# SPECIES COMPOSITION, TREE QUALITY AND WOOD PROPERTIES OF SOUTHERN PINE STANDS UNDER ECOSYSTEM MANAGEMENT ON NATIONAL FORESTS IN THE PIEDMONT AND COASTAL PLAIN

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## ABSTRACT

National Forests in the United States are under sustainable ecosystem management to conserve biodiversity, achieve sustainable conditions and improve the balance among forest values. This paper reports on a study established to identify the implications of ecosystem management strategies on natural stands in the Piedmont and Coastal Plain. The impact of partial harvests, group selections, seed tree cuts and no human disturbance on species composition, wood properties and tree quality of pine stands in the Piedmont and Coastal Plain is described.

## INTRODUCTION

National Forests in the united States are now under sustainable forest ecosystem management to improve the balance among forest values, conserve biodiversity, and achieve sustainable, healthy, productive forest lands while retaining the esthetic, historic, and spiritual qualities of the land. Under sustainable ecosystem management pine and pine/hardwood stands on National Forests in the Piedmont and the Coastal Plain are being converted from evenage monocultures to unevenaged or two-aged pine and mixed species stands.

The Piedmont physiographic region of the southeastern United States was extensively cleared for cotton and other row-crop production in the eighteenth century. By the 1930's, most topsoil had eroded and productive cultivation was difficult. Thus, in the 1930's the Federal government purchased abandoned farm land later included in the National Forest system. National Forest lands account for only 2 percent of the timberland in the Piedmont. Under Forest Service management this land now supports productive forests. Currently, Piedmont National Forests contain 58 percent of their growing stock in pine, 3 percent in other softwoods, 18 percent in soft hardwoods, and 21 percent in hard hardwoods. The majority of stands are natural even aged pine or pine/hardwood stands.

National Forest land in the Gulf and Atlantic Coastal Plain was either abandoned farm land or cut-over forest land that was also purchased by the Federal government in the 1930's. Today, the National Forests in the Coastal Plain account for less than 4 percent of timbered land, contain 63 percent of their growing stock in pine, 12 percent in other softwoods, 20 percent in soft hardwoods, and 5 percent in hard hardwoods.

This paper reports on a study established to monitor the effects of sustained ecosystem management on loblolly (*Pinus teada* L.) and shortleaf (*P. echinata* Mill) pine stands in the Piedmont and longleaf pine (*P. palustris* Mill) in the Coastal Plain of the Southeast. The impacts of partial harvests, group selections, seed tree cuts and no human disturbance on species composition, wood properties and tree quality are reported.

## PROCEDURES

A series of permanent measurement plots have been established in loblolly/shortleaf pine stands in the Piedmont on the Oconee, Sumter and Uwharrie NF and in the longleaf pine stands in the Coastal Plain on the Apalachicola and Conecah NF to monitor the response of these stands to an array of ecosystem management practices. The management practices included: (1) partial cuts, (2) group selection cuts, (3) seed tree cuts and (4) reserve areas. Included in the partial cuts are single tree selection, salvage cuts, stand improvement cuts and shelterwood cuts. Reserve areas are stands in which no human disturbance is planned. Each monitoring plot is a cluster group (CG) consisting of three 0.08 hectare circular plots and is randomly located within each stand selected for monitoring. Cluster groups are inventoried at establishment, then prior to and following harvest treatments. Cluster groups will also be inventoried every five years and after any natural disturbances. Cluster groups were established in stands representative of five 20-year age classes (1, 20, 40, 60, and 80 years) and two broad site-index (SI) classes SI $< 24$ and SI $\geq$ 24 in the Piedmont and SI $\leq 21$ and $> 21$ in the Coastal Plain for each management practice.

On each 0.08 hectare plot all trees $\geq 12.7$ cm in diameter at breast height (d.b.h.) were located by azimuth and distance from plot center. Species, d.b.h., total height, merchantable height, crown class, tree grade and defect indicators were recorded for each live and dead tree. Five 0.0013 hectare micro-plots were located 9.1 meters from plot center at 72° intervals within each 0.08 hectare plot to tally seedling and saplings. Seedlings (trees up to 2.54 cm d.b.h. were tallied by species count. Saplings (trees 2.54 cm to 12.7 cm d.b.h.) were tallied by species, d.b.h. and total height. Softwoods 12.7 cm to 22.6 cm d.b.h. and hardwoods 12 .7 to 27.7 cm d.b.h. were classified as pole timber. Softwoods $\geq$ 22.9- and hardwoods $\geq$ 27.9-cm d.b.h. were classified as sawtimber if they contain one or more 4.9 m sawlog. Pine sawtimber trees were classified using a tree classification system for natural pine developed by Clark and McAlister (1) and hardwood sawtimber trees were classified using USDA Forest Service hardwood tree grades (3). The sawtimber pine trees were classified based on size and frequency of branches, bole straightness and other visual defect indicators. The pine classification system placed a tree into one of three grades where lumber yield would be expected to meet the following specifications:

Grade 1: Tree of high quality which would yield $\geq$ 40% No.1 & BTR lumber
Grade 2: Tree of average quality which would yield $\geq$ 20% but $\leq$ 40% No. 1 & BTR lumber
Grade 3: Tree of below average quality which would yield $<$ 20% No. 1 & BTR lumber

Increment cores (5 mm in diameter) for wood properties analysis were extracted from bark to pith 1.4 meters above ground from four trees in each 0.08 hectare plot. The largest diameter pine in 90° sectors in each plot was selected for boring. A total of 942 trees were bored. Increment cores were analyzed to determine tree age, earlywood and latewood annual radial growth and amount of juvenile wood, sapwood and heartwood at breast height. Species diversity and evenness were calculated using Shannon's indices of diversity and evenness based on species stem counts. (4).

## RESULTS

### SPECIES COMPOSITION

A high proportion of Americans now want the values for managing National Forests to be water preservation, improved wildlife habitat, and increased recreation, rather than managing to increase timber for commodity consumption. To achieve these values increased species richness, diversity and evenness are important. The average stems per hectare, species diversity, richness, and evenness by management practice for the natural pine stands sampled in the Piedmont and Coastal Plain are shown in tables 1 and 2, respectively. Average number of stems per hectare for seedlings, saplings, and pole and sawtimber was highest in the reserve stands and lowest in the seed tree cuts in the Piedmont. Species richness, diversity and evenness were lower in the Coastal Plain stands than in the Piedmont stands. In the Piedmont natural stands the three most abundant species in the seedling class were red maple (*Acer rubrum* L.) (18 percent),

loblolly pine (15 percent), and sweetgum (*Liquidambar styraciflua* L.) (13 percent). In the sapling class, the most abundant species were sweetgum (25 percent), loblolly pine (18 percent) and dogwood (*Cornus florida* L.) (11 percent). The most abundant species in the pole and sawtimber class were loblolly pine (57 percent), sweetgum (13 percent) and shortleaf pine (6 percent).

The three most abundant species in the pole and sawtimber class in the Coastal Plain were longleaf pine (84 percent), slash pine (*P. elliottii*) (6 percent) and flowering dogwood (2 percent). Longleaf pine (52 percent), southern red oak (*Quercus falcata* Michx. var. *falcata*) (8 percent) and scarlet oak (*Q. coccinea* Muenchh) (6 %) were the most abundant species in the sapling class. Sassafras (*Sassafras albidum*) (9 percent), water oak (*Q. nigra* L.) (7 percent) and flowering dogwood (6 percent) were the most abundant species in the seedling class in the Coastal Plain.

| Characteristic | Management practice | | | |
|---|---|---|---|---|
| | Partial cut[a] | Group selection[a] | Seed tree | Reserve |
| | ----------Number---------- | | | |
| Stands sampled | 28 | 2 | 7 | 4 |
| Seedlings (trees <2.45 cm. d.b.h.) | | | | |
| stems/hectare | 37, 045 | 30, 171 | 26, 375 | 71, 560 |
| Richness | 19 | 16 | 18 | 20 |
| Diversity | 1.9 | 1.8 | 2 | 1.6 |
| Evenness | 0.7 | 0.7 | 0.7 | 0.6 |
| Saplings (trees ≥2.45<12.4 cm. d.b.h.) | | | | |
| Stems/hectare | 1, 102 | 1, 260 | 855 | 1, 557 |
| Richness | 5 | 4 | 3 | 7 |
| Diversity | 1.2 | 0.7 | 0.6 | 1.4 |
| Evenness | 0.8 | 0.6 | 0.5 | 0.7 |
| Pole and sawtimber (trees ≥12.7 cm. d.b.h.) | | | | |
| Stems/hectare | 378 | 284 | 77 | 469 |
| Richness | 8 | 6 | 4 | 10 |
| Diversity | 1.2 | 1.1 | 0.8 | 1.4 |
| Evenness | 0.8 | 0.6 | 0.5 | 0.6 |

[a] Stand conditions before harvest.

Table 1. Average stems per hectare, species richness, diversity, and evenness for seedlings, saplings, and pole and sawtimber by management practice for natural stands in the Piedmont

| Characteristic | Management practice | | |
|---|---|---|---|
| | Partial cut[a] | Group selection | Reserve |
| | ----------Number---------- | | |
| Stands sampled | 15 | 4 | 6 |
| Seedlings (trees <2.45 cm. d.b.h.) | | | |
| Stems/hectare | 36, 857 | 58, 785 | 65, 037 |
| Richness | 13 | 6 | 10 |
| Diversity | 1.6 | 1.0 | 1.3 |
| Evenness | 0.7 | 0.6 | 0.6 |
| Saplings (trees ≥2.45<12.4 cm d.b.h.) | | | |
| Stems/hectare | 378 | 49 | 519 |
| Richness | 2 | 1 | 3 |
| Diversity | 0.5 | 0.2 | 0.7 |
| Evenness | 0.4 | 0.2 | 0.5 |
| Pole and sawtimber (trees ≥12.7 cm. d.b.h.) | | | |
| Stems/hectare | 378 | 346 | 326 |
| Richness | 3 | 1 | 3 |
| Diversity | 0.6 | 0.1 | 0.3 |
| Evenness | 0.4 | 0.1 | 0.2 |

[a] Stand conditions before harvest.

Table 2. Average stems per hectare, species richness, diversity, and evenness for seedlings, saplings, and pole and sawtimber by management practice for natural stands in the Coastal Plain.

## WOOD PROPERTIES

Managing National Forests for threatened and endangered (T&E) species habitat is the most important factor considered by forest managers. On National Forests managing for red-cockaded woodpecker (Picoides boreales) (RCW) habitat the effect of management practice, site productivity and tree characteristics on heartwood formation are important. The RCW, a T&E species, requires a minimum of 12.7 cm of heartwood at cavity height to envelop the nesting cavity. One result of this long-term study will be increased knowledge on how and where forest mangers can expect to find increased heartwood for RCW cavity habitat.

Regression equations developed by Clark (2) were used to estimate heartwood diameter at 6.7 m based on d.b.h, tree age and heartwood diameter at 1.4 m determined from increment cores collected on each study plot. Study results confirm that the diameter of heartwood at cavity height (6.7 m) increases not only with tree age but with site productivity. The proportion of trees bored that had ≥ 12.7 cm of heartwood at 6.7 m was higher for loblolly and shortleaf pines in the Piedmont growing in stands with SI ≥ 24 and higher for longleaf pines in the Coastal Plain growing in stands with SI ≥ 21. No pines in Piedmont or Coastal Plain under 50 years of age had sufficient heartwood at 6.7 m for RCW cavities. This indicates that managers should concentrate RCW recruitment activities not only in older stands but also in high-productivity sites.

## TREE QUALITY

The straightness of a tree bole and size and frequency of branches are strong indicators of the value of a tree for commodity products. The proportion of pine basal area per hectare in grade 1, 2, or 3 sawtimber trees, pulpwood and standing dead is a good measure of a stand's ecological and commodity value (figures 1 and 2). On average the proportion of pine stand basal area in the Piedmont in pulpwood trees decreased and proportion in grade 1 trees increased significantly with increasing stand age (figure 1). The proportion of pine basal area per hectare in grade 2 trees and dead standing trees increased slightly and proportion in grade 3 trees remained relatively constant with increasing stand age. In the Coastal Plain (figure 2) the change in proportion of pulpwood and sawtimber by tree grade with stand age was similar to that of the Piedmont. However, the proportion of grade 1 sawtimber was only about half that for grade 1 trees in the Piedmont. The Coastal Plain plots contained almost no standing dead trees.

The impact of harvest operations on volume of trees cut and harvested, cut and not removed, accidentally downed in harvest, and the health of the residual stand are important. After monitoring plots were established in the natural pine stands seven of the stands were harvested using some type of partial cut, two harvested using group selection, and four harvested using seed tree cut. The monitoring plots were remeasured following this tree length harvesting. In the partial cuts in the Piedmont stands only 1 percent of the basal area marked was cut and not harvested, 1 percent was pushed down during harvest, 65 percent was left standing healthy, but 7 percent of the initial basal areas or 11 percent of the residual timber contained logging damage (table 3). In the Piedmont group selection cuts, 5 percent of the initial stand basal area marked was cut but not removed. This increase in volumes of trees cut and not removed was because the feller-bunches felled all the trees in the hectare opening into a crisscross pile and then the skidder removed the felled trees. When operating in these small openings it appears best to cut and skid a portion of the trees at a time.

In Piedmont stands marked for seed tree cuts, none of the marked trees were cut and not removed, 3 percent of the original basal area was pushed over during the harvest and 25 percent of the initial basal area was left standing and healthy. However, 5 percent of the initial basal area or 16 percent of the residual standing timber contained logging damage.

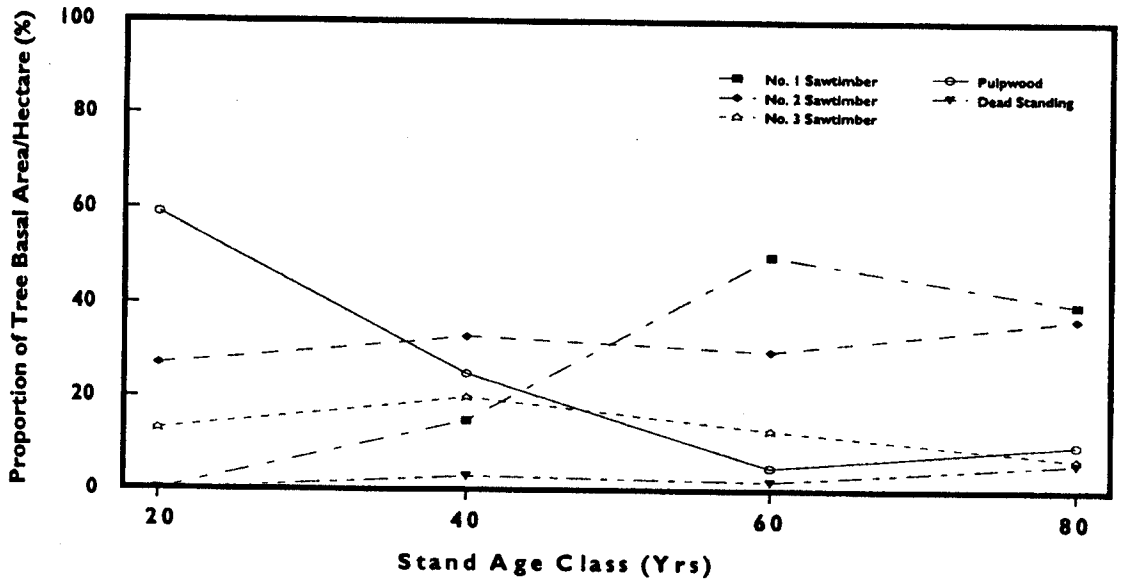


Figure 1. Effect of stand age on proportion of pine basal area/hectare in grade 1, 2, and 3 sawtimber, pulpwood and dead standing trees in natural pine stands in Piedmont (N = 54 cluster groups)

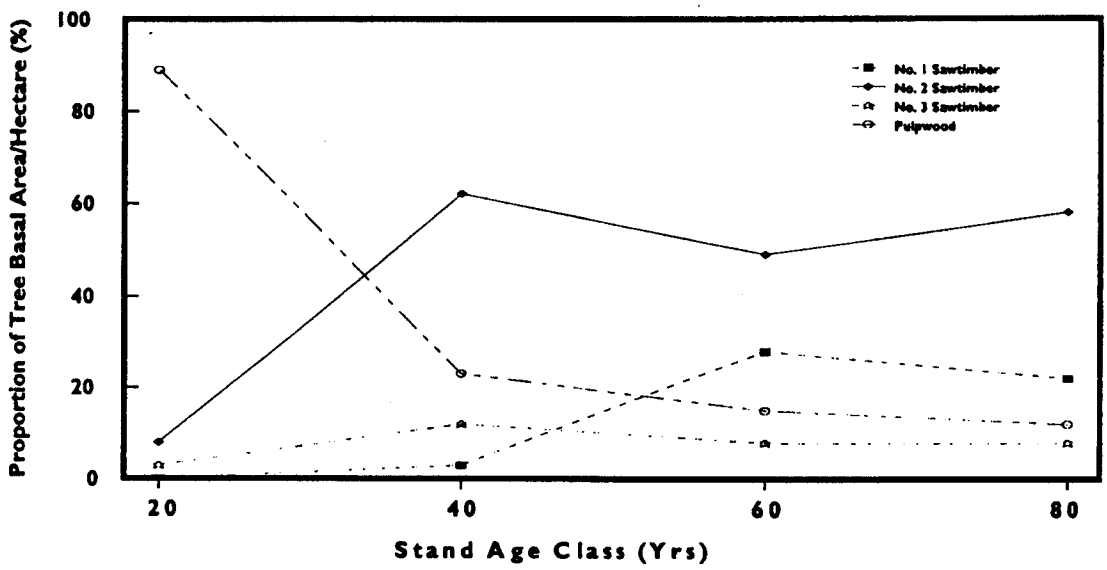


Figure 2. Effect of stand age on proportion of pine basal area/hectare in grade 1, 2, and 3 sawtimber and pulpwood in pine stands in the Coastal Plain (N = 28 cluster groups)

| Stocking Before Harvest | Trees Cut & Harvested | Trees Cut Not Harvested | Trees Down In Harvest | Residual Standing Healthy | Standing Logging Damage |
|---|---|---|---|---|---|
| $BA/H^{m2}$ | ----------%---------- | | | | |
| | | | Partial Cut (N = 7) | | |
| 7.3 | 26 | 1 | 1 | 65 | 7 |
| | | | Group Selection (N = 2) | | |
| 6.8 | 90 | 5 | 2 | 3 | 0 |
| | | | Seed Tree (N = 4) | | |
| 7.6 | 73 | 0 | 3 | 27 | 5 |

[1]Trees ≥ 12.7 cm d.b.h

[2]Tree length logging

Table 3. Proportion of initial stocking[1] harvested[2], cut & not harvested, down during harvest, residual standing healthy, and standing with logging damage by type of management practice for natural pine stands in Piedmont

## SUMMARY

This paper describes a research project established to monitor the effects of ecosystem management practices on species composition, wood properties and tree quality of natural loblolly/shortleaf pine stands in the Piedmont and longleaf pine stands in the Coastal Plain. Variation in species richness, diversity and evenness by management practice are described. The effect of tree age and site productivity on heartwood formation in the Piedmont and Coastal Plain for RCW cavity habitat is discussed. The impact for various management practices and tree length logging on proportion of basal area cut and not harvested, pushed over during harvest, and left standing with logging damage is discussed.

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