Mid-rotation rate of return (ROR) estimates with a single nitrogen+phosphorus or nitrogen+phosphorus+potassium fertilizer application in loblolly, longleaf, and slash pine stands

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Introduction

Between 500,000 to 1,200,000 pine plantation acres (primarily loblolly) have been fertilized annually since the mid-1990's in the southeastern U.S. Common pine stand fertilization "windows" are at pine stand establishment (pre-plant or within two to three years of planting to rectify a phosphorus (P) or nitrogen and phosphorus (NP) deficiency) and at mid-rotation (after canopy closure to enhance pine straw production and tree growth or after a thinning using NP or NP+postassium (K)). Approximately 50 percent of annual forest fertilization is performed at planting and 50 percent is performed at mid-rotation. Fertilization of loblolly, longleaf, and slash pine stands can be beneficial if the (1) stand/site in question has a deficiency in one or more nutrients (typically P, NP, or NPK), (2) is moderately to highly responsive to the nutrient(s) being added, and (3) the site is large enough to operationally feasible to fertilize (20 to 40 acres or more). To be economically beneficial, pine stand fertilization considerations include (1) cost per acre, (2) the anticipated extra wood and/or pine straw yields over a 6 to 10-year period, and (3) the value of those forest products grown at time of harvest. Pine stand response to mid-rotation fertilization generally peaks three to four years after application and lasts five to eight years on most soils (shorter time to peak response and duration of response on deep, well to excessively well drained sands and longer time to peak response and duration of response on soils with good water and nutrient holding capacities).

There are cases where a pine stand is determined to be nutrient deficient using diagnostic tools, soil series and land use history knowledge but other stand to site limiting factors will often preclude a large enough growth response to make single dose fertilization financially attractive. Site and stand limiting factors include: soils with a low water and nutrient holding capacity (excessively well drained deep sands, like Kershaw, Lakeland, Foxworth and Alpin soils series), shallow soils, level of competing vegetation, high pine basal area, low live crown ration (slash pine), and other factors. There are also investment risks with fertilization such as ice or snow storms, tornados, hurricanes, and insect (pine beetles) or diseases (pitch canker, stem fusiform rust, annosum root rot) that can reduce the stand's additional wood yields or pine straw that should be considered. This publication is intended to assist forest landowners with determining the financial attractiveness of fertilization on their property at mid-rotation using an eight year response period.

Estimating rate of return for a single fertilizer application

There are three components to estimating a mid-rotation rate of return from a single fertilizer application: (1) determine cost per acre, (2) estimate the eight-year growth response, and (3) estimate the average pine stumpage price for the wood grown at the end of the eight-year period. The fertilizer cost per acre can change daily to weekly. There are a number of publications and pine growth simulator models that will give fertilization growth response estimates. Pine stumpage price estimates can often be obtained from consulting foresters, county agents and state foresters.

1. *Determining cost per acre*

Figure 1 is a graph of common fertilizer material prices for south Georgia from July 1999 through mid-July 2010. Once a forest landowner or consultant has determined that a pine stand has a moderate to large probability of response to a single dose of P, NP, or NPK based on diagnostic tools, soil series and land use history knowledge (Dickens, Moorhead, Kissel, and Morris 2010; A checklist for fertilization….), then a fertilizer material application level is determined using Table 2 and 3 from Dickens, Moorhead, Kissel, and Morris 2010 (Fertilization response expectations….). Next a cost per acre can be determined by calling local fertilizer vendors if one plans to fertilize him or herself or forest fertilizer applicators that work the area. Check your state forestry commission or Extension Service of a list of fertilization vendors or web sites (www.gatrees/org).

2. *Estimating eight-year growth response*

Mid-rotation fertilization growth response will be pine species, stand, and site conditions specific. Table 1 lists growth responses for loblolly, longleaf, and slash pine based on a number of studies.

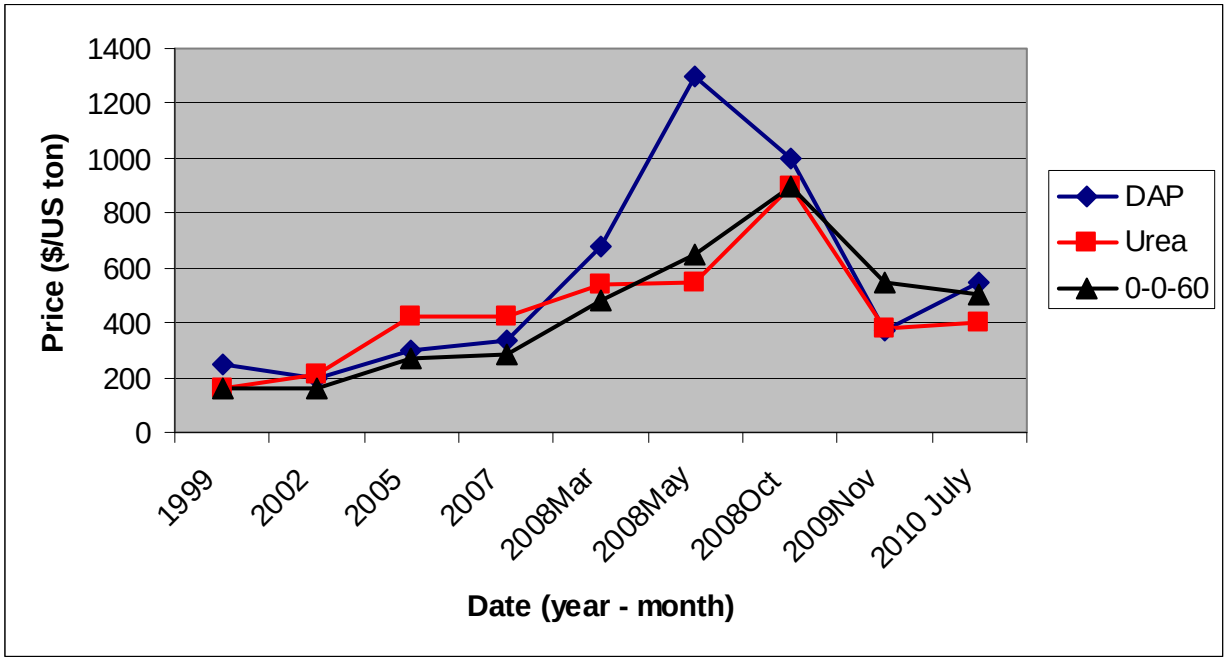

Figure 1. Common fertilizer materials prices for south Georgia from July 1999 through mid-July 2010. DAP = diammonium phosphate (18-46-0), urea = 46-0-0, and 0-0-60 = muriate of potash (0-0-60). Monoammium phosphate (MAP; 11-52-0) is recently become more available and can be substituted for DAP when DAP is not available (urea application level will need to be adjusted).

Table 1. A summary of an 8 year fertilizer response to a single NP or NPK fertilizer application at or after canopy closure

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	0.96	2.24
Longleaf	1.00	0.60	1.40
Slash	1.35	0.81	1.89

[1] A 40% plus or minus the mean growth response covers 80% of cited NP fertilization sites based on work at NCSU Forest Nutrition Cooperative for loblolly pine

3. *Estimiating an average pine stumpage price*

Historical pine stumpage price estimates can be obtained from a number of sources. Figure 2 pine stumpages for Georgia are from Timber-Mart South ©.

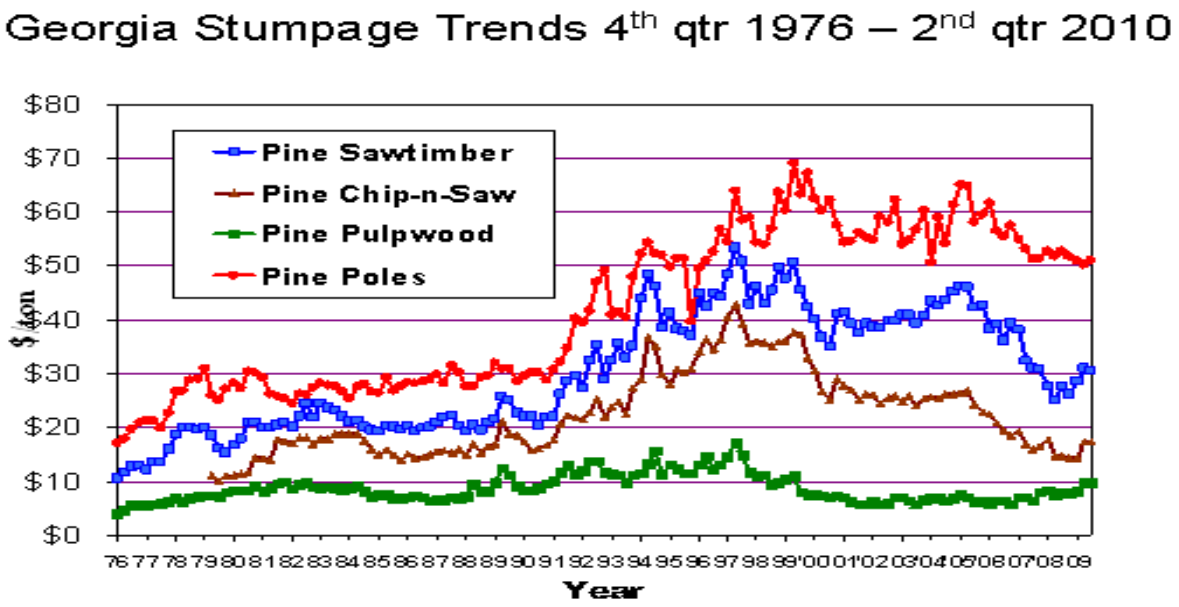

Figure 2. Historical pine stumpage prices for Georgia.

Table 2. Eight-year revenues from extra wood grown with a single fertilizer application at mid-rotation

Extra growth tons/ac/yr	---------- Average pine stumpage price ($/ton) ----------							
	10	15	20	25	30	35	40	45
	---------- Increased revenue ($/acre) from fertilization ----------							
0.5	40	60	80	100	120	140	160	180
1	80	120	160	200	240	280	320	360
1.5	120	180	240	300	360	420	480	540
2	160	240	320	400	480	560	640	720

Examples for estimating rate of return

1. A landowner has a 16-year-old thinned loblolly pine stand leaving 150 to 250 good quality trees per acre. This stand has a moderate to high probability of response to a single NP fertilizer application. His current NP fertilizer +application cost is $120/acre. He anticipates an average stumpage price of $20/ton when the stand is 24-years-old when he will strongly consider clear-cutting the stand. Because there are no other growth limiting factors, he estimates that a 1.5 tons/ac/yr response is realistic. This landowner will use Table 5 ($120/ac fertilizer cost), then in the "Extra growth" column, he or she will go down to 1.5 tons/ac/yr and over to the $20 "Average pine stumpage price" and he or she will speculatively achieve a 9.05 percent rate of return from this fertilization investment.

2. A landowner has an unthinned 10-year-old slash stand. This stand has a moderate to high probability of response to a single NP fertilizer application. His current NP fertilizer +application cost is $100/acre. Because there are no other growth limiting factors, he estimates that a 1.35 tons/ac/yr response is realistic. This landowner will use Table 4 ($100/ac fertilizer cost). Because this landowner will only be thinning the stand, he or she will realize approximately ½ of the extra wood grown (other ½ of extra wood grown is left in the stand to continue to grow) Therefore ½ of the slash pine average growth rate will be used or 0.5 and 1.0 tons/ac/yr "Extra growth" rows will be used. Since the first thinning wood will be mostly pulpwood, the landowner uses a price of $10/ton "Average pine stumpage price". The landowner will (speculatively) achieve a negative rate of return from this fertilization investment, meaning the fertilization cost more that the realized extra wood grown ($100/ac cost and $40/ac or $80/ac in extra wood from the thinning). In this case fertilization is not cost-effective.

3. A landowner has 21-year-old thinned longleaf pine stand leaving 150 to 225 good quality trees per acre. This stand has a moderate to high probability of response to a single NPK fertilizer application. His current NPK fertilizer +application cost is $140/acre (longleaf needs less N than slash or loblolly, reducing cost while adding K increases cost). He anticipates an average stumpage price of $30/ton when the stand is 29-years-old. Because there are no other growth limiting factors, he estimates that a 1.0 tons/ac/yr response is realistic. This landowner will use Table 6 ($140/ac fertilizer cost), then in the "Extra growth" column, he or she will go down to 1.0 tons/ac/yr and over to the $30 "Average pine stumpage price" and he or she will speculatively achieve a 6.97 percent rate of return from this fertilization investment.

Table 3. Rate of return estimates for a single NP or NPK fertilizer application at $80/acre eight years after application

Extra growth tons/ac/yr	---------- Average pine stumpage price ($/ton) ----------							
	10	15	20	25	30	35	40	45
	---------- Rate of return (%) ----------							
0.5	-8.3	-3.53	0.00	2.83	5.20	7.25	9.05	10.67
1	0.00	5.20	9.05	12.14	14.72	16.95	18.92	20.68
1.5	5.20	10.67	14.72	17.97	20.68	23.03	25.10	26.96
2	9.05	14.72	18.92	22.28	25.10	27.54	29.68	31.61

Table 4. Rate of return estimates for a single NP or NPK fertilizer application at $100/acre eight years after application

Extra growth tons/ac/yr	Average pine stumpage price ($/ton)							
	10	15	20	25	30	35	40	45
	Rate of return (%)							
0.5	-10.82	-6/19	-2.75	0.00	2.31	4.30	6.05	7.62
1	-2.75	2.31	6.05	9.05	11.56	13.74	15.65	17.36
1.5	2.31	7.62	11.56	14.72	17.36	19.65	21.66	23.47
2	6.05	11.56	15.65	18.92	21.66	24.03	26.12	27.99

Table 5. Rate of return estimates for a single NP or NPK fertilizer application at $120/acre eight years after application

Extra growth tons/ac/yr	Average pine stumpage price ($/ton)							
	10	15	20	25	30	35	40	45
	Rate of return (%)							
0.5	-12.83	-8.30	-4.94	-2.25	0.00	1.95	3.66	5.20
1	-4.94	0.00	3.66	6.59	9.05	11.17	13.04	14.72
1.5	0.00	5.20	9.05	12.14	14.72	16.95	18.92	20.68
2	3.66	9.05	13.04	16.24	18.92	21.23	23.27	25.10

Table 6. Rate of return estimates for a single NP or NPK fertilizer application at $140/acre eight years after application

Extra growth tons/ac/yr	Average pine stumpage price ($/ton)							
	10	15	20	25	30	35	40	45
	Rate of return (%)							
0.5	-14.50	-10.05	-6.76	-4.12	-1.91	0.00	1.68	3.19
1	-6.76	-1.91	1.68	4.56	6.97	9.05	10.89	12.53
1.5	-1.91	3.19	6.97	10.00	12.53	14.72	16.65	18.38
2	1.68	6.97	10.89	14.02	16.65	18.92	20.92	22.72

Table 7. Rate of return estimates for a single NP or NPK fertilizer application at $160/acre eight years after application

Extra growth tons/ac/yr	Average pine stumpage price ($/ton)							
	10	15	20	25	30	35	40	45
	Rate of return (%)							
0.5	-15.91	-11.54	-8.30	-5.71	-3.53	-1.66	0.00	1.48
1	-8.30	-3.53	0.00	2.83	5.20	7.25	9.05	10.67
1.5	-3.53	1.48	5.20	8.17	10.67	12.82	14.72	16.42
2	0.00	5.20	9.05	12.14	14.72	16.95	18.92	20.68

Table 8. Rate of return estimates for a single NP or NPK fertilizer application at $180/acre eight years after application

Extra growth tons/ac/yr	---------- Average pine stumpage price ($/ton) ----------							
	10	15	20	25	30	35	40	45
	---------- Rate of return (%) ----------							
0.5	-17.14	-12.83	-9.64	-7.08	-4.94	-3.09	-1.46	0.00
1	-9.64	-4.94	-1.46	1.33	3.66	5.68	7.46	9.05
1.5	-4.94	0.00	3.66	6.59	9.05	11.17	13.04	14.72
2	-1.46	3.66	7.46	10.50	13.04	15.24	17.18	18.92

Table 9. Rate of return estimates for a single NP or NPK fertilizer application at $200/acre eight years after application

Extra growth tons/ac/yr	---------- Average pine stumpage price ($/ton) ----------							
	10	15	20	25	30	35	40	45
	---------- Rate of return (%) ----------							
0.5	-18.22	-13.97	-10.82	-8.30	-6.19	-4.36	-2.75	-1.31
1	-10.82	-6.19	-2.75	0.00	2.31	4.30	6.05	7.62
1.5	-6.19	-1.31	2.31	5.20	7.62	9.72	11.56	13.22
2	-2.75	2.31	6.05	9.05	11.65	13.74	15.65	17.36

Summary

Of the three factors that go into estimating a rate of return for a single fertilization investment, the cost per acre factor is the easiest to come up with. The users of this publication may want to run a number of scenarios for their pine stand that they are considering to fertilize to feel more comfortable with the decision they make. For example (once the cost per acre is determined); use two “extra growth” rates of 1.0 and 1.5 tons/ac/yr for slash pine and two “average stumpage prices” of $20 and $25/ton for 20-28-year-old clear-cut wood. Using the $120 cost/acre table 5, the rates of return would be 3.66, 6.59, 9.05, or 12.14 %. The landowner would then decide if these rate or return estimates are acceptable or not. Since the “average stumpage price” used is for wood sold eight years from the fertilizer application and investment; the rate of return estimates here are nominal, meaning they are directly comparable to stock yields, CDs, and savings yields.

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