Silvicultural Guidelines For Pinestraw Management In The Southeastern United States

by
Lawrence A. Morris
Eric J. Jokela
and
James B. O’Connor, Jr.
About The Authors

Lawrence A. Morris is an Associate Professor in the Warnell School of Forest Resources, University of Georgia, Athens. He received a B. S. in Forest Science from the University of Maine, an M. S. degree in Silviculture and Forest Influences from the State University of New York and a Ph. D. in Soil Science from the University of Florida. He is a specialist in forest soils and tree nutrition.

Eric J. Jokela is an Associate Professor of Silviculture in the School of Forest Resources and Conservation, University of Florida. He received his B. S. and M. S. in Forestry from the University of Minnesota and his Ph. D. in Silviculture and Forest Soils from the State University of New York, College of Environmental Science and Forestry. He is a specialist in tree nutrition and forest stand dynamics.

James B. O'Connor, Jr. was formerly a Graduate Research Assistant at the University of Georgia. He now works for Champion International Corporation in Newberry, S. C. He received his B. S. in Forest Resources and Master of Forest Resources (MFR) degree from the Warnell School of Forest Resources.
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Figure 1: Pinestraw is commercially baled using either a box-baler (left) or a modified hay baler (right). Note the stack of loose pinestraw ready for baling.

Background

The increasing popularity of natural landscaping in urban and suburban areas has resulted in the rapid development of a business centered on procurement and harvest of longleaf, slash and loblolly pinestraw. In North Carolina, where the industry has the longest history, pinestraw harvesting has been estimated to be a 50 million dollar per year industry (Anonymous 1987). Southwide, revenues from this industry may exceed 150 million dollars per annum. This industry can be expected to grow for two reasons. First, few materials can compete with pinestraw for landscaping uses. It is attractive, easy to work with and stays in place when used in slope positions. Second, use of pinestraw mulch in landscaping is expected to increase as water use restrictions are enacted by state and local governments, and water efficient landscaping (xeriscaping) is encouraged.

Pinestraw falls from southern pines at all times during the year and, therefore, pinestraw harvesting is a year-round business. Pinestraw producers fall into three categories, 1) those who rake, bale and sell directly to the retailer, 2) those who rake and bale for a wholesaler and 3) those who rake and sell straw on a retail level. Most pinestraw is processed by large producers in the first two categories, but some straw is raked and sold by small, independent operators. Methods of collection and baling pinestraw vary, ranging from completely mechanized collection and machine baling to hand-raking and box-baling (Fig. 1).

Pinestraw is purchased both on a price-per-bale and a lump sum price-per-acre basis; the method of purchase varies depending on location and individual contractors. There are advantages and disadvantages to each method. Purchase of pinestraw on a price-per-acre basis has the advantage of providing the landowner with exact a priori revenues to be expected from the harvesting operation. Sale by this method requires accurate assessment of potential yield in bales-per-acre from the area. Few landowners have such expertise and they must depend on estimates of yield supplied by the producer. In areas where estimates are available from a number of producers, fair value will be received for the pinestraw, and this method of sale is acceptable. Sale on a price-per-bale basis has the advantage of providing exact revenues for the pinestraw removed. Also, the landowner can develop a system to independently check bale removal to avoid theft. Major disadvantages to this method are that producers will be tempted to rake only the most accessible areas of a stand and they have less incentive to work with the landowner to improve stand conditions and pinestraw harvest. Ultimately, no method is necessarily better; both depend on working with reputable and experienced producers. Silvicultural operations are most easily evaluated in terms of additional bales produced and, for this reason, it may be preferable to sell pinestraw on a price-per-bale basis.

The retail value of baled pinestraw ranges from an average of $3.50 in Atlanta, GA to $5.00 in Jacksonville, FL.
with individual prices ranging from a low of $2.98 to a high of $7.99/bale. Harvesting and transportation costs are a major portion of these retail costs. Typically, a landowner receives from $0.40 to $1.00 per bale of straw, the harvesting contractor makes $0.75 to $1.00/bale profit and the retail outlet makes from $0.75 to $1.50 bale profit.

Pine straw harvesting represents an attractive income opportunity in pine stands prior to commercial harvest. Annual income from pine straw harvest shortens the period over which initial investments in regeneration must be held, and provides a source of income for intermediate silvicultural treatments such as thinning, competition control, and fertilization, which can increase the value of final timber harvests. In certain cases, pine straw may actually represent the primary product for which a stand is managed and wood is a secondary product.

Despite the potential benefits afforded by pine straw harvest, there is concern that it may have detrimental impacts on forest stand growth. Pine straw plays an important role in maintaining tree growth on relatively infertile soils that support southern pine forests. Each year a major portion of the nutrients absorbed by a stand of trees is returned to the soil in pine straw. As these pine needles decompose, the nutrients they contain become available for root uptake to support further growth (Switzer and Nelson 1972, Jorgensen and Wells 1986). Thus, nutrients are “reused” a number of times during the growth cycle of a forest stand. When pine straw is raked, this cycle is interrupted and tree growth can be reduced. Pine straw also has an important effect on soil moisture. Although pine straw may intercept some rainfall and keep it from entering the soil, it more often serves as a water conserving mulch. Its removal can increase tree water stress on dry sites (McLeod et al. 1979, Ginter et al. 1979).

An accurate assessment of financial and biological aspects of pine straw harvesting cannot be made without information on changes in stand growth associated with pine straw removal. Unfortunately, little information on growth responses to pine straw removal or to silvicultural treatments that may be utilized in a pine straw management program is available. We believe that, with suitable management, many sites can be managed for pine straw production while maintaining or improving stand growth. In this report, we present preliminary guidelines for pine straw management.

### Pine Straw Production and Nutrient Removal

Annual pine straw production within the southeastern United States depends upon many factors, among which stand age, species and site fertility are dominant. Previous research has demonstrated that, for unfertilized southern pine stands (lobolly, slash, longleaf), needlefall amounts increase with stand age until about age 15 years when needle biomass production approaches an annual maximum (Switzer and Nelson 1972; Wiegert and Monk 1972; Gresham 1982; Gholz et al. 1985). During that period, needles constitute approximately 75 to 90% of total litterfall mass because significant branch and bark shedding has not begun.

Expected pine straw production rates for young and semimature stands is closely correlated with stand basal area (Fig. 2). For young-fully stocked slash pine plantations, for every 18 ft²/ac of cumulative basal area, pine straw production increases by about 900 lbs/ac up to an annual maximum of about 4,500 lbs/ac. Similarly, with lobolly pine, pine straw production will reach some upper level (4,500-5,000 lbs/ac) when stand basal area approaches 100 to 110 ft²/ac. For less intensively managed mature plantations and mixed stands, rates are lower for a given basal area. Fig. 2 can be used by practitioners as a general guide for estimating needlefall in managed plantations and natural southern pine stands.

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1 Telephone survey conducted in mid-February 1991 of major home and garden centers in Atlanta, Birmingham, Charlotte, Jacksonville, New Orleans, and Raleigh.

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![Needlefall graph](image-url)

**Figure 2: Relationships between annual pine straw production (litterfall) and basal area in experimentally established slash and lobolly pine plantations and in mature stands of southern pine. Data plotted from Dalla-Tea and Jokela 1991 and Gresham 1982.**
The annual pine straw production values presented in Fig. 2 represent the upper biological limits for annual removal for these species. Pine straw removal during commercial harvests will be lower because not all of the surface area is actually raked due to the presence of understory plants, overstory hardwoods or debris. Results from a survey of pine straw removal during commercial pine straw harvesting operations in Georgia are presented in Table 1. On average, about 75% of the surface is raked during these operations, removing about 2500 lbs/acre (142 bales/acre) of pine straw. The relationship between actual pine straw removal and stand basal area is poor (Fig. 3). Differences in recovery and period of straw accumulation since the last disturbance contribute to this variability, as do differences in site quality, tree vigor, tree species and age.

Nutrient removals associated with pine straw harvesting vary from site to site, and are largely a function of the proportion of harvestable area, and site and stand conditions which affect pine straw production. Removals in any single harvest are not large, ranging from 5-60 lbs/acre for nitrogen, 0.5-5.0 lbs/acre for phosphorus, 0.5-29 lbs/acre for potassium, 3-21 lbs/acre for calcium and 0.75-5.0 lbs/acre for magnesium (Table 1). Low phosphorus and potassium removals are partially due to low concentrations resulting from leaching of these nutrients from the pine straw by rainfall prior to harvest (Duffey and Scheiber 1990). Potentially, removals of nutrients in loblolly pine straw are greater than removals in either slash or longleaf pine because of 1.) greater nutrient requirements and higher foliage nutrient concentrations (Polglase et al. 1992, 2.) greater needle production (see Fig. 2) and 3.) higher overall fertility of sites where loblolly pine commonly occurs.

Although nutrient removals in a single harvest are small, they become significant in stands repeatedly raked (Fig. 4). For instance, annual raking in a slash pine plantation beginning at age 10 years would remove about 225 lbs/acre of nitrogen, 16 lbs/acre of phosphorus, 13 lbs/acre of potassium, 104 lbs/acre of calcium and 25 lbs/acre of magnesium from an "average" stand prior to harvest at age 22. These removals exceed those calculated for complete above-ground harvest of all trees. For nitrogen, phosphorus and potassium, these removals are two- to four-fold greater than removals in harvest of merchantable portions of the stems (Neary et al. 1984). Removals of calcium and magnesium are about equal to removals in merchantable stem harvest.

### Selecting Sites for Pine Straw Production

#### Stand Conditions

At present, few differences exist in bale price at either the wholesale or retail level for pine straw from loblolly, slash or longleaf pine. As customer experience increases, and more suitable land become available for pine straw harvest, a differential is expected to develop. Straw from longleaf pine will likely command a higher price than slash or loblolly pine for landscaping purposes, as straw from this species is of greater length and retains its reddish-brown color longer than needles from slash or loblolly pine. Loblolly pine straw does provide a better mulch for use around vegetable crops and, in many areas, will remain equally as marketable.

To be marketable, pine straw must be free from hardwood leaves, understory vegetation, and large numbers of twigs and pine cones. Fully-stocked stands with a

![Lbs./acre/year](image)

*Figure 3: The relationship between pine straw removal in commercial harvesting operations and stand basal area. Line is for pine straw production for mature stands (data of Gresham 1982) from Fig. 2.*
closed crown and non-existent understory are ideal for pine straw harvesting. While it is possible to take pine straw in stands having an understory of grass (particularly wiregrass), it cannot be easily accomplished in areas containing litter from broad-leaved vegetation.

Forest stands in which pine straw is commercially harvested fall mainly into two categories: mature stands of naturally regenerated longleaf or mixed longleaf-slash pine and intensively managed slash and loblolly pine plantations. Most raking in natural stands is done by hand, avoiding areas with excessive understory vegetation. Pine straw is harvested in plantations both by hand and machine raking. Harvesting can begin as soon as the tree canopy closes and understory vegetation is eliminated. This can occur as early as age 8 and can continue until the first thinning or harvest.

Soil Factors

Three soil factors affect site suitability for pine straw harvesting: erosion potential, susceptibility to compaction, and reductions in fertility.

Erosion Potential. Removal of pine straw at 2 to 3 year intervals is unlikely to increase soil erosion because the layer of partially decomposed and fragmented needles remains largely intact. More frequent removal of fresh pine straw eliminates the source of material which maintains this soil cover and will result in exposure of mineral soil within a few years. Because of this, only sites with low erosion potential belong in intensive pine straw harvesting programs. Flatwoods sites with low relief (< 2% slope) and coarse-textured surface soils are ideal from this standpoint. Similarly, upland sites with sandy or sandy loam surface soils, and slopes that are less than 8%, would be characterized as having low erosion potential.

Compaction. Any forest management operation that subjects a site to machine traffic can cause soil compaction and reduce tree growth; however, the potential for significant compaction to occur as a consequence of pine straw harvest operations is low for several reasons. Only small, low ground pressure equipment is used and most sites where pine straw will be harvested have coarse-textured surfaces which are relatively resistant to compaction. In addition, pine straw is usually collected and baled only under dry conditions when soils are least susceptible to compaction. Although sites with fine-textured soils (sandy clay-loams to clay-loam) can be raked, some risk of soil damage is associated with repeated harvesting on these sites.

Soil Fertility. Few forested sites can be expected to support repeated removals of pine straw without fertilization. With fertilization, most sites can support higher pine straw harvests. Inherent fertility is greatest on old field sites (such as Conservation Reserve Program sites) in the Middle and Upper Coastal Plain and, from a nutritional standpoint, these sites are most suitable for pine straw production. Because of past agricultural fertilization, potassium, phosphorus and calcium storage is high. Nitrogen is the nutrient most likely to limit growth during the first five years of an annual pine straw production program. Cutover sites in the Middle and Upper Coastal Plain have a lower reserve from which to supply nitrogen, phosphorus, and potassium when contrasted with old-field sites in the same area, and will benefit from fertilization with these elements. Flatwoods sites are inherently less fertile than

<table>
<thead>
<tr>
<th>Stand Type</th>
<th>Stand Basal Area (basal ft²/acre)</th>
<th>Pine straw removed (ton/acre)</th>
<th>Dry weight (lb/ton)</th>
<th>Nutrients Removed</th>
<th>Mg</th>
<th>Ca</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural - Longleaf</td>
<td>66.4</td>
<td>0.2</td>
<td>87</td>
<td>37.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Natural - Longleaf</td>
<td>76.8</td>
<td>0.2</td>
<td>89</td>
<td>37.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Natural - Longleaf</td>
<td>87.2</td>
<td>0.3</td>
<td>91</td>
<td>37.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Natural - Longleaf</td>
<td>97.7</td>
<td>0.4</td>
<td>94</td>
<td>37.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Average</td>
<td>82.2</td>
<td>0.3</td>
<td>89</td>
<td>37.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 1. Pine straw and nutrient removal during commercial pine straw harvesting in Georgia. Mean and range indicated.
Figure 4: Nitrogen inputs and removals for a flatwoods slash pine stand from which pine straw is removed annually beginning at age 10. All values are in lbs./acre. (Source: Gholz et al. 1985, Morris and Pritchett 1982, and present study).

Figure 5: Effectiveness of various herbicide formulations (in lbs./acre a.i. or a.e.) for understory vegetation control in Coastal Plain slash pine. Control greater than 90% is considered adequate for pine straw production. (Redrawn from Rivers and Edwards 1990).
Middle and Upper Coastal Plain sites and will also require additions of nitrogen, phosphorus, and potassium as part of any regular pine straw harvesting program. Recent evidence further suggests that some flatwoods soils suffer from micronutrient deficiencies (Jokela et al. 1991b) and these will require corrective fertilization.

Those flatwoods sites characterized by soils underlain by a clay horizon (argillic) will have greater potential to retain added nutrients, and are more suitable for pine straw harvesting than sites without such a horizon. Sandy upland sites having low organic matter (e.g. sandhills) are the most nutritionally impoverished and, thus, are the least suitable to support nutrient removals from pine straw harvesting.

Silvicultural Options

Fertilization

Pine straw harvesting without fertilization is not recommended for two reasons. First, in most cases, fertilization can be expected to increase straw production and stem growth. Second, without fertilization, there is a strong probability that stand growth will decline. A fertilization program for pine straw production will closely resemble programs currently used in managing southern pine timberlands which include applications of various combinations of nitrogen, phosphorus and potassium. While nutritional limitations of other nutrients have been demonstrated, they are isolated and no general recommendation is appropriate.

Recommended rates and timing of fertilizer applications for pine straw harvesting are presented in Table 2. Two general regimes are identified. The first is suitable for pine plantations from which pine straw is annually harvested. Repeated fertilizer applications are recommended in these stands beginning at, or near, crown closure (age 8 years). Thereafter, fertilization will occur approximately every five years. The suggested application rates are based on nutrient removal estimates, inherent fertility regimes of site types within physiographic regions, and general nutrient use efficiencies of southern pines (which average about 50% of that applied). Site types associated with the second management regime, where litter raking represents a by-product of normal forest operations (i.e., raked 2-3 times only), will be fertilized once during mid-rotation. Typically, this occurs after crown closure when stands are between 8 and 12 years of age. Because tests indicate that numerous application methods (i.e., broadcast vs. banded; aerial vs. ground-based systems) are equally effective in producing growth response, factors such as equipment availability, terrain accessibility, cost, uniformity of spread, and timeliness of the operation should be considered when formulating a prescription (Jokela et al. 1991a).

Competition Control

Many stands not currently suited for pine straw management can be placed into production by reducing understory competition through herbicide application, or in some instances, mowing. To be effective in a pine straw harvesting operation, herbicide treatments should achieve 90% control of understory vegetation by October of the growing season prior to harvesting. It is not practical to expect such complete control in stands with a dense understory, and herbicide application is likely to be cost effective only in stands with low to moderate amounts of understory vegetation.

Available research on herbicide applications for pine straw production is limited. In a study of slash pine plantations in the Coastal Plain of Georgia (Fig. 5), spring applications of ARSENALI achieved control in the most cost-effective manner. In the summer, applications of ACCORDI resulted in the most effective control. Information on herbicide application rates and effectiveness are available from state forestry agencies and extension services. These sources should be contacted for information on available herbicides, application methods, rates, environmental considerations, and a list of recommended contractors.

Recovery of pine straw from old-field plantations, which contain only grass or small shrubs in the understory, can be increased by mowing. Mowing should be completed after the spring growth period but well in advance of pine straw harvesting. For example, mowing should be completed in late spring prior to fall or winter harvest.

Stand Monitoring

Little, if any, long-term data are available to predict the outcome of repeated pine straw harvests on future site productivity. Consequently, monitoring the effects of pine straw removal on site nutrient status and stand growth should be an integral component of a management program. The intensity of the recommended monitoring program depends on the intensity of the harvesting program. For plantations in which pine straw is removed annually beginning at a young age, foliar analyses should be made periodically during the tree rotation in the winter prior to fertilization to assess the effects of pine straw removal on pine nutrient status and to aid in prescribing fertilizer additions. In established stands from which pine straw is removed only 1-3 times before tree harvest, baseline foliar analyses prior to mid-rotation fertilization should be sufficient.

Current-year pine foliar samples should be collected in January from the first growth flush of the second whorl from the apex of the crown from 10 to 15 dominant/codominant trees across the area. Needles should be removed from the branch, composted, and dried in a forced-draft oven at 70°C. Tissue samples should be analyzed for N, P, K, Ca, and Mg using a laboratory with approved methodologies. Many state laboratories provide analytical services that include an evaluation of nutritional status. Guidelines for interpreting foliage analyses are available for both slash and loblolly pine (Pritchett and Comerford 1983, Comerford and Fisher 1984, Wells and Allen, 1985).

Calculating the Returns from Silvicultural Investments

The relatively high value of pine straw makes investment in silvicultural operations that increase straw production, or harvesting recovery and efficiency, attractive. To evaluate the value of these investments, it is important to consider:

"Does not constitute an endorsement of commercial products nor does it exempt the user from any legal obligation under federal, state or local statutes."
1. the initial cost of the investment;
2. opportunity costs associated with investing in silvicultural treatments (these costs are usually determined by selecting a real (non-inflated) rate of return for an alternative investment such as in money market funds);
3. returns on the investment from:
   a. increased/decreased pine straw production
   b. increased/decreased wood production and value
   c. increased/decreased costs of other forest management activities (e.g. harvesting, regeneration)

As an example, consider the return on an investment in nitrogen plus phosphorus fertilization in a 17-year-old slash pine plantation on a flatwoods site (Table 3). At current prices of $175/ton for diammonium-phosphate, $180/ton for urea and ground application costs of $12.50/acre, fertilization with 150 lbs/acre N and 25 lbs/acre phosphorus will require a $54/acre investment. A second cost of $2/acre is associated with foliage sampling and analyses which we recommend as part of any pine straw management program. Both increased pine straw production and increased wood volume growth will generate a return from this investment. Research on fertilization response in slash pine stands indicates a median increase in straw production of about 1050 lbs./acre/year for the first 3 years following mid-rotation fertilization (N.C. State Forest Tree Nutrition Cooperative and Cooperative Research in Forest Fertilization (CRIFF) unpublished data). Assuming 75% recovery (see Table 1), this corresponds to 175 bales/acre of additional pine straw production over the three year period. Stem volume growth can also be expected to increase. On the basis of mid-rotation fertilization trials conducted in slash pine plantations, an average increase of 2.5 cords/acre of additional volume growth can be expected by the end of the rotation for fertilized trees when compared to growth for a non-fertilized stand (Fisher and Garbett 1980, Stearns-Smith et al. 1989). The net present value of the additional income generated by the fertilization is $72 when associated costs of fertilization and nutrient monitoring are amortized at an inflation-free rate of 4%. The sensitivity of the analysis to changes in the value of additional pine straw and/or timber produced is illustrated in Fig. 6. Although fertilization is not an economically attractive investment when the net present value of additional revenue falls below fertilization costs, it may still be worthwhile hedge against possible productivity loss.

A second example could be applied to herbicide treatments which increase harvestable area of a 14-year-old plantation from 60% to 90% and increase pine straw recovery from 115 bales per acre to 170 bales per acre for each annual raking prior to harvest at age 22 (Table 4). An investment in herbicide application of $50/acre/treatment has a present value of $113 and generates $56 in additional income. The sensitivity of this analysis to changes in the cost of herbicide application and the value of additional straw produced is illustrated in Fig. 7.
<table>
<thead>
<tr>
<th>Site Type</th>
<th>Stand Condition</th>
<th>Raking Frequency</th>
<th>Recommended Fertilization Regime</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatwoods with fine-textured subsoils</td>
<td><strong>Young Plantations</strong>&lt;br&gt; Suitable on sites with &lt; 20% palmetto-brush ground cover</td>
<td>Annual beginning @ age 8</td>
<td>200N, 50P, 80K, @ age 6; 200N, @ ages 11, 16</td>
<td>Fokar macro &amp; micro-nutrients @ ages 11 and 16;</td>
</tr>
<tr>
<td></td>
<td><strong>Established Stands</strong>&lt;br&gt; Suitable on sites with &lt; 50% palmetto-broad leaved ground cover</td>
<td>Twice during rotation following mid-rotation fertilization</td>
<td>150-200N, 50P @ ages 8-12</td>
<td>Macro &amp; micro-nutrients prior to mid-rotation fertilization</td>
</tr>
<tr>
<td>Flatwoods without fine-textured horizons</td>
<td><strong>Young Plantations</strong>&lt;br&gt; Suitable on sites with &lt; 20% palmetto - broad leaved cover</td>
<td>Annual beginning @ age 8</td>
<td>200N, 50P, 80K @ age 6; 200N, @ ages 11, 16</td>
<td>Macro &amp; micro-nutrients sample @ ages 11 and 16;</td>
</tr>
<tr>
<td></td>
<td><strong>Established Stands</strong>&lt;br&gt; Suitable on sites with &lt; 50% palmetto-broad leaved ground cover</td>
<td>Twice during rotation following mid-rotation fertilization</td>
<td>150-200N, 50P @ ages 8-12</td>
<td>Macro &amp; micro-nutrients prior to mid-rotation fertilization</td>
</tr>
<tr>
<td>Upper and Middle Coastal Plain Uplands with loamy to sandy surfaces 20-40” deep</td>
<td><strong>Young Plantations</strong>&lt;br&gt; Suitable on sites with slopes &lt; 8%; moderately and well-drained</td>
<td>Annual beginning @ age 8</td>
<td>Old fields: 200N, 50P, @ age 6 200N @ ages 11,16</td>
<td>Macronutrients only - sample at ages 11 and 16;</td>
</tr>
<tr>
<td></td>
<td><strong>Established Stands</strong>&lt;br&gt; Suitable with slopes &lt; 12%; moderately well and well-drained</td>
<td>2-3 times during rotation following mid-rotation fertilization</td>
<td>Cutover: 200N, 50P, 50K @ age 6 200N, @ ages 11, 16</td>
<td>Macronutrients only - sample @ ages 11 and 16</td>
</tr>
<tr>
<td>Middle &amp; Upper Coastal Uplands with fine loamy to clay-textured horizons &lt; 20” from the surface</td>
<td><strong>Young Plantations</strong>&lt;br&gt; Suitable on slope &lt; 5% in erosion class 1 (uneroded)</td>
<td>Annual beginning @ age 8</td>
<td>200N, 50P, @ age 6 200N, @ ages 11, 16</td>
<td>Macronutrients only - sample prior to mid-rotation fertilization</td>
</tr>
<tr>
<td></td>
<td><strong>Established Stands</strong>&lt;br&gt; Suitable on slopes &lt; 8% in erosion classes 1 and 2</td>
<td>2-3 times during rotation following mid-rotation fertilization</td>
<td>200N, 50P, 50K @ ages 8-12</td>
<td>Macronutrients only - sample prior to mid-rotation fertilization</td>
</tr>
<tr>
<td>Sandhill sites characterized by soils with sandy surfaces &gt; 40” deep or without fine-textured subsoil</td>
<td><strong>Young Plantations</strong>&lt;br&gt; Not Recommended</td>
<td>None recommended</td>
<td>Growth plots</td>
<td></td>
</tr>
</tbody>
</table>

//Decreased productive potential is possible for even a single raking on these sites. Such a decrease in tree growth must be balanced against income from straw production.
Table 3. Cash flows for a hypothetical acre in a slash pine plantation fertilized for pinestraw production at age 17. Benefits are for incremental gains associated with the treatment.

<table>
<thead>
<tr>
<th>Plantation Age</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
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<tbody>
<tr>
<td><strong>COSTS:</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fertilizer Application</td>
<td>(54.00)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Foliage collection &amp; Analysis</td>
<td>(2.00)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>BENEFITS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Pinestraw Production (^1)</td>
<td>0</td>
<td>17.50</td>
<td>23.33</td>
<td>20.42</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased Pulpwood Yield (^2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.50</td>
<td></td>
</tr>
<tr>
<td><strong>NET RETURNS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discounted @ 4%</td>
<td>(56.00)</td>
<td>16.92</td>
<td>21.57</td>
<td>18.15</td>
<td>0</td>
<td>71.95</td>
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<tr>
<td>Present Value</td>
<td>128.49 • 56.00 = 72.49</td>
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</tbody>
</table>

\(^1\) Calculated assuming an increase of 900,1200 and 1050 lbs/acre litterfall during the first 3 years following fertilization; 75% recovery; mean bale weight of 18 lbs and a price-per-bale of $0.35.

\(^2\) Assumes 5-year volume response to fertilization of 2.5 cords/acre at $35/cord.

Table 4. Cash flows for a hypothetical acre in a slash pine plantation following herbicide application at ages 12 and 18. Benefits are for incremental gains associated with the treatment.

<table>
<thead>
<tr>
<th>Plantation Age</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COSTS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Herbicide Application</td>
<td>(50.00)</td>
<td>0</td>
<td>0</td>
<td>(50.00)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>BENEFITS:</strong></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>NET RETURN:</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discounted @ 4%</td>
<td>(30.75)</td>
<td>18.51</td>
<td>17.79</td>
<td>17.11</td>
<td>(26.28)</td>
<td>15.82</td>
<td>15.21</td>
<td>14.63</td>
<td>14.07</td>
</tr>
<tr>
<td>Present Value</td>
<td>$113.14 • 57.03 = $56.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

\(^1\) Assumes 55 bale/acre/year increase in straw recovery and market value of $0.35/bale.
Additional Considerations

As already discussed, not all sites are suited for pine straw management programs. Pine straw should not be harvested from sites with above average erosion potential, or which are susceptible to surface soil compaction. Sites characterized by deep sandy soils are sensitive to organic matter removal and productivity of these soils may be damaged by pine straw harvesting. On such sites, fertilization with inorganic nutrients is unlikely to compensate for nutrient and organic matter removal in pine straw harvests. Fertilization can also stimulate growth of undesirable understory plants, particularly raspberry and honeysuckle vines. Since widespread occurrence of these vines can affect the suitability of a site for raking, intensive pine straw management should not include sites with vines established in the understory.

The effective use of fertilizer requires that practitioners appreciate the many effects that nutrient additions can have on a forest ecosystem. For example, many reports have shown that the incidence and severity of certain tree diseases such as fusiform rust and pitch canker increase with increasing fertility and more intensive forest management (Dins in and Schmidtling 1971, Hollis et al. 1975). Although the causal mechanisms are not fully understood, managers are encouraged to monitor health in stands that receive repeated applications of fertilizer as part of a pine straw management program.

Finally, the grass-free and shrub-free understory conditions that are ideal for pine straw harvesting operations provide little understory vegetation diversity and few wildlife benefits. The costs associated with this more limited habitat are not considered in the example financial analyses provided in tables 3 and 4. Benefits associated with reduced pine stand regeneration costs resulting from understory reduction are also excluded from the analyses in these tables. Thus, these analyses must be considered preliminary. Additional evaluation will be required as information from recently installed studies of pine straw management becomes available.

Summary

1. Pine straw can be commercially harvested from longleaf, slash and loblolly pine beginning at age 8. Straw is most easily harvested from stands free from understory competition but can be raked from stands containing a grass understory.

2. Site suitability for pine straw production is influenced by erosion potential, water and nutrient supply characteristics of the site. Old-field sites with low slope in the middle and upper Coastal Plain are most suitable for pine straw production. Flatwoods sites are intermediate in suitability and sandy upland sites are least suitable for pine straw management programs.

3. Supplemental fertilization will be required for sites from which pine straw is harvested.

4. Financial analyses of pine straw management programs require reliable information on straw production and forest growth; the costs of silvicultural operations, and the value of products produced. Initial analyses indicate that investment in pine straw production can be profitable.

5. Monitoring of the effects of pine straw management on site and stand conditions is recommended as an integral component of a pine straw management program. The flexibility to adjust to changing stand conditions should be maintained.

Research on pine straw management is currently underway in Georgia, Alabama, Florida and North Carolina.
REFERENCES


