Straw Raking in Southern Pine Stands and Fertilization Recommendations

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Introduction

Pine straw, the uppermost forest floor layer of undecayed needles, is raked, baled, and sold as landscaping mulch in the southeastern U.S. The value of pine straw as a forest product is increasing in Georgia. Forest landowners in Georgia received $15.5, $17.5, and $22.4 million revenues from pine straw in 2000, 2001, and 2002, respectively (Boatright and McKissick 2003). Conversely, annual timber revenues in Georgia have declined by over 18% during this same period (Boatright and McKissick 2003). Pine straw revenues have helped many landowners maintain reasonable cash flows to achieve attractive rates of return (Dickens et al. 2001) on their forestland. Internal rates of return can be increased from 8 to 11 % without pine straw production to 13 to 20 % with annual pine straw income in loblolly and slash pine stands (Dickens et al. 2001).

How Pine Straw is Commonly Sold

Pine straw can be sold by the bale or by the acre. Current per acre reported prices in Georgia range from $35 to $90/ ac for each raking (Doherty et. al. 2001). Revenues as high as $290/ac have been reported for high quality longleaf pine stands (Haywood et al. 1998). Pine straw can also be sold by the bale. Per bale prices range from $0.25 to $0.30/bale for loblolly, from $0.25 to $0.60/bale for slash, and from $0.40 to $1.00/bale for longleaf paid to the forest landowner.

Pine Straw Production Factors and Rates

A number of factors affect pine straw production rates. They are:

- ♦species,
- ♦site productivity,
- ♦stand density (basal area) and age ,
- ♦ hand versus mechanical baling (packing density),
- ♦percent rakable stand, and
- ♦raking intensity (semi-annual, annual, or periodic).

All the above factors affect pine straw production rates with the most intensively managed stands and best sites producing the most straw and the poor sites (deep sands of the Sand Hills or shallow soils of the Piedmont) and low or no inputs producing the least straw. Table 1 lists pine straw bale/acre production rates by species.

Table 1. Common annual pine straw production rates based on nine studies in the southeastern U.S.

Species	Low bales/acre	High bales/acre	Common range
Loblolly	80 to 100	200 to 400	150 to 275
Longleaf	60 to 80	150 to 250	80 to 200
Slash	80 to 100	200 to 400	125 to 250

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Species Preference, Raking Period(s), and Stand Conditions in Southern Pine Stands

In the southeastern U.S. loblolly, longleaf, and slash pine stands are commonly raked. The order of preference is longleaf, slash, and then loblolly straw. Longer needle length, better color retention, and slower rate of deterioration are factors for this order of reference. Southern pine stands that are clean of understory vegetation and debris (dead stems, branches, and cones), good road access (all weather roads, graveled roads, wide roads, good turn-around areas), and proximity to local markets are important factors in making pine straw harvesting attractive to pine straw buyers or contractors. In Georgia, longleaf, slash and loblolly pine stands (that are suitable to rake) are commonly raked starting at canopy closure (age 6 to 10-years-old depending on stocking, species, and growth rate) until the first thinning. If the stand is attractive to a contractor, the contractor may negotiate a 4 to 7 year (5-years is common) written agreement with the landowner to rake the stand. Thinned stands are less attractive due to new understory growth and reduced needle production. Thinned stands are often raked in S.C. and N.C. once crowns rebuild and understory vegetation is controlled.

Where Fertilization has Increased Pine Straw Production

Generally fertilization using nitrogen (N), phosphorus (P), and potassium (K) and to a lesser extent magnesium (Mg), calcium (Ca), manganese (Mn), boron (B), or copper (Cu) has been proven to increase pine straw and wood yields **on low fertility sites, cut-over, and/or low water holding capacity sites:**

1. Pine straw yields from annual raking regimes without fertilization were reduced compared to pine straw yields from no raking sites (McLeod et al.1979, Ross et al. 1995, Lopez-Zamora et al. 2001)
2. Fertilization (NP or NPK) in annually raked stands maintained (Haywood et al. 1998, Ogden and Morris in press) or increased pine straw production (Ross et al. 1995, Dickens 1999, Ogden and Morris in press) over raked, unfertilized stands.
3. Annual raking without fertilization reduced diameter growth increment significantly one (McLeod et al. 1979, Troup soil), two (McLeod et al. 1979, Fuquay soil), or three years (Haywood et al. 1998) after raking commenced.

Where Fertilization has not Significantly Increased Pine Straw Production

Generally fertilization using nitrogen (N), phosphorus (P), and potassium (K) has not been proven to increase pine straw beyond one year **on highly fertile sites, most old-fields with good water and nutrient holding capacities:**

1. Young pine stands planted on old-field sites with high residual fertility (take foliage samples to determine nutrient sufficiency/deficiency) appear to have a one year benefit (Dickens et al. 2004) or no significant fertilization benefit to increasing pine straw production (Lopez-Zamora et al. 2001, Ogden and Morris in press).
2. Tree mortality and disease incidence can significantly increase with fertilization and annual intensive pine straw raking (Lopez-Zamora et al. 2001, Ogden and Morris in press) in unthinned stands with a high basal area, especially in slash pine stands.
3. **Note:** In all but one study site fertilization occurred prior to the first pine straw raking on these old-field fertile sites. Therefore nutrient removal via pine straw raking had not yet occurred. Fertilization with NP or NPK may maintain or enhance pine straw production and tree growth after stands have been raked intensively for 3 to 5 years or more.

Using diagnostic tools to determine fertilizer needs

The use of the following diagnostic tools, **collectively,** can greatly improve the benefit to fertilization in longleaf, slash, and loblolly pine stands. When many stands are considered for fertilization to maintain or enhance pine straw production, they should be ranked in order of probability of response to fertilization to gain a good return on one's investment.

1. Leaf area index (LAI) taken at peak leaf area (commonly in July and August) is the best indicator of stand N needs. Take LAI estimates from at least 10 sample points in a stand (from under individual trees if BA/ac < 80 ft2, or between rows if BA/ac > 80 ft2). If LAI mean of sample points < 2.25 to 2.5 for loblolly, <2.0 for slash, or < 1.5 for longleaf then there is a good probability that the stand will be response to an N addition (N helps with crown building).
2. Take needle samples during the dormant season (in South Georgia from 15 December to 10 February, in north Georgia from 1 December to 28 February) from 10 dominant trees per stand (refer to www.bugwood.org/fertilization/foliage.html for complete directions). The needle analysis will give an indication of fertilizer need for P and K and less commonly Mg, Ca, S, Mn, B, and Cu.
3. Soil sampling any time of year from 20 points within a stand to a depth of 6 to 8 inches (refer to www.bugwood.org/fertilization/csoillab.html) will further indicate stand P needs.

Fertilization and Stand Conditions

1. Fertilize when bale/acre production starts to decline and/or when
2. Ocular estimates of leaf area in the majority of the stand decline.
3. Fertilize before basal area gets too high (<100 ft2/ac) to optimize both pine straw and wood volume gains and reduce stand mortality.
4. Try to time fertilization at least 3 to 4-years before a thinning or final cut to realize the most benefit to enhancing pine straw production and wood volume.

Fertilization Rates, Splitting doses, and Precautions

Fertilization rates are listed in Tables 2 and 3. Loblolly is the most nutrient demanding of the three southern pine species raked for straw and therefore N recommendation is the highest. Slash pine is intermediate in nutrient demand and response to fertilization. Longleaf pine is the least nutrient demanding and N application levels are much lower than for loblolly or slash pine (Table 2). Overloading younger longleaf stands (mean dbh <6 inches) with too much N in a single dose (>100 lbs N/ac) can cause unacceptable mortality.

Split application of N, NP, or NPK fertilizer materials may be attractive to some landowners in some cases. Where stem fusiform rust cankers are greater than 25% for slash pine or 30% for loblolly pine N application should be split over a two to three year period to minimize stem breakage.

Fertilizers should not be applied to stands when (1) the risk of annosus root rot incidence is moderate to high or (2) where pitch canker is currently in the stand. Fertilization can increase (1) mortality by accelerating stand development (Dickens et al. 2004, Ogden and Morris in press), disease incidence (pitch canker or fusiform rust, Lopez-Zamora et al. 2001), and understory competition (increasing the need for herbicide use).

Competition Control

Good competition control is essential to keep raked stands clean, particularly after fertilization. Good competition control can also have stand growth benefits. Fortson et al. (1996) and Oppenheimer et al. (1989) noted that complete weed control in age 9- to 15-year-old slash and loblolly pine stands increased wood volume production by 1/3 and 1/2 cord/ac /yr for 8 to 14

years in unraked stands, respectively. Hardwoods should be controlled when the hardwood basal area is greater than 10 percent of stand basal area if maximizing pine growth is a priority.

Table 2. Recommended fertilizer rates for a five year application regime

Species	**age(yrs)/ size (dbh)**	**N (lbs/ac)**	**Elemental-P (lbs/ac)**	**Elemental -K[3] (lbs/ac)**	**other nutrients[4] (lbs/ac)**
Loblolly[1] and Slash[2]	Canopy closure to mid-teens	125 (slash) to 150 (loblolly)	25 (Piedmont) 40-50 (Coastal Plain)	50-80	as needed based on foliar analysis
Longleaf	<6" dbh	75	25 (Piedmont) 40-50 (Coastal Plain)	50-80	as needed based on foliar analysis
Longleaf	=>6" dbh	75 - 150	as above	50-80	as above
Loblolly and Slash[2]	After mid-teens	150 (slash) to 200 (loblolly)	25 (Piedmont) 40-50 (Coastal Plain)	50-80	as above

[1,2] When in an unthinned stand N should be split applied over 2 to 3 years where fusiform canker incidence is greater than >30% in loblolly pine stands and > 25% in slash pine stands.

[3] As needed based on foliar analysis. If < 0.35% for loblolly, <0.30% for longleaf, and < 0.25 to 0.30% for slash then K is recommended (100 lbs 0-0-60/ac=50 lbs elemental-K/ac and 160 lbs 0-0-60/ac=80 lbs K/ac)

[4] As needed based on foliar analysis. If Ca is <0.12% for loblolly, <0.10% for longleaf and <0.08 to 0.12% for slash then 20-25 lbs Ca/ac is recommended. If Mg is < 0.07% for loblolly, <0.06% for longleaf, and <0.04 to 0.06% for slash then add 25 lbs Mg/ac as K-mag or some other Mg form. If S is <0.12% for loblolly pine and < 0.10% for longleaf and slash then add 20-30 lbs S/ac. If foliar B is < 4-8 ppm then add 1 lb B/ac and if Cu is < 2-4 ppm then add @ 3 lbs/ac.

Table 3. Fertilizer application rates for loblolly, longleaf and slash pine at or after canopy closure using common fertilizer forms based on Table 2 N and P recommendations.

Species	**Rate (lbs ac^{-1}) of N + elemental-P**	**N as urea + P as DAP (lbs ac^{-1})**	**N as NH_4NO_3 (AN) + P as DAP (lbs ac^{-1})**
Loblolly[1] and Slash[2]	125 N + 25 P	223 urea + 125 DAP	308 AN+ 125 DAP
Slash	150 N + 50 P	228 urea + 250 DAP	315 AN + 250 DAP
	200 N + 25 P	386 urea + 125 DAP	533 AN + 125 DAP
	200 N + 50 P	337 urea + 250 DAP	465 AN + 250 DAP
Longleaf mean dbh<6"	75 N + 25 P 75 N + 50 P	114 urea + 125 DAP 65 urea + 250 DAP	158 AN + 125 DAP 90 AN + 250 DAP
Longleaf mean dbh=>6"	125 N + 25 P 125 N + 50 P	223 urea + 125 DAP 174 urea + 250 DAP	308 AN + 125 DAP 240 AN + 250 DAP

[1,2] When in an unthinned stand N should be split applied over 2 to 3 years where fusiform canker incidence is greater than >30% in loblolly pine stands and > 25% in slash pine stands. Hardwood BA/ac should be <10% of stand BA/ac for all three species when pine straw and pine wood volume gains are high priority.

Cited and Related Literature

Blevins, D., H.L. Allen, S. Colbert, and W. Gardner. 1996. Woodland owner notes: nutrition management for longleaf pinestraw. NCSU Coop. Ext. Service WON-30. Raleigh, NC. 8 p.

Boatright, S.R. and J.C. McKissick. 2003. Two-thousand and two farmgate value report. UGA CAES Center for Agribusiness and Econ. Development, AR-03-01. Athens, GA 180 p.

Dickens, E.D. 1999. Effect of inorganic and organic fertilization on longleaf pine tree growth and pine straw production. In: Proceedings of the 10th Biennial So. Silvi. Res. Conf., Shreveport, LA. Feb. 16-18, 1999. pp. 464-468.

Dickens, E.D., C.W. Dangerfield, Jr., and D. J. Moorhead. 2001. Short rotation management options for slash and loblolly pine in Southeast Georgia. In: Proceedings of the 31st Annual Southern Forest Economics Workshop. March 27-28, 2001. Atlanta, GA. pp. 61-66.

Dickens, E.D. 2001. Fertilization options for longleaf pine stands on marginal soils with economic implications. In: Proceedings of the 31st Annual Southern Forest Economics Workshop. March 27-28, 2001. Atlanta, GA. pp. 67-72.

Dickens, E.D., D.J. Moorhead, and B.C. McElvany. 2004. PPI-FAR 2003 GA-21F summary report. www.ppi-far.org 7 p.

Doherty, B.A., R.J. Teasley, J.C. McKissick, and B. Givan. 2000. Nineteen ninety-nine farmgate value report. UGA CAES Center for Agribusiness and Econ. Development, Center Staff Report No. 6. Athens, GA 160 p.

Fortson, J.C., B.D. Shiver, and L. Shackleford. 1996. Removal of competing vegetation from established loblolly pine plantations increases growth on Piedmont and Upper Coastal Plain sites. SJAF 20:188-192.

Ginter, D.L., K.W. McLeod, and C. Sherrod, Jr. 1979. Water stress in longleaf pine induced by litter removal. For. Ecol. Manage. 2: 13-20.

Gholz, H.L., C.S. Perry, W.P. Cropper, and L.C. Hendry. 1985. Litterfall decomposition and nitrogen and phosphorus dynamics in a chronosequence of slash pine (*Pinus elliottii*) plantations. For. Sci. 31:463-478.

Gresham, C.A. 1982. Litterfall patterns in mature loblolly and longleaf pine stands in coastal South Carolina. For. Sci. 28:223-231.

Haywood, J.D., A.E. Tiarks, M.L. Elliott-Smith, and H.R. Pearson. 1995. Management of longleaf stands for pine straw harvesting and the subsequent influence on forest productivity. In: Proceedings of the 8th Biennial So. Silvi. Res. Conf., Auburn, AL, Nov. 1-3, 1994.

Haywood, J.D., A.E. Tiarks, M.L. Elliott-Smith, and H.R. Pearson. 1998. Response of direct seeded *Pinus palustris* and herbaceous vegetation to fertilization, burning, and pine straw harvesting. Forest Ecology and Mgmt. 14(2): 157-167.

Hennessey, T.C., P.M. Doughtery, P.M. Cregg, and B.M. Wittwer. 1992. Annual variation in needle fall of a loblolly pine stand in relation to climate and stand density. Forest Ecology and Mgmt. 51: 329-338.

Jokela, E.J., W.W. McFee, and E.L. Stone. 1991. Micronutrient deficiency in slash pine: response and persistence to added manganese. Soil Sci. Soc. Am. J. 55:492-496.

Jokela, E.J. and S.C. Stearns-Smith. 1993. Fertilization of established southern pine stands: effects of single and split nitrogen applications. South. J. Appl. For. 17(3):135-138.

Jorgensen, J.R. and C.G. Wells. 1985. Forester's primer on nutrient cycling - a loblolly pine management guide. USDA Forest Service GTR SE-37. Asheville, NC. 42 p.

Lopez-Zamora, I., M.L. Duryea, C. McCormack-Wild, N.B. Comerford, and D.G. Neary. 2001. Effect of pine needle removal and fertilization on tree growth and soil P availability in a *Pinus elliottii* Engelm. var. *elliottii* stand. Forest Ecology and Mgmt. 148: 125-134.

Morris, L.A., E.J. Jokela, and J.B. O'Conner, Jr. 1992. Silvicultural guidelines for pinestraw management in the SE US. GA Forest Research Paper No. 88. Atlanta, GA: GFC. 11 p.

McLeod, K.W., C. Sherrod, Jr., and T.E. Porch. 1979. Response of longleaf pine plantations to litter removal. Forest Ecology and Mgmt. 2:1-12.

North Carolina State University Forest Nutrition Coop. 1998. Twenty-eighth annual report. NCSU, Raleigh, NC. 28 p.

Ogden, E.A. and L.A. Morris.in press. Effects of annual pine straw removal and mid-rotation fertilization on pine growth in unthinned plantations in Georgia . In: The Slash Pine Symposium GTR, USDA Forest Service. 15 p.(in press)

Oppenheimer, M.J., B.D. Shiver, and J.W. Rheney. 1989. Ten-year response of mid-rotation slash pine plantations to control of competing vegetation. Can. Journal of Forest Res. 19: 329-334.

Pritchett, W.L. and R.F. Fisher. 1987. Properties and Management of Soils. 2nd Edition. John Wiley and Sons. NY,NY. 494 p.

Roise, J.P., J. Chung, and R. Lancia. 1991. Red-cockaded woodpecker habitat management and longleaf pine straw production: an economic analysis. South. J. Appl. For. 15(2):88-92.

Ross, S.M., W.H. McKee, Jr., and M. Mims. 1995. Loblolly and longleaf pine responses to litter raking, prescribe burning, and nitrogen fertilization. In: Proceedings of the 8th Biennial So. Silvi. Res. Conf., Auburn, AL, Nov. 1-3, 1994. pp. 220-224.

Shan, J., L.A. Morris, and R.L. Hendrick. 2001. The effects of management on soil and plant carbon sequestration in slash pine plantations. Journal of Applied Ecology 38:932-941.

Shoulders, E. and A.E. Tiarks. 1987. Slash pine shows mixed response to potassium fertilization. In: Proceedings of the 4th Biennial So. Silvi. Res. Conf. Atlanta, GA. USDA-FS GTR-SE-42. pp. 425-428.

Stearns-Smith, S.C., E.J. Jokela, and N.B. Comerford. 1989. Research report-B300 experiments: Fertilization rate-response relationships in semi-mature southern pine stands of the lower Coastal Plain. Coop. Res. In For. Fert., Dept Forestry, Univ. of Florida, Gainesville. 98 p.