130
Understory	1984	2130	1554	627
Total	5557 ab	6316 a	3749 bc	1988 c

[a] (CC) commercial clearcut—all trees 5 inches and larger removed;
(SC) silvicultural clearcut—all trees over 6 feet in height or taller felled;
(FnB) fell-and-burn; and (BnB) brown-and-burn.
[b] Mockernut, pignut, and shagbark
[c] Black oak, scarlet oak, and southern red oak.
[d] Within each row, means not followed by the same letters differ significantly at P=.05.
[e] Shortleaf pine, and Virginia pine.

Table 3—Survival, height, and d.b.h. for loblolly pine and white pine after six growing seasons following establishment, using four different site preparation methods

Treatment	Survival	Height	D.b.h.
	Percent	*Feet*	*Inches*
Loblolly pine			
Brown-and-burn	68 a[a]	17.0 a	3.3 a
Fell-and-burn	63 a	15.9 a	2.9 a
Silvicultural[b]	23 b	10.8 b	1.9 b
Commercial[c]	2 b	11.2 b	1.7 b
White pine			
Brown-and-burn	76 a	9.8 a	1.3 a
Fell-and-burn	72 a	8.7 a	1.0 ab
Silvicultural[b]	30 b	4.7 b	0.4 b
Commercial[c]	27 b	4.1 b	0.4 b

[a] Means within each column not followed by the same letter differ significantly at P =.05.
[b] Silvicultural clearcut - all trees over 6 feet in height or taller felled.
[c] Commercial clearcut - all trees 5-inches and larger removed.

The use of fire increased both planted and natural pine establishment and growth. The increased intensity of the brown-and-burn treatment resulted in lower numbers of hardwood stems than did the fell-and-burn treatment. Several hardwood species (Carolina buckthorn, black cherry, sugar maple) were not present, and others (flowering dogwood and the hickories) were less frequent in plots treated with herbicides. The stand resulting from this treatment will result in an open pine stand with a minor hardwood component. The stand developing in the fell-and-burn treatment has established both a hardwood and pine component.

The fell-and-burn treatment offers the NIPF landowners an opportunity to increase the productivity of their forests by introducing a pine component in future stands. This is accomplished at a low cost and without reducing wildlife benefits.

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SITE PREPARATION METHODS AND THEIR IMPACTS ON TIMBER AND NONTIMBER VALUES OF FOREST STANDS

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Abstract—This study evaluated timber values and nontimber benefits of forest stands generated 15 years earlier using four site preparation methods in the Tuskegee National Forest. Timber values of the forest stands were assessed with yields predicted by the SE TWIGS model. Nontimber benefits were evaluated through the Contingent Valuation Method using 200 user interviews. Results indicate that the majority (62 percent) of users felt that the national forest should be managed for both timber and nontimber products. The soil-active herbicide method was projected to produce the highest timber value. For the nontimber benefits, the public seemed to prefer the forest stand without site preparation to those generated by the chainsaw felling, soil-active herbicide, or tree injection methods. When both timber and nontimber values are considered, the no-site-preparation method is the generally preferred alternative to best meet the desires of citizens with different or even conflicting preferences over timber and nontimber products.

INTRODUCTION

Silvicultural practices affect both timber and nontimber values of forest stands. Driven by public demand, national forests in the United States are required to be managed for “multiple uses” that include timber and nontimber uses. Understanding impacts of silvicultural treatments on timber and nontimber values is essential to (a) identifying preferred forest management strategies to meet the public’s diverse demand, and (b) comprehensively assessing benefits and costs associated with forest management.

Effects of site preparation methods on timber yields and growth have been studied widely for different tree species and in various locations (Dangerfield and Edwards 1991, Glover and Zutter 1993, Greene and Lowe 1992, Knowe and Stein 1995, Minore and Weatherly 1990, Pienaar and Rheney 1993a, 1993b, South and others 1995). However, studies on the effects of site preparation methods on nontimber values, particularly on both timber and nontimber values, are quite limited. This is partially due to the difficulty in assessing nontimber values. Unlike timber, most of the nontimber products from a forest are environmental goods. Markets for these goods do not exist; thus no price information on these goods is available.

This study was designed to investigate the impact of the four site preparation methods on the timber and nontimber values of the forest stands in the Tuskegee National Forest. The specific objectives were: (1) to predict/estimate the timber values of the forest stands treated with the four site preparation methods; (2) to assess the nontimber values of the forest stands; and (3) to rank the four site preparation methods in terms of both timber and nontimber values generated.

METHODS

The Tuskegee National Forest is located in Macon County, east-central Alabama, in the loam hills of the Hilly Coastal Plain Physiographic Province. Fifteen years ago, 16 1.2-acre research plots were established in a recently harvested stand. Only pines with diameter at breast height (d.b.h.) larger than 4 inches (in.) were harvested. Four site preparation methods were tested: (1) no site preparation, (2) chainsaw felling of all woody plants taller than 4 feet (ft), (3) herbicide tree injection with Pathway (picloram +2, 4-D) of both hardwoods and pines, and (4) soil-active herbicide (Velpar) applied in a spot-grid. Loblolly pine seedlings were planted on all plots using an 8 by 8 ft spacing. The experiment was a randomized complete block design with four replications of the four treatments. The site index (base 50 years) ranged from 76 to 95 for the four blocks.

Timber yields of the forest stands treated with the four site preparation methods were projected using the SE TWIGS Model Version 6.1 (Bolton and Meldahl 1990a, 1990b). This model was designed for uneven-aged stand projections. Three rotation lengths of 40, 70, and 100 years were used. No thinning was assumed in predicting timber yields. The volumes of sawtimber were measured in International 1/4-inch. The merchantable standards used were: 5 to 9 in. d.b.h. for pine pulpwood and >9 in. d.b.h. to 7 in. top for pine sawtimber. Because of the lack of a market for hardwood sawtimber, all hardwood timber yield was converted to pulpwood yield. A two-way analysis of variance was conducted to test whether treatment, age, and interaction between them had a significant impact on timber values. A Duncan multiple range test was also performed to compare the mean timber values yielded by the four site preparation treatments.

In addition to timber yields, the economic return from the timber production was also evaluated using the criteria of Net Present Value and Annual Equivalent Revenue. The mean yield for each treatment was used. The timber prices used in this analysis were $186 per mean board foot (MBF) for pine sawtimber, $21 per cord for pine pulpwood, and $10 per cord for hardwood pulpwood. The costs of the four site preparation methods were estimated based on current

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Forest Service contracts, Forest Farmer's 1995 Manual (Dubois and others 1995), and herbicide application costs from Miller and Glover (1995). These costs were zero for the no site preparation, $50 per acre for the chainsaw felling, $77.50 per acre for the tree injection, and $36.34 per acre for the soil-active herbicide, respectively. The seedling price was estimated to be $0.064 per seedling. And planting costs were $39.00 per acre for the no-site preparation and $37.90 per acre for the other treatments. No taxes or land rent were included in the economic analysis.

The nontimber benefits of the forest stands were evaluated by using the Contingent Valuation Method (Gan and others, in press; Hargrove and others, in press). This method induces respondents to release their preferences over a specific nonpriced good by directly asking them about the amount of their willingness to pay for the good (Cummings and others 1986, Mitchell and Carson 1989). Two hundred persons randomly selected from three counties surrounding or near the Tuskegee National Forest were interviewed by using a carefully designed survey questionnaire. These counties were Macon, Lee, and Montgomery. The interviewees were presented with four enlarged, color photographs that showed the 15-year old forest stands resulting from the four silvicultural treatments. They were asked to give their preferences and the dollar value that they were willing to pay for various nontimber benefits in each of the forest stands. The questions regarding willingness to pay were open-ended, i.e., no monetary value or range was suggested or indicated in the questionnaire. The interviewees were given no information on how the forest stands were generated. In other words, they were not told that chemicals were used in the tree injection and soil-active herbicide methods. Further, the respondents were informed that the management of the national forest was fully financed by taxes. The color photos used for the interviews were taken in April 1995. The interviews were conducted from April to December 1995 by seven trained interviewers.

A multiattribute assessment approach was used to rank the four site preparation methods in terms of the timber and nontimber values generated. This approach enables an individual to select among choices with different attributes (Keeney and Raiffa 1976). Usually, a weighted-additive utility function is used. For multiple attribute measures x_1, x_2, …, x_n, the weighted-additive utility function can be specified as:

$$\mu(x_i, x_2, ..., x_n) = \sum_{i=1}^{n} w_i \mu_i (x_i) \qquad (1)$$

where

w_i is the weight for the ith attribute with $w_i \geq 0$ and $\sum_{i=1}^{n} w_i = 1$

One disadvantage of the weighted-additive utility function is that all the weights must be known *a priori*. The weights can be difficult to determine, particularly when many decision makers—in our case the taxpayers—who share different sets of weights, are involved. To overcome this problem, we used an algorithm developed by Kirkwood and Sarin (1985), which requires only partial information on the weights. This approach requires only the ordering of the importance of the attributes, not the exact values of the weights for the attributes. However, this approach also has its limitation. Using the partial information on the weights may result in the inability to distinguish the ranking of some alternatives.

The attributes considered in this study were timber and nontimber benefits. The site preparation methods were compared by using two sets of the parameters: (1) the ratios of the timber and nontimber values to the establishment costs of the forest stands, and (2) the Net Present Value of timber production and the nontimber value. Using the first set of parameters implies that the forest establishment costs are jointly borne by timber and nontimber production. When using the second set of parameters, we allocated all the establishment costs to timber production. Before applying the multiattribute assessment approach, the value of each attribute was transformed to an index value ranging from 0 to 10 to overcome the unit difference in the attributes. Then, the multiattribute algorithm was employed to find the efficient set of alternatives and to rank the alternatives.

RESULTS

Timber Value

In general, the test site preparation methods generated four distinctly different stand types. No site preparation with planting produced mixed uneven-aged stands with scattered older hardwoods. The application of the soil-active herbicide Velpar also yielded uneven-aged stands but with scattered older residual pines, due to the resistance of pine to this herbicide. Both chainsaw felling and tree injection yielded even-aged stands, with mostly resprouted hardwoods with felling and mostly pines with herbicide injection.

According to the projected average timber volumes, the soil-active herbicide will produce the highest volumes of sawtimber, followed by the tree injection, no-site preparation, and chainsaw felling methods for the 40-, 70-, and 100-year rotations. The soil-active herbicide method will also generate the highest timber value, whereas the chainsaw felling method will produce the lowest timber value at the 40-year rotation and the no-site-preparation method will have the lowest timber value at the 70- and 100-year rotations (table 1).

The overall F-value of the two-way (treatment and age) analysis of variance was 28.13 (p=.0001). Treatment and age were significant at p=.0476 and p=.0001, respectively. The interaction between treatment and age was not significant. A Duncan multiple range test (p=.05) showed that mean timber values yielded by soil-active herbicide and tree injection are not significantly different, and those resulting from tree injection, no-site preparation, and chainsaw felling are not significantly different, either. But soil-active herbicide produced significantly higher timber values than no-site preparation and chainsaw felling.

Table 1—Average projected timber yield and value of the forest stands treated with different site preparation methods

Site preparation method	Sawtimber	Pine pulpwood	Hardwood pulpwood	Value
	Bd ft	- - - - - - Cords/ac	- - - - - -	$
40-year rotation				
No-site preparation	9,369	8.5	5.0	1,971
Chainsaw felling	7,272	9.5	7.8	1,630
Tree Injection	9,654	12.2	4.2	2,094
Soil-active herbicide	11,938	10.9	1.6	2,465
70-year rotation				
No-site preparation	20,998	2.5	11.2	4,070
Chainsaw felling	20,615	1.7	20.6	4,076
Tree Injection	22,685	2.8	12.5	4,403
Soil-active herbicide	24,126	2.6	5.2	4,598
100-year rotation				
No-site preparation	24,803	0.1	13.7	4,760
Chainsaw felling	25,745	0.2	22.2	5,015
Tree injection	27,138	0.3	14.0	5,194
Soil-active herbicide	27,750	0.4	6.6	5,236

Economic returns from timber production are presented in table 2. Based on the Net Present Value or the Annual Equivalent Revenue from timber production at a 4-percent real discount rate, the soil-active herbicide method is most profitable at the 40-year rotation, while the no-site-preparation method is most profitable at the 70- and 100-year rotations.

Nontimber Value

The selected sociodemographic characteristics of the respondents resemble quite well those of the population in the three counties surrounding and near the Tuskegee National Forest. Some 63 percent of the respondents did not have college degrees, 35 percent had earned at least a bachelor's degree. The medial annual household income for the respondents was between $20,000 and $30,000. Approximately 60 percent of the respondents were employed, the rest of them were not in the labor force (including unemployed, youth, students, retired, etc.). Fifty-three percent of the interviewees were male and 47 percent were female. About 53 percent of the respondents lived within a radius of 25 miles from the Tuskegee National Forest.

About one-third of the 200 people interviewed had visited the Tuskegee National Forest. The major purposes for their visits were hiking/walking/cycling, picnicking, and camping, which accounted for more than 70 percent of the respondents who had visited the national forest.

Sixty-two percent of interviewees indicated that the national forest should be managed for both timber and nontimber products. Among the nontimber products identified, wildlife habitats, water protection, and hiking/walking/cycling were ranked as the top three most important nontimber benefits for the respondents. According to the respondents' preferences, timber was ranked the fifth most important product from the national forest.

The values (willingness to pay) of the nontimber products released by the respondents are presented in the following tabulation:

Site preparation method	Willingness to pay ($/person)
No-site preparation	158
Chainsaw felling	141
Tree injection	129
Soil-active herbicide	129

In terms of the total values of the nontimber benefits, the respondents valued the forest stands generated by the no-site-preparation method as the highest, followed by those resulting from chainsaw felling, tree injection, and soil-active herbicide.

Rankings of the Site Preparation Methods

Three scenarios were considered in ranking the site preparation methods. They were: (1) timber and nontimber values are equally important, (2) timber value is more important than nontimber value, and (3) nontimber value is more important than timber value. Rankings were done by using two sets of parameters: (1) the ratios of the timber and nontimber values to the forest establishment costs (table 3), and (2) the Net Present Value of timber production and the nontimber value (table 4).

Table 2—Net present value and annual equivalent revenue of timber production[a]

Rotation age	No-site preparation	Chainsaw felling	Tree injection	Soil-active herbicide
40 years	328/16.57[b]	208/10.51	227/14.00	396/19.99
70 years	179/7.64	130/5.57	124/5.29	177/7.59
100 years	12/0.47	-32/-1.32	-56/-2.29	-14/-0.58

[a] No taxes or land rent were included, and a 4-percent discount rate was used.
[b] Net Present Value ($)/Annual Equivalent Revenue ($/yr).

Table 3—Rankings of the site preparation methods based on the ratios of the timber and nontimber values to the forest establishment costs

Site preparation method	$w_t = w_n$[a]	$w_t >> w_n$[b]	$w_t << w_n$[c]
40-year rotation			
No-site preparation	1	1	1
Chainsaw felling	3	4	3
Tree injection	4	3	4
Soil-active herbicide	2	2	2
70-year rotation			
No-site preparation	1	1	1
Chainsaw felling	3	3	3
Tree injection	4	4	4
Soil-active herbicide	2	2	2
100-year rotation			
No-site preparation	1	1	1
Chainsaw felling	3	3	3
Tree injection	4	4	4
Soil-active herbicide	2	2	2

[a] Timber and nontimber values are equally important.
[b] Timber value is more important than nontimber value.
[c] Nontimber value is more important than timber value.

Table 4—Rankings of the site preparation methods based on the net present value of timber production at a 4-percent real discount rate and the nontimber value

Site preparation method	$w_t = w_n$[a]	$w_t >> w_n$[b]	$w_t << w_n$[c]
40-year rotation			
No-site preparation	1	2	1
Chainsaw felling	4	4	2
Tree injection	3	3	4
Soil-active herbicide	2	1	3
70-year rotation			
No-site preparation	1	1	1
Chainsaw felling	3	3	2
Tree injection	4	4	4
Soil-active herbicide	2	2	3
100-year rotation			
No-site preparation	1	1	1
Chainsaw felling	2	3	2
Tree injection	4	4	4
Soil-active herbicide	3	2	3

[a] Timber and nontimber values are equally important.
[b] Timber value is more important than nontimber value.
[c] Nontimber value is more important than timber value.

When the ratios of the timber and nontimber values to the forest establishment costs are used as the parameters for ranking the site preparation methods, the most preferred method is no-site preparation for all of the three rotation lengths, regardless of the priority/preference over timber and nontimber values. This implies that the no-site-preparation method is the best alternative for groups with different or even conflicting preferences over timber and nontimber products. At the 70- and 100-year rotations, even the order of ranking of the four site preparation methods is the same across the three scenarios: (1) equal importance between timber and nontimber values, (2) more importance of timber value than nontimber value, and (3) less importance of timber value than nontimber value. In this case, the best alternative is no site preparation, followed by soil-active herbicide, chainsaw felling, and tree injection (table 4).

When the Net Present Value of timber production at a 4-percent real discount rate and the nontimber value are used for ranking, the best alternative is also the no-site-preparation method except the scenario in which timber value is more important than nontimber value at the 40-year rotation. In this scenario, the best site preparation method is soil-active herbicide, and no-site preparation is the second best alternative (table 4).

CONCLUSIONS AND DISCUSSION

The four site preparation methods affected the timber and nontimber values of the forest stands they generated differently. The soil-active herbicide method has the highest projected timber value at the 40-, 70-, and 100-year rotations, while the forest stand resulting from no-site preparation is most preferred by the respondents in terms of the nontimber benefits. This stand type is characterized as an uneven-aged mixed stand with mainly hardwoods. According to the Net Present Value (at a 4-percent real discount rate) of timber production only, the best site preparation alternative is the soil-active herbicide method at the 70- and 100-year rotations, and the no-site-preparation method at the 40-year rotation, respectively.

The respondents seemed to desire both timber and nontimber benefits from the Tuskegee National Forest. Sixty-two percent of the respondents felt that the national forest should be managed for both timber and nontimber products. When both timber and nontimber values are considered, the best site preparation method is no-site preparation except at the 40-year rotation, when all the establishment costs are borne by timber production and timber has higher priority than nontimber products. Therefore, in general, the no-site-preparation method is the alternative that can satisfy the goals of the groups with different preferences over timber and nontimber products.

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