Opportunities for Intensive Pine Plantation Management

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Recent research conducted at the University of Georgia Warnell School of Forest Resources has demonstrated that current pine productivity of 1 to 2 cords per acre per year can be doubled or tripled through application of intensive pine plantation establishment and management practices. As a result, pine plantation productivity in Georgia can rival that of the most productive areas in the world.

Table 1. Mean Annual Increment (MAI) of total volume in ft^3/ac & cords per acre for loblolly pine plantations world-wide.

Location	MAI ft^3/ac	MAI Cds/ac	Stand Age
South Africa	523	5.8	22
Brazil	442	4.9	8
Waycross, GA (flatwoods site)	**420**	**4.6**	**9**
Australia	382	4.2	16
Hawaii	371	4.1	11
S. Carolina	352	3.9	11
Waycross, GA (upland site)	**348**	**3.8**	**9**
Tifton, GA	**317**	**3.5**	**8**
Eatonton, GA	**307**	**3.4**	**8**
Eatonton, GA	**278**	**3.1**	**8**
Athens, GA	**263**	**2.9**	**7**
Louisiana	252	2.8	19

Most current intensive-pine-plantation management practices are aimed at short-rotation production of fiber. Intensive practices enable current 20 to 25 year pulpwood rotations to be reduced to 12 to 15 years or less, while producing the same fiber volumes. Projections indicate that intensive-pine-plantation management practices could produce a sustainable level of our current annual fiber supply on 70 percent of the current land base now in forest production. Chip-n-saw and sawtimber production may be achieved by careful application of fertilizers and pruning to meet wood quality standards. Increased per acre production results in more efficient land use. While intensive management requires relatively large per acre capital investment, more management activity and more landowner choices, returns are attractive. Demand for fiber stumpage, competition among the 16 pulp/paper mills in the state results in attractive stumpage prices to the landowner.

General Concepts of Intensive Management

Intensive management is a package of treatments designed to enhance pine plantation production throughout an entire rotation. Key features include:

- **Site preparation** to clear debris from the planting site, control residual vegetation, and to improve soil rooting volume;
- **Herbicide treatments** to control woody and herbaceous weeds; and,
- **Fertilization** to correct inherent site nutrient limitations and provide adequate nutrition for trees to achieve growth potential.

Site preparation treatments and costs can vary widely depending on site conditions. On cut-over sites, combinations of mechanical and chemical treatments are usually necessary to remove debris to facilitate soil cultivation and planting operations, and to control established woody competition. When residual trees and brush are present on a site following harvest, shearing, raking and spot piling may be required before subsequent treatments are applied. When debris loads are moderate to light, soil tillage treatments can be applied using tractors with ”V“ blades to move debris out of the

1998. The Entomology and Forest Resources Digital Information Work Group, College of Agricultural and Environmental Sciences and Warnell School of Forest Resources, The University of Georgia, Tifton, Georgia 31793 U.S.A. BUGWOOD 98-002
http://www.bugwood.caes.uga.edu/

planting row. Productivity on sites with soils that are compacted and/or eroded can be enhanced by soil tillage to increase available rooting volume. Combination or subsoil plows can be used to subsoil or to shatter compacted hardpans, and to disk the planting row to improve soil tilth and rooting volume. Tillage treatments should be carefully placed along contours on upland sites to minimize erosion.

Figure 1. Piedmont site prepared with a combination plow, subsoil/disk/bed to increase rooting volume.

Bedding plows are typically used to create raised planting beds on flatwoods sites with poor surface drainage, usually after shearing and piling. Planting on beds allows newly planted seedling roots to remain above seasonally high standing water to increase survival and early season growth.

Herbicide treatments to control woody and herbaceous vegetation is the most important factor in accelerating pine plantation growth. Mechanical site preparation treatments may leave a site looking weed free, but seldom provides long term residual control. Herbicides are necessary to effectively reduce weed competition in intensively-managed sites. At site preparation, control of established woody vegetation is critical. Recently cut-over sites need ample time for sprouts to flush before herbicides are applied to maximize uptake by the vegetation. Most site preparation herbicide treatments are applied in early to mid summer where leaf surface of the hardwoods is greatest. Following treatment, the vegetation is allowed to "brown up" and then a broadcast prescribed burn is done.

Following planting, herbaceous weed control is necessary to provide a rooting zone free of broadleaf weeds and grasses. Treatments may be banded over the planting row or broadcast over the site. Repeat treatments are recommended in the second year. Weed development must be monitored in the stand, paying particular attention to woody sprouts or seedlings that may become established. If competing sprouts and seedlings become established, they can be controlled with a woody release herbicide treatment applied in mid-rotation.

Fertilization is used to provide adequate nutrition during all phases of establishment and growth. Phosphorus may be deficient on wet sites as well as on some uplands. If a soil test indicates availability of less than 2 pounds of P per acre, apply 40 to 50 pounds of elemental P during site preparation or planting. Triple superphosphate, or ground rock phosphate (on acid soils) are commonly used. Phosphorus applied at planting gives a 15 to 20 year growth response averaging 50 cubic feet of volume per acre per year (assume 90 cubic feet to a standing cord).

The nitrogen demand of newly planted seedlings is low and soil reserves can usually meet seedling demands, particularly on cut-over sites that have N available through the breakdown of logging debris. If N is added at planting in the form of diammonium phosphate, broadcast herbaceous weed control treatments will reduce growth of competing vegetation.

Nitrogen demand increases in excess of site supply, as the seedlings reach age 3 to 5 years. At this time N or N + P fertilization is necessary in order to keep/promote adequate leaf (needles) surface area required for rapid growth. Broadcast applications of 175 to 200 pounds of elemental N and 25 pounds of elemental P are typically applied per acre. Urea (46-0-0) + diammonium phosphate (18-46-0; supplies 20% elemental P) are typically used in this application. Additional N is needed as tree size increases requiring fertilization to be repeated at 4 to 5 year intervals to maintain growth rates.

Site preparation, use of herbicides, and fertilization are the most important factors in an intensive management program. Other considerations include species selection, with loblolly pine most commonly grown for pulp production. Slash pine is also suited for intensive management with some growers preferring slash for operations that may shift into chip-n-saw and sawtimber production. Common planting densities range from 600 to over 700 trees per acre. Thinning and pruning may be used in stands managed for solid wood products.

Some industrial operations also control insect damage, primarily Nantucket pine tip moth, which feeds in the shoots of loblolly pine. While tip-moth infestations can be severe enough to cause growth loss, control requires multiple insecticide sprays during the growing season to prevent infestations from the 3 to 5 moth generations that occur through the season. Treatments on private nonindustrial sites may be cost effective in the first and second growing seasons. Once the trees reach 10 feet in height, infestations and damage is minimal.

Production Scenarios

To date, most intensively managed pine plantations are set up to produce fiber on short rotations. Intensive site preparation, weed control and multiple fertilizer applications are commonly used to increase volume production on short rotations.

Pulp production

- Mechanical and chemical site preparation (fertilize with P if required)
- Planting density range of 600 to 700+ trees per acre
- Apply herbaceous weed control following planting and again in year 2
- Fertilize with N + P beginning at age 2 to 6, and repeat at 4-year intervals
- Harvest at 12 to 15 years
- Tip-moth treatments in loblolly pine stands may be an option in years 1 and 2.

Figure 2. Intensively managed loblolly pine - 1st growing season.

Figure 3. Intensively managed loblolly pine - 2nd growing season.

Figure 4. Intensively managed loblolly pine - 3rd growing season.

Figure 5. Intensively managed loblolly pine - 4th growing season.

Chip-n-saw and sawtimber production may be possible by modifying treatments to produce trees with acceptable wood quality properties. Delay of initial fertilization, and fertilization following thinnings in combination with pruning can produce trees with acceptable wood quality for solid wood products. Pruning is used to produce logs in short rotations that yield knot-free lumber. The goal is to develop a clear 16-foot log which requires pruning to 17 feet to allow for stump height. In order to maintain growth, a 35 to 40 percent live crown (relative to total tree height) must be maintained following pruning. The live crown is measured from the lower green branches to the top of the tree. Pruning can be done in two steps beginning at age 5 to 8 to clear the first 8 to 10 feet of bole, and then completed following the first thinning to 17 feet. Generally, 150 crop trees per acre are selected for pruning.

Chip-n-saw & sawlog production

- Mechanical and chemical site preparation (fertilize with P if required)
- Planting density range of 600 to 700+ trees per acre
- Apply herbaceous weed control following planting and again in year 2
- Fertilize with N + P at age 5 to 8 years (option: begin pruning to an 8 to 10 foot clear bole)
- Thin and fertilize with N + P at age 12 to14 years (option: prune 150 crop trees per acre to a 17 foot clear bole)
- Thin and fertilize with N + P at age 17-20
- Clearcut at 22-25 years.

Intensive Management Costs

Relative to standard pine plantation management, intensive management costs are high. The following costs represent a short rotation pulpwood scenario established on a cut-over site. Reforestation expenses, including cost of initial site preparation, including mechanical and chemical treatments, seedlings and planting, and herbaceous weed control, can be charged fully for the year incurred but receive a 10-percent investment credit and a seven-year amortization schedule to recover 95-percent of the cost. A maximum of $10,000 annually of reforestation expenses can be claimed in this category. Reforestation amounts in excess of $10,000 annually can be capitalized and carried over the length of the rotation in a timber depletion account. Costs of herbaceous weed control and fertilization treatments, subsequent to establishment can be expensed out in the year **they occur when the landowner qualifies as an active participant in forest production.**

Table 2. Costs of intensive management practices they occur when the landowner qualifies as an active participant in forest production for a 14-year pulpwood rotation.

Year	Treatment	Cost ($/acre)
0	Site preparation	200
1	Planting	80
1	Herbaceous weed control	50
2	Fertilization	75
2	Herbaceous weed control	50
6	Fertilization	75
10	Fertilization	75
	Total	**605**

Because per acre volume is increased and rotation length is decreased, attractive financial returns can be realized.

Table 3. Bare land values[1] in $ per acre for a 14 year intensive management rotation (Table 2.) at three yield ranges and three pulpwood stumpage values.

Stumpage value ($/cord)	Mean Annual Increment Yield Range: Low 3.1 cords/acre/year	Medium 3.5 cords/acre/year	High 3.9 cords/acre/year
	----------------------**Bare Land Value** ($/acre)---------------------------		
40	452	675	860
45	656	906	1,115
50	860	1,138	1,370

[1] Bare land value is calculated as the net present worth of perpetual repetitions of the investment

Opportunities to Reduce Costs

Many nonindustrial private landowners are interested in intensive management, but may find the high costs prohibitive. Costs can be reduced, while maintaining productivity, by careful site and stand selection. Old-field sites can be established at lower initial costs than cut-over sites. Fallow fields and marginal cropland are excellent sites to establish plantations at relatively low costs. On these sites the lack of established woody vegetation, logging debris and the ease of soil tillage treatments allow mechanical and chemical site preparation costs to be significantly reduced. Weed competition can be controlled by less costly herbaceous herbicide treatments. Often old-field sites have a moderate to high level of residual fertility resulting from past cropping activities.

Advantages of pine plantation establishment and management on old-field sites have been demonstrated in the Conservation Reserve Program, which supported establishment of pine plantations on marginal cropland. Dramatic growth increases, from use of genetically improved seedling and herbaceous weed control, have been observed in CRP plantations over old-field stands established in the 1960’s and 1970’s. Growth increases for 20-year unthinned loblolly pine on CRP sites, as compared to previously established old-fields from 1960-1970’s, are presented in Table 4 along with financial returns in Table 5.

Table 4. Planted old-field Conservation Reserve Program pine wood-flow projections for 20-year, unthinned loblolly pine in Georgia.

	Harvested Cords			
Site Productivity	**Old Model[1]**	**New Model[2]**	**Change**	**Percent**
Low	37	46	+9	24
Medium	43	51	+8	18
High	49	56	+14	14

[1] Yield from stands planted in 1960's - 1970's.
[2] Yield from CRP stands 1985-1992.

Overall, controlling woody and herbaceous competition alone has given the greatest consistent growth responses. If you have to prioritize treatments with limited dollars to invest, be sure that an effective weed control program is implemented. Fertilization is a secondary priority, unless P is needed at planting on deficient sites. Many CRP stands can be managed using the chip-n-saw & sawlog production scenario previously described.

Table 5. Planted old-field pine financial performance projections for 20-year, unthinned loblolly pine pulpwood rotations in Georgia[1]. Values in parenthesis are old model estimates.

Site Productivity	**NPW[2] $/acre**	**IRR[3] %**	**AEV[4] $/acre/year**
Low	332 (94)	15.8 (11.3)	34 (10)
Medium	410 (147)	16.7 (12.6)	42 (15)
High	499 (209)	17.7 (13.8)	51 (21)

[1] 8% discount rate; 1986 Prices: PW = $25/cord, C-N-S = $44/cord, ST = $164/MBF (PW inflated at 3.5% per year, ST inflated at 4.0% per year); 1997 Price-equivalents: PW = $35/cord, C-N-S = $62/cord, ST = $243/MBF.
[2] Net present worth is calculated with revenues discounted to present year less costs discounted to present year at an 8% discount rate. A net present worth value greater than zero indicates that at least the discount rate is being earned on the investment.
[3] Internal rate of return is the interest rate at which discounted revenues equal discounted costs. It assumes that all intermediate revenues are reinvested into the project. A project is considered profitable if the internal rate of return exceeds the discount rate.
[4] Annual equivalent value is the net present worth expressed as an annuity over the planning horizon, computed at the discount rate. Annual equivalent value is a useful measure for comparing investments over unequal time periods.

Intensive Management Wood Quality Issues

To date, the rapid production of fiber for pulp manufacturing has been the focus of most intensive pine plantation management efforts. While tree diameters may meet the size requirements for chip-n-saw and perhaps small sawtimber by 10 to 15 years, the quality of rapidly-grown wood will not meet current standards for solid wood products. Production of chips from rapidly grown stands for use in composite panels will likely increase. However, there will be markets for solid/sawn lumber in the foreseeable future for high-end appearance-grade products, such as paneling, molding, furniture and other "luxury" items. Because of the impression of high quality and durability implied by the term "solid wood", and because many composite products do not provide a very "satisfying" appearance, composite products will not be able to fill these markets for a long time, if ever.

Solid/sawn products will have markets in the foreseeable future for the majority of construction-lumber in sizes from 2x2 through 2x12, and 4x4 through 6x6 posts. Because of processing costs and adhesives prices, composite products will probably not be price competitive with such solid/sawn material for a long time, if ever.

Nominal 2" thick dimension lumber when dressed/dried is actually only 1 ½" thick. Very fast-grown trees produce ring widths that can result in lumber with high proportions of very low density earlywood (EW) on faces exposed to high stress and/or wear. Such lumber can fail to provide expected performance even when matching criteria for a particular grade. It may also have nailing surfaces that consist predominately of low-density EW which can **not** provide holding power of higher-density wood.

Much lumber from fast-grown timber comes from juvenile-wood, with its lower proportions of latewood (LW), which is lower density than mature LW. Large fibril angles in juvenile-wood cells also cause more longitudinal shrinkage and consequently greater risk of severe warping than mature wood. Finally, low proportions of cellulose in juvenile wood affect its performance in ways not necessarily reflected in lumber grades.

Solid/sawn product requirements

- Large pith-centered solid/sawn products, such as timbers nominally 4" thick and larger, are often used as treated posts, supporting predominately vertical loads in exposed locations. Such products from intensively managed timber stands will consist mainly of juvenile wood. **Maximum growth ring width** should be **½"** (2 rings per inch) **for no more than the first 4 rings** (maximum 4" diameter of these wide rings). **The proportion of LW** (%LW) **in these wide rings must be at least 1/6** (approx. 15%) **total ring width**. Beyond the center 4 rings, **average ring count** should be **no less than 4 rings per inch (rpi)** with **LW proportion at least 1/4 ring width** (25%).

- For solid/sawn lumber 2" or less thick from intensively managed timber stands, **average ring width** should be **no more than 1/4"** (ring count 4 rpi or more) with **maximum ring width of 1/3"** (3 rpi) **occurring in no more than 1/4 the volume of a piece**. **Average latewood proportion** should be **no less than 1/4 ring width** (25%).

- **Average specific gravity (SG) for solid sawn construction lumber and timbers** from intensively managed timber stands should be **no less than .45 (28 lbs./cu.ft.), based on oven-dry (OD) volume**.

- **Maximum branch/knot size on 2 of 4 "faces"** (a grading surface extending the entire height of the log and 1/4 the circumference of the tree) **on the first 16' log** in trees of intensively managed timber stands, should be **no greater than 2"**.

References

Anonymous. 1994. Voluntary Product Standard PS 20-94, American softwood lumber standard. Developed under procedures published by the Department of Commerce in Part 10, title 15, of the Code of Federal Regulations. The American Lumber Standard Committee. 35p.

Borders, B.E., and R.L. Bailey. 1997. Loblolly pine - pushing the limits of growth. Consortium on Accelerated Pine Production Studies, Warnell School of Forest Resources, The University of Georgia. Tech. Rep. CAPPS 1997-1. 9 p.

Campbell, R.A. 1962. A Guide to grading features in Southern pine logs and trees. USDA Forest Service, SE For.Expt.Sta. Station Paper No.156. 22 p.

Dangerfield, C.W, Jr., and D.J. Moorhead. 1997. Revised modeling used to evaluate impacts of management and rotation on wood-flow and profitability from Conservation Reserve Program pine plantations in Georgia. Proceedings 27th Southern Forest Economics Workshop, Little Rock, AR. 5 p.

Pienaar, L.V., and J.W. Rheney. 1996. An evaluation of the potential productivity of intensively managed pine plantations in Georgia. Georgia Consortium for Technological Competitiveness in Pulp and Paper Technology - Fiber Supply. Final Report. 33 p.

Southern Pine Inspection Bureau. 1991. Standard grading rules for Southern pine lumber. Southern Pine Inspection Bureau. 134 p. +66 p. Appendixes.