Outreach
Warnell School of Forestry & Natural Resources
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Longleaf Pine Stand Fertilization

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BACKGROUND

Numerous southern pine fertilization studies have been performed in the southeastern U.S. since the 1960's. Loblolly pine fertilization studies have been the most numerous and extensive, followed by slash pine studies, and lastly those in longleaf pine. Table 1 summarizes 8-year responses to nitrogen+phosphorus (NP) or nitrogen+phosphorus+potassium (NPK) for these commercially important species. Loblolly pine is the most responsive to NP or NPK fertilization, followed by slash (22% less than loblolly), and lastly longleaf (50% less than loblolly). Table 2 summarizes pine straw yield responses to NPK fertilization in longleaf stands. The benefit of a single NPK application lasted two to three years on a cut-over site (previous crop was trees) with excessively well drained deep sandy soils having low fertility. On more fertile soils with better nutrient and water holding capacity and former old-field sites a single application gave a response for four years and a split application lasted six years.

The major "windows" to fertilize pine stands are: (1) at planting, mostly with a one-time P or NP treatment (150 – 250 lbs triple super phosphate or diammonium phosphate) to rectify a phosphorus deficiency on poorly drained lower Coastal Plain soils and some P deficient geological terraces, (2) a one-time or five to six year interval application of NP or NPK for (a) enhancing pine straw production from canopy closure (age 8 to 12 years old) to first thinning age or (b) for increasing pulpwood production in intensively managed loblolly pine stands on a 14 to 20 year short rotation, and (3) to enhance higher value sawtimber and pole production after a first or second thinning. Generally fertilization at planting for longleaf pine has little growth benefit as we mostly plant longleaf on well drained upland sites that are not P deficient. NP or NPK fertilization can be beneficial on low fertility, cut-over sites for enhancing pine straw production and increasing wood production, but not to the extent that loblolly or slash responds to fertilization (Table 1). Table 2 illustrates longleaf pine straw gains that can be realized with NPK fertilization. The pine straw increases lasted two to three years on excessively or well drained sandy soils from a one-time NPK application and four to six years on moderately well drained loamy sand soils from a one time or split NPK application. Longleaf NP or NPK fertilization at ages 15 to 19 -years on old-field sites generally results in small wood gains over a six to ten year period, whereas NP or NPK fertilization in 9- and 32-year-old longleaf stands on low fertility cut-over sites produced 0.5 to 1.0 ton/ac/yr wood gains over 10 years, respectively with two NPK applications.

Table 1. Eight-year fertilizer responses to a single NP or NPK fertilizer application at or after canopy closure on low fertility cut-over sites

Pine species	Average 8 – year growth response	Low end of response[1]	Upper end of response[1]
	-------------------tons per acre per year ---------------------		
Loblolly	1.60	1.00	2.20
Longleaf	0.80	0.50	1.10
Slash	1.25	0.80	1.70

[1] Mean growth responses cited for NP fertilization studies by the NCSU Forest Nutrition Cooperative for loblolly pine, slash from UGA, NCSU, and UFL studies, and longleaf from NCSU and UGA studies and are within 40% of mean values in 80% of instances.

Table 2. Longleaf pine straw response to NPK in a single or split (½ NPK in the beginning and ½ NPK two years after) fertilizer applications in unthinned and thinned stands.

Land use history	Location	Study period stand ages (years)	Average for no fertilizer (bales*/acre/year)	Average for single dose NPK (bales/acre/year)	Average for split dose NPK (bales/acre/year)
Old-field unthinned	Screven Co, GA	17 – 23 (benefit lasted 4-6 yrs)	225	250	260
Old-field unthinned	Tift Co, GA	17-23 (benefit lasted 4-6 yrs)	205	240	250
Cut-over unthinned	Chesterfield Co, SC	9-14 (benefit lasted 2 yrs) deep sandy soils	95	130	--
Cut-over thinned twice	Chesterfield Co, SC	32 – 36 (benefit lasted 3 yrs) deep sandy soils	85	130	--

*A bale was 13x13x26 inches or 20 lbs field weight and 17 lbs dry weight.

DIAGNOSTIC TOOLS TO DETERMINE NUTRIENT NEEDS

The main diagnostic tools to determine if a longleaf stand would be responsive to NP or NPK fertilization are: (1) foliage sampling, (2) soil sampling, and (3) leaf area index. Foliage sampling is done in the dormant season, collecting longleaf needles from the upper 1/3 of the crown on the south side of the tallest trees in the stand, taken from the first flush of foliage of the previous year's growth. A sufficient needle sample for analysis will fill up at least ½ of a 9x12 inch envelope. Take at least three longleaf tree foliage samples per bag and at least three sample envelopes per 10-15 acres. Foliage analysis should include total forms of N, P, K, calcium (Ca), magnesium (Mg), boron (B), copper (Cu) and iron (Fe). Foliage "minimum" (sufficiency) concentrations for loblolly, longleaf and slash pine are found in Table 5. If any of the nutrients are below the minimum, then there is a good chance that the stand will respond to the addition of that (or those) nutrient(s). Soil sampling can be done any time of year, taking a clean plastic bucket and soil probe (or narrow shovel or trowel) and some soil sample bags into the stand. Brush aside the forest floor, collecting from the top of the mineral soil to a 6 inch depth. Place each soil sample in the plastic bucket. Collect from six to eight locations per 10 acres within the stand. Mix the soil and place enough in the soil bag (from a private lab of University Extension office) to the "fill" line. Leaf area index estimates are taken in the July – August period when leaf areas are at their maximum. Take several leaf area index samples (10 per 20-30 acres) from the stand, writing each value on a notepad. Take a map of the stand and write notes where each sample is taken. If soil available-P is less than 6-10 lbs/acre, foliar P is less than 0.08%, foliar N is less than 0.90% and leaf area index is less than 1.5 then the stand will likely respond to a NP application. If the stand also has a foliar K value less than 0.25% then the stand will likely respond to a NPK application. Refer to Tables 2 and 3 for NP or NPK application levels for longleaf pine. Use *bugwood.org* to find more information and the proper use of these diagnostic tools.

OTHER FACTORS THAT DETERMINE FERTILIZATION NEEDS (OR LACK OF NEED)

Land Use History

Land use history is an important factor in deciding if fertilization will be of economic and stand health value. Most studies have found that traditional one-time or split NP or NPK applications of inorganic fertilizer materials, animal manures and biosolids (from treated wastewater meeting land application criteria) on former old-field, pasture or hay cutting fields are not economically beneficial to wood growth or pine straw yields. This is due to the moderate to high levels of residual fertilizer in the soil from previous land use practices. Conversely, cut-over sites are often low in N and P or N, P, and K and will respond to a single or intervals of NP or NPK applications.

Visual Symptoms

In some cases a longleaf stand may look like it is not growing well. Visual symptoms that may lead to finding a nutrient deficiency include: light green or yellow (chlorotic) needles, short needles, needles in tufts at the end of branches, stunted growth, and poor crown development. If you know what a healthy longleaf stand looks like, then these symptoms should be easy to see. If a longleaf stand (of any age) has these needle and crown symptoms, take some soil and foliage samples from the stand and see if there are nutrients that are below the sufficiency level for longleaf pine.

Soil Series Knowledge

Knowing what each candidate stand's soil series are can be of great help in determining the magnitude and duration of fertilizer benefit. For example; if part of a longleaf stand (for example; the northeastern 50 acre corner of a 200 acre stand) is Lakeland and Kershaw soils (typified by turkey oak and other scrub oaks and poor pine growth rates), these deep sandy, excessively drained soils, having low inherent fertility generally will not respond to inorganic NP of NPK fertilization or may respond for a short term of three to four years. However, they may respond to animal manures and biosolids for a longer term, four to seven years, because nutrients are slowly released from these organic materials. Soils that have a restrictive layer to leaching, such as a clay layer known as an argillic horizon, within 40 to 50 inches of the surface and are moderately well to well drained are better soils to fertilize using inorganic and organic materials with a larger and longer lasting response. Use the NRCS web soil survey to find the soil series on your property.

Stand Conditions and Factors

When fertilizing longleaf stands, the following factors are important considerations to optimize the fertilizer benefit to crop trees. (1) Understory and mid-story vegetation should be minimal. (2) Diseases such as fusiform rust and pitch canker (and other diseases) should not be present or be minimal, because diseases can worsen with fertilization. (3) Longleaf pine basal area (the combination of trees per acre and their diameters) should not be more than 100 square feet per acre before fertilization. When basal area is too high the stand is too dense for crowns to expand as a response to fertilization, and thinning may be considered to open up the stand. To gain the full response to fertilization it should be done at least four to six years prior to the final harvest cutting in even-aged management.

ADDITIONAL FERTILIZATION CONSIDERATIONS

If a longleaf stand is determined to be responsive using the three diagnostic tools (soil available-P analysis, foliar nutrient analysis, and leaf area index) and where soil series and land use history , stand conditions, and other important factors indicate that the stand will respond favorably, then the landowner should consider: (1) the fertilizer materials and application costs, (2) the estimated growth response over a five to ten year period to the single or split fertilizer application, (3) the anticipated stumpage price for the wood gain from fertilization at the end of the period, and (4) where pine straw is being raked, the total value of the straw yield gain. Use the application rates shown in Table 3 for nitrogen (N), phosphorus (P), and potassium (K) and the rates of various fertilizer materials shown in Table 4. Do not go over the 75 lbs N/acre application rate in stands where diameter at breast height (dbh; 4 ½ feet above groundline) is less than six inches. Photo 1 illustrates a young longleaf stand where 150 lbs N/ac was applied, leaning over 20% to 25% of the trees, which never recovered.

ESTIMATED NUTRIENT REMOVALS WITH PINE STRAW RAKING

Studies have shown that annual pine straw raking (removing the top fresh, undecomposed needles) removes an average of 15 lbs/ac N, 2 lbs/ac P, 7 lbs/ac K, 10 lbs/ac Ca and 2.5 lbs/ac Mg. Three studies have shown that near-term (lasting 1 to 3 years) diameter growth with annual raking, but without fertilization, can be reduced by 0.20 to 0.70 inches. The same studies showed that diameter growth after 2 to 3 years of annual raking was the same as unraked stands. Fertilization alleviated the near-term diameter growth losses.

Table 3. Recommended fertilizer application rates (elemental – lbs/ac) for longleaf pine

Species	Stand phase/size	Nitrogen (N)	Phosphorus[1] (P)	Potassium[2] (K)	Ca, Mg, S, B, Cu, Mn, Fe[3]
Longleaf	dbh < 6”	75	25 - 50	50 - 80	as needed
	dbh ≥ 6”	125			

[1]To convert from elemental-P to P_2O_5 multiply by 2.3. To convert from P_2O_5 to elemental-P divide by 2.3.
[2]To convert from elemental-K to K_2O multiply by 1.2. To convert from K_2O to elemental-K divide by 1.2.
[3]Approximate application levels are based on stand needs: 25 to 40 lbs Ca/ac, 25 lbs Mg/ac, 25 to 40 lbs S/ac, 0.5 to 1 lb B/ac, 3 to 5 lbs Cu/ac, 3 to 5 lbs Mn/ac, and 10 to 15 lbs Fe/ac

Table 4. Application rate recommendations using common fertilizer materials for longleaf pine stands after canopy closure that have a good probability of response to fertilization

Pine species & age or size	Urea[1] (46-0-0)	Diammonium phosphate[2] (DAP; 18-46-0)	Muriate of potash (0-0-60)
	------------------------------Pounds per acre ------------------------------		
Longleaf < 6” dbh	65 - 115	125 - 250	100 - 160
Longleaf ≥ 6” dbh	170 - 220		

[1]Use the low Urea application level when used with the high DAP or MAP dose and the converse when a low DAP or MAP dose is used.
[2]Mono-ammonium phosphate (MAP; 11-52-0) may be available and can be used in place of DAP @ 88 – 176 lbs/ac to achieve 20 to 40 lbs elemental-P/acre (46 to 92 lbs P_2O_5/ac) but urea dosage will need to be increased to achieve N application levels in Table 3.

Table 5. Foliar nutrient sufficiency (minimum) guidelines for loblolly, longleaf, and slash pine

Nutrient	Loblolly pine[a]	Longleaf pine[b]	Slash pine[a]
	---------------------------------- percent ------------------------------------		
Nitrogen (N)	1.2	0.95	1.0
Phosphorus (P)	0.12	0.08	0.09
Potassium (K)	0.30	0.30	0.25 – 0.30
Calcium (Ca)	0.15	0.10	0.08 – 0.12
Magnesium (Mg)	0.08	0.06	0.06
Sulfur (S)	0.10	--	0.08
	---------------------- parts per million (ppm) --------------------------------		
Boron (B)	4 - 8	--	4 – 8
Copper (Cu)	2 - 3	--	1.5 – 3
Iron (Fe)	20 - 40	--	15 -35
Manganese (Mn)	20 - 40	--	20 – 40
Zinc (Zn)	10 – 20	--	10 – 20

[a] Allen (1987); Jokela (2004); Pritchett and Comerford (1983); Wells, Crutchfield, Berenyi, and Davey (1973).
[b]Blevins, Allen, Colbert, and Gardner. (1996) for N, P, K, Ca, and Mg. No literature available to date for longleaf sufficiency for S, B, Cu, Fe, Mg, or Zn.

Photo 1. A ten-year-old longleaf stand in South Carolina where 150 lbs N + 50 P + 50 K per acre was applied one time. In this case the nitrogen (N) application rate was too high, creating needle production that was too much (too heavy) for the stem diameters to support, causing 20 to 25% of the trees to lean over (many greater than 45 degrees) and those trees never did straighten up.

When most stem diameters at 4.5 feet in a longleaf stand are less than 6 inches, use no more than 75 lbs N/acre with P and K so this does not happen.

Literature Cited:

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Photo 2. A forty-two year old longleaf stand in South Carolina growing on an excessively well drained deep sandy soil (Alpin soil series) that was NPK fertilized twice in a ten year period, improving both pine straw production and sawtimber and pole production.

Citation:
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