Fertilizing Southern Pine Plantations to Improve Growth and Financial Performance

LSU AgCenter
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Forest owners who wish to increase the profitability of growing sawtimber with loblolly or slash pine plantations should consider including fertilization in their management plans. Fertilization increases the growth rates of loblolly and slash pine by 20 to 40 percent, which shortens the length of time it takes for trees to reach a merchantable size. Simply put, fertilizing pine plantations helps produce *more timber, more quickly.*

Increasing yields and shortening rotation lengths improves financial performance of managing loblolly and slash pine plantations. *Table 1* provides predictions of yields, harvest age and returns on investment for loblolly pine plantations on sites of lower-than-average quality (as indicated by a site index of 55 feet on a 25-year basis), average quality (indicated by a site index of 75) and higher-than-average quality (indicated by a site index of 95). All site types responded positively to fertilization because the same volumes of forest products could be grown in 2 to 4 fewer years. These earlier harvests improved the land expectation value (LEV) of all site types, which indicates that fertilization improved the value of the land for producing timber. The level of improvement in LEV increased as site quality decreased, with LEV increasing 23, 30 and 72 percent for the high-, average- and low-quality sites, respectively. This trend shows that landowners with sites of lower-than-average site quality (site indices ~55%) have the most to gain by using fertilizer to "upgrade" their soil fertility. Fertilization can also be an economically viable part of plantation management on a variety of site types.

As with any investment, there are risks associated with fertilization to consider.

The potential returns on fertilizer investments can be negatively affected by increases in fertilizer costs and market shifts that lead to reductions in sawtimber value. Declines in sawtimber value reduce potential returns on fertilizer investments much more dramatically than increases in fertilizer price (*Table 2*). Other factors that can reduce the potential returns on fertilizer investments include: (1) insect, disease and storm damages; (2) drought in the year of fertilization; and (3) incorrect diagnosis of nutrient deficiencies.

Several factors should be considered before fertilizing. First and foremost is the management objective, which should be defined in a forest management plan. If the primary management goal is to produce sawtimber, fertilization can be an important management tool. Important steps in the process of fertilization are provided below. A university extension agent, forestry consultant or government forester can be helpful in providing guidance through this process.

I. Evaluate stand conditions.

It is important to take into account the acreage you wish to fertilize. Generally, small

Table 1. Predicted final harvest age, yields of forest products throughout the rotation and land expectation value (LEV) in response to fertilization of loblolly pine plantations on low-, average- and high-quality sites (as indicated by site indices of 55, 75 and 95 on a 25-year basis, respectively).

Site index	Fertilization	Harvest age	Pulpwood	Chip-and-saw	Sawtimber	Total products	LEV
(ft)		(yr)	(tons)				($/acre)
55	No	32	25	41	67	133	24
55	Yes	27	25	59	62	146	85
75	No	24	24	63	61	148	296
75	Yes	22	24	62	62	148	420
95	No	23	35	86	88	509	597
95	Yes	20	35	89	78	202	776

Note: Yield estimates were developed using the FASTLOB growth and yield program based on fertilizer research trials done throughout the southeastern U.S. All management scenarios included two partial harvests (thinnings). Fertilizer scenarios consisted of nitrogen- and phosphorus-containing fertilizer applied one time in the year after a second thinning. Prices of preplant herbicide, seedling planting, and fertilizer used in LEV determination were average prices in the southeastern U.S. in 2006. A minimum acceptable rate of return on investment of 10% was a component of LEV calculation as well.

Table 2. Effects of sawtimber and fertilizer application costs on the internal rate of return (%) associated with fertilization of loblolly pine forests in the southeastern U.S.

	Sawtimber price ($/ton)				
	$5	$20	$30	$40	$50
Fertilizer cost ($/acre)	Internal rate of return (%)				
No fertilizer	3.04	11.15	19.27	27.35	35.45
50	3.37	12.26	21.11	29.97	38.82
100	3.30	12.24	21.10	29.96	38.81
200	3.18	12.20	21.08	29.94	38.80
300	3.05	12.16	21.06	29.93	38.78
400	0	12.12	21.03	29.91	38.77

Note: These rates of return are based on fertilizing loblolly pine plantations with average growth rates and average growth responses to fertilization. It is also assumed that the stand is managed for sawtimber production and thinned at age 15 to 18 to control pine density before fertilization and harvested at age 30.

plantations (30 acres or less) are more difficult to profitably fertilize because of fertilizer cost, yield increase potential and harvesting limitations. Dense plantations do not respond well to fertilization because of tree-to-tree competition for the fertilizer. Fertilizer responses are poor when stand densities exceed basal areas of 150 ft^2 per acre, which is approximately comparable to: (1) 4,000 to 7,000 trees per acre for stands below age 5; (2) 2,500 to 4,000 trees per acre for stands between ages 5 and 10; (3) 300 to 1,000 trees per acre between ages 10 and 15; and (4) 200 to 600 trees per acre between ages 15 to 25. Stand density can be controlled by planting spacing and thinning. Similarly, pines respond poorly to fertilization when there is a preponderance of hardwood trees competing for the applied nutrients. Generally, if more than 30 percent of the trees in a plantation are hardwood trees similar in height and diameter to the pine trees, fertilization should be avoided or postponed until the hardwood trees are removed through herbicide or harvesting.

The stage of stand development is another important concern. Midrotation (between ages 12 to 20) is a convenient and profitable timeframe for fertilization (typically with nitrogen and phosphorus) because: (1) a portion of the thinning revenues can be used to pay for fertilization, (2) fertilizer costs can be expensed for tax purposes, (3) tree density is reduced by thinning, (4) the fertilization cost after tax credit is carried for only half the rotation and (5) the fertilizer will promote faster development of trees into the valuable chip-and-saw and sawtimber product classes. Some younger plantations (ages 0 to 12) can be profitably fertilized with phosphorus because it is highly deficient in several soil types in the Western Gulf region, and growth improvements from phosphorus fertilization can last for 15 to 20 years.

2. Assess nutrient needs.

Foliage testing

A convenient and affordable means to gauge whether a forest needs fertilization involves collecting leaves for nutrient testing. A $20- to $40-foliage nutrient test can prevent spending thousands of dollars on fertilizing forests that do not need it. To accurately test a plantation's nutrient needs, take samples of pine needles in each plantation under consideration for fertilization. Needle samples should be collected in the months of December, January or February.

It is important to take needle samples in a way that accurately measures the nutrients in the stand. For instance, taking all needle samples from trees near creeks would provide a poor estimate of the nutrients in trees farther from creeks. An accurate way to sample trees is to pick trees of good height and form from each corner of the plantation and from a few scattered points within the center of the plantation. A total of 10 trees is typically sufficient to

Table 3. Minimum foliage nutrient levels needed for adequate growth of loblolly and slash pine in the southeastern U. S. For each nutrient, foliage test results lower than these values indicate a deficiency. Adapted from Wells and others (1973), Pritchett and Comerford (1983), Allen (1987), Dickens (2002), and Jokela (2004).

Species	Nutrients[1]										
	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	%						(ppm)				
Loblolly pine	1.20	0.12	0.30	0.15	0.08	0.10	8.0	3.0	40	40	20
Slash pine	1.00	0.09	0.30	0.12	0.06	0.08	8.0	3.0	35	40	20

[1] N = nitrogen, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium, S = sulfur, B = boron, Cu = copper, Mn = manganese.

Table 4. Fertilizer type and rates for remedying nutrient deficiencies in loblolly and slash pine forests.

Stand age	Low nutrient	Fertilizer type[1]	Fertilizer rate (lb/ac)
0 to 4	Nitrogen	Urea[2]	90
	Phosphorus	TSP, DAP[2], or MAP[2]	250
	Potassium	Muriate of potash	30
	Sulfur	Ammonium sulfate	100
	Boron	Borax	5
	Copper	Copper sulfate	12
5 to 10	Nitrogen	Urea + TSP	260 urea + 30 TSP
	Phosphorus	TSP, DAP, or MAP	250
	Potassium	Muriate of potash	70
	Boron	Borax	9
	Copper	Copper sulfate	16
10 +	Nitrogen	Urea + TSP	330 urea + 30 TSP
	Phosphorus	TSP, DAP, or MAP	250
	Potassium	Muriate of potash	100
	Sulfur	Ammonium sulfate	160
	Boron	Borax	9
	Copper	Copper sulfate	20

1 TSP = triple superphosphate, DAP = diammonium phosphate, MAP = monoammonium phosphate.

2 Fertilization with this fertilizer is inadvisable unless underbrush is controlled with herbicide.

characterize the nutrition of a plantation.

To sample needles, shoot (using a shotgun with a full choke) or prune a branch from the tree and strip 10 to 20 needles from the lower part of the branch. The most accurate measurement of a tree's nutrients comes from needles in the upper third of the tree, so strive to shoot branches from the upper portion of the tree. Mix all the needles collected in the stand in a bag or bucket and randomly pull out 100 to 200 needles. Put the needles in a paper bag and ship them overnight in an icepack-filled cooler to a laboratory for analysis.

Soil testing

Fertilizer needs also can be assessed through soil testing, which is a necessity when considering preplant fertilization. To accurately soil test, walk in a zigzag pattern in each corner and in scattered points within the center of the plantation and dig 20 soil samples down to a 6-inch depth at random. Before digging the soil samples, lightly brush aside the layer of leaf debris from the topsoil. After collecting the samples, allow them to dry out in the open air; do not dry the samples with an oven because the oven can heat some of the nutrients out of the samples. Combine the 20 samples taken per stand or stand section into a bucket and mix the soil thoroughly. Remove enough soil to fill a soil sample bag or box that is provided by the laboratory that will run the soil analysis. Remove any large rocks or pieces of plant material from the soil before placing it in the bag or box.

Foliage and soil tests are $7 to $14 per sample at the Louisiana State University AgCenter Soil Testing and Plant Analysis Laboratory. Samples can be mailed directly to the laboratory. If needed, personnel at LSU AgCenter extension offices or research stations can provide assistance in finding and completing the sample order forms used by the laboratory.

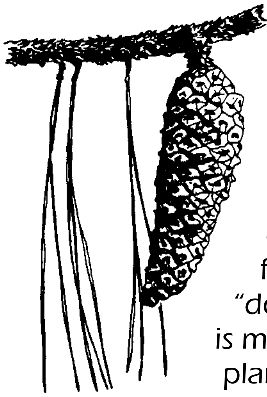
3. Interpreting the test results.

The interpretation of foliage test results is made possible through research that has determined the "critical values" of several nutrients for southern pine. A "critical value" is the minimum level of a nutrient needed for optimum tree growth; a listing of several critical values for southern pines is provided in *Table 3*. These critical values are helpful guides in determining nutrient deficiencies, especially for nitrogen and phosphorus. When reading foliage test results, compare the concentration of each nutrient in the test to its critical value as listed in *Table 3*. If the concentration of a nutrient in the foliage test is less than the critical value, the stand may need an application of a fertilizer that contains the nutrient.

Only phosphorus has a known critical nutrient value for loblolly and slash pine that can aid in soil test interpretation. For the Mehlich 3 soil test for phosphorus used by the LSU AgCenter Soil Testing and Plant Analysis Laboratory, phosphorus fertilization is needed if the soil test shows phosphorus concentrations lower than 25 parts per million (50 lb per acre).

4. Applying the fertilizer.

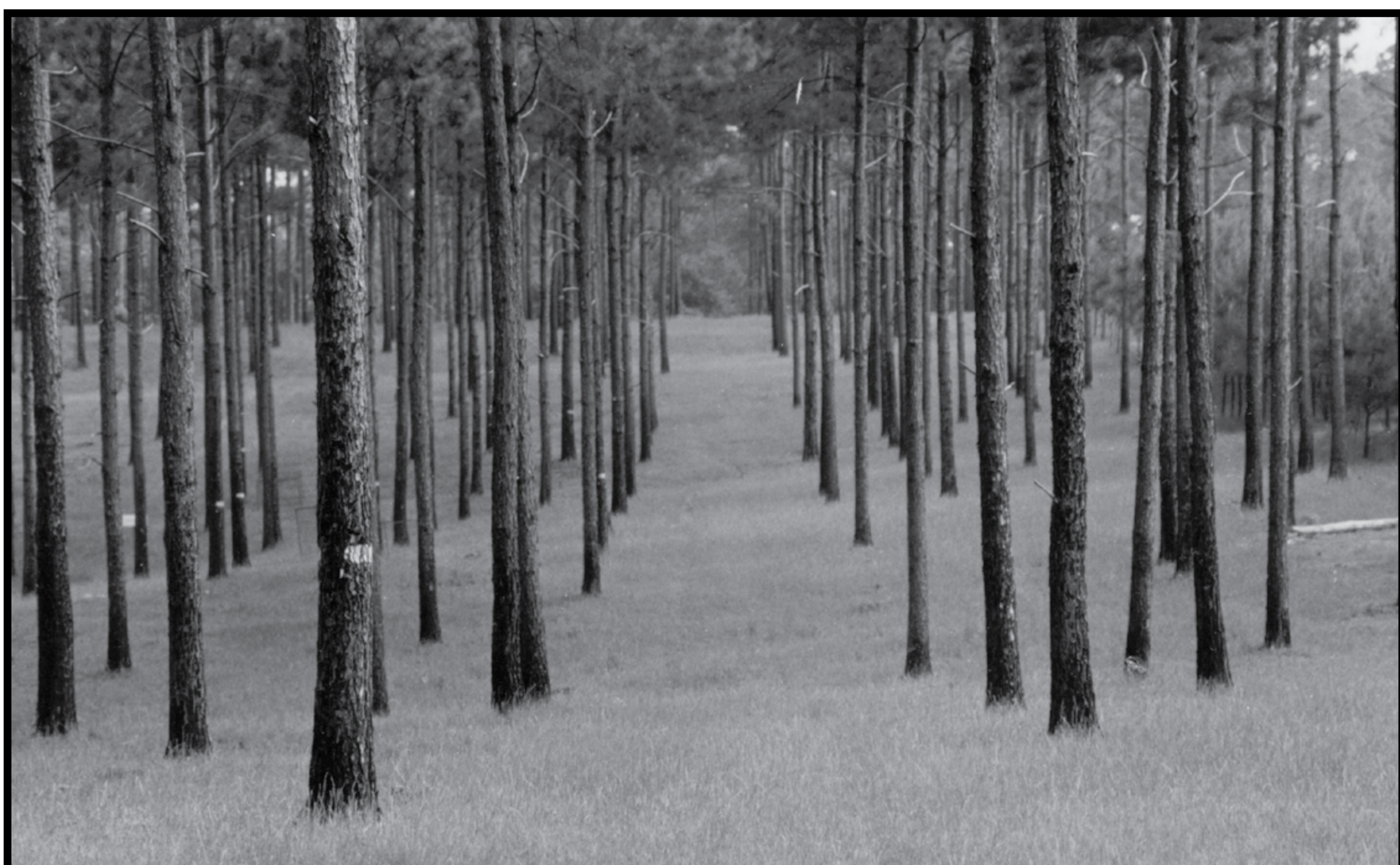
Once nutrient testing identifies any deficient nutrients, fertilizer that includes the deficient nutrient is applied. Fertilizer is best applied in midspring or early fall because at those times trees will more effectively take up and use fertilizer for growth.



It has been less common to fertilize in early fall, but recent research has shown that tree growth responses to fall applications are equivalent or superior to those of midspring applications. A list of common fertilizers and the rates at which they are typically applied is provided in *Table 4*. Most forest fertilization is currently done by aircraft at an average cost of $50 to $150 per acre. Fertilizer also can be applied with skidder-mounted spreaders at costs comparable to that of aerial fertilization. Fertilizer applications are typically conducted by contractors; a consulting forester or forestry extension agent is helpful in locating applicators. If there is sufficient spacing between trees and rows between trees are relatively free of vegetation and debris, it is also possible to apply fertilizer with tractor-mounted spreaders. If one owns a tractor, tractor-mounted fertilization equipment is available at farmer's cooperatives. This "do-it-yourself" approach is most viable for smaller plantations (less than 30 acres) and can reduce application costs by as much as 40 to 60 percent.

Summary

Fertilization is a practice worth considering for plantations that have been given the best opportunities to grow by planting trees with good genetic potential and giving those trees adequate freedom from competition from understory vegetation and other crop trees for light, water and nutrients through timely thinnings and understory control treatments. Fertilization can take growth rates and financial performance of such plantations to "the next level" if the plantations are growing on soils with inadequate nutrition. There are well-established techniques for diagnosing the need for fertilization to make sure plantations get only the nutrients they need, and there are well-known plantation growth increases after fertilization on nutrient-deficient soils. Fertilizer prices may continue to climb upward in the coming years as agricultural demands for fertilizer and costs of fertilizer production rise. However, financial returns associated with fertilization are much more affected by sawtimber prices than by fertilizer prices. Long-term demand for sawtimber is expected to increase for decades to come, so fertilization will likely continue to be a vital tool for increasing sawtimber production in pine plantation management.



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