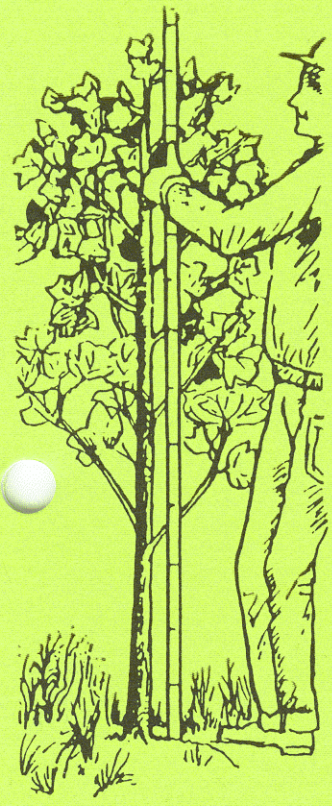

Occasional Report # 123
April 1995

White Pine Old-Field Plantation Yield Study

By Thomas A. Dierauf and John A. Scrivani

Virginia
Department of Forestry

White Pine Old-Field Plantation Yield Study

By Thomas A. Dierauf and John A. Scrivani

Introduction

White pine is the primary species planted in the mountains of Virginia. In recent years, planting in the foothills and piedmont has increased on sites where loblolly pine has usually been planted in the past. White pine occurs naturally in scattered locations in the piedmont and even in a few locations in the coastal plain. There are several reasons why white pine is encroaching on areas formerly considered loblolly country. Compared to loblolly pine, white pine is less susceptible to ice and snow damage, is less susceptible to bark beetle attack, does not require early thinnings for pulpwood, can be grown in longer rotations, and produces greater sawtimber yields. Pulpwood thinning of white pine is difficult to impossible to get done in Virginia, so it is fortunate that thinnings do not seem necessary. White pine expresses dominance very well and stand vigor does not seem to be adversely affected by high stand densities.

When old-field plantations reach an age of about 25, diameters are usually large enough that landowners begin to be approached by sawmillers trying to arrange a sale. In the southern mountains of Virginia, where the heaviest concentration of white pine occurs (most of it, of course, in natural stands), few plantations reach the age of 40 before they are harvested.

Over the past 30 years, we made a total of 112 measurements of 59 plots in 48 different plantations. The latest measurements on 41 of these plots, that were age 26 or older and never thinned, were used in an analysis of yields related to age and average height of dominant and codominant trees. Sawtimber volumes are based on a total height volume table constructed from 20 trees felled in each of five plantations. Site index curves were constructed from all 77 separate measurements on 24 plots that were measured from 2 to 5 times.

Plot Installation

Circular, $^1/_5$ acre plots were used, although in a few long, narrow plantations, we used rectangular , 1 by 2 chain plots. A buffer at least 2 rows wide occurred around each plot. Surviving pines had to be fairly well distributed with no unusually large openings. Plots were not established where excessive numbers of volunteer trees (not planted) occurred. Planted trees comprised at least 80 percent of total basal area in trees 3.5 inches DBH or larger, and most volunteers were considerably smaller than planted trees. Volunteers were both pines and hardwoods. Virginia pine, yellow-poplar, black locust, and black cherry were the most common volunteers.

The DBH of all living trees, both planted and volunteer, was measured to the nearest inch. A sample of tree heights in each DBH class was measured to the nearest

foot. The larger DBH classes were sampled more heavily. Heights of dominant and codominant trees were circled on the tally sheets. All living, dead, and "missing" trees were tallied. A missing tree was tallied where the planting spacing suggested that a tree had been planted, but no trace of a dead tree could be found. Plantation age was estimated by counting branch whorls where no reliable planting records could be found.

Construction of a Volume Table

A volume table, based on DBH and total height, was constructed using 100 trees from five different plantations (20 trees from each plantation). When selecting the 20 trees in each plantation, we tried to sample the full range of diameters, but made no attempt to select better or poorer than average trees. Log lengths were laid off in crayon, including a 6 inch trim allowance, using good, local, bucking procedures. Log lengths of 8, 10, 12, 14, and 16 feet were used, attempting to get the longer logs whenever possible. Diameters outside bark were measured to the nearest 0.1 inch at breast height and at the top of each log. Bark thickness was measured with a bark gauge at two points on opposite sides of the tree, and added together to get double bark thickness at the top of each log. The total height of each tree was measured with a steel tape to the nearest foot. Girard form class was measured on each tree. The volume of each log was calculated from a series of equations for the International $^1/_4$ inch rule[1], then summed up for each tree to get the total board foot volume of each tree.

Form class for the 100 trees ranged from 69 to 87 and averaged 80.9, with a standard deviation of 3.4 points.

Separate linear regressions of the form:

$$\text{Volume} = b_0 + b_1 (D^2H)$$

were fitted for the 20 trees of each of the five plantations. These separate regressions were not significantly different (Figure 1), and the data from all five plantations was combined. The combined prediction equation was:

$$\text{B.F. Volume} = -32.8854 + .0139315\ D^2H,\ r^2 = .983$$

A weighted linear regression was also fitted to the data, using the reciprocal of D^2H as the independent variable. This gave a slightly better fit based on Furnival's Index of Fit, and this was the equation we used to calculate plot volumes. The prediction equation was:

$$\text{B.F. Volume} = -30.367 + .013695\ D^2H$$

[1] A Collection of Log Rules, USDA Forest Service, General Technical Report FPL 1.

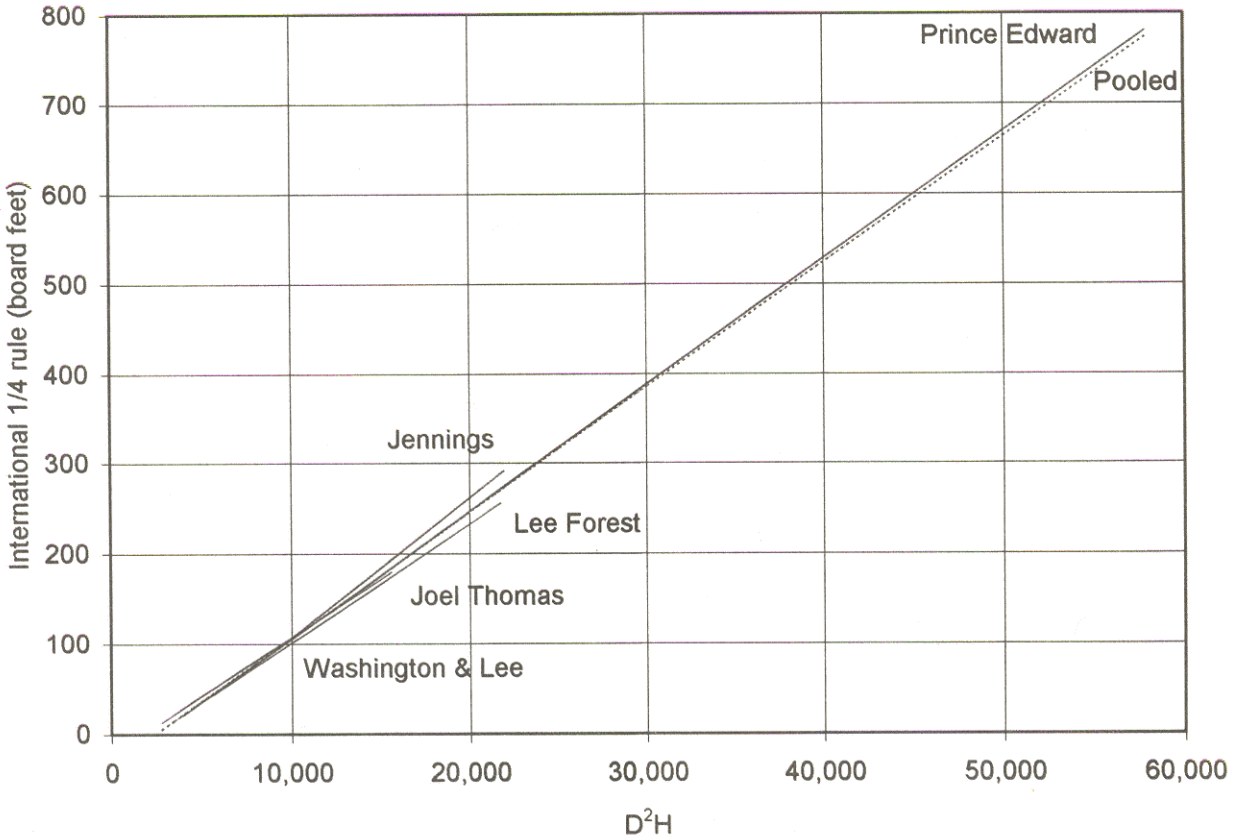

Figure 1. Tree sawtimber volume, 5 plantations.

Site Index

Whenever we measured a plot, we estimated site index using two different published site index curves, a curve by Vimmerstedt[2] for plantations and a curve by Beck[3] for natural stands, both developed from data collected in the southern Appalachians. Of the 59 plots, 24 were measured a second time, 13 were measured a third time, 12 were measured a fourth time, and 4 were measured a fifth time. These remeasurements showed that dominant and codominant trees on our plots were growing faster than Vimmerstedt's curves predicted but slower than Beck's curves predicted. In other words, as plantation age approached 50, estimates of site index increased using Vimmerstedt's curves and decreased using Beck's curves.

We constructed site index curves using 77 separate measurements from the 24 plots that were measured 2 or more times. Average dominant and codominant height

[2] Vimmerstedt, John P., 1962. Southern Appalachian White Pine Plantations - Site, Volume, and Yield. S.E.F.E.S. Station Paper No. 149.
[3] Beck, Donald E. 1971. Polymorphic Site Index Curves for White Pine in the Southern Appalachians. S.E.F.E.S. Research Paper SE-80.

for each of the 77 measurements were fitted to a nonlinear Richards growth function, yielding the equation:

$$\text{Site Index}_{50} = 0.616739\ (\text{Height})\ (1 - e^{-0.0233565\ \text{Age}})^{-1.29721}$$

The approximate nonlinear r^2 value was 0.992.

This equation was transformed to:

$$\text{Height} = 1.62143\ (\text{Site Index}_{50})\ (1 - e^{-0.0233565\ \text{Age}})^{1.29721}$$

to produce the site index curves shown in Figure 2. The height growth predicted by these curves is intermediate to the Vimmerstedt and Beck curves (Figure 3).

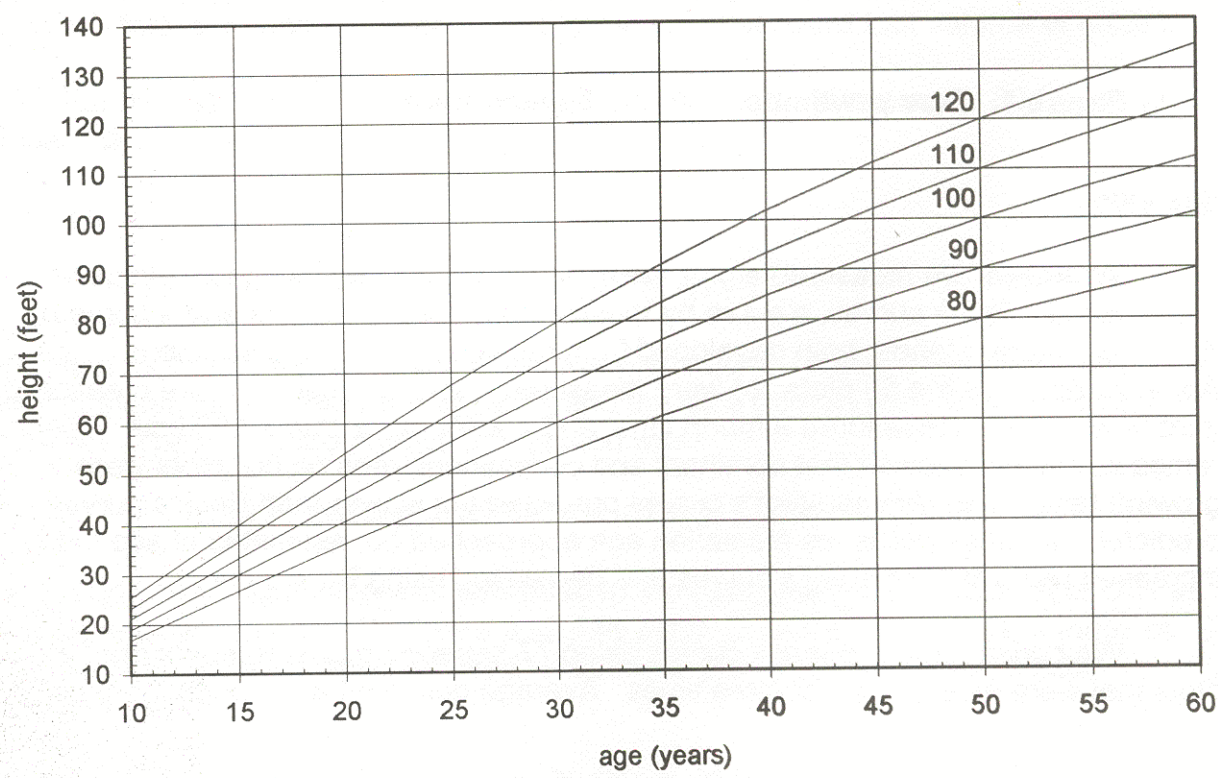

Figure 2. Site index/height growth curves, old-field white pine plantations, Virginia.

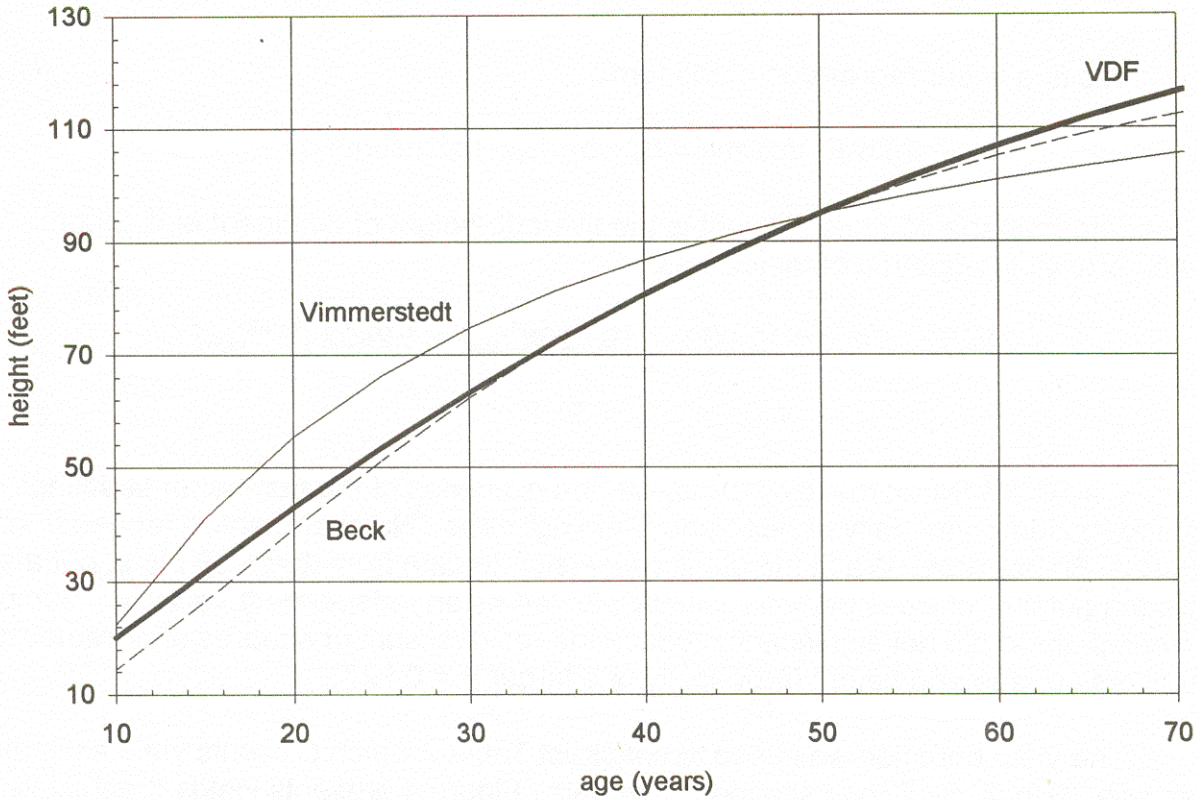

Figure 3. Comparison of site index curves from Beck , Vimmerstedt and this study.

Board Foot Yields

The last measurements (prior to thinning for plots that were thinned) of 41 plots in 30 different plantations were used in an analysis of sawtimber yields. No measurements less than age 26 were used, and the oldest measurement was 56 years. The distribution of these 41 plots by age and site index is shown in Table 1.

Table 1. Distribution of 41 yield plots by age and site index.

	Site Index (base age 50)					
Age	**80-89**	**90-99**	**100-109**	**110-119**	**120-129**	**Totals**
26-31	5	10	5	1	1	22
32-37	1	6	5	2	-	14
38-43	-	2	1	1	-	4
44-49	-	-	-	-	-	-
50-55	-	-	-	-	-	-
56	1	-	-	-	-	1
Totals	**7**	**18**	**11**	**4**	**1**	**41**

We fit a linear regression of the form:

$$\ln \text{B.F. Volume} = b_0 + b_1 \, {}^{1}/_{age} + b_2 \text{ height/age}$$

to the data from the 41 plots. Height is the average height of dominant and codominant trees. The yield equation obtained was:

$$\ln \text{B.F. Yield} = 11.039 - 119.820 \, ({}^{1}/_{age}) + 1.2402 \, ({}^{height}/_{age})$$

$$R^2 = .924$$

For all but two of these 41 plots, we had estimates of the number of seedlings planted, based on the tally of dead and "missing" trees. Number planted ranged from 425 to 1760 per acre. We fit the same regression to data from these 39 plots, but also included number of trees per acre initially planted as an independent variable. Number of trees planted did not significantly reduce the residual sum of squares after removing the effects of age and height (probability of a larger F = 0.827),

The yield equation was used to construct Table 2 which presents yield estimates from age 26 to 40 by 5-year site index intervals. Figure 4 presents yields graphically.

Table 2. Predicted board foot yields (in thousands) by age and site index.

	Site Index						
Age	**85**	**90**	**95**	**100**	**105**	**110**	**115**
26	6.6	7.6	8.8	10.1	11.5	13.3	15.3
27	7.8	9.0	10.3	11.8	13.6	15.7	18.0
28	9.1	10.4	12.0	13.8	15.8	18.2	20.9
29	10.4	12.0	13.8	15.8	18.2	20.9	24.0
30	11.9	13.7	15.7	18.0	20.7	23.7	27.2
31	13.4	15.4	17.7	20.3	23.2	26.7	30.6
32	15.1	17.2	19.8	22.6	26.0	29.8	34.1
33	16.7	19.1	21.9	25.1	28.8	33.0	37.7
34	18.4	21.1	24.1	27.6	31.6	36.1	41.5
35	20.1	23.0	26.3	30.2	34.5	39.5	45.2
36	21.9	25.1	28.7	32.8	37.5	42.9	49.0
37	23.7	27.1	31.0	35.3	40.4	46.2	52.8
38	25.5	29.1	33.2	38.0	43.4	49.5	56.6
39	27.3	31.2	35.5	40.6	46.4	52.9	60.5
40	29.1	33.3	37.9	43.3	49.3	56.3	64.2

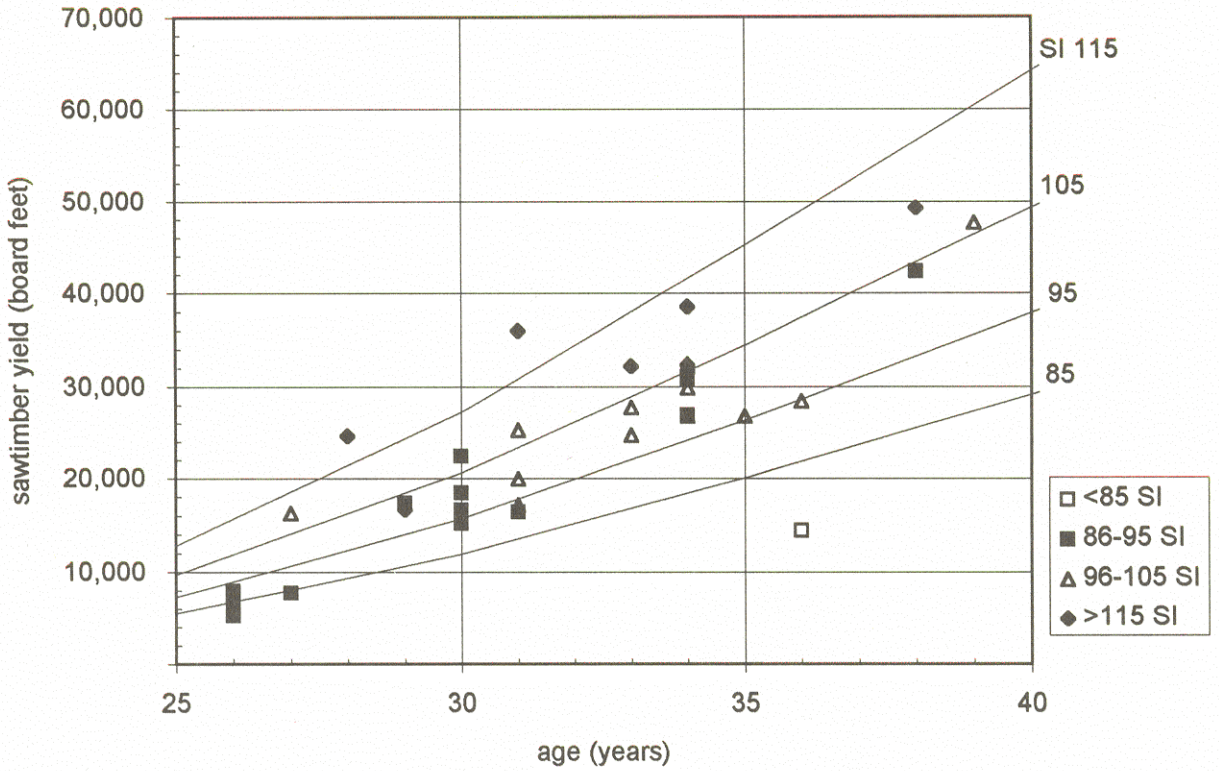

Figure 4. Sawtimber yields for 41 plots, age 26 and older.

Effect of Thinning on Yields

White pine stands can carry very high basal areas. Figure 5 is a plotting of basal area over age for the 41 plots used in the sawtimber yield analysis. The curve fitted to this data is the regression of basal area over the reciprocal of age. One plot had almost 300 square feet. Stand health and vigor does not seem to be adversely affected by such high density, and pulpwood thinning in white pine stands is extremely difficult to get done in Virginia.

We were able to arrange for a pulpwood thinning in 9 different plantations containing 13 plots. Nine of these plots were used in the analysis of sawtimber yields, using measurements made prior to thinning. We continued to measure these plots periodically following thinning. Thinning reduced basal areas considerably, and consequently reduced sawtimber yields. The yields of these 13 plots at ages ranging from 36 to 57 averaged only 64 percent of the predicted yields for unthinned plantations of the same age and site index, and the basal areas averaged only 62 percent of the predicted basal areas for unthinned plantations from the regression in Figure 5. Years since thinning ranged from 9 to 22 years and averaged 19 years.

Consequently, pulpwood thinning of young white pine plantations does not seem to be a good practice.

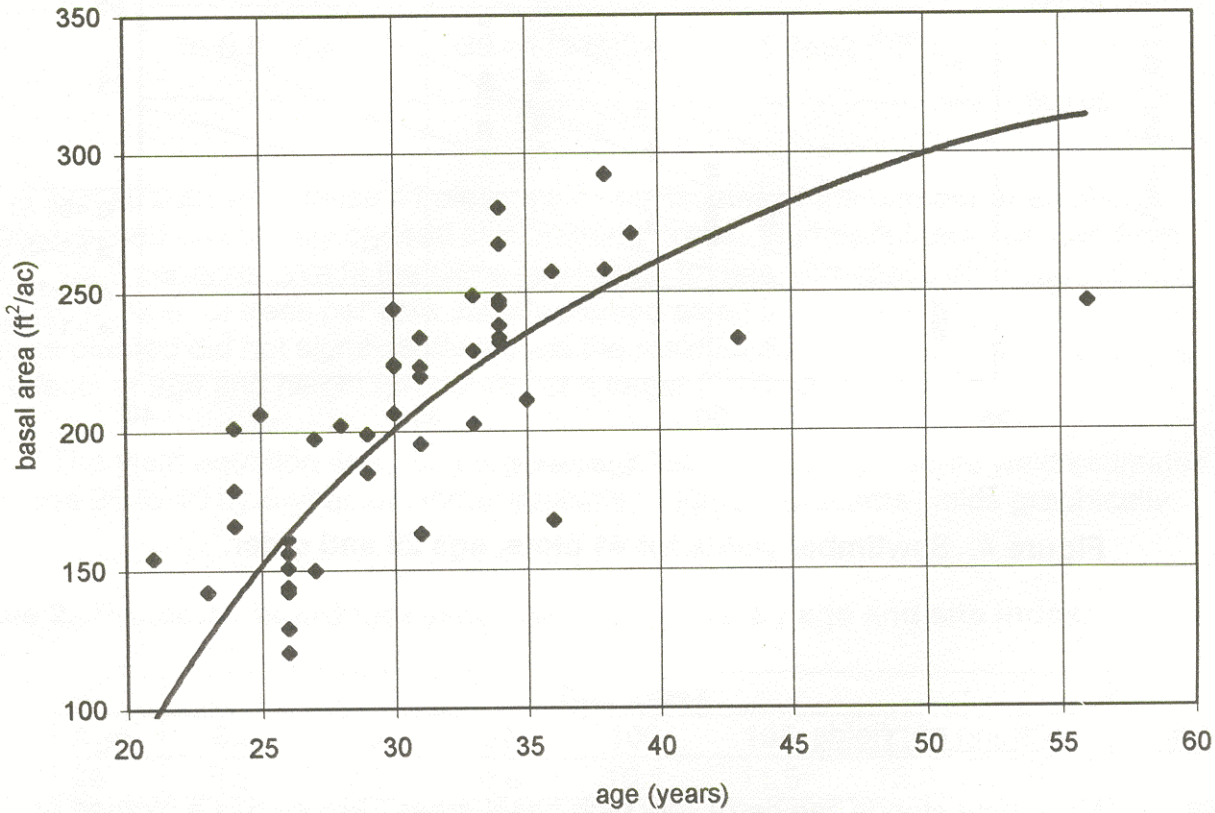

Figure 5. Basal area over age for 41 unthinned yield plots.