White Pine and Red Pine Volume Growth Under Uniform Shelterwood Management in Algonquin Provincial Park

1995

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ABSTRACT

This paper outlines the development and use of a compatible growth and yield model for red pine and white pine stands under a uniform shelterwood silvicultural system in the Algonquin Provincial Park. The model incorporates stand age, residual (postharvest) basal area, site index, composition index (proportion of pine basal area), and projected age as predictor variables for estimating residual gross merchantable pine volume and for projecting basal area and gross merchantable pine volume growth over a given time period. The results suggest that red pine and white pine stands in the park experience continually increasing volume growth for up to 25 years following uniform shelterwood harvesting over an age range of 40 to 130 years. The model is most suitable for making volume growth projections for periods of up to 25 years following uniform shelterwood harvesting.

RÉSUMÉ

Ce document décrit de façon succincte l'élaboration et l'utilisation d'un modèle compatible de la croissance et du rendement de peuplements de pins rouges et de pins blancs soumis à un régime sylvicole par coupes progressives uniformes dans le parc provincial Algonquin. Le modèle utilise l'âge du peuplement, la surface terrière résiduelle (postrécolte), l'indice de station, l'indice de composition (proportion de la surface terrière occupée par des pins) et l'âge projeté comme variables explicatives pour estimer le volume marchand brut résiduel de pin et prévoir la surface terrière et l'accroissement du volume marchand brut de pin pendant une période donnée. Les résultats permettent de supposer que les peuplements de pins rouges et de pins blancs du parc, lorsqu'ils sont âgés de 40 à 130 ans, connaissent un accroissement continu de leur volume au cours des 25 années postérieures à des coupes progressives uniformes. Le modèle est particulièrement bien adapté à l'établissement de prévisions de l'accroissement du volume pour des périodes allant jusqu'à 25 ans après la pratique de coupes progressives uniformes.

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WHITE PINE AND RED PINE VOLUME GROWTH UNDER UNIFORM SHELTERWOOD MANAGEMENT IN ALGONQUIN PROVINCIAL PARK

INTRODUCTION

Estimating the growth and yield of forest stands that have been subjected to one or more selective harvests is an elusive task. This is particularly problematic in white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) stands in the southern Great Lakes–St. Lawrence Forest Region, including the Algonquin Provincial Park, where the uniform shelterwood management system is applied. Yield tables and other management aids currently available for white pine and red pine have been based largely on old-growth, natural unmanaged stand data. These models do not provide reliable estimates of residual growth and yield beyond the initial harvest. Foresters must often adapt yield tables developed from unmanaged stands in order to predict the growth and yield of the managed forest (Tesch et al. 1983).

More reliable information on growth rates of pine in managed stands would aid in management planning and would assist forest managers in preparing preharvest silvicultural prescriptions. Information on the volume of red pine and white pine that could be expected in the future would aid forest industry clients in planning long-term capital improvements to their mills and harvest operations. The information could also help to determine long-term employment levels at the various mills that depend on pine from the park and adjacent areas.

The objective of this research is to develop volume growth models for white pine and red pine under uniform shelterwood management in the Algonquin Provincial Park.

METHODOLOGY

The Model

Predicting future yields following a selective harvest, such as might be carried out using a uniform shelterwood silvicultural system, requires detailed knowledge of the stand density (basal area) of pine and other tree species immediately following the harvest, some measure of site productivity (such as site index), and the age of the dominant and codominant pine trees in the residual stand. It also requires knowledge of the stand development process that occurs following release by harvesting.

The modeling approach used in this research was initially presented by Buckman (1962) and Clutter (1963). In his work with loblolly pine (*Pinus taeda* L.), Clutter (1963) developed a system of equations based on the concept that a derivative-integral relationship must exist between the growth function and the yield function. In essence, a growth function, when integrated over time, should provide the same predicted value for yield as a yield function. Such a set of equations must constitute an algebraically consistent model for basal area and volume.

Development of the model was refined by Sullivan and Clutter (1972), who addressed the difficulties of correlated errors associated with repeated measurements on sample plots and the lack of statistical independence. Model development is based on simultaneously solving for three equations in one analysis for each species or species group, and requires two sets of measurements on each growth plot: one for residual (postharvest) conditions and another for present plot conditions. Thus:

$$[1]\quad E(\ln V_1) = \beta_0 + \beta_1 S + \beta_2 A_1^{-1} + \beta_3 \ln B_1$$

$$[2]\quad E(\ln V_2) = \beta_0 + \beta_1 S + \beta_2 A_2^{-1} + \beta_3 \ln B_2$$

$$[3]\quad E(\ln B_2) = \left(\frac{A_1}{A_2}\right)\ln B_1 + \alpha_1\left(1 - \frac{A_1}{A_2}\right) + \alpha_2\left(1 - \frac{A_1}{A_2}\right)S$$

where E indicates expected value

$\ln V_i$ = logarithm to the base e of cubic-meter volume per hectare at the i^{th} measurement

S = site index in meters

A_i = stand age in years at the i^{th} measurement

$\ln B_i$ = logarithm to the base e of basal area per hectare in square meters at the i^{th} measurement

In most yield analyses employing least squares regression techniques, the logarithm of yield is often used as the dependent variable. This transformation is done in order to conform to the assumptions made in linear regression analysis, and as a means to mathematically express the interaction of independent variables with yield (Avery and Burkhart 1993). The measure of density is often subjected to logarithmic transformation, especially in models employing basal area (Avery and Burkhart 1993). Site index can sometimes be transformed using logarithmic or reciprocal transformation (Beck and Della-Bianca 1972), or it may not be transformed at all (Sullivan and Clutter 1972, Burkhart and Sprinz 1984). Stand age is often expressed as a reciprocal to allow for the "leveling off" (asymptotic) effect of yield with increasing age (Avery and Burkhart 1993).

The regression analysis involves developing a single model relating stand volume to initial stand age, projected age, site index, and initial basal area. This model is derived

by replacing lnB_2 in Equation [2] with its expected value from Equation [3], to obtain:

$$[4]\quad E(\ln V_2) = \beta_0 + \beta_1 S + \beta_2 A_2^{-1} + \beta_3\left(\frac{A_1}{A_2}\right)\ln B_1 + \beta_4\left(1-\frac{A_1}{A_2}\right) + \beta_5\left(1-\frac{A_1}{A_2}\right)S$$

where $\beta_4 = \beta_3\alpha_1$ and $\beta_5 = \beta_3\alpha_2$

A more detailed description of the model formulation is given in Sullivan and Clutter (1972). Results from the regression analysis provide three equations: one for predicting volume per hectare immediately after harvest, another for predicting volume per hectare any time after the harvest, and a third that predicts the basal area at any time after the harvest.

This approach to growth and yield modeling has been successfully applied to a number of different species, including loblolly pine (Sullivan and Clutter 1972, Burkhart and Sprinz 1984), red pine (Buckman 1962), and yellow poplar (*Liriodendron tulipifera* L.) (Beck and Della-Bianca 1972). As presented by both Clutter (1963) and Sullivan and Clutter (1972), the desirable features of this yield model include the following:

- the mathematical form of the variates implies relationships that agree with our biological concepts of even-aged stand development;
- use of lnV as the dependent variable rather that V will generally be more compatible with the statistical assumptions customarily made in regression analysis (linearity, normality, additivity, and homogeneity of variance); and
- use of lnV as the dependent variate is a convenient way to mathematically express the interaction of the independent variables in their effect on V. (For example, the change in expected volume occurring as a result of a change in site index from 60 to 70 would depend on the associated values of lnB and A^{-1}.)

In the present study, one goal is to predict the yield of only a single species group—pine (i.e., white pine plus red pine), while still using stand characteristics such as total basal area per hectare, which describe a mixed stand composed of a number of species. Thus, the model must include a component that can describe the contribution of the single species group to the whole stand. One approach used to predict the yield for one species group growing in a mixed stand is the incorporation of a "composition index" into the yield model, as first applied by MacKinney and Chaiken (1939). This composition index (C) was measured as the ratio of basal area per hectare of the preferred species group to the total stand basal area, and was incorporated into the yield equation in the following way (MacKinney and Chaiken 1939):

$$[5]\quad E(\log Y) = \beta_0 + \beta_1 S + \beta_2 A^{-1} + \beta_3 \log SDI + \beta_4 C$$

Different transformations of the composition index were tested and a logarithmic transformation gave better estimations of pine yield. In addition, reciprocal transformation of site index also provided better empirical results in estimating yield.

Therefore, for this study, Clutter's (1963) model was modified to include a composition index in the form:

$$[6]\quad E(\ln Vp_1) = \beta_0 + \beta_1 S^{-1} + \beta_2 \ln C + \beta_3 A_1^{-1} + \beta_4 \ln B_1$$

$$[7]\quad E(\ln Vp_2) = \beta_0 + \beta_1 S^{-1} + \beta_2 \ln C + \beta_3 A_2^{-1} + \beta_4 \ln B_2$$

$$[8]\quad E(\ln B_2) = \left(\frac{A_1}{A_2}\right)\ln B_1 + \alpha_1\left(1-\frac{A_1}{A_2}\right) + \alpha_2\left(1-\frac{A_1}{A_2}\right)S^{-1} + \alpha_3\left(1-\frac{A_1}{A_2}\right)\ln C + \alpha_4(A_2-A_1) + \alpha_5(A_2-A_1)S^{-1} + \alpha_6(A_2-A_1)\ln C$$

where lnVp$_i$ = logarithm to the base e of gross merchantable volume (m^3) per hectare of pine at the i^{th} measurement

lnC = logarithm to the base e of composition index (basal area of pine divided by the total stand basal area per hectare at the i= 1 measurement

lnB$_i$ = logarithm to the base e of total basal area (m^2) per hectare at the i^{th} measurement

All other variables are as described before.

The assumption was made that C remains constant over the projection period, which is valid for the short time periods for which the model is designed.

Note also that a variable describing the time since harvest (i.e., [A_2 - A_1]) was incorporated into Equation [8]. This term was included in the projected basal area model since there was significant empirical evidence that time since harvest, in addition to relative time since harvest (i.e., [1 - A_1/A_2]), contributed to the ability to predict future basal areas.

The regression analysis involves developing a single model relating stand volume to initial stand age, projected age, site index, initial total basal area, and initial composition index. This model is derived by replacing lnB_2 in Equation [7] with their expected values from Equation [8], to obtain:

$$[9]\quad E(\ln V_{p_2}) = \beta_0 + \beta_1 S^{-1} + \beta_2 \ln C + \beta_3 A_2^{-1} + \beta_4\left(\frac{A_1}{A_2}\right)\ln B_1 + \beta_5\left(1-\frac{A_1}{A_2}\right) + \beta_6\left(1-\frac{A_1}{A_2}\right)S^{-1} + \beta_7\left(1-\frac{A_1}{A_2}\right)\ln C + \beta_8(A_2-A_1) + \beta_9(A_2-A_1)S^{-1} + \beta_{10}(A_2-A_1)\ln C$$

Equation [9] produces a yield projection model that can estimate pine yield by using V_{p2} as the dependent variable. The model can also be adapted to estimate the yield of all species by using V_2 as the dependent variable. When $A_2 = A_1 = A$, i.e., the projection period is zero years, then $B_2 = B_1 = B$ and Equation [9] reduce to a general yield model:

$$[10] \quad lnVp = \beta_0 + \beta_1 S^{-1} + \beta_2 lnC + \beta_3 A^{-1} + \beta_4 lnB$$

The projected basal area B_2 at the projected age A_2 in the form of Equation [8] can be solved from Equation [9] in the form:

$$[11] \quad E(lnB_2) = \left(\frac{A_1}{A_2}\right) lnB_1 + \frac{\beta_3}{\beta_4}\left(1 - \frac{A_1}{A_2}\right) + \frac{\beta_6}{\beta_4}\left(1 - \frac{A_1}{A_2}\right) S^{-1} + \frac{\beta_7}{\beta_4}\left(1 - \frac{A_1}{A_2}\right) lnC + \frac{\beta_8}{\beta_4}(A_2 - A_1) + \frac{\beta_9}{\beta_4}(A_2 - A_1) S^{-1} + \frac{\beta_{10}}{\beta_4}(A_2 - A_1) lnC$$

By taking the first derivative of the basal area yield model, Equation [11], with respect to age, the equation for instantaneous basal-area growth is (Beck and Della-Bianca 1972):

$$[12] \quad \frac{dB}{dA} = B \cdot [A^{-1}\left(\frac{\beta_5}{\beta_4} + \frac{\beta_6}{\beta_4} S^{-1} + \frac{\beta_7}{\beta_4} lnC\right) + \left(\frac{\beta_8}{\beta_4} + \frac{\beta_9}{\beta_4} S^{-1} + \frac{\beta_{10}}{\beta_4} lnC\right)]$$

Similarly, the first derivative of the gross merchantable volume yield projection model, Equation [9], gives the volume growth model (Beck and DellaBianca 1972):

$$[13] \quad \frac{dVp}{dA} = Vp^{*} \cdot [-\beta_2 A^{-2} + \beta_3 B^{-1} \frac{dB}{dA}]$$

The variable Vp^{*} is the gross merchantable yield predicted with Equation [10].

Data

The data was collected from 280 growth plots within the white pine working group and 42 growth plots from the red pine working group located on the eastern portion of the Algonquin Provincial Park. The plots were stratified according to site class and the number of years since harvesting had been carried out.

A minimum of two sets of measurements were derived from each growth plot for each working group; one describing the present condition of the plot, and another characterizing the residual (postharvest) condition. For those plots that were harvested more than 5 years ago, intermediate plot conditions at 5-year intervals starting at the time of harvest were also reconstructed.

Current breast height age of dominant/codominant pine trees within each plot was estimated by increment cores. Present stand age at breast height was estimated by taking the mean breast height age of residual pine stems. Age at the time of harvest was estimated by subtracting the years since harvest from the current age.

The diameter of all stumps found in the growth plots was also measured. The diameter at breast height (DBH) of these trees was estimated using stump diameter–DBH relationships developed by the Algonquin Forestry Authority.[1] This information was used to estimate the basal area of the stands prior to harvest. Accuracy of the stump diameter measurements was affected by the length of time since harvesting was carried out, since older stumps were often in advanced stages of decomposition.

All stems 9.0-cm DBH and over were measured and tallied to the nearest 0.1 cm. All white pine and red pine trees were increment cored at breast height. Bark thickness, and ring widths in 5-year intervals starting at the time of harvest, were measured to the nearest 1.0 mm. Past DBH's of white pine and red pine trees, in 5-year intervals starting at the time of harvest, were estimated based on current DBH, bark thickness, and increment data.

For all other species, individual trees showing no deformities were selected at random and increment cored at breast height. The total width of rings from the time of harvest to the present was measured to the nearest 1.0 mm. Past DBH's for these trees, in 5-year intervals starting at the time of harvest, were estimated by interpolation between current DBH and estimated DBH at the time of harvest. For all other trees, linear regression analysis was used to develop an empirical model for each species that would predict past DBH (DBH_t) as a function of current DBH (DBH_0) and elapsed time (t) from the present back to harvest, in the form:

$$[14] \quad DBH_t = \beta_0 + \beta_1 DBH_0 + \beta_2 t + \beta_3 (DBH_0 * t) + \beta_4 t^2 + \beta_5 (DBH_0 * t^2)$$

The results were used to estimate the past DBH of individual, noncored trees in 5-year intervals beginning at the time of harvest and extending to the present. For those species that did not have a sufficient number of samples to model past DBH growth, the equation developed for another species of the same family was used.

Total tree heights for all healthy, nondeformed white pine and red pine trees were measured to the nearest 0.1 m

[1] $DBH_{PW} = 2.19 + (0.819) \times (\text{stump diameter})$; $R^2 = 0.98$
$DBH_{PR} = -0.756 + (0.912) \times (\text{stump diameter})$; $R^2 = 0.99$

using a suunto clinometer. For all other species, individual trees showing no deformities were selected at random for height measurements. Several different model forms for estimating height–diameter relationships, as given in Arabatzis and Burkhart (1992), were assessed. The polynomial form of the function:

$$[15] \quad H = \beta_0 + \beta_1 DBH + \beta_2 \sqrt{DBH} + \beta_3 DBH^2 + \beta_4 DBH^3$$

provided the best fit of the data for most species. For those species that did not have a sufficient number of samples to develop a height–diameter curve, the equation developed for another species of the same family was used. The results were used to estimate total height for trees not measured at present, and to estimate the heights of all trees at different time periods in the past. A correction factor was applied to past height estimates based on the ratio of measured current height to estimated current height.

Gross merchantable volume (GMV) of individual red pine and white pine trees was estimated using standard volume equations currently used by the Algonquin Forestry Authority. These use DBH and tree height as predictor variables. For all other species, merchantable volumes (stump height = 30 cm, minimum top diameter = 7 cm) were determined from existing equations (Honer et al. 1983).

Plot summaries of gross merchantable volume and basal area per hectare were compiled using standard mensurational techniques. If the past DBH of an individual tree was less then 9.0 cm, that tree was excluded from plot summary calculations for that measurement period only.

Site index for each plot was determined using site index curves developed for white pine within the Algonquin Provincial Park by the Ontario Ministry of Natural Resources. These curves require breast height age and total height as input variables. For those plots that did not have sufficient information (i.e., no white pine trees in the plot, no age estimate due to rotten increment cores, etc.), the age and/or average height of the plot was obtained from Forest Resource Inventory data for the stand. For plots in the red pine working group, site index at the age of 50 years was estimated from Plonski's yield tables (Plonski 1974).

All regression analyses were performed using the SAS™ statistical computer package running on a SUN SPARC station. Least squares regression analysis was used for parameter estimation.

RESULTS

Table 1 lists statistics for individual trees tallied for the growth plot summary data by species. The parameter estimates for the individual ree, and diameter increment

Table 1. Summary statistics of individual tree characteristics tallied for the growth plot summaries by species.

Species code	Common name	Diameter at breast height (cm)				Total tree height (m)			
		n	min.	mean	max.	n	min.	mean	max.
1	White pine	3512	9.0	28.4	75.0	1943	5.0	21.2	38.1
2	Red pine	1243	9.0	29.1	63.0	619	5.8	20.5	31.4
3	Jack pine	35	13.4	25.6	34.9	22	9.9	19.6	25.8
12	White spruce	394	9.0	16.5	47.6	209	5.7	13.0	29.5
13	Black spruce	123	9.0	15.3	29.5	67	2.8	13.3	24.7
19	Hemlock	104	9.0	17.1	40.2	33	6.1	13.0	20.6
20	Balsam fir	586	9.0	12.9	56.0	211	6.4	12.0	23.5
22	White cedar	40	9.0	20.1	35.4	21	7.8	12.5	17.8
30	Sugar maple	144	9.3	18.7	45.9	61	9.0	16.4	22.6
32	Red maple	660	9.0	15.0	56.7	180	6.7	14.7	25.5
37	Yellow birch	18	9.4	20.8	36.7	13	7.6	14.9	19.8
38	White birch	286	9.1	19.6	43.1	106	10.5	18.1	29.8
41	Red oak	305	9.3	23.3	52.6	160	6.8	16.2	23.6
44	Beech	72	9.0	16.5	31.2	31	7.6	14.1	20.6
45	Black ash	4	9.0	13.8	21.4	3	11.5	14.3	16.7
51	Basswood	3	22.3	31.7	45.0	2	21.2	21.9	22.6
56	Ironwood	37	9.2	12.3	19.4	22	7.4	11.8	15.9
70	Largetooth aspen	254	9.2	31.0	59.0	117	12.8	22.8	30.7
74	Trembing aspen	111	9.2	28.4	56.4	55	11.2	22.0	30.3

equations developed for each species, are given in Table 2. Parameter estimates for the height–diameter curves developed for each species are given in Table 3. Table 4 provides summary statistics for the growth plots used in the analysis. Tables 5 and 6 show the distribution of plots by pine composition, site index, and number of measurements over time for the white pine and red pine working groups, respectively.

Figures 1 and 2 display time-series information on total basal area per ha and gross merchantable pine volume per ha, respectively, over plot age for each plot. Plots were separated into four site index classes to simplify presentation of the data.

The model as specified in Equation [9] was estimated using stepwise linear regression analysis, and by selecting only statistically significant ($p < 0.05$) variables. Results of this analysis indicated that the model fit the data very well. (White pine working group, pine yield $R^2 = 0.97$, s.e. = 0.105; all species yield $R^2 = 0.94$, s.e. = 0.097. Red pine working group, pine yield $R^2 = 0.97$, s.e. = 0.083; all species yield $R^2 = 0.97$, s.e. = 0.07.) Not all independent variables in the yield model specified in Equation [9] were significant at the $p = 0.05$ level (Table 7). A plot of residuals against each independent variable showed no systematic distortions.

The results were used to develop growth and yield curves and yield tables for the white pine (Appendices 1 and 2) and red pine (Appendices 3 and 4) working groups, respectively. The site classes in the appendices correspond to Plonski's (1974) site classes for white pine and red pine. To convert site index to site class for white pine, site index values of 17.8 for Site Class 1, 12.1 for Site Class 2, and 9.0 for Site Class 3 were used. For the red pine working group, the three site classes had site index values of 18.6, 15.5, and 12.1, respectively.

Table 2. Parameter estimates for equations used to predict past tree DBH for species growing in pine stands in the Algonquin Provincial Park.

Species code	Common name	Parameter estimates for past DBH equation[1]						Number of trees	MSE*	R^{2}**
		β_0	β_1	β_2	β_3	β_4	β_5			
1	White pine	0.0551	1.0013	-0.1680	-0.008066	0.004252	n.s.[2]	1932	2.1180	0.9864
2	Red pine	-0.1731	1.0064	-0.0864	-0.007137	n.s.	0.0001278	611	1.2070	0.9888
3	Jack pine	-0.2871	1.0093	n.s.	n.s.	-0.006731	n.s.	21	0.2848	0.9942
12	White spruce	0.1514	0.9973	-0.2990	0.002879	n.s.	n.s.	188	2.3115	0.9592
13	Black spruce	0.0414	1.0029	-0.2581	0.004250	n.s.	n.s.	62	1.1303	0.9681
19	Hemlock	0.0418	0.9962	0.2799	-0.005222	-0.018677	n.s.	32	0.6180	0.9924
20	Balsam fir	0.1360	0.9932	-0.2087	-0.004135	n.s.	n.s.	199	2.2123	0.8974
22	White cedar	0.0120	1.0032	-0.1757	-0.000951	n.s.	n.s.	21	0.9901	0.9822
30	Sugar maple	-0.1036	1.0038	-0.2363	0.002882	n.s.	n.s.	60	0.6357	0.9918
32	Red maple	-0.1204	1.0087	-0.1210	n.s.	-0.003666	n.s.	156	0.8966	0.9858
37	Yellow birch	-0.3177	1.0152	-1.2924	n.s.	0.061785	n.s.	11	1.5080	0.9818
38	White birch	-0.0295	1.0040	n.s.	-0.002509	-0.013583	0.0004377	95	0.6408	0.9888
41	Red oak	0.1719	0.9960	-0.2414	0.008281	n.s.	-0.0002448	115	0.5315	0.9910
44	Beech	-0.1867	1.0115	-0.1616	n.s.	-0.004302	n.s.	29	0.4406	0.9909
45	Black ash	0.0000	1.0000	-0.1003	-0.001805	n.s.	0.0000562	3	0.0000	1.000
51	Basswood	-	-	-	-	-	-	0	-	-
56	Ironwood	0.0515	0.9970	-0.2470	0.009288	n.s.	n.s.	18	0.4753	0.9553
70	Largetooth aspen	0.2941	0.9939	-0.5375	0.010908	0.020483	-0.0007155	107	1.9820	0.9784
74	Trembling aspen	-0.3640	1.0175	-0.3692	n.s	n.s	0.0001663	52	3.9150	0.9736

[1] Model: $DBH_t = \beta_0 + \beta_1 * DBH_0 + \beta_2 * t + \beta_3 * (DBH_0 * t) + \beta_4 * t^2 + \beta_5 * (DBH_0 * t^2)$.
DBH_0 = diameter at breast height now (cm).
t = numbers of years in the past.
DBH_t = diameter at breast height t years in the past (cm).

[2] n.s. = parameter estimate not significantly different from zero ($p = 0.05$).

* MSE = Mean square error.

** R^2 = Coefficient of determination.

Table 3. Parameter estimates for height–diameter equations for species growing in pine stands in the Algonquin Provincial Park.

Species code	Common name	Parameter estimates for height–diameter curves[1]					Number of trees	R^{2}*	MSE**
		β_0	β_1	β_2	β_3	β_4			
1	White pine	-17.772	-0.5847	10.630	n.s.[2]	n.s.	1943	0.7841	8.191
2	Red pine	-38.525	-2.2296	21.844	0.00863717	n.s.	619	0.6998	7.546
3	Jack pine	-6.077	n.s	5.160	n.s.	n.s.	22	0.6303	7.477
12	White spruce	1.295	0.6840	n.s.	n.s.	-0.00004362	209	0.8103	4.585
13	Black spruce	2.386	0.7067	n.s.	n.s.	n.s.	67	0.7636	4.616
19	Hemlock	-0.220	n.s.	3.013	n.s.	n.s.	33	0.6373	4.823
20	Balsam fir	-4.566	n.s.	4.615	n.s.	n.s.	211	0.5280	5.12
22	White cedar	5.458	0.3260	n.s.	n.s.	n.s.	21	0.7046	2.304
30	Sugar maple	-19.593	-1.0532	12.932	n.s.	n.s.	61	0.6916	3.918
32	Red maple	1.449	n.s.	3.377	n.s.	n.s.	180	0.6303	4.472
37	Yellow birch	-0.411	n.s.	3.377	n.s.	n.s.	13	0.6353	4.574
38	White birch	-9.843	-0.6527	9.246	n.s.	n.s.	106	0.6306	3.903
41	Red oak	3.894	n.s.	2.540	n.s.	n.s.	160	0.3812	5.578
44	Beech	-1.943	n.s.	3.959	n.s.	n.s.	31	0.7747	2.733
45	Black ash	-	-	-	-	-	3	-	-
51	Basswood	-	-	-	-	-	2	-	-
56	Ironwood	-2.063	n.s.	3.941	n.s.	n.s.	22	0.3904	3.717
70	Largetooth aspen	-10.430	-0.6094	9.480	n.s.	n.s.	117	0.4306	9.596
74	Trembing aspen	-7.539	-0.4067	7.741	n.s.	n.s.	55	0.7654	4.593

[1] Model: $H = \beta_0 + \beta_1 * DBH + \beta_2 * DBH + \beta_3 * DBH^2 + \beta_4 * DBH^3$.
H = total tree height (m).
DBH = tree diameter at breast height (cm).

[2] n.s. = parameter estimate not significantly different from zero ($p = 0.05$).

* R^2 = Coefficient of determination.

** MSE = Mean square error.

Table 4. Summary statistics of growth plot characteristics used in the growth and yield modeling.

Working group	Growth plot characteristic	Summary statistics		
		Minimum	Mean	Maximum
White pine (n = 280 plots)	Preharvest total basal area (m^2/ha)	7.1	28.5	58.2
	Residual total basal area (m^2/ha)	0.2	19.5	38.3
	Average age of residual pine stems (yrs)	18.3	90.1	160.3
	Composition Index (% pine basal area)	0.0	69.8	100.0
	Site Index (m at age 50 years)	9.0	14.8	20.0
	Preharvest gross merchantible pine volume (m^3/ha)	0.0	233.9	633.8
	Residual gross merchantible pine volume (m^3/ha)	0.0	139.8	427.9
Red pine (n = 42 plots)	Preharvest total basal area (m^2/ha)	14.7	30.8	52.5
	Residual total basal area (m^2/ha)	5.0	21.8	38.1
	Average age of residual pine stems (yrs)	47.9	88.2	115.0
	Composition Index (% pine basal area)	20.4	81.8	100.0
	Site Index (m at age 50 years)	11.2	15.2	19.0
	Preharvest gross merchantible pine volume (m^3/ha)	57.6	250.6	484.8
	Residual gross merchantible pine volume (m^3/ha)	35.2	165.5	345.9

Table 5. Distribution of white pine working group growth plots by composition class (% pine basal area), site index (average height of pine trees, m, at the age of 50 years), and number of measurements taken from the time of harvest to the present on 5-year intervals.

Composition class (%)	Site Index (m)	Number of measurements taken per plot						Total
		2	3	4	5	6	7	
0	9 – 11	-	-	-	-	-	-	9
	12 – 14	-	2	1	3	-	-	
	15 – 17	-	1	-	2	-	-	
	18 – 20	-	-	-	-	-	-	
10	9 – 11	-	-	-	-	-	-	4
	12 – 14	-	-	-	1	-	-	
	15 – 17	-	-	2	-	-	-	
	18 – 20	-	-	1	-	-	-	
20	9 – 11	-	-	1	-	-	-	7
	12 – 14	-	1	1	-	-	-	
	15 – 17	-	-	1	-	-	1	
	18 – 20	-	-	1	1	-	-	
30	9 – 11	-	-	-	-	-	-	6
	12 – 14	-	1	-	1	-	-	
	15 – 17	-	-	1	2	-	-	
	18 – 20	-	-	-	-	1	-	
40	9 – 11	-	-	-	-	-	-	20
	12 – 14	2	2	1	3	2	-	
	15 – 17	1	1	2	1	1	-	
	18 – 20	1	1	-	1	1	-	
50	9 – 11	-	1	-	3	-	-	28
	12 – 14	-	-	2	4	2	-	
	15 – 17	1	3	2	3	1	-	
	18 – 20	1	-	1	2	1	1	
60	9 – 11	1	-	-	-	-	-	27
	12 – 14	5	1	5	3	-	-	
	15 – 17	-	2	2	3	-	1	
	18 – 20	1	1	-	2	-	-	
70	9 – 11	-	1	2	-	-	-	30
	12 – 14	2	3	4	8	-	1	
	15 – 17	2	1	1	2	-	1	
	18 – 20	1	-	-	1	-	-	
80	9 – 11	-	-	2	-	-	-	55
	12 – 14	3	5	16	2	-	-	
	15 – 17	5	7	4	6	1	-	
	18 – 20	1	1	-	1	-	1	
90	9 – 11	-	-	1	1	-	-	48
	12 – 14	2	2	2	5	2	-	
	15 – 17	4	4	8	6	-	2	
	18 – 20	1	2	1	1	3	1	
100	9 – 11	-	-	2	-	-	-	46
	12 – 14	3	5	6	2	-	2	
	15 – 17	8	7	1	3	2	1	
	18 – 20	2	-	1	-	-	2	
Total		47	55	75	73	17	13	280

Table 6. Distribution of red pine working group growth plots by composition class (% pine basal area), site index (average height of pine trees, m, at the age of 50 years), and number of measurements taken from the time of harvest to the present on 5-year intervals.

Composition class (%)	Site Index (m)	Number of measurements taken per plot						Total
		2	3	4	5	6	7	
0	9 – 11	-	-	-	-	-	-	0
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
10	9 – 11	-	-	-	-	-	-	0
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
20	9 – 11	-	-	-	-	-	-	1
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	1	-	-	
	18 – 20	-	-	-	-	-	-	
30	9 – 11	-	-	-	-	-	-	0
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
40	9 – 11	-	-	-	-	-	-	1
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	1	-	-	
	18 – 20	-	-	-	-	-	-	
50	9 – 11	-	-	-	-	-	1	2
	12 – 14	-	-	-	-	1	-	
	15 – 17	-	-	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
60	9 – 11	-	-	-	-	-	-	2
	12 – 14	-	-	-	-	-	-	
	15 – 17	-	-	-	2	-	-	
	18 – 20	-	-	-	-	-	-	
70	9 – 11	1	-	-	-	-	-	6
	12 – 14	1	-	1	-	-	-	
	15 – 17	-	3	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
80	9 – 11	-	-	-	-	-	-	8
	12 – 14	-	1	-	-	-	2	
	15 – 17	4	-	1	-	-	-	
	18 – 20	-	-	-	-	-	-	
90	9 – 11	-	-	-	-	-	-	8
	12 – 14	-	-	3	1	1	1	
	15 – 17	-	2	-	-	-	-	
	18 – 20	-	-	-	-	-	-	
100	9 – 11	-	-	-	-	-	-	14
	12 – 14	1	-	-	3	-	1	
	15 – 17	2	3	2	1	-	-	
	18 – 20	1	-	-	-	-	-	
Total		10	9	7	9	2	5	42

Table 7. Parameter estimates for growth and yield regression equations predicting gross merchantible volume of both all species and of pine stems only for white pine and red pine working groups.

Regression model[1] parameters	White pine working group		Red pine working group	
	Pine yield only	All species yield	Pine yield only	All species yield
β_0	2.71658	2.61604	2.58220	2.62259
β_1	-5.97523	-5.83672	-6.80229	-7.99638
β_2	1.08279	0.17833	0.92928	n.s.[2]
β_3	-3.04979	-2.20482	-15.24062	-11.40681
β_4	1.02859	1.04106	1.09481	1.08796
β_5	1.97873	1.67016	4.06546	3.72634
β_6	n.s.	n.s.	n.s.	n.s.
β_7	n.s.	-0.38183	n.s.	n.s.
β_8	0.02469	0.03311	n.s.	n.s.
β_9	0.09142	0.08641	0.17152	0.23471
β_{10}	-0.01675	n.s.	n.s.	n.s.
n	1018	1018	148	148
MSE*	0.01102	0.00941	0.00702	0.00499
R^{2**}	0.9710	0.9478	0.9725	0.9738

Note:[1]*Model:*

$$E(\ln Y_2) = \beta_0 + \beta_1 S^{-1} + \beta_2 \ln C + \beta_3 A_2^{-1} + \beta_4 \left(\frac{A_1}{A_2}\right) \ln B_1 + \beta_5 \left(1 - \frac{A_1}{A_2}\right) + \beta_6 \left(1 - \frac{A_1}{A_2}\right) S^{-1} + \beta_7 \left(1 - \frac{A_1}{A_2}\right) \ln C + \beta_8 (A_2 - A_1) + \beta_9 (A_2 - A_1) S^{-1} + \beta_{10} (A_2 - A_1) \ln C$$

where Y_2 = gross merchantible volume (m^3/ha) of pine or all species at the 2nd measurement.
All other variables as defined previously.
[2] n.s. = parameter estimate not significantly different from zero (p = 0.05).
*MSE = Mean square error.
**R^2 = Coefficient of determination.

Since gross merchantable volume was shown to vary with the proportion of pine in the residual stand, it was necessary to develop several growth and yield curves and yield tables that reflected the range of residual pine composition spanned by the data for each combination of working group and site class.

The basal area of the stands prior to harvest was estimated from information on stump diameters and residual basal area. This resulted in an estimation of the harvested basal area. Only stands harvested within the last 10 years were used to estimate this relationship. It was decided that diameter measurements taken on stumps from stands harvested more than 10 years ago might not be reliable and could introduce errors when estimating preharvest conditions. Appendix 5A depicts the relationship between the preharvest basal area and the basal area harvested of a particular species. The relationship between the percentage of basal area of red pine and white pine and the percentage of total basal area occupied by those species is shown in Appendix 5B.

The instantaneous growth rate (immediately after harvest) and the periodic annual increment (P.A.I.) for the first 15 years after harvest were also estimated for the average stand on each site class. Figures 3.1a through 3.3b demonstrate how the instantaneous and periodic growth rates (volume and basal area) for pine will vary with the age of the residual pine at the time of harvest and the residual basal area. The most common conditions are represented by a stand having 70 percent residual pine based on basal area, an average age of residual pine of 90 years, and growing on Site Class 2.

DISCUSSION

The data used in the analysis represent stand conditions at various time periods since shelterwood harvesting was

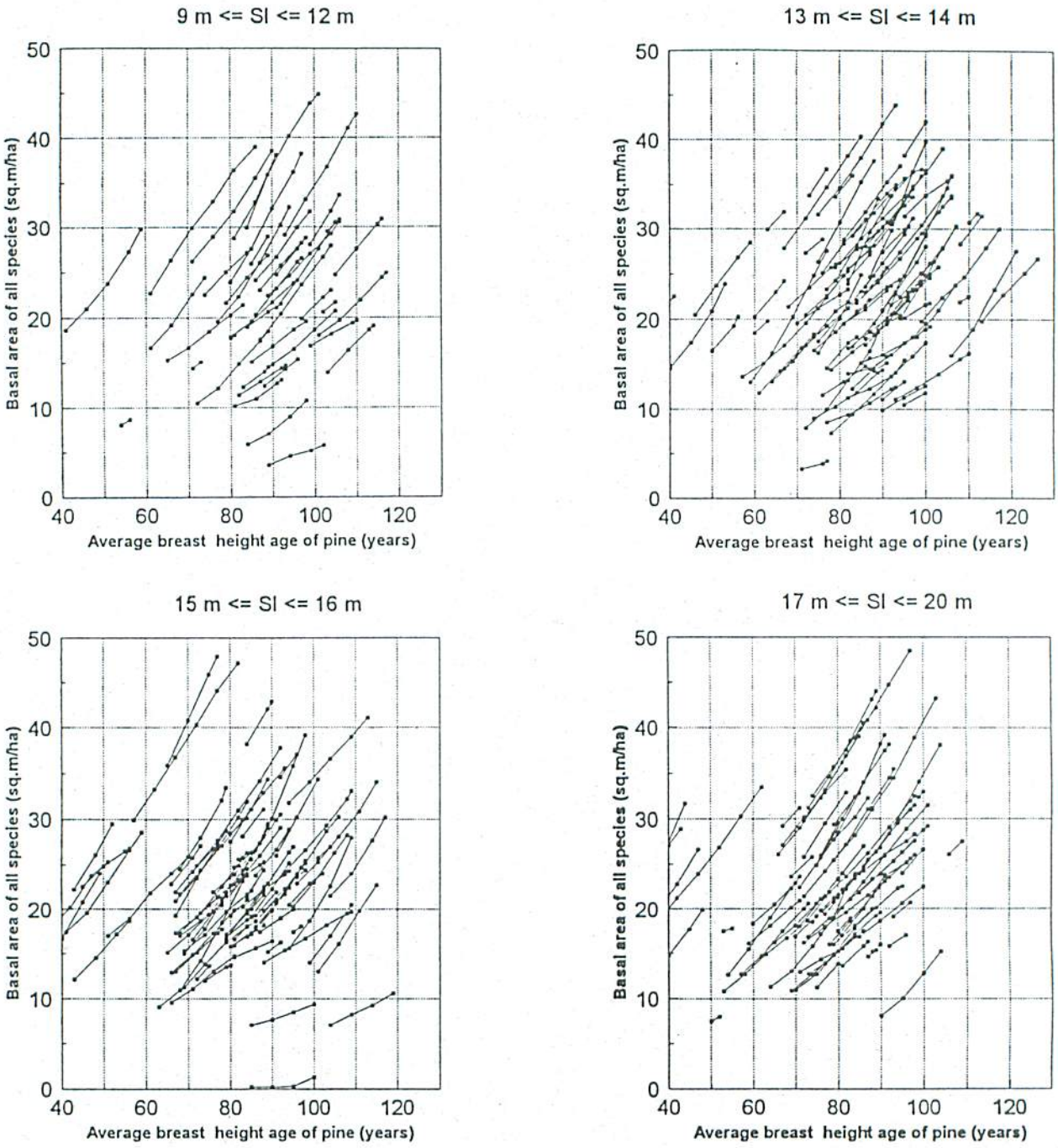

Figure 1. Basal area per hectare related to stand age and site index for growth plots.

last conducted. As no field measurements were carried out at the time of harvest, it was necessary to reconstruct the residual stand conditions that existed immediately after harvesting. Residual DBH's of most trees were calculated from current DBH and increment data. However, some trees were not increment cored. For these cases, data from cored trees were used with linear regression analysis to develop empirical models that would predict residual DBH as a function of current DBH and elapsed time since harvesting (Equation [14]). Past DBH's estimated using this approach are considered to be extremely reliable. The R^2 was always greater than 0.89 and the maximum s.e. was 1.97 (Table 2).

The results of the height–diameter estimation for individual trees (Equation [15]) suggest that tree height can be reliably estimated as a function of DBH using polynomial

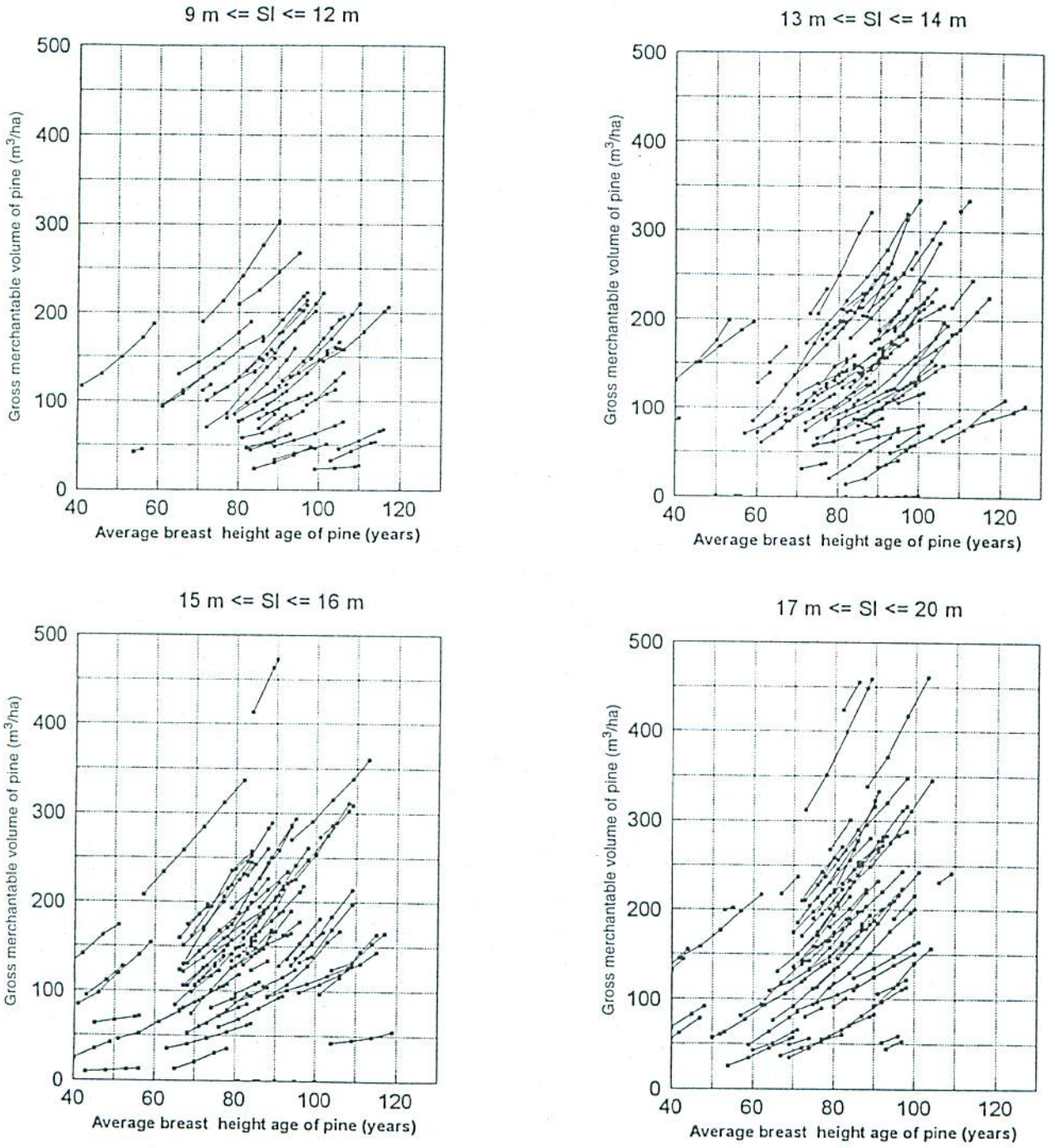

Figure 2. Gross merchantable volume per hectare related to stand age and site index for growth plots.

regression analysis. The R^2 varied from 0.38 to 0.76 depending on the species, and the s.e. varied from 1.51 to 3.09 (Table 3). Given the large number of observations taken for most species and the statistical significance of the height–diameter relationship, the height–diameter model represented by Equation [15] could be used to estimate individual tree height based on DBH for subsequent management decisions.

The data did not account for mortality that may have occurred since the stands were harvested, and no estimate of future mortality is included in the model. Therefore, the model will tend to underestimate the residual basal area and GMV immediately following the harvest, and may possibly overestimate future basal area and GMV. The effects of mortality on basal area and volume predictions are expected to be minor over short-term projections of

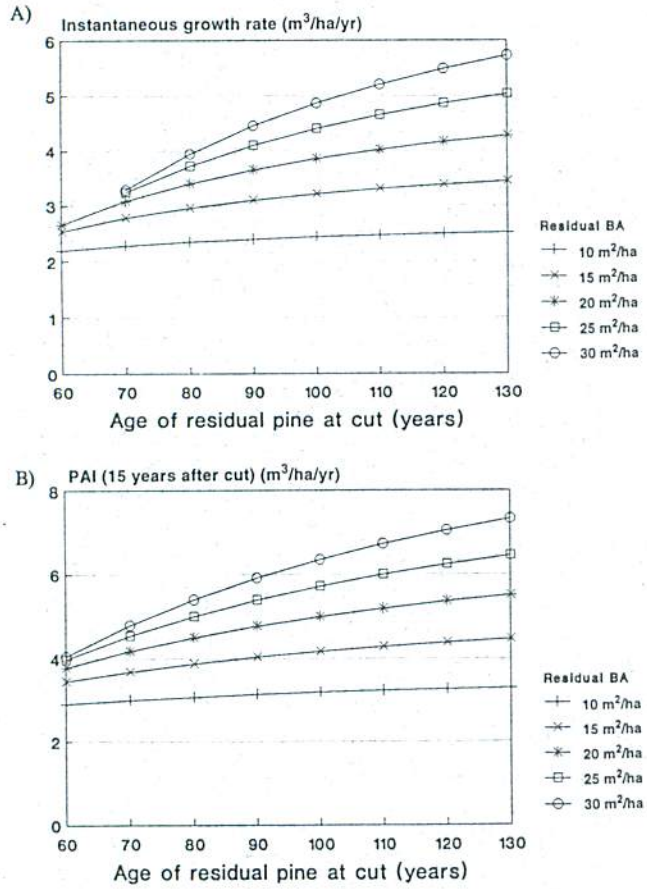

Figure 3.1. Growth rates of residual pines following a uniform shelterwood harvest growing on Site Class 1 (site index = 17.9 m) in the Algonquin Provincial Park. Graphs show the effects of average age of residual pine and the amount of residual basal area (m^2/ha) of all species on pine growth. (Projections were based on an average pine composition of 70 percent of the total basal area.) Growth rates are estimated both as (A) the instantaneous growth at harvest (i.e., first derivative of the yield equation) and (B) the projected periodic annual increment (P.A.I.) for the first 15 years after harvest.

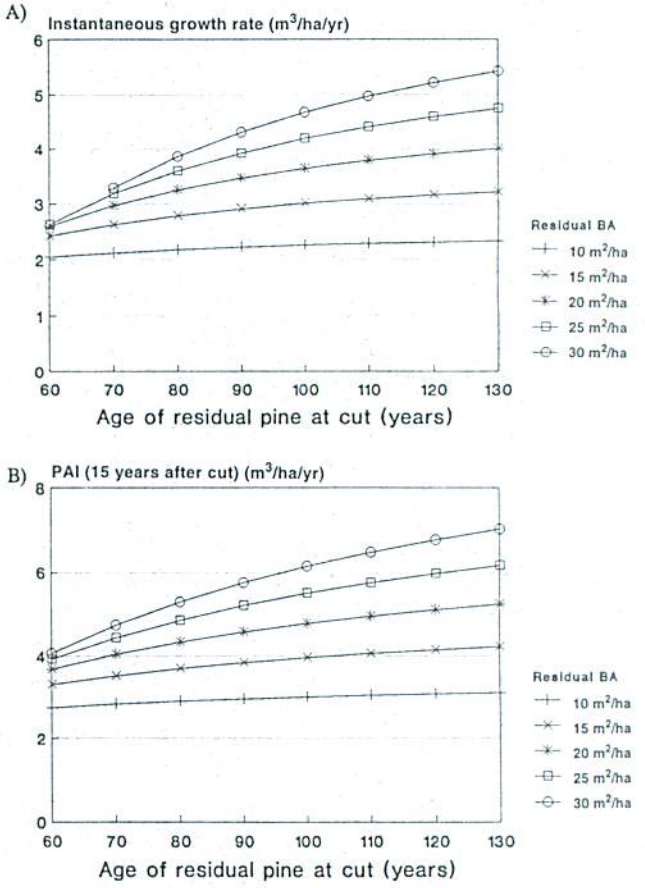

Figure 3.2. Growth rates of residual pines following a uniform shelterwood harvest growing on Site Class 2 (site index = 12.1 m) in the Algonquin Provincial Park. Graphs show the effects of average age of residual pine and the amount of residual basal area (m^2/ha) of all species on pine growth. (Projections were based on an average pine composition of 70 percent of the total basal area.) Growth rates are estimated both as (A) the instantaneous growth at harvest (i.e., first derivative of the yield equation) and (B) the projected periodic annual increment (P.A.I.) for the first 15 years after harvest.

5-year to 10-year growth periods, but could increase with longer growth periods. Therefore the model should not be used to project growth for more than 25 years after uniform shelterwood cutting, or in untreated stands. This problem could be overcome by using data from long-term permanent sample plots (Avery and Burkhart 1993).

The results of the volume growth models are consistent with those of Clutter (1963) and others. The results suggest that the total basal area growth and volume growth of white pine and red pine under uniform shelterwood management are affected by site productivity as reflected in site index. Volume growth is also influenced by the proportion of pine in the residual stand.

With reference to Table 7 the positive sign on β_2, the coefficient on the pine composition index, suggests that as the percentage of pine in the residual stand increases the GMV of pine in the stand also increases. This is consistent with intuitive expectations. However, the negative sign on the coefficient β_{10} indicates that as the percentage of pine in the residual stand increases, the overall basal area

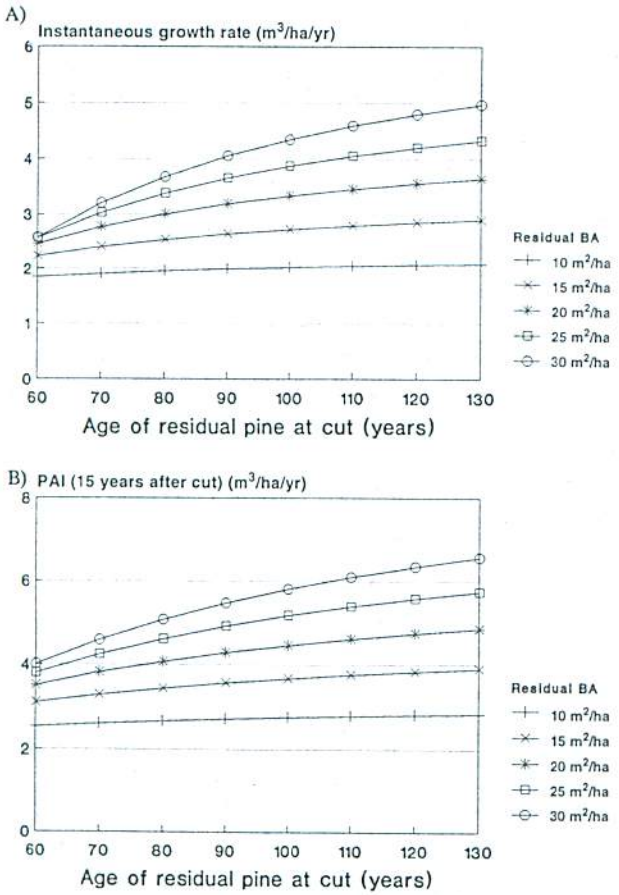

Figure 3.3. Growth rates of residual pines following a uniform shelterwood harvest growing on Site Class 2 (site index = 9.0 m) in the Algonquin Provincial Park. Graphs show the effects of average age of residual pine and the amount of residual basal area (m^2/ha) of all species on pine growth. (Projections were based on an average pine composition of 70 percent of the total basal area.) Growth rates are estimated both as (A) the instantaneous growth at harvest (i.e., first derivative of the yield equation) and (B) the projected periodic annual increment (P.A.I.) for the first 15 years after harvest.

growth of all species actually declines. One possible explanation for these two results is that pine may have slower basal area (diameter) growth, but faster volume (height) growth relative to other species.

The coefficient on β_2 is also positive and significant for the yield of all species for the white pine working group. This suggests that as the percentage of pine increases, the GMV for all species also increases. However, this does not hold true for the red pine working group, where the coefficient β_2 for all species is not significant. This could be due to low variability in pine composition for the red pine working group plots, where more than 70 percent of the plots have 80–100 percent pine composition. In the white pine working group plots the pine composition exhibits greater variability (*see* Tables 5 and 6). The composition index does not affect the basal area growth of pine or of all species in the red pine working group.

Intuitively, volume yield per hectare would be expected to reach a maximum and then level off or decline after a certain age, depending on the species involved. For example, according to Plonski's (1974) normal yield tables for unmanaged white pine, Site Class 1, the species achieves its maximum yield after 190 years of age. This is well beyond the age of most of the stands used in the analysis. The sample plots used for the study do not show any growth decline over the periods measured. This growth habit is reflected in the model, where results suggest that the white pine and red pine stands in the Algonquin Provincial Park experience continually increasing volume growth for up to 25 years following uniform shelterwood harvesting over an age range of 40 to 130 years.

These results are also consistent with the field observations of forest managers who note that during the first 5 years following initial release through harvesting, energy expenditure in white pine and red pine is primarily for crown development. After 5 years following release, energy is used for stem development and volume growth.

The growth and yield models can be used to estimate the residual GMV of pine and all species in a stand at the time of harvest, and projected GMV over some management cycle (e.g., 15 to 20 years). Consider, for example, a stand within the white pine working group composed of 60 percent pine and growing on Site Class 2 as shown in Figure 4. Yield tables for the same stand are given in Table 8.

Assume that this stand has a breast height age for the residual pine of 90 years and has been thinned to a residual basal area of 23.9 m^2 per ha for all species. This stand closely resembles the "average" stand in the white pine working group.

To graphically project gross merchantable volume yield, it is necessary to first project basal area. On Figure 4a, locate point **A** (at age 90 and 23.9 m^2/ha). This point lies on the curve of expected development for a stand having a 4 m^2 per ha basal area at the age of 40. This implies that our example stand (age = 90, BA = 23.9) will develop in approximately the same way as a stand with a basal area of 4 m^2 per ha at the age of 40.

The residual GMV of pine is read off the left axis from Figure 4b. Enter at age 90 and go up to point **B** on the curve for a basal area of 4 m^2 per ha at the age of 40. Estimated pine GMV in the stand is approximately 135 m^3 per ha.

The residual GMV of all species is obtained from Figure 4c. Enter at age 90 and go up to point **C** on the curve for basal area of 4 m^2 per ha at the age of 40. Estimated GMV of all species in the stand is approximately 205 m^3 per ha.

Assume a 15-year management cycle is anticipated. Projecting along the 4 m^2 per ha basal area at the age 40 curve for 15 years (i.e., at age 105) in Figure 4a to point **D** reveals that the stand will have approximately a 35 m^2 per ha basal area for all species in 15 years time. Projecting along the 4 m^2 per ha basal area at the age 40 curve for 15 years in Figure 4b to point **E** the GMV of pine is estimated to be approximately 200 m^3 per ha at the age of 105. Similarly, the GMV for all species is estimated to be 305 m^3 per ha at the age of 105 (point **F** on Figure 4c).

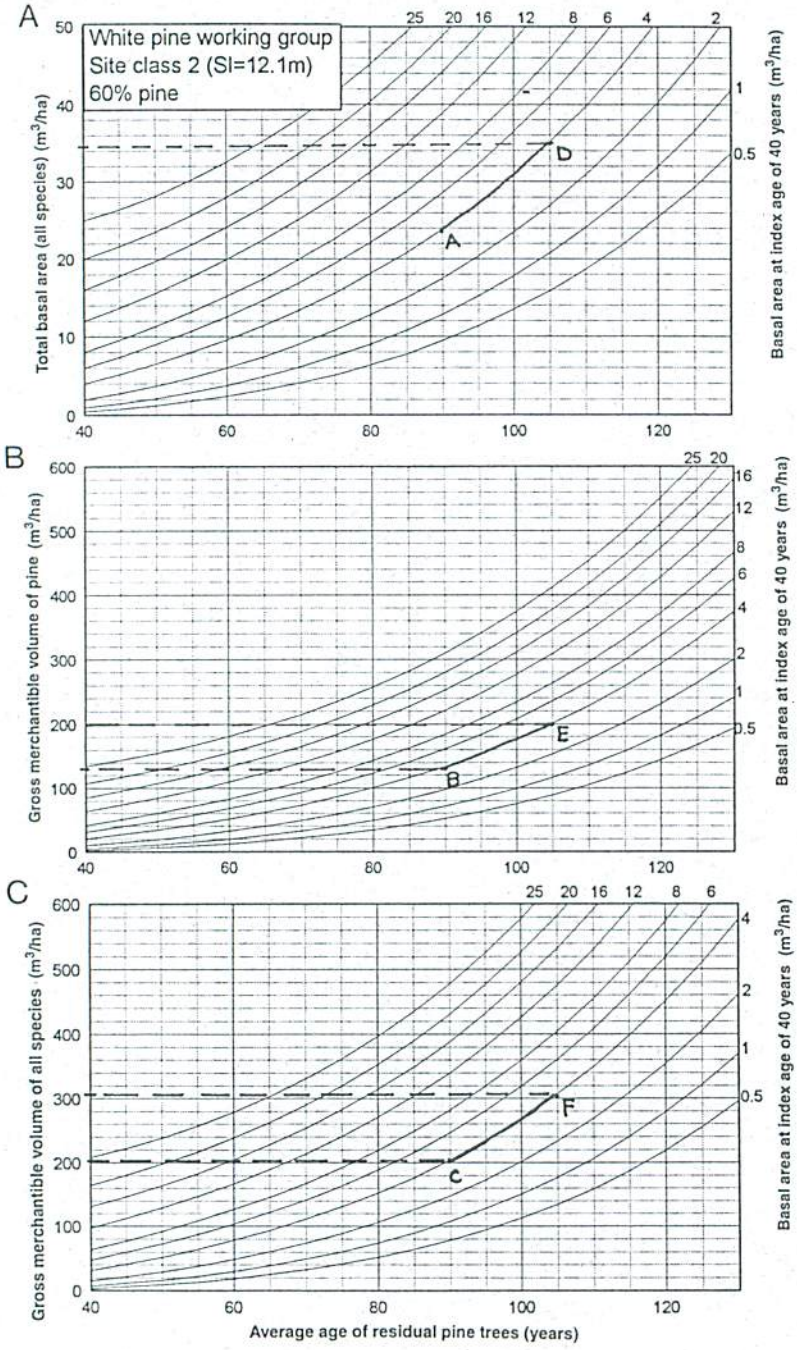

Figure 4. Application of the growth and yield model for an average stand within the white pine working group in the Algonquin Provincial Park, composed of 60 percent pine and growing on Site Class 2.

The GMV can also be read from the yield table (Table 8). Locate the residual stand age of 90 years in Table 8(a). Move across the row to a 23.9 m^2 per ha residual basal area for all species (highlighted with ( ) brackets). This point falls within the column representing a residual basal area at the age of 40 of 4 m^2 per ha. The basal area for all species at the age of 105 is expected to be 35.2 m^2 per ha. In Table 8(b), locate the column representing a residual basal area at the age of 40 of 4 m^2 per ha and move down the column to the age of 90. The residual GMV of pine is 134.1 m^3 per ha. The GMV of pine in the stand at the age of 105 is expected to be 201.0 m^3 per ha. The residual GMV of all species is 204.5 m^3 per ha and the GMV for all species at the age of 105 is expected to be 307.5 m^3 per ha (Table 8c).

The model is estimated using data representing growth since the most recent harvest. As most of the plots are located in stands that have been harvested within the past 25 years, the volume projections are considered to be highly reliable over growth periods of up to 25 years. This is generally appropriate for purposes of management planning. However, there is considerable risk associated with using the results to project growth beyond 25 years, as might be desired when estimating the long-term timber supply.

With reference to Appendix 5A, the results indicate that the proportion of basal area of red pine and of all species harvested was relatively constant regardless of the preharvest basal area of those species. However, when the basal area of white pine in the stand was low (< 20 m^2 per ha), then 37 percent of the basal area of white pine was harvested on average; when the basal area of white pine was high, approximately 45 percent of the

Table 8. Application of the growth and yield model for an average stand within the white pine working group in the Algonquin Provincial Park, composed of 60% pine and growing on Site Class 2.

A. Residual total basal area (m^2/ha)

Stand age	Residual total basal area at index age 40 years (m^2/ha)									
(years)	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.8	5.2	7.4	9.6	13.7	17.8	21.6	26.4
50	1.2	2.1	3.7	6.5	9.0	11.3	15.6	19.7	23.5	28.1
55	1.8	2.9	4.8	8.0	10.7	13.2	17.7	21.8	25.6	30.2
60	2.4	3.8	6.0	9.6	12.6	15.2	19.9	24.1	28.0	32.5
65	3.2	4.9	7.4	11.4	14.6	17.4	22.4	26.7	30.6	35.2
70	4.1	6.1	9.0	13.4	16.9	19.9	25.1	29.6	33.6	38.1
75	5.1	7.5	10.8	15.6	19.4	22.6	28.0	32.7	36.8	41.5
80	6.4	9.0	12.8	18.1	22.1	25.6	31.3	36.2	40.4	45.2
85	7.8	10.8	15.0	20.8	25.2	28.8	34.9	40.0	44.4	49.3
90	9.5	12.9	17.5	(23.9)	28.6	32.5	38.9	44.2	48.8	53.9
95	11.4	15.2	20.4	27.3	32.3	36.5	43.3	48.9	53.7	58.9
100	13.5	17.8	23.5	31.0	36.5	40.9	48.1	54.0	59.0	64.5
105	15.9	20.8	27.0	(35.2)	41.1	45.8	53.5	59.7	65.0	
110	18.7	24.1	31.0	39.8	46.2	51.3	59.4	65.9		
115	21.8	27.8	35.4	45.0	51.8	57.3	65.9			
120	25.4	32.0	40.3	50.7	58.1	63.9				
125	29.3	36.6	45.7	57.1	65.0					
130	33.8	41.9	51.8	64.2						

B. Gross merchantible volume of white pine and red pine (m^3/ha)

Stand age	Residual total basal area at index age 40 years (m^2/ha)									
(years)	0.5	1	2	4	6	8	12	16	20	25
40	2.4	4.9	10.0	20.5	31.1	41.8	63.4	85.2	107.2	134.9
45	4.0	7.6	14.3	26.9	39.0	50.8	73.5	95.7	117.3	143.9
50	6.2	10.9	19.3	34.2	47.8	60.5	84.5	107.1	128.7	154.6
55	9.0	15.0	25.2	42.4	57.4	71.2	96.5	119.6	141.4	167.0
60	12.4	19.9	32.1	51.6	68.1	83.0	109.6	133.4	155.5	181.2
65	16.6	25.7	39.9	61.8	79.9	95.9	123.9	148.7	171.3	197.2
70	21.6	32.4	48.8	73.3	93.0	110.1	139.8	165.5	188.7	215.2
75	27.5	40.2	58.9	86.1	107.5	125.9	157.3	184.2	208.2	235.3
80	34.4	49.2	70.3	100.4	123.7	143.4	176.6	204.8	229.7	257.6
85	42.5	59.5	83.2	116.3	141.6	162.7	198.0	227.6	253.5	282.5
90	51.8	71.2	97.7	(134.1)	161.5	184.2	221.7	252.8	280.0	310.0
95	62.6	84.5	114.1	154.0	183.6	208.0	247.9	280.8	309.2	340.6
100	74.9	99.6	132.5	176.2	208.2	234.4	276.9	311.7	341.7	374.5
105	89.0	116.7	153.2	(201.0)	235.6	263.7	309.1	346.0	377.6	
110	105.0	136.1	176.4	228.6	266.0	296.3	344.8	383.9		
115	123.3	158.0	202.4	259.4	299.9	332.4	384.3			
120	144.0	182.6	231.6	293.8	337.6	372.6				
125	167.5	210.4	264.4	332.1	379.5					
130	194.1	241.7	301.0	374.9						

(cont'd)

Table 8. Application of the growth and yield model for an average stand within the white pine working group in the Algonquin Provincial Park, composed of 60% pine and growing on Site Class 2. (concl.)

C. Gross merchantible volume of all species (m^3/ha)

Stand age	Residual total basal area at index age 40 years (m^2/ha)									
(years)	0.5	1	2	4	6	8	12	16	20	25
40	3.5	7.3	15.0	30.9	47.1	63.6	97.0	130.8	165.0	208.2
45	5.9	11.3	21.4	40.7	59.2	77.2	112.4	146.7	180.3	221.7
50	9.2	16.3	29.0	51.7	72.5	92.1	129.1	164.1	197.6	238.0
55	13.3	22.5	38.0	64.2	87.2	108.4	147.4	183.3	217.0	257.0
60	18.4	29.8	48.3	78.1	103.5	126.4	167.5	204.5	238.7	278.7
65	24.7	38.6	60.1	93.8	121.6	146.2	189.5	227.9	262.9	303.3
70	32.3	48.8	73.7	111.2	141.6	168.0	213.9	253.8	289.8	331.0
75	41.2	60.6	89.0	130.8	163.9	192.2	240.8	282.5	319.7	361.9
80	51.7	74.2	106.5	152.7	188.6	219.1	270.5	314.2	352.9	396.4
85	64.0	89.8	126.2	177.2	216.1	248.8	303.5	349.4	389.8	434.8
90	78.2	107.7	148.4	(204.5)	246.8	281.9	340.1	388.5	430.7	477.6
95	94.5	128.1	173.5	235.1	280.9	318.6	380.6	431.7	476.1	525.0
100	113.3	151.2	201.8	269.3	318.9	359.4	425.6	479.7	526.4	577.7
105	134.8	177.5	233.6	(307.5)	361.2	404.8	475.4	532.9	582.2	
110	159.4	207.2	269.4	350.2	408.3	455.3	530.8	591.9		
115	187.4	240.9	309.6	397.9	460.8	511.4	592.3			
120	219.2	278.9	354.7	451.1	519.3	573.8				
125	255.4	321.8	405.3	510.6	584.5					
130	296.4	370.1	462.1	577.0						

white pine was harvested. This suggests that the silvicultural prescriptions favored leaving white pine in stands where the preharvest basal area of that species was low, and increased the proportion of white pine harvested when it was more prevalent in the stand. These conclusions are supported by Appendix 5B.

The instantaneous volume growth rate and periodic annual volume increment for the first 15 years after harvest are observed to vary according to site class, although conditions of 70 percent residual pine by basal area and an average age of residual pine of 90 years are held constant over all three site classes (Table 9a). Pine volume growth represents 70 to 90 percent of the total volume growth depending on the site class.

When referring to Table 9b, the reader will note that the basal area growth rate for other species is shown as zero, although volume growth attributed to other species is indicated in Table 9a. This is not to suggest that the basal area of other species did not increase following harvest. However, the data reveal that pine represents the larger diameter and dominant stems in the residual stands while other species tend to be suppressed with correspondingly smaller diameter stems. Thus pine will tend to dominate total basal area growth following harvest.

CONCLUSIONS

A model has been developed to estimate growth and yield in red pine and white pine stands under uniform shelterwood management in the Algonquin Provincial Park. The total basal area growth and volume growth of these trees under uniform shelterwood management are affected by site productivity and the proportion of pine in the residual stand. The results also suggest that red pine and white pine stands in the park experience continually increasing volume growth following uniform shelterwood harvesting over an age range of 40 to 130 years.

The model can be used to make volume growth projections over periods of up to 25 years. This is generally appropriate for purposes of management planning and for preparing preharvest silvicultural prescriptions for stands in red pine and white pine working groups. However, there is considerable risk associated with using the results to project growth beyond 25 years, as might be desired when estimating the long-term timber supply.

It should be noted that these models have been developed from Algonquin Provincial Park data and must be tested and calibrated for other sites.

Table 9. Instantaneous and periodic growth in (A) gross merchantable volume and (B) basal area of the "average" white pine stand managed under the uniform shelterwood system in the Algonquin Provincial Park.

Characteristics of this "average" white pine stand include:

- 70 percent pine after cut ($Pw_6\ Pr_1\ OH_3$)
- average age of residual pine is 90 years
- residual basal area of all species is 20 m^2/ha

A) Gross merchantable volume

Site Class	Instantaneous growth (m^3/ha per yr)			P.A.I. (for 15 years after cut) (m^3/ha per yr)		
	Total	Pine	Other	Total	Pine	Other
1	4.78	3.65	1.13	6.33	4.77	1.56
2	4.53	3.47	1.06	6.07	4.58	1.49
3	4.17	3.18	0.99	5.66	4.28	1.38

B) Basal area

Site Class	Instantaneous growth (m^2/ha per yr)			P.A.I. (for 15 years after cut) (m^2/ha per yr)		
	Total	Pine	Other	Total	Pine	Other
1	0.46	0.46	0.00	0.59	0.59	0.00
2	0.50	0.50	0.00	0.65	0.65	0.00
3	0.55	0.55	0.00	0.73	0.73	0.00

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The authors wish to thank Bob Pick, from the Algonquin Forestry Authority and Roj Miller, from the Ontario Ministry of Natural Resources for their assistance and guidance throughout this project. They also acknowledge the Ontario Ministry of Natural Resources, Central Region Science and Technology Unit, for their assistance with data collection. This project was prepared on behalf of the Algonquin Forestry Authority with funding provided by the Northern Ontario Development Agreement (NODA).

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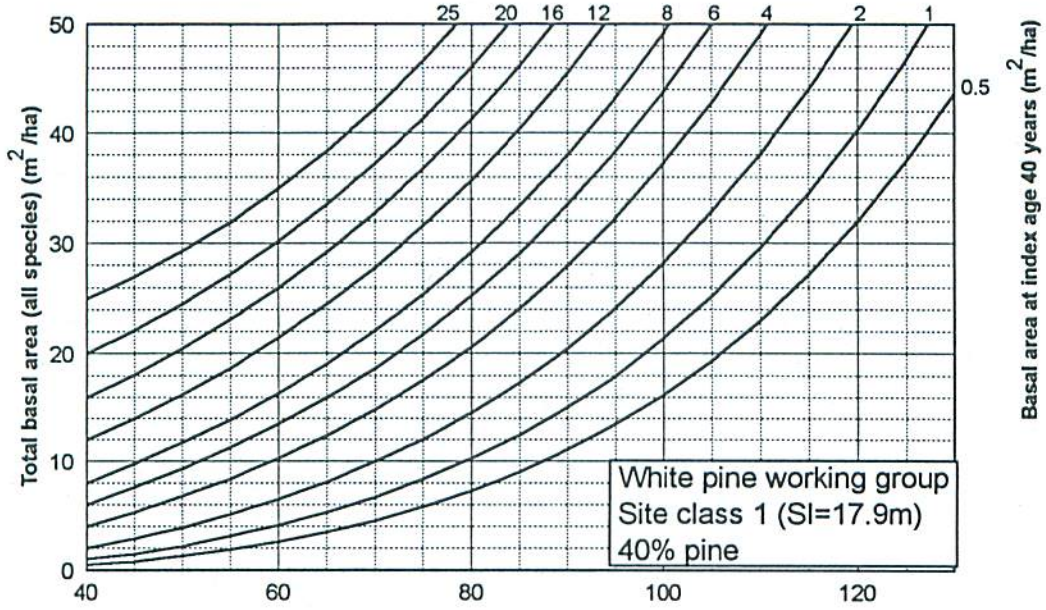
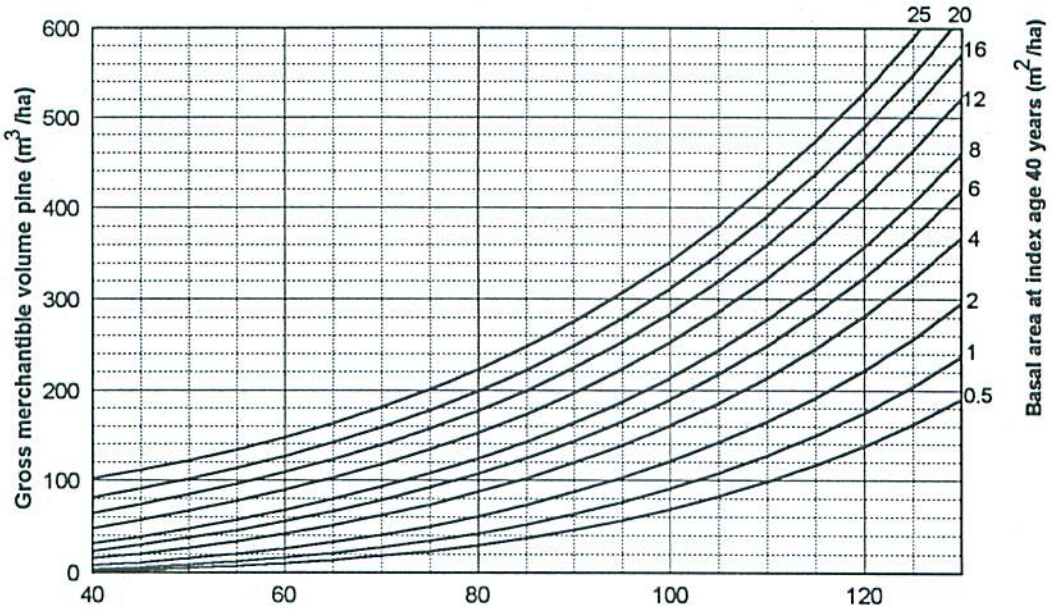
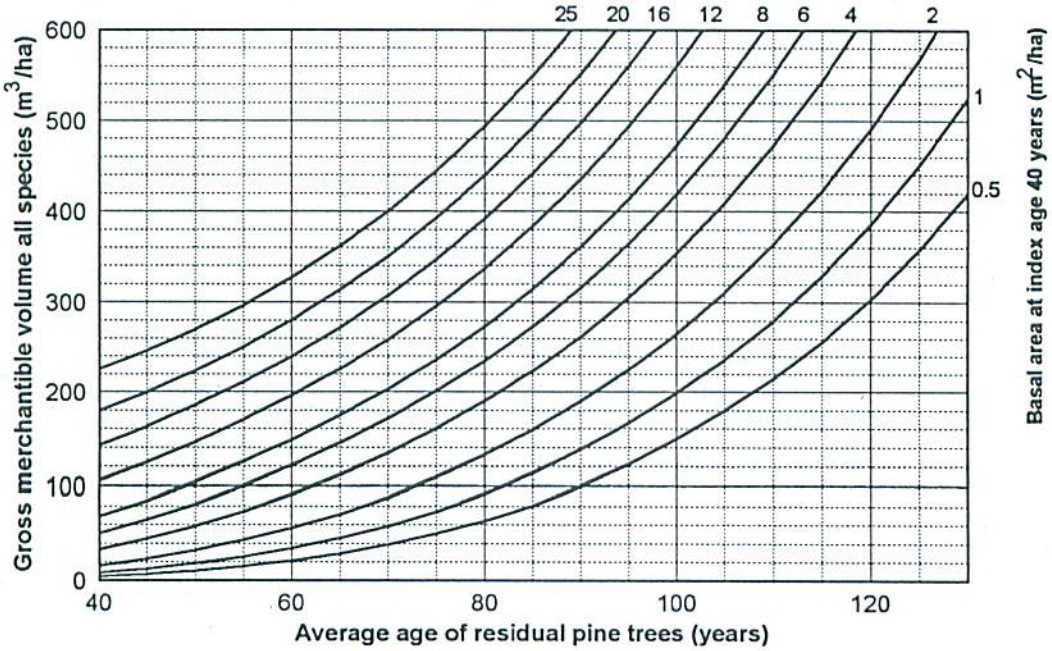
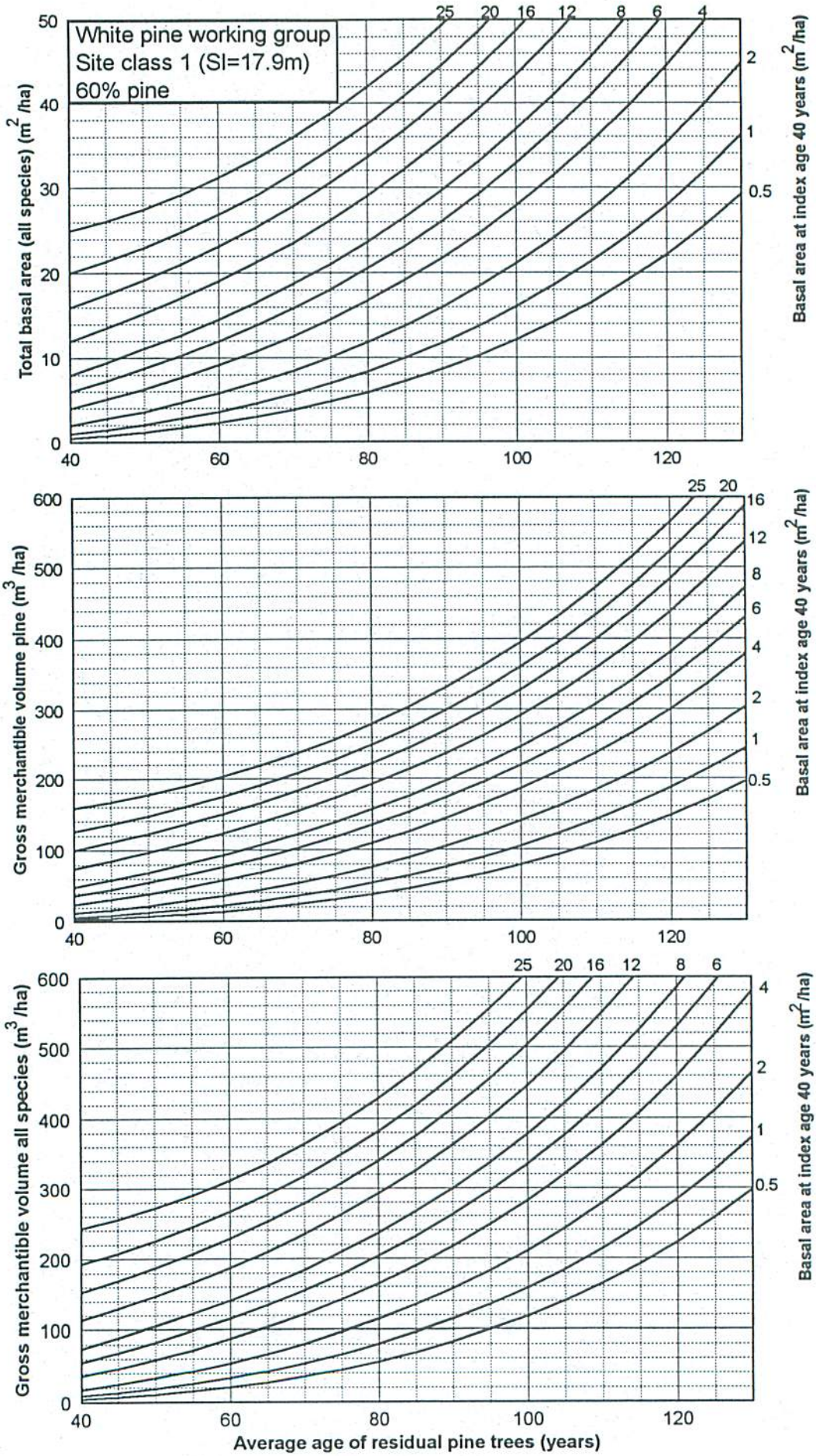
APPENDIX 1

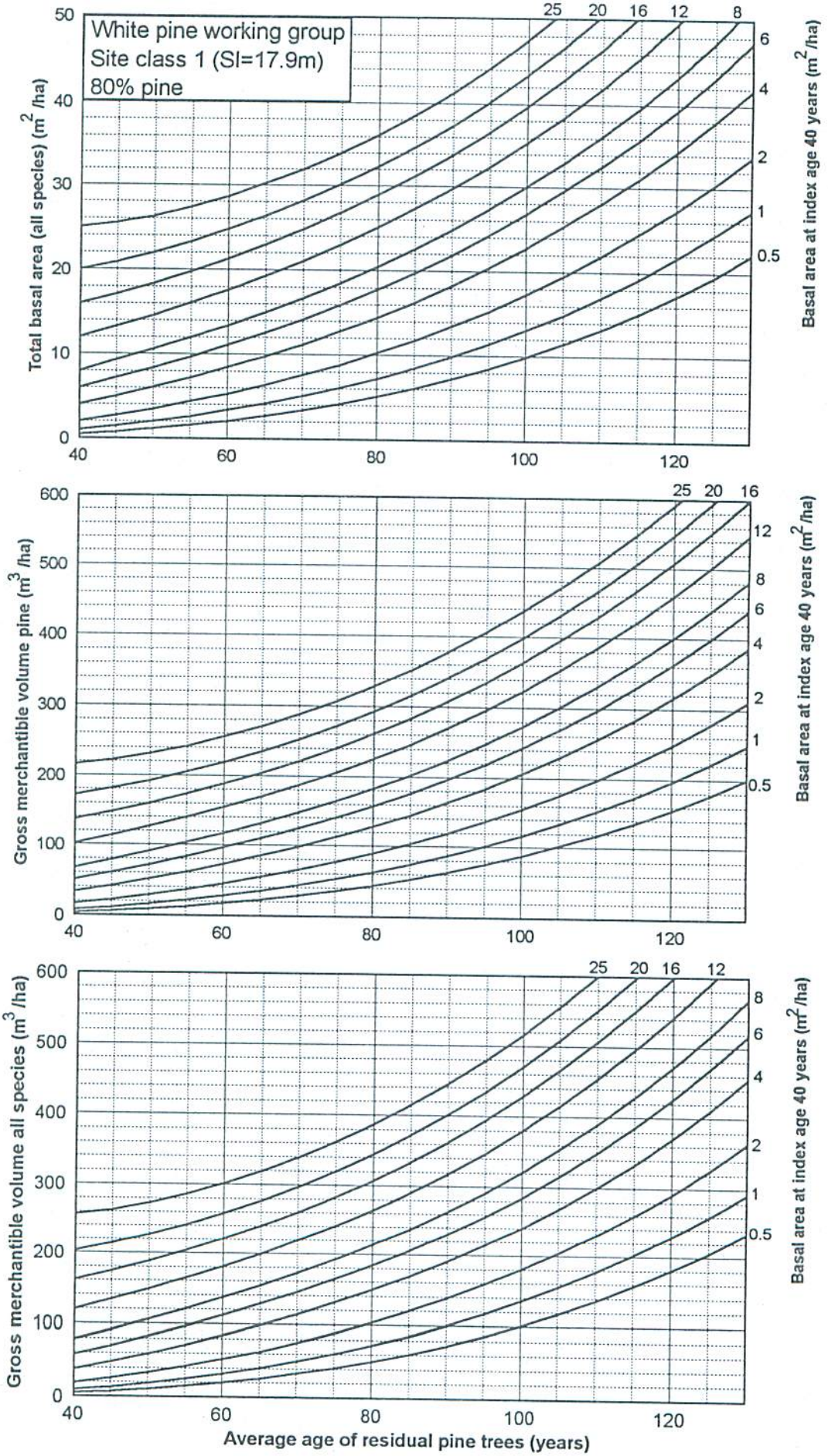
WHITE PINE WORKING GROUP YIELD CURVES

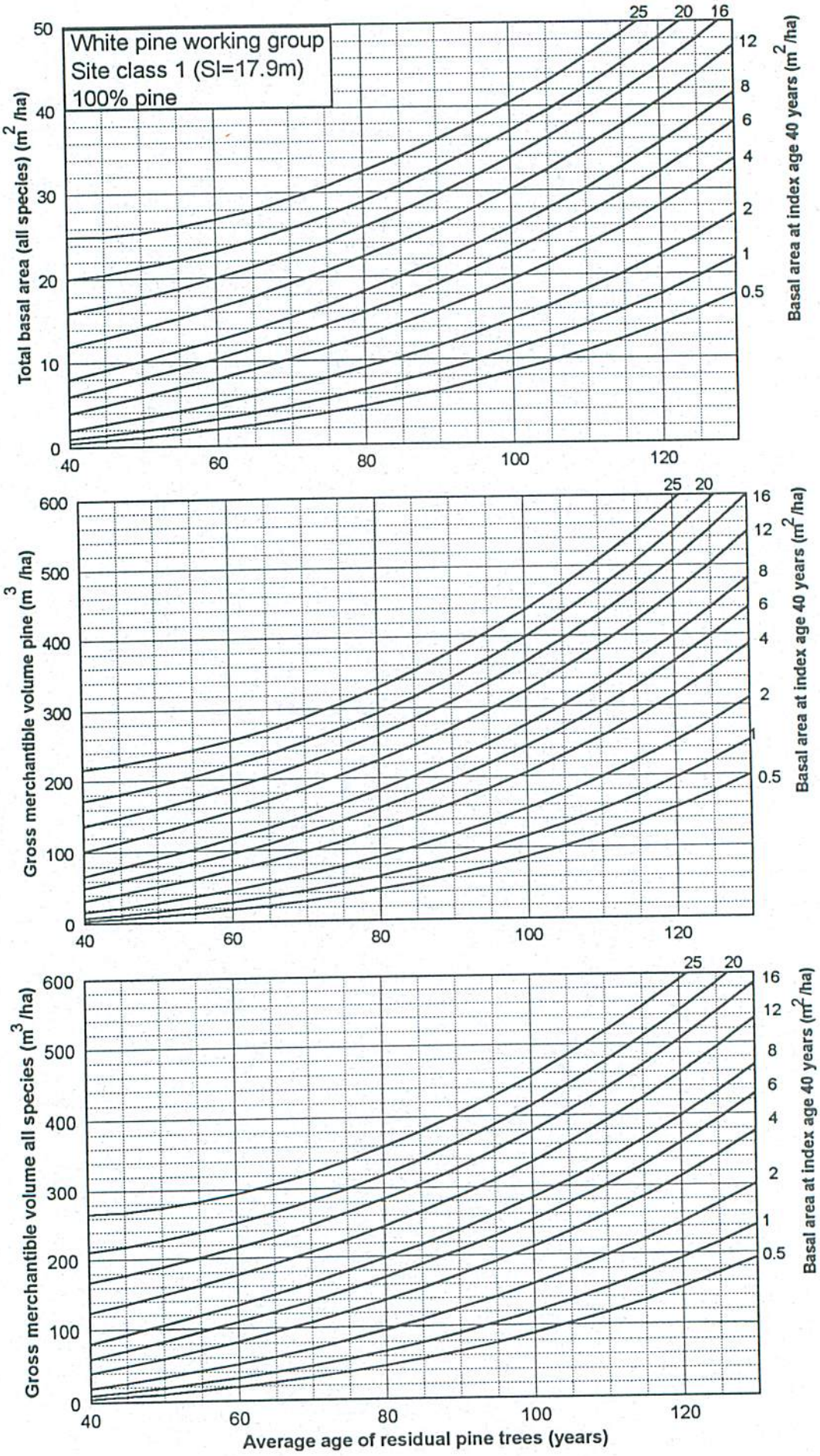

Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
White pine working group
Site class 1 (SI=17.9m)
40% pine

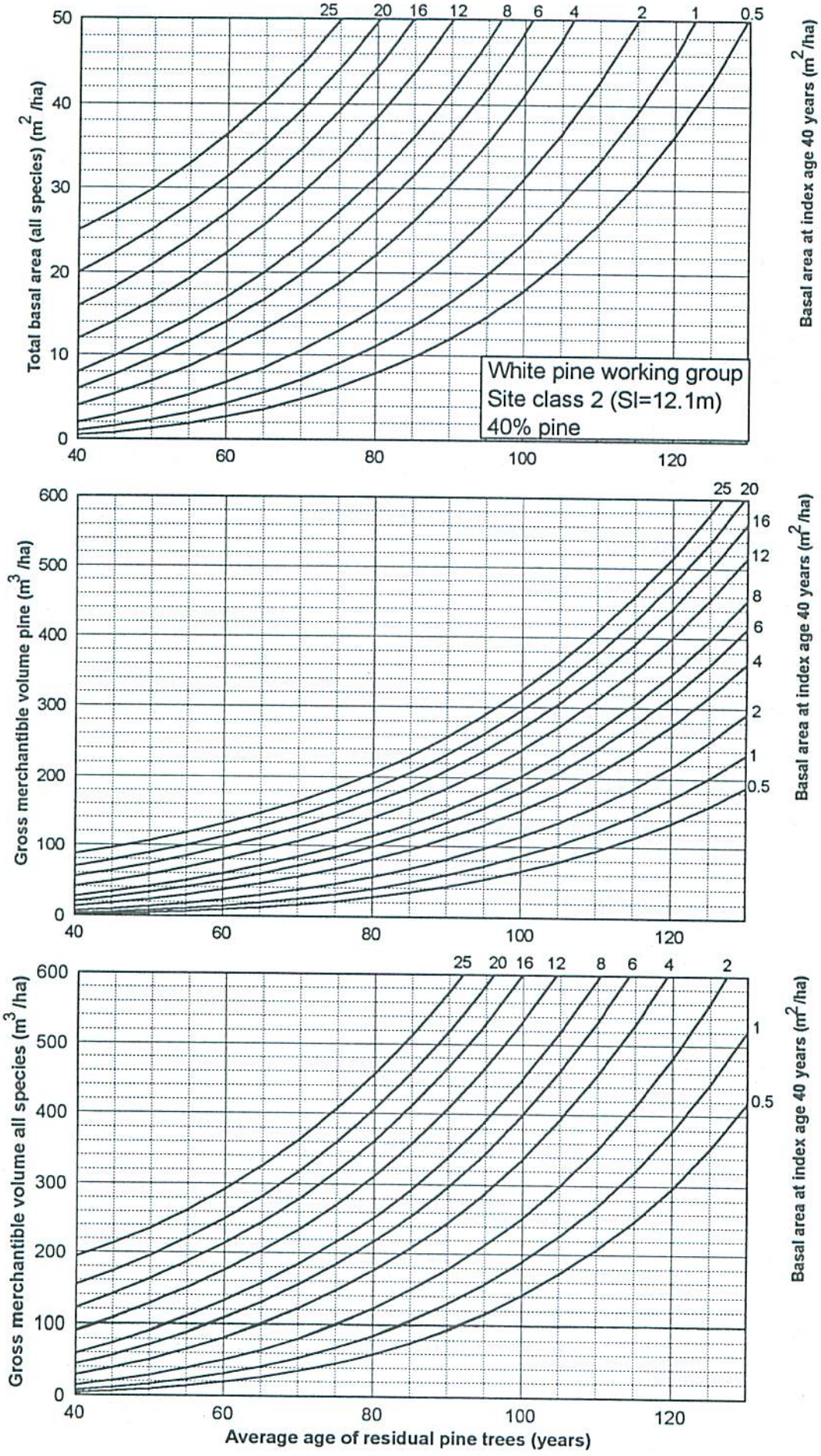

Gross merchantible volume pine (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5

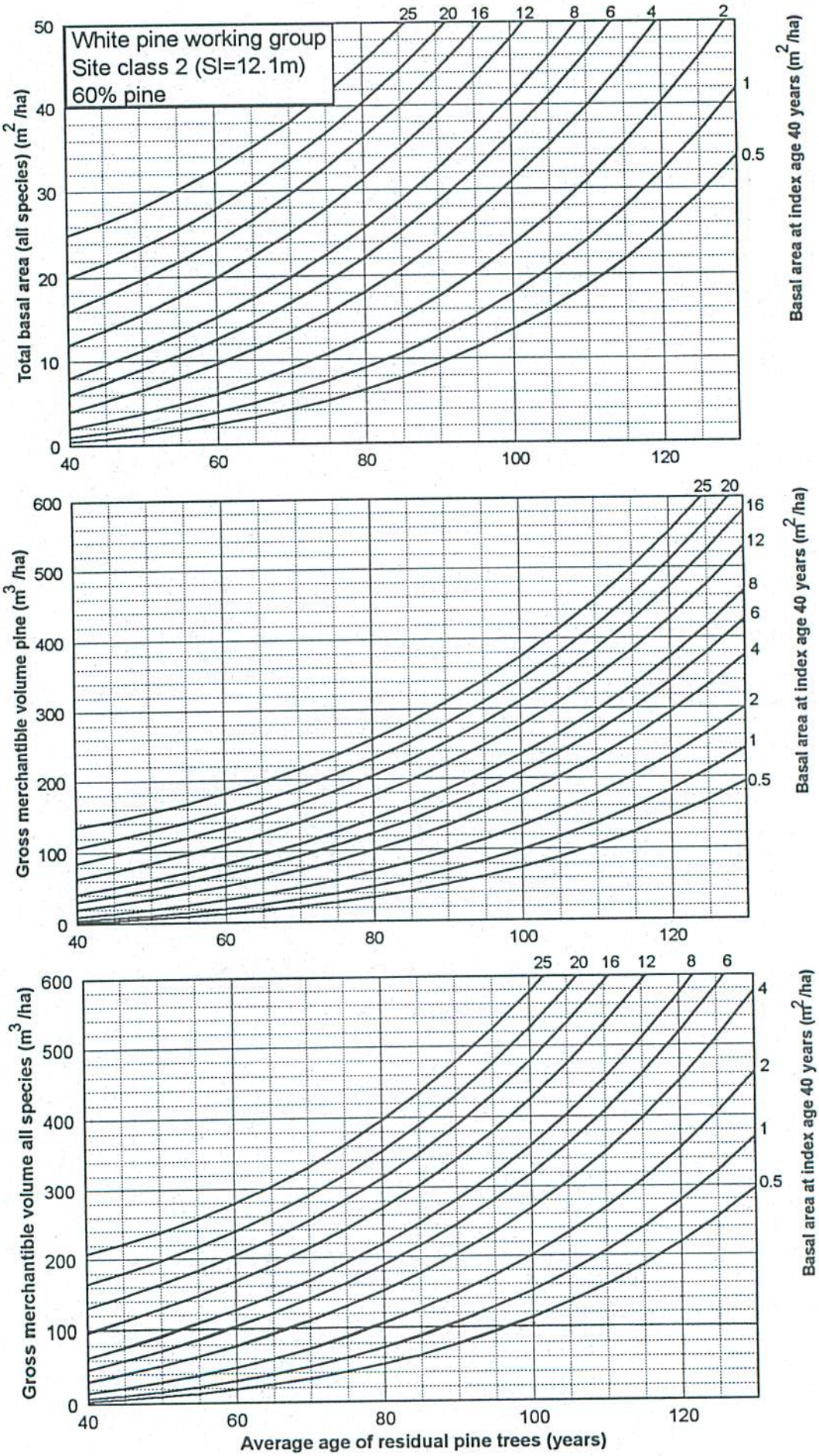

Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
Average age of residual pine trees (years)

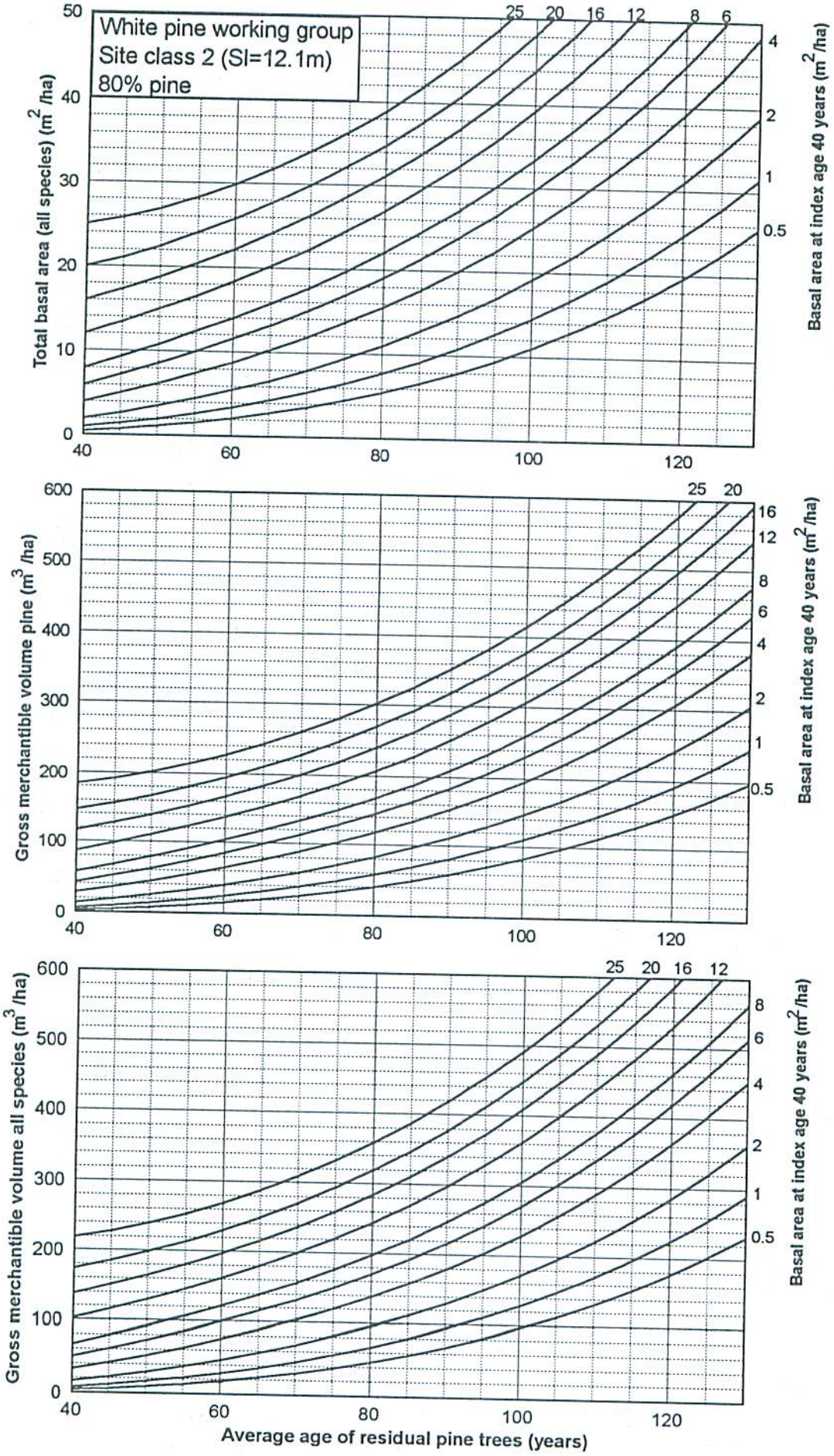

White pine working group
Site class 1 (SI=17.9m)
60% pine
Total basal area (all species) (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
Average age of residual pine trees (years)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
100
200
300
400
500
600
40
60
80
100
120

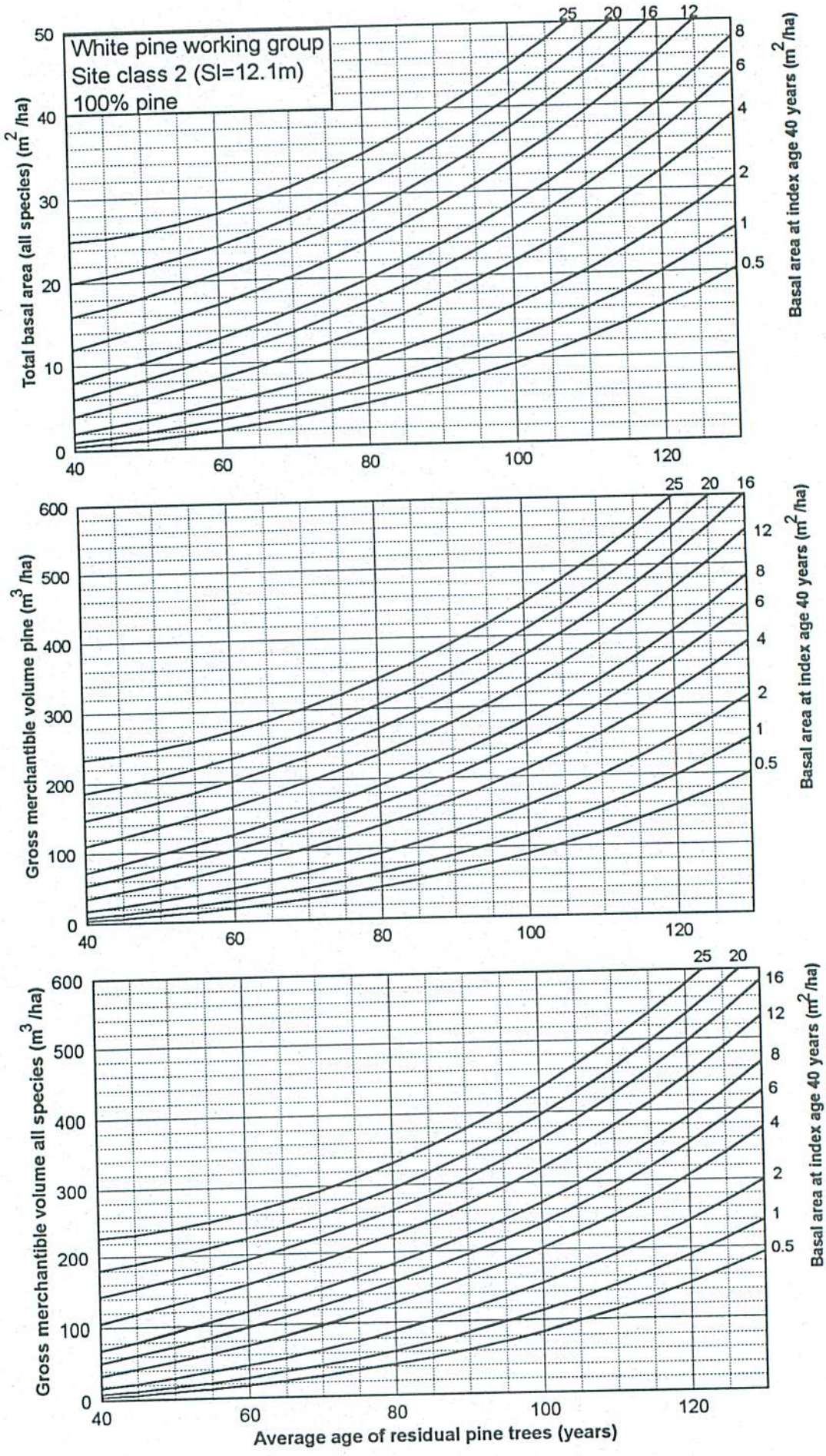

White pine working group
Site class 1 (SI=17.9m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8
6 4 2 1 0.5
Gross merchantible volume pine (m3/ha)
25 20 16
12 8 6 4 2 1 0.5
Gross merchantible volume all species (m3/ha)
25 20 16 12
8 6 4 2 1 0.5
0 100 200 300 400 500 600
0 10 20 30 40 50
40 60 80 100 120
Average age of residual pine trees (years)

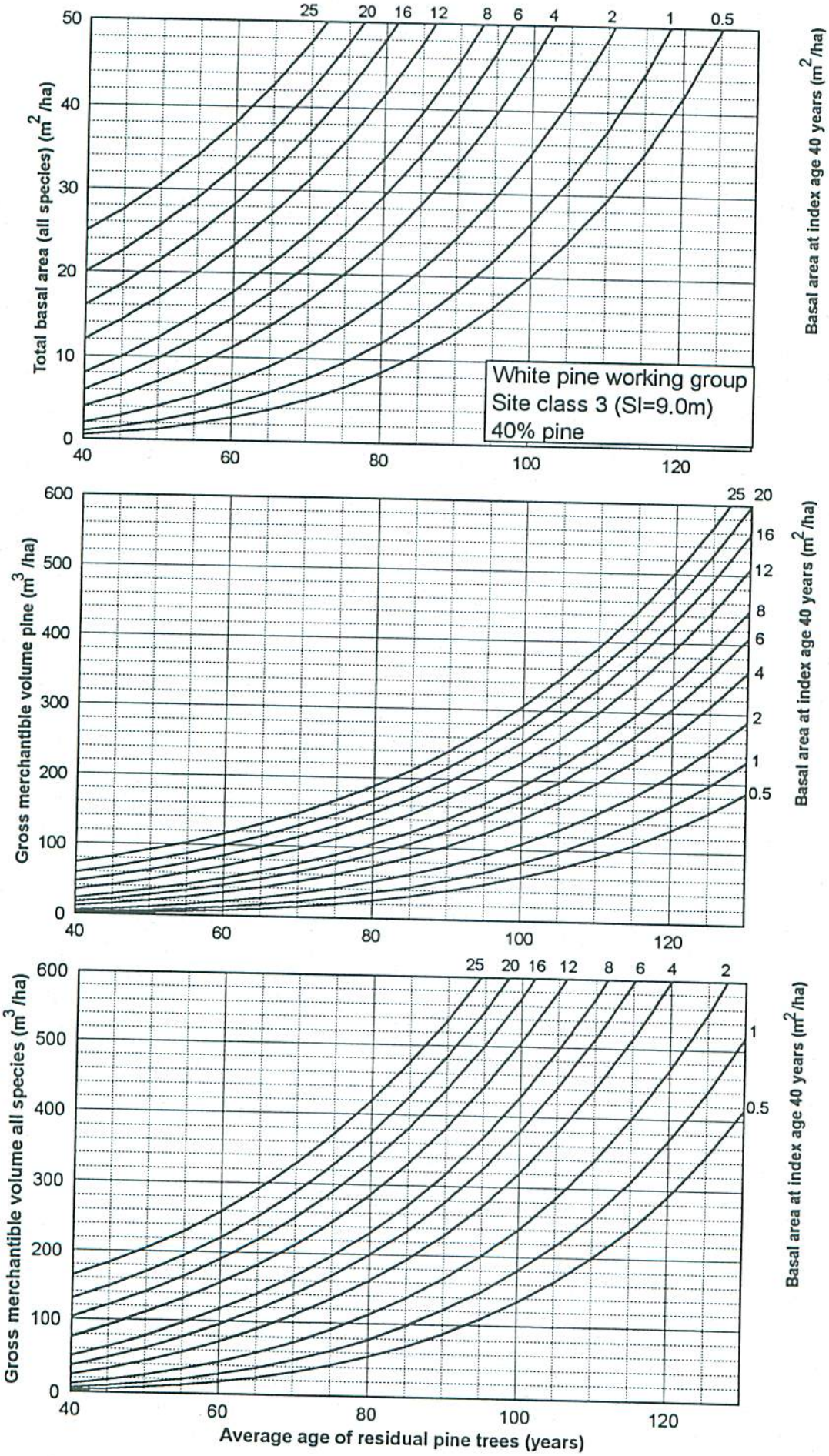

White pine working group
Site class 1 (SI=17.9m)
100% pine
Total basal area (all species) (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
100
200
300
400
500
600
40
60
80
100
120
Average age of residual pine trees (years)

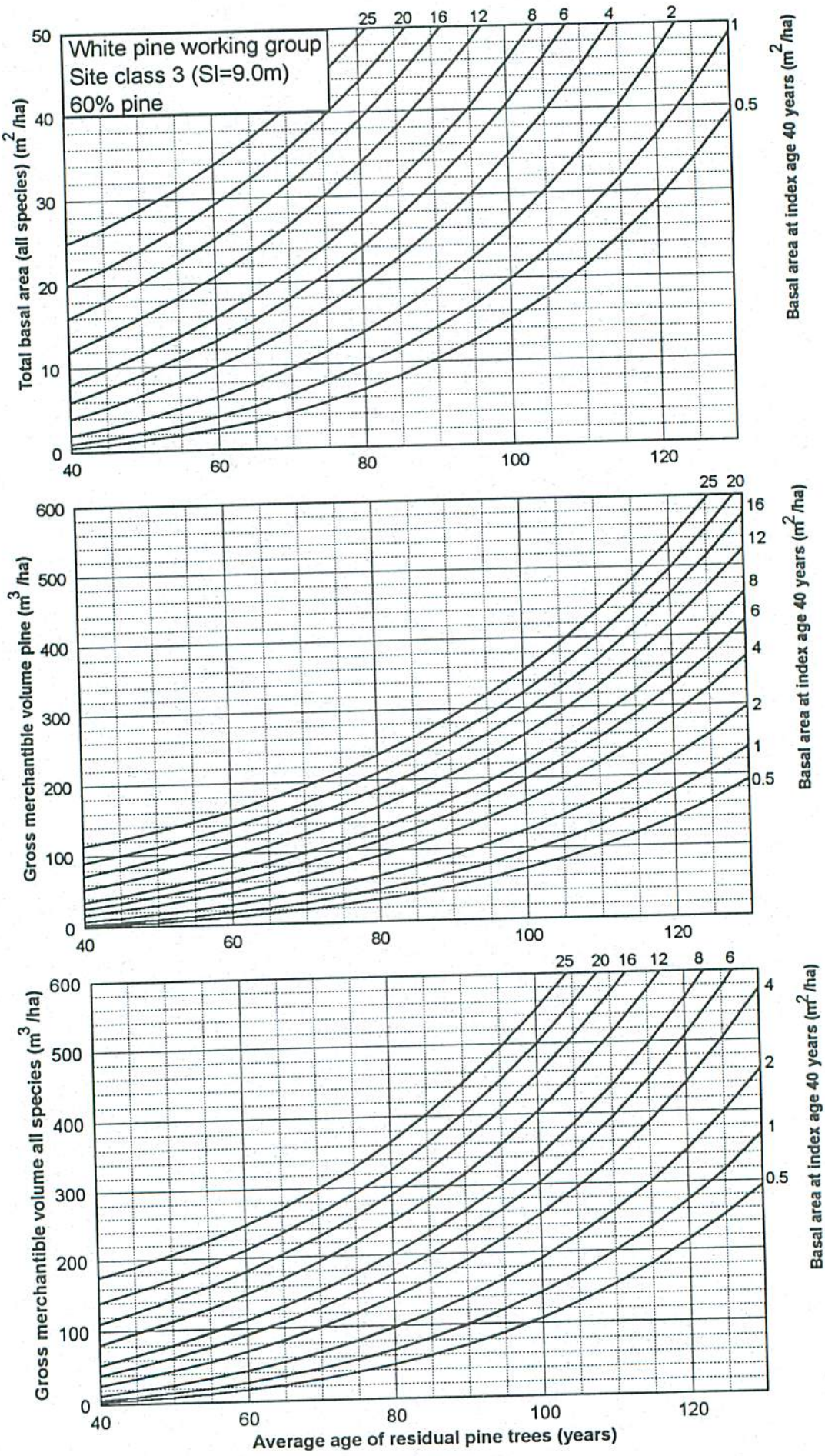

Total basal area (all species) (m2 /ha)
Basal area at index age 40 years (m2 /ha)
25 20 16 12 8 6 4 2 1 0.5
White pine working group
Site class 2 (SI=12.1m)
40% pine
Gross merchantible volume pine (m3 /ha)
Basal area at index age 40 years (m2 /ha)
25 20 16 12 8 6 4 2 1 0.5
Gross merchantible volume all species (m3 /ha)
Basal area at index age 40 years (m2 /ha)
25 20 16 12 8 6 4 2 1 0.5
Average age of residual pine trees (years)

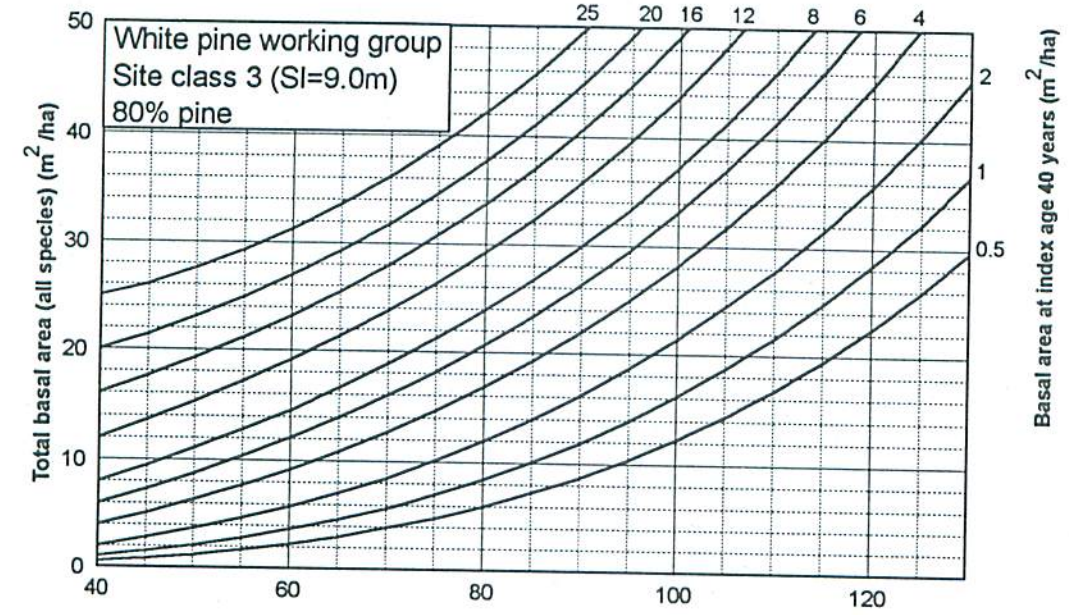

White pine working group
Site class 2 (SI=12.1m)
60% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 10 20 30 40 50
40 60 80 100 120
Gross merchantible volume pine (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 100 200 300 400 500 600
40 60 80 100 120
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 100 200 300 400 500 600
40 60 80 100 120
Average age of residual pine trees (years)

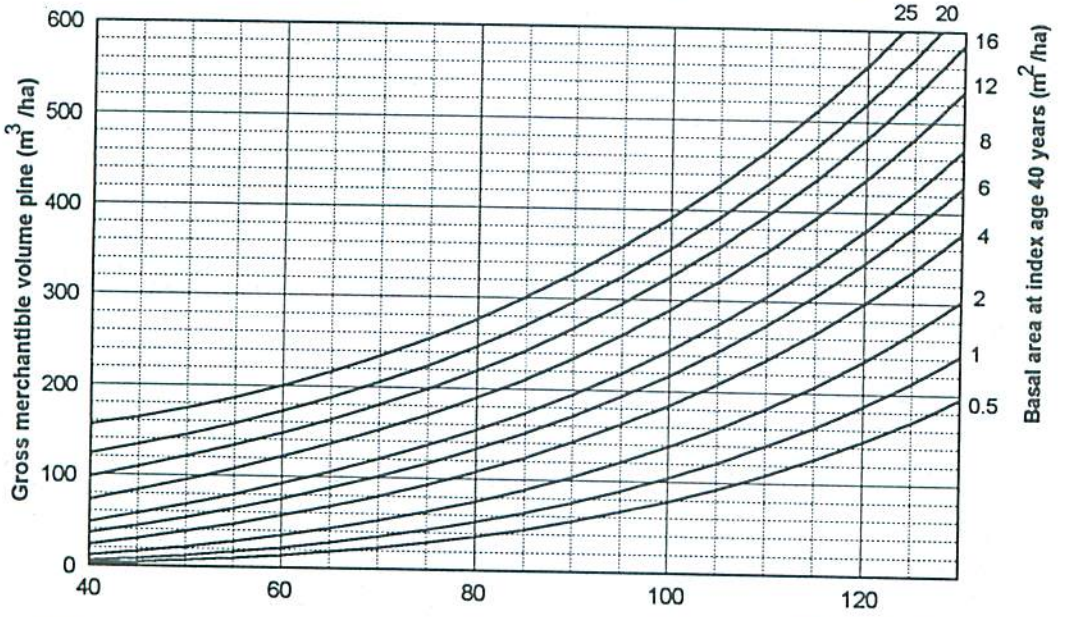

White pine working group
Site class 2 (SI=12.1m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Average age of residual pine trees (years)


White pine working group
Site class 2 (SI=12.1m)
100% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
Gross merchantible volume pine (m3/ha)
25 20 16 12 8 6 4 2 1 0.5
Gross merchantible volume all species (m3/ha)
25 20 16 12 8 6 4 2 1 0.5
0 10 20 30 40 50
0 100 200 300 400 500 600
40 60 80 100 120
Average age of residual pine trees (years)


Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
White pine working group
Site class 3 (SI=9.0m)
40% pine
Gross merchantible volume pine (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
Average age of residual pine trees (years)


White pine working group
Site class 3 (SI=9.0m)
60% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 10 20 30 40 50
40 60 80 100 120
Gross merchantible volume pine (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 100 200 300 400 500 600
40 60 80 100 120
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4 2 1 0.5
0 100 200 300 400 500 600
40 60 80 100 120
Average age of residual pine trees (years)


White pine working group
Site class 3 (SI=9.0m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6 4
2
1
0.5
0 10 20 30 40 50
40 60 80 100 120


Gross merchantible volume pine (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20
16
12
8
6
4
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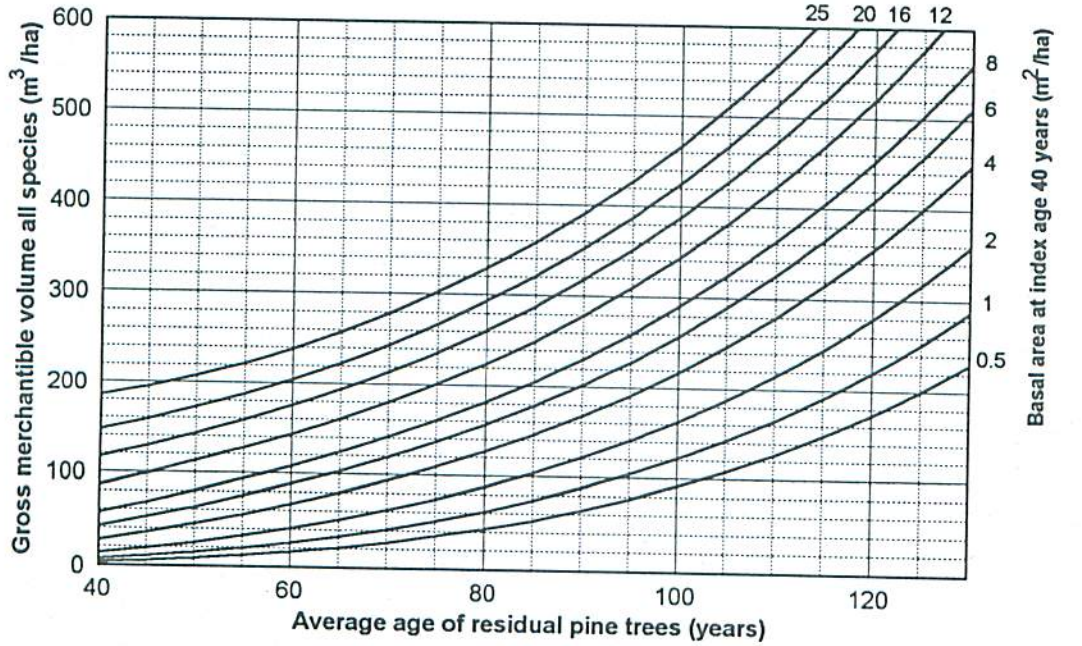
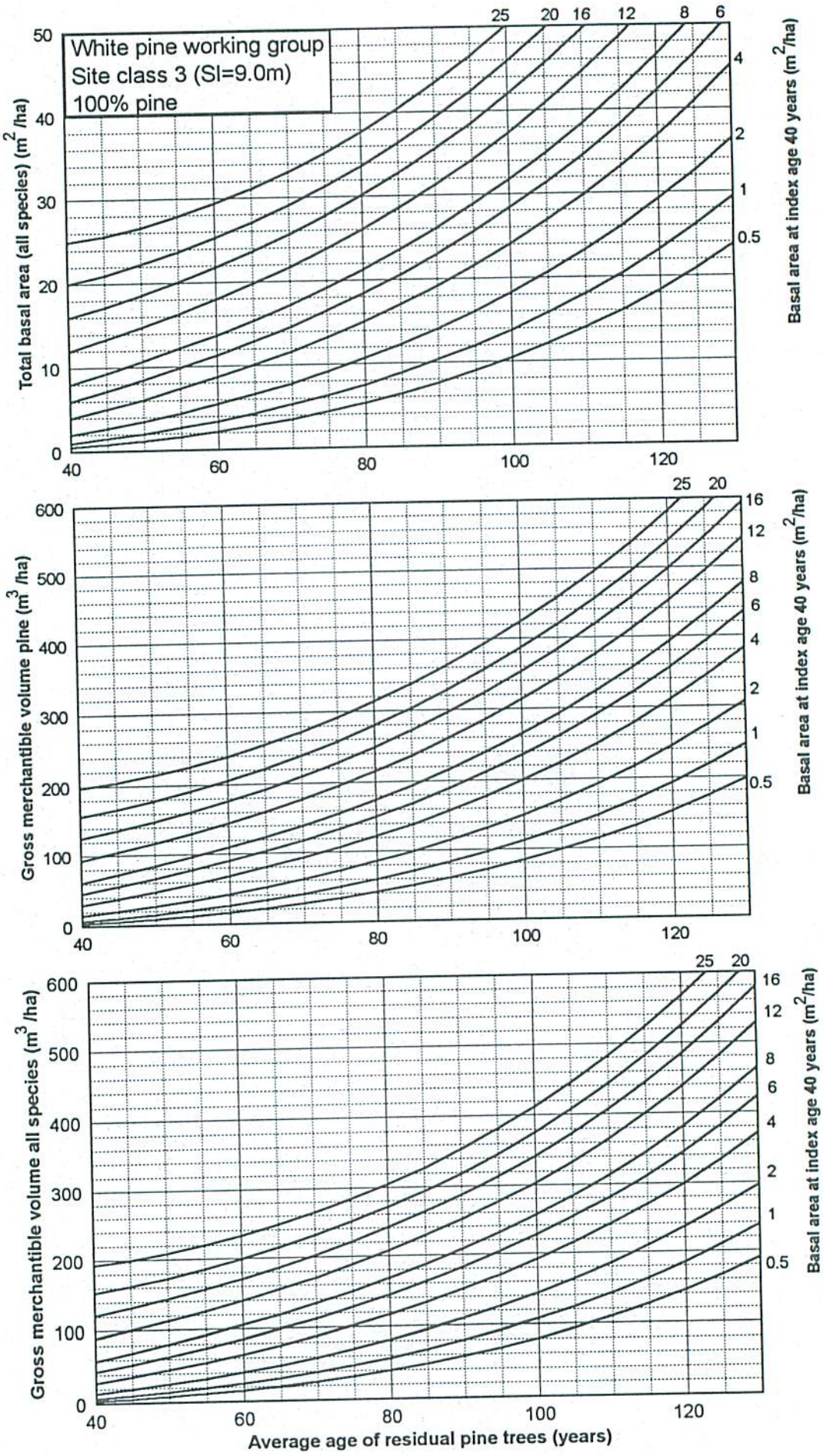
0.5
0 100 200 300 400 500 600
40 60 80 100 120


Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12
8
6
4
2
1
0.5
0 100 200 300 400 500 600
40 60 80 100 120
Average age of residual pine trees (years)


White pine working group
Site class 3 (SI=9.0m)
100% pine
Total basal area (all species) (m2 /ha)
Gross merchantible volume pine (m3 /ha)
Gross merchantible volume all species (m3 /ha)
Basal area at index age 40 years (m2/ha)
25 20 16 12 8 6
4
2
1
0.5
16
12
8
6
4
2
1
0.5
0 10 20 30 40 50
0 100 200 300 400 500 600
40 60 80 100 120
Average age of residual pine trees (years)

APPENDIX 2

WHITE PINE WORKING GROUP YIELD TABLES

White pine working group

Site Class 1 (SI=17.9 m)
Composition Index: 40% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.9	5.3	7.6	9.8	14.0	18.1	22.1	27.0
50	1.3	2.2	3.9	6.8	9.3	11.8	16.3	20.5	24.5	29.3
55	1.9	3.1	5.1	8.4	11.3	13.9	18.7	23.1	27.2	31.9
60	2.6	4.1	6.5	10.3	13.5	16.4	21.5	26.0	30.2	35.0
65	3.5	5.3	8.1	12.4	16.0	19.1	24.5	29.2	33.5	38.4
70	4.5	6.7	10.0	14.9	18.7	22.1	27.8	32.8	37.3	42.3
75	5.8	8.4	12.1	17.6	21.8	25.4	31.6	36.8	41.4	46.7
80	7.3	10.3	14.6	20.6	25.3	29.2	35.7	41.3	46.1	51.6
85	9.0	12.5	17.4	24.1	29.1	33.4	40.4	46.2	51.3	57.0
90	11.1	15.1	20.5	28.0	33.5	38.0	45.6	51.8	57.2	63.1
95	13.5	18.0	24.2	32.3	38.4	43.3	51.4	58.0	63.7	
100	16.2	21.4	28.2	37.3	43.8	49.2	57.8	64.9		
105	19.4	25.2	32.9	42.8	50.0	55.7	65.1			
110	23.0	29.6	38.1	49.1	56.8	63.1				
115	27.2	34.6	44.1	56.1	64.6					
120	32.0	40.3	50.8	64.0						
125	37.5	46.8	58.4							
130	43.7	54.1	66.9							

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.8	3.7	7.6	15.5	23.5	31.6	48.0	64.5	81.1	102.0
45	3.1	5.9	11.0	20.8	30.2	39.2	56.8	74.0	90.7	111.2
50	4.9	8.6	15.3	27.0	37.7	47.7	66.6	84.4	101.4	121.9
55	7.2	12.1	20.3	34.0	46.1	57.2	77.4	96.0	113.5	134.1
60	10.1	16.3	26.2	42.1	55.6	67.7	89.4	108.9	126.9	147.9
65	13.7	21.3	33.1	51.3	66.3	79.5	102.8	123.3	142.0	163.6
70	18.2	27.3	41.1	61.7	78.3	92.7	117.7	139.4	158.9	181.2
75	23.5	34.4	50.3	73.5	91.9	107.6	134.4	157.3	177.8	201.0
80	29.8	42.6	60.9	87.0	107.1	124.2	153.0	177.4	199.0	223.2
85	37.3	52.2	73.1	102.2	124.4	142.9	173.9	199.9	222.7	248.1
90	46.2	63.4	87.0	119.4	143.7	164.0	197.3	225.1	249.3	276.0
95	56.5	76.2	102.9	138.9	165.6	187.6	223.6	253.3	279.0	
100	68.4	91.0	121.1	161.0	190.3	214.2	253.0	284.8		
105	82.3	108.0	141.8	186.0	218.0	244.0	286.1			
110	98.4	127.6	165.3	214.2	249.3	277.6				
115	117.0	149.9	192.1	246.2	284.6					
120	138.3	175.4	222.5	282.2						
125	162.9	204.6	257.1							
130	191.0	237.9	296.2							

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.9	7.9	16.3	33.6	51.3	69.2	105.5	142.3	179.5	226.4
45	6.6	12.5	23.8	45.2	65.8	85.9	125.0	163.1	200.5	246.5
50	10.4	18.5	32.9	58.7	82.2	104.5	146.4	186.1	224.1	269.9
55	15.3	25.9	43.8	74.1	100.7	125.2	170.2	211.7	250.6	296.8
60	21.7	35.1	56.7	91.8	121.6	148.4	196.7	240.2	280.4	327.4
65	29.5	46.0	71.8	111.9	145.1	174.5	226.2	272.0	313.8	362.0
70	39.1	59.1	89.3	134.8	171.6	203.7	259.2	307.6	351.3	401.1
75	50.7	74.5	109.5	160.9	201.5	236.5	296.2	347.4	393.3	445.1
80	64.6	92.6	132.8	190.5	235.3	273.3	337.6	392.1	440.4	494.6
85	80.9	113.7	159.6	224.2	273.4	314.8	384.0	442.1	493.2	550.2
90	100.2	138.1	190.4	262.3	316.5	361.5	436.1	498.2	552.4	612.5
95	122.8	166.4	225.5	305.6	365.0	414.1	494.6	561.1	618.8	
100	149.2	199.1	265.7	354.6	419.9	473.3	560.3	631.7		
105	179.8	236.7	311.6	410.2	481.7	540.0	634.2			
110	215.3	279.9	363.9	473.1	551.6	615.0				
115	256.3	329.5	423.5	544.3	630.4					
120	303.7	386.2	491.3	624.8						
125	358.1	451.2	568.3							
130	420.7	525.3	655.9							

White pine working group

Site Class 1 (SI=17.9 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.8	5.1	7.3	9.5	13.6	17.5	21.4	26.1
50	1.2	2.1	3.6	6.3	8.8	11.1	15.3	19.2	23.0	27.5
55	1.7	2.8	4.7	7.7	10.3	12.7	17.1	21.1	24.8	29.2
60	2.3	3.6	5.8	9.2	12.0	14.6	19.1	23.2	26.9	31.2
65	3.0	4.6	7.1	10.8	13.9	16.6	21.3	25.4	29.1	33.4
70	3.8	5.7	8.5	12.6	15.9	18.8	23.6	27.9	31.7	36.0
75	4.8	7.0	10.1	14.6	18.1	21.1	26.2	30.6	34.5	38.8
80	5.9	8.4	11.9	16.8	20.6	23.7	29.1	33.6	37.5	42.0
85	7.2	10.0	13.8	19.2	23.2	26.6	32.2	36.8	40.9	45.4
90	8.7	11.8	16.0	21.8	26.1	29.7	35.6	40.4	44.6	49.3
95	10.3	13.8	18.5	24.7	29.4	33.1	39.3	44.4	48.7	53.5
100	12.2	16.1	21.2	28.0	32.9	36.9	43.4	48.7	53.2	58.2
105	14.3	18.6	24.2	31.5	36.8	41.0	47.9	53.4	58.2	63.3
110	16.6	21.4	27.5	35.4	41.0	45.6	52.8	58.6	63.6	
115	19.3	24.5	31.2	39.7	45.8	50.6	58.2	64.4		
120	22.2	28.0	35.3	44.5	50.9	56.1	64.2			
125	25.6	31.9	39.9	49.8	56.6	62.1				
130	29.3	36.3	44.9	55.5	62.9					

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.8	5.8	11.8	24.0	36.5	49.0	74.4	100.0	125.8	158.3
45	4.7	8.8	16.6	31.2	45.2	58.8	85.2	110.9	136.0	166.8
50	7.1	12.5	22.2	39.2	54.8	69.4	96.9	122.8	147.5	177.2
55	10.2	17.1	28.7	48.1	65.2	80.8	109.5	135.8	160.4	189.6
60	13.9	22.4	36.1	58.0	76.6	93.3	123.2	150.0	174.8	203.7
65	18.5	28.6	44.4	68.9	89.1	106.8	138.1	165.7	190.8	219.8
70	23.9	35.8	53.9	81.0	102.8	121.7	154.4	182.9	208.5	237.8
75	30.1	44.1	64.5	94.3	117.8	138.0	172.3	201.8	228.1	257.8
80	37.4	53.5	76.4	109.1	134.4	155.9	192.0	222.6	249.7	280.0
85	45.9	64.1	89.7	125.5	152.7	175.5	213.6	245.5	273.5	304.7
90	55.5	76.2	104.6	143.6	172.9	197.2	237.3	270.7	299.7	331.9
95	66.5	89.8	121.2	163.7	195.1	221.0	263.4	298.4	328.6	362.0
100	79.0	105.1	139.8	185.9	219.6	247.2	292.1	328.8	360.5	395.1
105	93.2	122.3	160.4	210.5	246.8	276.2	323.8	362.4	395.5	431.6
110	109.2	141.6	183.5	237.8	276.7	308.1	358.6	399.3	434.1	
115	127.3	163.2	209.1	267.9	309.7	343.3	396.9	440.0		
120	147.7	187.3	237.6	301.3	346.3	382.2	439.2			
125	170.6	214.4	269.3	338.3	386.6	425.0				
130	196.4	244.6	304.6	379.3	431.2					

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	4.1	8.5	17.6	36.1	55.1	74.3	113.4	153.0	193.0	243.4
45	6.9	13.0	24.7	47.0	68.3	89.2	129.8	169.4	208.2	256.0
50	10.5	18.6	33.2	59.1	82.8	105.2	147.5	187.4	225.7	271.8
55	15.0	25.4	42.9	72.5	98.6	122.6	166.6	207.2	245.3	290.5
60	20.7	33.4	54.1	87.5	115.9	141.5	187.5	228.9	267.3	312.0
65	27.4	42.8	66.7	104.0	134.9	162.2	210.3	252.8	291.7	336.5
70	35.5	53.6	81.0	122.4	155.7	184.8	235.2	279.1	318.8	364.0
75	45.0	66.1	97.1	142.7	178.7	209.7	262.6	308.1	348.8	394.8
80	56.0	80.3	115.2	165.2	204.1	237.0	292.7	340.0	381.9	428.9
85	68.7	96.5	135.5	190.2	232.0	267.1	325.9	375.2	418.5	466.9
90	83.3	114.7	158.1	217.9	262.9	300.3	362.3	413.9	458.9	508.8
95	99.9	135.4	183.5	248.6	297.0	336.9	402.5	456.6	503.5	555.2
100	118.9	158.7	211.8	282.7	334.7	377.3	446.7	503.6	552.6	606.4
105	140.5	184.9	243.4	320.5	376.4	421.9	495.5	555.4	606.7	662.9
110	164.9	214.4	278.7	362.4	422.5	471.1	549.2	612.4	666.4	
115	192.5	247.4	318.0	408.8	473.4	525.4	608.5	675.3		
120	223.7	284.5	361.9	460.3	529.8	585.4	673.9			
125	258.8	326.0	410.7	517.3	592.2	651.7				
130	298.3	372.4	465.0	580.6	661.1					

White pine working group

Site Class 1 (SI=17.9 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.7	5.0	7.2	9.3	13.3	17.1	20.9	25.5
50	1.2	2.0	3.5	6.1	8.4	10.6	14.6	18.4	22.0	26.3
55	1.6	2.6	4.4	7.2	9.7	12.0	16.1	19.8	23.3	27.4
60	2.1	3.4	5.3	8.5	11.1	13.4	17.6	21.3	24.8	28.7
65	2.7	4.2	6.4	9.8	12.6	15.0	19.3	23.0	26.4	30.3
70	3.4	5.1	7.6	11.2	14.2	16.7	21.1	24.8	28.2	32.0
75	4.2	6.1	8.8	12.8	15.9	18.5	23.0	26.8	30.2	34.0
80	5.1	7.2	10.3	14.5	17.8	20.5	25.1	29.0	32.4	36.2
85	6.1	8.5	11.8	16.3	19.8	22.6	27.4	31.3	34.8	38.7
90	7.3	9.9	13.5	18.3	21.9	24.9	29.8	33.9	37.4	41.3
95	8.5	11.4	15.3	20.5	24.3	27.4	32.5	36.7	40.3	44.3
100	9.9	13.1	17.3	22.8	26.8	30.1	35.4	39.7	43.4	47.5
105	11.5	14.9	19.5	25.4	29.6	33.0	38.5	43.0	46.8	51.0
110	13.2	17.0	21.9	28.1	32.6	36.2	41.9	46.5	50.5	54.7
115	15.1	19.2	24.5	31.1	35.8	39.6	45.6	50.4	54.5	58.9
120	17.2	21.7	27.3	34.4	39.4	43.3	49.6	54.6	58.8	63.4
125	19.5	24.4	30.4	38.0	43.2	47.4	53.9	59.1	63.5	
130	22.1	27.3	33.8	41.8	47.4	51.8	58.6	64.1		

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.9	7.9	16.1	32.8	49.8	66.9	101.6	136.6	171.8	216.1
45	6.2	11.7	22.1	41.6	60.3	78.4	113.6	147.8	181.3	222.3
50	9.2	16.4	28.9	51.2	71.4	90.5	126.4	160.1	192.4	231.2
55	13.0	21.8	36.6	61.5	83.3	103.4	140.0	173.6	205.1	242.4
60	17.5	28.1	45.2	72.8	96.1	117.1	154.6	188.3	219.4	255.7
65	22.8	35.3	54.8	85.0	109.8	131.8	170.3	204.3	235.3	271.0
70	28.9	43.5	65.3	98.2	124.6	147.6	187.3	221.8	252.9	288.3
75	36.0	52.6	77.0	112.6	140.6	164.6	205.6	240.8	272.1	307.6
80	44.0	62.8	89.7	128.2	157.9	183.1	225.5	261.5	293.3	328.9
85	53.1	74.2	103.8	145.2	176.7	203.0	247.1	284.0	316.4	352.5
90	63.3	86.9	119.2	163.7	197.0	224.7	270.5	308.5	341.6	378.3
95	74.7	100.9	136.2	183.9	219.1	248.2	295.9	335.1	369.1	406.6
100	87.5	116.4	154.8	205.8	243.2	273.8	323.5	364.1	399.1	437.5
105	101.7	133.5	175.2	229.8	269.4	301.5	353.5	395.7	431.8	471.3
110	117.6	152.4	197.5	256.0	297.9	331.7	386.1	429.9	467.4	508.0
115	135.2	173.3	222.0	284.5	328.9	364.6	421.5	467.2	506.1	548.1
120	154.7	196.3	248.9	315.7	362.8	400.4	460.1	507.8	548.2	591.7
125	176.4	221.6	278.3	349.7	399.6	439.3	502.0	551.9	593.9	
130	200.3	249.4	310.6	386.8	439.8	481.7	547.6	599.8		

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	4.4	9.0	18.5	38.0	58.0	78.2	119.3	161.0	203.1	256.2
45	7.0	13.4	25.4	48.2	70.2	91.6	133.3	174.0	213.9	263.0
50	10.5	18.7	33.3	59.4	83.2	105.7	148.2	188.3	226.8	273.1
55	14.8	25.0	42.3	71.4	97.1	120.7	164.1	204.1	241.6	286.1
60	20.0	32.3	52.3	84.5	112.0	136.8	181.2	221.3	258.3	301.6
65	26.1	40.6	63.3	98.8	128.1	154.0	199.6	240.0	276.9	319.5
70	33.2	50.1	75.6	114.2	145.4	172.5	219.6	260.6	297.6	339.8
75	41.3	60.7	89.2	131.0	164.1	192.6	241.2	282.9	320.3	362.5
80	50.6	72.6	104.1	149.4	184.5	214.2	264.6	307.3	345.2	387.7
85	61.1	85.8	120.6	169.3	206.5	237.8	290.0	333.9	372.5	415.5
90	73.0	100.6	138.6	191.1	230.5	263.3	317.6	362.9	402.3	446.1
95	86.3	117.0	158.5	214.8	256.6	291.1	347.7	394.4	434.9	479.6
100	101.3	135.1	180.4	240.7	285.0	321.3	380.3	428.8	470.5	516.3
105	117.9	155.2	204.3	269.0	315.9	354.1	415.9	466.2	509.3	556.4
110	136.5	177.4	230.7	299.9	349.7	389.9	454.6	506.9	551.5	600.2
115	157.1	202.0	259.6	333.6	386.4	428.8	496.7	551.2	597.6	647.9
120	180.1	229.0	291.3	370.5	426.5	471.3	542.5	599.4	647.7	699.9
125	205.5	258.9	326.1	410.8	470.2	517.5	592.4	652.0	702.3	
130	233.7	291.8	364.3	454.9	517.9	567.9	646.7	709.1		

White pine working group

Site Class 1 (SI=17.9 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.4	2.7	4.9	7.0	9.1	13.0	16.8	20.5	25.0
50	1.1	1.9	3.4	5.9	8.1	10.2	14.1	17.8	21.3	25.4
55	1.5	2.5	4.2	6.9	9.2	11.4	15.3	18.8	22.2	26.1
60	2.0	3.2	5.0	7.9	10.4	12.6	16.5	20.0	23.2	27.0
65	2.5	3.9	5.9	9.1	11.7	13.9	17.8	21.3	24.4	28.0
70	3.1	4.7	6.9	10.3	13.0	15.3	19.3	22.7	25.8	29.3
75	3.8	5.5	8.0	11.6	14.4	16.7	20.8	24.2	27.3	30.7
80	4.6	6.5	9.2	12.9	15.8	18.3	22.4	25.9	28.9	32.4
85	5.4	7.5	10.4	14.4	17.4	20.0	24.2	27.7	30.7	34.1
90	6.3	8.6	11.7	16.0	19.1	21.7	26.0	29.6	32.7	36.1
95	7.4	9.9	13.2	17.7	21.0	23.7	28.1	31.7	34.8	38.2
100	8.5	11.2	14.8	19.5	22.9	25.7	30.2	33.9	37.1	40.5
105	9.7	12.6	16.4	21.4	25.0	27.9	32.5	36.3	39.5	43.0
110	11.0	14.2	18.3	23.5	27.2	30.2	35.0	38.9	42.2	45.8
115	12.5	15.9	20.2	25.7	29.6	32.8	37.7	41.7	45.1	48.7
120	14.1	17.7	22.4	28.2	32.2	35.5	40.6	44.7	48.2	51.9
125	15.8	19.7	24.6	30.8	35.0	38.4	43.7	47.9	51.5	55.3
130	17.7	21.9	27.1	33.6	38.0	41.5	47.1	51.4	55.1	59.0

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	4.9	10.0	20.5	41.8	63.4	85.2	129.3	173.9	218.7	275.2
45	7.8	14.6	27.6	52.0	75.3	98.0	142.0	184.7	226.5	277.8
50	11.4	20.1	35.6	62.9	87.8	111.2	155.3	196.8	236.4	284.1
55	15.7	26.4	44.3	74.5	100.9	125.1	169.4	210.1	248.2	293.3
60	20.9	33.5	54.0	86.8	114.6	139.6	184.4	224.6	261.7	305.0
65	26.8	41.6	64.5	100.0	129.2	155.0	200.4	240.4	276.9	318.9
70	33.6	50.5	75.9	114.0	144.7	171.4	217.5	257.6	293.6	334.8
75	41.3	60.3	88.2	129.1	161.2	188.8	235.8	276.1	312.1	352.7
80	49.8	71.2	101.7	145.2	178.9	207.4	255.5	296.2	332.3	372.7
85	59.4	83.1	116.2	162.5	197.8	227.3	276.6	318.0	354.2	394.6
90	70.0	96.1	132.0	181.2	218.1	248.7	299.4	341.4	378.1	418.7
95	81.8	110.4	149.0	201.2	239.8	271.7	323.8	366.8	404.0	445.0
100	94.7	125.9	167.5	222.8	263.2	296.3	350.1	394.1	432.0	473.5
105	108.9	142.9	187.5	246.0	288.4	322.8	378.4	423.5	462.2	504.5
110	124.5	161.4	209.2	271.1	315.5	351.3	408.9	455.3	494.9	538.0
115	141.7	181.5	232.6	298.1	344.7	382.0	441.7	489.5	530.2	574.3
120	160.4	203.5	258.1	327.3	376.1	415.1	477.0	526.4	568.3	613.5
125	180.9	227.3	285.6	358.8	410.0	450.7	515.0	566.2	609.3	655.8
130	203.4	253.3	315.4	392.7	446.5	489.1	556.0	609.0	653.6	701.4

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	4.5	9.3	19.2	39.6	60.4	81.4	124.2	167.6	211.4	266.6
45	7.2	13.7	25.9	49.3	71.7	93.6	136.2	177.7	218.4	268.5
50	10.5	18.8	33.5	59.6	83.5	106.1	148.8	189.1	227.7	274.2
55	14.6	24.7	41.8	70.6	96.0	119.3	162.2	201.7	238.8	282.7
60	19.4	31.5	50.9	82.3	109.1	133.2	176.5	215.5	251.6	293.7
65	25.0	39.0	60.9	94.9	123.0	147.9	191.8	230.6	266.0	306.9
70	31.4	47.5	71.7	108.3	137.8	163.5	208.2	247.0	282.1	322.1
75	38.7	56.8	83.5	122.7	153.6	180.2	225.7	264.8	299.8	339.3
80	46.8	67.1	96.3	138.1	170.5	198.1	244.6	284.2	319.2	358.5
85	55.8	78.4	110.1	154.7	188.7	217.2	265.0	305.1	340.3	379.6
90	65.9	90.8	125.2	172.5	208.1	237.8	286.8	327.7	363.3	402.8
95	77.1	104.4	141.5	191.8	229.1	259.8	310.4	352.1	388.3	428.2
100	89.4	119.3	159.2	212.5	251.6	283.6	335.7	378.5	415.3	455.8
105	102.9	135.5	178.4	234.8	275.8	309.1	363.1	407.0	444.6	485.7
110	117.9	153.2	199.2	259.0	301.9	336.7	392.5	437.7	476.3	518.2
115	134.2	172.5	221.7	285.0	330.1	366.3	424.3	470.8	510.5	553.4
120	152.2	193.6	246.2	313.2	360.5	398.3	458.5	506.6	547.4	591.5
125	171.8	216.5	272.7	343.6	393.2	432.8	495.4	545.2	587.3	632.6
130	193.4	241.4	301.5	376.4	428.6	470.0	535.2	586.8	630.3	677.0

White pine working group

Site Class 2 (SI=12.1 m)
Composition Index: 40% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.6	2.9	5.4	7.7	9.9	14.2	18.3	22.4	27.3
50	1.3	2.3	4.0	6.9	9.6	12.0	16.6	21.0	25.1	29.9
55	1.9	3.2	5.3	8.7	11.7	14.4	19.4	23.9	28.1	33.0
60	2.7	4.3	6.8	10.8	14.1	17.1	22.4	27.1	31.4	36.5
65	3.6	5.6	8.5	13.1	16.8	20.1	25.7	30.7	35.2	40.4
70	4.8	7.1	10.6	15.8	19.9	23.4	29.5	34.8	39.5	44.9
75	6.2	9.0	13.0	18.8	23.3	27.2	33.7	39.3	44.3	49.9
80	7.9	11.1	15.7	22.2	27.2	31.4	38.5	44.4	49.7	55.5
85	9.8	13.6	18.9	26.1	31.6	36.2	43.8	50.2	55.7	61.9
90	12.1	16.5	22.5	30.6	36.6	41.6	49.8	56.6	62.5	
95	14.8	19.9	26.6	35.6	42.2	47.7	56.6	63.8		
100	18.0	23.7	31.3	41.3	48.6	54.5	64.1			
105	21.7	28.2	36.7	47.8	55.8	62.3				
110	25.9	33.3	42.9	55.2	63.9					
115	30.8	39.2	49.9	63.5						
120	36.5	45.9	57.9							
125	43.0	53.7	67.0							
130	50.5	62.5								

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.6	3.2	6.5	13.2	20.0	26.9	40.9	54.9	69.1	86.9
45	2.7	5.1	9.5	18.0	26.0	33.8	49.0	63.8	78.2	95.9
50	4.3	7.5	13.3	23.5	32.8	41.6	58.1	73.6	88.5	106.3
55	6.3	10.6	17.9	30.0	40.6	50.4	68.2	84.6	100.0	118.1
60	9.0	14.5	23.3	37.4	49.4	60.2	79.5	96.9	112.9	131.6
65	12.3	19.1	29.7	46.0	59.5	71.4	92.2	110.7	127.5	146.8
70	16.5	24.7	37.2	55.9	70.9	83.9	106.5	126.2	143.8	164.0
75	21.4	31.4	45.9	67.1	83.8	98.2	122.6	143.6	162.3	183.4
80	27.5	39.2	56.0	80.0	98.6	114.3	140.8	163.2	183.1	205.3
85	34.6	48.4	67.7	94.7	115.3	132.5	161.2	185.3	206.5	230.0
90	43.1	59.2	81.3	111.6	134.3	153.1	184.3	210.2	232.8	
95	53.1	71.7	96.8	130.7	155.8	176.5	210.4	238.3		
100	64.9	86.3	114.8	152.6	180.3	203.0	239.9			
105	78.6	103.1	135.3	177.6	208.2	233.0				
110	94.6	122.6	158.9	206.0	239.7					
115	113.3	145.1	186.0	238.3						
120	134.9	171.1	216.9							
125	159.9	200.9	252.3							
130	188.8	235.1								

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.3	6.8	14.0	28.7	43.8	59.1	90.2	121.7	153.5	193.7
45	5.7	10.9	20.6	39.2	57.0	74.4	108.2	141.2	173.6	213.4
50	9.1	16.2	28.8	51.4	72.0	91.5	128.2	163.0	196.2	236.3
55	13.6	22.9	38.8	65.6	89.1	110.8	150.6	187.3	221.7	262.5
60	19.4	31.3	50.7	82.0	108.6	132.6	175.7	214.5	250.4	292.4
65	26.6	41.5	64.7	100.9	130.8	157.2	203.9	245.2	282.8	326.3
70	35.6	53.7	81.2	122.6	156.0	185.2	235.7	279.6	319.3	364.7
75	46.5	68.3	100.4	147.5	184.8	216.8	271.5	318.5	360.5	408.1
80	59.7	85.6	122.8	176.1	217.5	252.6	312.0	362.4	407.0	457.1
85	75.4	105.9	148.7	208.8	254.7	293.2	357.7	411.8	459.4	512.4
90	94.1	129.6	178.7	246.2	297.0	339.3	409.3	467.6	518.5	
95	116.1	157.4	213.3	289.0	345.2	391.6	467.8	530.6		
100	142.1	189.7	253.1	337.8	400.0	450.9	533.8			
105	172.5	227.1	299.0	393.6	462.3	518.1				
110	208.1	270.5	351.7	457.2	533.1					
115	249.5	320.7	412.2	529.8						
120	297.6	378.6	481.5	612.5						
125	353.5	445.3	561.0							
130	418.1	522.1								

White pine working group

Site Class 2 (SI=12.1 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.8	5.2	7.4	9.6	13.7	17.8	21.6	26.4
50	1.2	2.1	3.7	6.5	9.0	11.3	15.6	19.7	23.5	28.1
55	1.8	2.9	4.8	8.0	10.7	13.2	17.7	21.8	25.6	30.2
60	2.4	3.8	6.0	9.6	12.6	15.2	19.9	24.1	28.0	32.5
65	3.2	4.9	7.4	11.4	14.6	17.4	22.4	26.7	30.6	35.2
70	4.1	6.1	9.0	13.4	16.9	19.9	25.1	29.6	33.6	38.1
75	5.1	7.5	10.8	15.6	19.4	22.6	28.0	32.7	36.8	41.5
80	6.4	9.0	12.8	18.1	22.1	25.6	31.3	36.2	40.4	45.2
85	7.8	10.8	15.0	20.8	25.2	28.8	34.9	40.0	44.4	49.3
90	9.5	12.9	17.5	23.9	28.6	32.5	38.9	44.2	48.8	53.9
95	11.4	15.2	20.4	27.3	32.3	36.5	43.3	48.9	53.7	58.9
100	13.5	17.8	23.5	31.0	36.5	40.9	48.1	54.0	59.0	64.5
105	15.9	20.8	27.0	35.2	41.1	45.8	53.5	59.7	65.0	
110	18.7	24.1	31.0	39.8	46.2	51.3	59.4	65.9		
115	21.8	27.8	35.4	45.0	51.8	57.3	65.9			
120	25.4	32.0	40.3	50.7	58.1	63.9				
125	29.3	36.6	45.7	57.1	65.0					
130	33.8	41.9	51.8	64.2						

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.4	4.9	10.0	20.5	31.1	41.8	63.4	85.2	107.2	134.9
45	4.0	7.6	14.3	26.9	39.0	50.8	73.5	95.7	117.3	143.9
50	6.2	10.9	19.3	34.2	47.8	60.5	84.5	107.1	128.7	154.6
55	9.0	15.0	25.2	42.4	57.4	71.2	96.5	119.6	141.4	167.0
60	12.4	19.9	32.1	51.6	68.1	83.0	109.6	133.4	155.5	181.2
65	16.6	25.7	39.9	61.8	79.9	95.9	123.9	148.7	171.3	197.2
70	21.6	32.4	48.8	73.3	93.0	110.1	139.8	165.5	188.7	215.2
75	27.5	40.2	58.9	86.1	107.5	125.9	157.3	184.2	208.2	235.3
80	34.4	49.2	70.3	100.4	123.7	143.4	176.6	204.8	229.7	257.6
85	42.5	59.5	83.2	116.3	141.6	162.7	198.0	227.6	253.5	282.5
90	51.8	71.2	97.7	134.1	161.5	184.2	221.7	252.8	280.0	310.0
95	62.6	84.5	114.1	154.0	183.6	208.0	247.9	280.8	309.2	340.6
100	74.9	99.6	132.5	176.2	208.2	234.4	276.9	311.7	341.7	374.5
105	89.0	116.7	153.2	201.0	235.6	263.7	309.1	346.0	377.6	
110	105.0	136.1	176.4	228.6	266.0	296.3	344.8	383.9		
115	123.3	158.0	202.4	259.4	299.9	332.4	384.3			
120	144.0	182.6	231.6	293.8	337.6	372.6				
125	167.5	210.4	264.4	332.1	379.5					
130	194.1	241.7	301.0	374.9						

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.5	7.3	15.0	30.9	47.1	63.6	97.0	130.8	165.0	208.2
45	5.9	11.3	21.4	40.7	59.2	77.2	112.4	146.7	180.3	221.7
50	9.2	16.3	29.0	51.7	72.5	92.1	129.1	164.1	197.6	238.0
55	13.3	22.5	38.0	64.2	87.2	108.4	147.4	183.3	217.0	257.0
60	18.4	29.8	48.3	78.1	103.5	126.4	167.5	204.5	238.7	278.7
65	24.7	38.6	60.1	93.8	121.6	146.2	189.5	227.9	262.9	303.3
70	32.3	48.8	73.7	111.2	141.6	168.0	213.9	253.8	289.8	331.0
75	41.2	60.6	89.0	130.8	163.9	192.2	240.8	282.5	319.7	361.9
80	51.7	74.2	106.5	152.7	188.6	219.1	270.5	314.2	352.9	396.4
85	64.0	89.8	126.2	177.2	216.1	248.8	303.5	349.4	389.8	434.8
90	78.2	107.7	148.4	204.5	246.8	281.9	340.1	388.5	430.7	477.6
95	94.5	128.1	173.5	235.1	280.9	318.6	380.6	431.7	476.1	525.0
100	113.3	151.2	201.8	269.3	318.9	359.4	425.6	479.7	526.4	577.7
105	134.8	177.5	233.6	307.5	361.2	404.8	475.4	532.9	582.2	
110	159.4	207.2	269.4	350.2	408.3	455.3	530.8	591.9		
115	187.4	240.9	309.6	397.9	460.8	511.4	592.3			
120	219.2	278.9	354.7	451.1	519.3	573.8				
125	255.4	321.8	405.3	510.6	584.5					
130	296.4	370.1	462.1	577.0						

White pine working group

Site Class 2 (SI=12.1 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.7	5.1	7.3	9.4	13.4	17.3	21.1	25.8
50	1.2	2.0	3.6	6.2	8.6	10.8	15.0	18.8	22.5	26.9
55	1.6	2.7	4.5	7.5	10.0	12.4	16.6	20.5	24.1	28.3
60	2.2	3.5	5.6	8.8	11.6	14.0	18.4	22.2	25.8	29.9
65	2.9	4.4	6.7	10.3	13.2	15.8	20.3	24.2	27.8	31.8
70	3.6	5.4	8.0	11.9	15.0	17.7	22.3	26.3	29.9	34.0
75	4.5	6.5	9.5	13.7	17.0	19.8	24.6	28.7	32.3	36.4
80	5.5	7.8	11.0	15.6	19.1	22.1	27.0	31.2	34.9	39.0
85	6.7	9.2	12.8	17.7	21.4	24.6	29.7	34.0	37.8	42.0
90	7.9	10.8	14.7	20.0	24.0	27.2	32.6	37.1	40.9	45.2
95	9.4	12.6	16.8	22.5	26.7	30.2	35.8	40.4	44.4	48.8
100	11.0	14.5	19.2	25.3	29.7	33.4	39.3	44.0	48.2	52.6
105	12.8	16.7	21.7	28.3	33.0	36.9	43.0	48.0	52.3	56.9
110	14.8	19.1	24.6	31.6	36.6	40.7	47.1	52.3	56.8	61.6
115	17.1	21.8	27.7	35.2	40.6	44.8	51.6	57.1	61.7	
120	19.6	24.7	31.1	39.2	44.9	49.4	56.5	62.2		
125	22.4	27.9	34.9	43.5	49.6	54.4	61.9			
130	25.5	31.5	39.0	48.3	54.7	59.8	67.7			

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.3	6.7	13.7	28.0	42.4	57.0	86.6	116.4	146.4	184.2
45	5.4	10.1	19.0	35.9	52.0	67.7	98.0	127.5	156.4	191.7
50	8.1	14.3	25.2	44.6	62.3	79.0	110.2	139.7	167.8	201.6
55	11.4	19.2	32.3	54.2	73.4	91.1	123.3	153.0	180.7	213.6
60	15.6	25.0	40.2	64.7	85.5	104.1	137.5	167.5	195.2	227.4
65	20.4	31.7	49.2	76.2	98.6	118.2	152.8	183.4	211.2	243.2
70	26.2	39.3	59.1	88.9	112.8	133.6	169.5	200.7	228.9	260.9
75	32.8	48.0	70.2	102.7	128.3	150.2	187.7	219.7	248.4	280.7
80	40.5	57.8	82.5	117.9	145.2	168.4	207.5	240.5	269.8	302.6
85	49.2	68.8	96.2	134.6	163.8	188.2	229.0	263.3	293.3	326.8
90	59.1	81.1	111.4	152.9	184.0	209.9	252.6	288.2	319.1	353.4
95	70.3	94.9	128.1	173.0	206.2	233.6	278.4	315.4	347.4	382.6
100	82.9	110.3	146.7	195.1	230.5	259.5	306.6	345.2	378.3	414.7
105	97.1	127.5	167.2	219.4	257.2	287.9	337.5	377.7	412.2	449.9
110	113.1	146.5	189.9	246.1	286.4	319.0	371.2	413.4	449.4	488.5
115	130.9	167.8	215.0	275.5	318.5	353.0	408.1	452.4	490.0	
120	150.9	191.3	242.7	307.8	353.7	390.3	448.6	495.1		
125	173.1	217.5	273.2	343.3	392.3	431.2	492.8			
130	198.0	246.5	307.0	382.3	434.6	476.1	541.3			

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.7	7.7	15.8	32.5	49.6	66.9	102.1	137.7	173.7	219.2
45	6.1	11.6	22.0	41.8	60.8	79.3	115.5	150.7	185.3	227.7
50	9.2	16.4	29.2	52.0	72.9	92.6	129.8	164.9	198.6	239.2
55	13.1	22.1	37.4	63.2	85.9	106.8	145.2	180.5	213.8	253.1
60	17.8	28.8	46.7	75.5	100.0	122.2	161.9	197.6	230.7	269.4
65	23.5	36.6	57.1	89.0	115.4	138.8	179.9	216.4	249.6	288.0
70	30.1	45.5	68.8	103.8	132.2	156.8	199.6	236.9	270.5	308.9
75	37.9	55.6	81.8	120.1	150.5	176.5	221.1	259.4	293.6	332.3
80	46.8	67.1	96.2	138.0	170.5	198.0	244.5	284.0	319.0	358.3
85	56.9	80.0	112.3	157.7	192.4	221.5	270.1	311.0	346.9	387.0
90	68.5	94.4	130.1	179.3	216.3	247.1	298.1	340.6	377.6	418.7
95	81.6	110.6	149.9	203.1	242.6	275.2	328.8	373.0	411.3	453.6
100	96.5	128.7	171.8	229.3	271.5	306.0	362.3	408.5	448.2	491.9
105	113.2	149.0	196.1	258.1	303.2	339.8	399.1	447.3	488.7	533.9
110	131.9	171.5	222.9	289.8	337.9	376.8	439.3	489.9	533.1	580.0
115	152.9	196.6	252.7	324.8	376.1	417.4	483.4	536.5	581.6	
120	176.5	224.5	285.5	363.2	418.1	461.9	531.7	587.6		
125	202.8	255.5	321.9	405.5	464.1	510.8	584.7			
130	232.2	290.0	362.0	452.0	514.7	564.4	642.7			

White pine working group

Site Class 2 (SI=12.1 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.4	2.7	5.0	7.1	9.2	13.2	17.0	20.8	25.3
50	1.1	2.0	3.4	6.0	8.3	10.4	14.4	18.2	21.7	26.0
55	1.6	2.6	4.3	7.1	9.5	11.8	15.8	19.5	22.9	26.9
60	2.1	3.3	5.2	8.3	10.9	13.1	17.2	20.9	24.2	28.1
65	2.7	4.1	6.2	9.5	12.3	14.6	18.8	22.4	25.7	29.5
70	3.3	4.9	7.3	10.9	13.7	16.2	20.4	24.1	27.4	31.1
75	4.1	5.9	8.5	12.4	15.4	17.9	22.2	25.9	29.2	32.9
80	4.9	7.0	9.9	13.9	17.1	19.7	24.1	27.9	31.2	34.8
85	5.9	8.1	11.3	15.6	18.9	21.7	26.2	30.0	33.4	37.0
90	6.9	9.4	12.8	17.5	20.9	23.8	28.5	32.4	35.7	39.5
95	8.1	10.9	14.5	19.5	23.1	26.0	30.9	34.9	38.3	42.1
100	9.4	12.4	16.4	21.6	25.4	28.5	33.5	37.6	41.1	45.0
105	10.8	14.1	18.4	23.9	27.9	31.1	36.3	40.6	44.2	48.1
110	12.4	16.0	20.5	26.4	30.6	34.0	39.4	43.8	47.5	51.5
115	14.1	18.0	22.9	29.2	33.6	37.1	42.7	47.2	51.0	55.1
120	16.1	20.2	25.5	32.1	36.7	40.4	46.3	51.0	54.9	59.1
125	18.1	22.7	28.3	35.3	40.2	44.1	50.2	55.0	59.1	63.5
130	20.4	25.3	31.3	38.8	43.9	48.0	54.4	59.4	63.6	

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	4.2	8.6	17.5	35.6	54.0	72.6	110.2	148.2	186.4	234.5
45	6.7	12.6	23.8	44.9	65.0	84.5	122.5	159.3	195.4	239.6
50	9.9	17.5	31.0	54.9	76.6	97.0	135.5	171.6	206.2	247.8
55	13.8	23.3	39.1	65.6	88.9	110.2	149.2	185.1	218.7	258.4
60	18.6	29.8	48.0	77.2	102.0	124.2	164.0	199.8	232.8	271.3
65	24.1	37.3	57.8	89.7	116.0	139.1	179.8	215.7	248.5	286.2
70	30.4	45.7	68.7	103.2	131.0	155.1	196.9	233.1	265.8	303.0
75	37.6	55.1	80.5	117.8	147.1	172.3	215.2	252.0	284.8	321.9
80	45.8	65.5	93.5	133.6	164.6	190.8	235.0	272.5	305.7	342.8
85	55.1	77.0	107.7	150.7	183.4	210.8	256.5	294.8	328.4	365.9
90	65.4	89.8	123.3	169.2	203.7	232.3	279.6	318.9	353.2	391.1
95	76.9	103.9	140.2	189.3	225.7	255.6	304.7	345.1	380.1	418.7
100	89.8	119.4	158.8	211.2	249.5	280.9	331.8	373.5	409.5	448.8
105	104.0	136.4	179.0	234.9	275.3	308.2	361.3	404.4	441.3	481.6
110	119.7	155.2	201.1	260.6	303.3	337.8	393.1	437.8	475.9	517.3
115	137.2	175.8	225.3	288.6	333.7	369.9	427.6	474.0	513.4	556.0
120	156.4	198.4	251.6	319.1	366.7	404.7	465.0	513.3	554.1	598.1
125	177.6	223.1	280.3	352.2	402.5	442.4	505.6	555.8	598.2	643.8
130	201.0	250.3	311.7	388.2	441.3	483.4	549.6	602.0	646.0	

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.9	8.0	16.4	33.8	51.6	69.6	106.2	143.3	180.8	228.1
45	6.2	11.8	22.5	42.7	62.1	81.0	117.9	153.9	189.2	232.6
50	9.2	16.4	29.3	52.2	73.1	92.9	130.3	165.6	199.4	240.1
55	12.9	21.9	37.0	62.5	84.9	105.6	143.5	178.4	211.2	250.1
60	17.4	28.1	45.5	73.5	97.4	119.0	157.6	192.5	224.7	262.4
65	22.6	35.2	54.8	85.5	110.9	133.3	172.9	207.8	239.8	276.6
70	28.6	43.2	65.2	98.4	125.3	148.7	189.2	224.6	256.5	292.9
75	35.4	52.1	76.5	112.4	140.8	165.2	207.0	242.8	274.8	311.1
80	43.2	62.0	89.0	127.6	157.6	183.1	226.1	262.6	295.0	331.3
85	52.0	73.1	102.6	144.1	175.7	202.3	246.8	284.1	317.0	353.6
90	61.9	85.3	117.5	161.9	195.4	223.2	269.2	307.5	341.0	378.1
95	72.9	98.8	133.8	181.3	216.6	245.7	293.5	333.0	367.2	404.9
100	85.1	113.6	151.7	202.4	239.7	270.2	319.8	360.6	395.7	434.2
105	98.8	130.0	171.2	225.3	264.7	296.6	348.4	390.5	426.6	466.1
110	113.9	148.1	192.5	250.3	291.8	325.4	379.4	423.0	460.3	500.9
115	130.7	167.9	215.8	277.4	321.3	356.6	413.0	458.3	496.9	538.7
120	149.2	189.7	241.3	306.9	353.3	390.4	449.4	496.6	536.6	579.8
125	169.6	213.7	269.2	339.1	388.1	427.2	488.9	538.1	579.7	624.4
130	192.2	239.9	299.6	374.1	426.0	467.1	531.9	583.2	626.4	

White pine working group

Site Class 3 (SI=9.0 m)
Composition Index: 40% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.8	10.0	14.4	18.6	22.7	27.6
50	1.3	2.3	4.1	7.1	9.8	12.3	17.1	21.5	25.7	30.7
55	2.0	3.3	5.4	9.0	12.1	14.9	20.0	24.7	29.0	34.2
60	2.8	4.5	7.1	11.2	14.7	17.8	23.4	28.3	32.9	38.1
65	3.8	5.9	9.0	13.8	17.7	21.2	27.2	32.4	37.2	42.7
70	5.1	7.6	11.3	16.8	21.1	24.9	31.4	37.0	42.1	47.8
75	6.6	9.6	13.9	20.2	25.0	29.2	36.2	42.2	47.6	53.6
80	8.5	12.0	17.0	24.0	29.5	34.0	41.7	48.1	53.8	60.1
85	10.7	14.8	20.6	28.5	34.5	39.5	47.8	54.7	60.8	
90	13.3	18.2	24.7	33.6	40.2	45.7	54.8	62.2		
95	16.4	22.0	29.5	39.5	46.8	52.8	62.7			
100	20.1	26.5	35.0	46.1	54.3	60.9				
105	24.4	31.7	41.3	53.8	62.8					
110	29.3	37.7	48.6	62.5						
115	35.1	44.7	56.9							
120	41.9	52.8	66.5							
125	49.7	62.1								
130	58.8									

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.3	2.7	5.5	11.1	16.9	22.7	34.5	46.3	58.3	73.3
45	2.3	4.3	8.1	15.3	22.2	28.9	41.9	54.5	66.9	82.0
50	3.7	6.5	11.5	20.3	28.4	36.0	50.2	63.7	76.5	91.9
55	5.5	9.3	15.6	26.2	35.5	44.0	59.6	73.9	87.4	103.2
60	7.9	12.8	20.6	33.1	43.7	53.2	70.2	85.5	99.7	116.2
65	11.0	17.1	26.4	41.0	53.0	63.6	82.2	98.6	113.6	130.8
70	14.8	22.2	33.4	50.2	63.8	75.5	95.8	113.5	129.4	147.5
75	19.5	28.5	41.6	60.9	76.1	89.1	111.3	130.3	147.3	166.4
80	25.1	35.9	51.3	73.2	90.2	104.6	128.8	149.4	167.5	187.9
85	31.9	44.7	62.5	87.4	106.4	122.2	148.8	171.0	190.5	
90	40.1	55.1	75.6	103.8	124.9	142.4	171.4	195.5		
95	49.8	67.2	90.8	122.6	146.1	165.5	197.2			
100	61.3	81.5	108.4	144.2	170.4	191.8				
105	74.8	98.2	128.8	169.0	198.1					
110	90.8	117.6	152.4	197.6						
115	109.4	140.2	179.7							
120	131.3	166.5	211.2							
125	156.8	197.0								
130	186.5									

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.8	5.7	11.8	24.3	37.1	50.1	76.4	103.1	130.0	164.0
45	4.9	9.3	17.7	33.6	48.9	63.8	92.9	121.2	149.0	183.2
50	7.9	14.1	25.0	44.6	62.5	79.4	111.4	141.5	170.4	205.2
55	11.9	20.1	34.0	57.5	78.2	97.3	132.2	164.4	194.6	230.5
60	17.2	27.8	44.9	72.7	96.3	117.6	155.8	190.2	222.1	259.3
65	23.8	37.2	57.9	90.3	117.1	140.8	182.6	219.5	253.3	292.2
70	32.2	48.6	73.4	110.8	141.0	167.3	213.0	252.7	288.6	329.6
75	42.4	62.3	91.5	134.5	168.5	197.6	247.5	290.4	328.7	372.1
80	54.9	78.7	112.9	161.9	200.0	232.3	286.9	333.2	374.3	420.3
85	69.9	98.2	137.9	193.6	236.2	271.9	331.7	381.9	426.0	
90	87.9	121.2	167.0	230.2	277.7	317.2	382.7	437.1		
95	109.4	148.3	201.0	272.3	325.3	369.0	440.8			
100	135.0	180.1	240.4	320.9	379.9	428.2				
105	165.1	217.4	286.2	376.7	442.4					
110	200.7	260.9	339.2	440.9						
115	242.4	311.6	400.5							
120	291.4	370.6	471.4							
125	348.6	439.1								
130	415.4									

White pine working group

Site Class 3 (SI=9.0 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.8	5.2	7.5	9.7	13.9	18.0	21.9	26.7
50	1.3	2.2	3.8	6.7	9.2	11.6	16.0	20.2	24.1	28.8
55	1.8	3.0	5.0	8.2	11.1	13.6	18.3	22.6	26.5	31.2
60	2.5	4.0	6.3	10.0	13.1	15.9	20.8	25.2	29.3	34.0
65	3.3	5.1	7.8	12.0	15.4	18.4	23.6	28.2	32.3	37.1
70	4.3	6.5	9.6	14.2	18.0	21.2	26.7	31.5	35.7	40.6
75	5.5	8.0	11.6	16.8	20.8	24.2	30.1	35.1	39.5	44.5
80	6.9	9.8	13.8	19.6	24.0	27.7	33.9	39.1	43.7	48.9
85	8.5	11.8	16.4	22.7	27.5	31.5	38.1	43.6	48.4	53.8
90	10.4	14.2	19.3	26.2	31.4	35.7	42.8	48.6	53.7	59.3
95	12.6	16.8	22.6	30.2	35.8	40.4	48.0	54.1	59.5	65.3
100	15.1	19.9	26.2	34.6	40.7	45.7	53.7	60.3		
105	17.9	23.3	30.4	39.6	46.2	51.5	60.1			
110	21.2	27.3	35.1	45.1	52.3	58.1	67.3			
115	24.9	31.7	40.3	51.3	59.1	65.3				
120	29.1	36.7	46.3	58.3	66.7					
125	34.0	42.4	52.9	66.1						
130	39.4	48.8	60.4							

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.0	4.2	8.5	17.3	26.2	35.2	53.5	71.9	90.4	113.8
45	3.4	6.5	12.2	23.0	33.3	43.4	62.8	81.7	100.3	122.9
50	5.3	9.5	16.7	29.6	41.3	52.3	73.1	92.6	111.2	133.7
55	7.8	13.1	22.1	37.1	50.2	62.3	84.3	104.6	123.6	146.0
60	10.9	17.6	28.3	45.5	60.1	73.2	96.7	117.8	137.3	160.0
65	14.8	22.9	35.5	55.1	71.2	85.5	110.5	132.5	152.6	175.8
70	19.4	29.2	43.9	65.9	83.7	99.1	125.7	148.9	169.8	193.6
75	25.0	36.5	53.4	78.1	97.6	114.2	142.7	167.1	188.9	213.5
80	31.5	45.0	64.3	91.9	113.1	131.2	161.6	187.4	210.2	235.7
85	39.2	54.9	76.7	107.3	130.6	150.1	182.7	210.0	233.9	260.6
90	48.2	66.2	90.9	124.8	150.2	171.3	206.2	235.1	260.4	288.3
95	58.7	79.2	106.9	144.4	172.1	194.9	232.4	263.2	289.9	319.3
100	70.8	94.1	125.2	166.5	196.7	221.4	261.6	294.5		
105	84.7	111.1	145.8	191.3	224.3	251.0	294.2			
110	100.7	130.5	169.2	219.2	255.2	284.1	330.7			
115	119.1	152.6	195.6	250.7	289.8	321.2				
120	140.2	177.8	225.5	286.0	328.6					
125	164.2	206.3	259.2	325.6						
130	191.7	238.7	297.3							

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.0	6.2	12.7	26.2	39.9	53.8	82.1	110.8	139.8	176.3
45	5.1	9.7	18.4	34.9	50.8	66.3	96.5	125.9	154.8	190.2
50	7.9	14.2	25.2	44.9	63.0	80.0	112.1	142.5	171.6	206.7
55	11.7	19.7	33.3	56.3	76.6	95.2	129.4	160.9	190.5	225.6
60	16.4	26.5	42.8	69.3	91.8	112.1	148.5	181.3	211.7	247.2
65	22.2	34.5	53.8	84.0	108.9	130.9	169.7	204.1	235.4	271.6
70	29.2	44.1	66.6	100.5	128.0	151.8	193.3	229.3	261.9	299.1
75	37.6	55.2	81.2	119.3	149.4	175.3	219.5	257.5	291.5	330.0
80	47.6	68.2	97.9	140.4	173.4	201.4	248.8	289.0	324.6	364.5
85	59.3	83.3	117.0	164.3	200.4	230.7	281.4	324.0	361.5	403.2
90	73.1	100.7	138.8	191.2	230.7	263.5	317.9	363.2	402.7	446.5
95	89.1	120.7	163.5	221.6	264.7	300.2	358.6	406.8	448.6	494.7
100	107.6	143.6	191.7	255.8	302.8	341.4	404.2	455.6		
105	129.0	169.8	223.6	294.3	345.7	387.5	455.0			
110	153.7	199.8	259.8	337.7	393.8	439.1	511.9			
115	182.1	234.0	300.8	386.6	447.8	496.9				
120	214.6	273.0	347.2	441.6	508.4					
125	251.9	317.3	399.7	503.6						
130	294.5	367.7	459.1							

White pine working group

Site Class 3 (SI=9.0 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.8	5.1	7.3	9.5	13.6	17.6	21.4	26.1
50	1.2	2.1	3.7	6.4	8.8	11.1	15.3	19.3	23.1	27.6
55	1.7	2.8	4.7	7.7	10.4	12.8	17.2	21.2	24.9	29.3
60	2.3	3.7	5.8	9.2	12.1	14.6	19.2	23.2	27.0	31.3
65	3.0	4.6	7.1	10.9	14.0	16.7	21.4	25.5	29.3	33.6
70	3.9	5.7	8.5	12.7	16.0	18.9	23.8	28.0	31.8	36.2
75	4.8	7.0	10.2	14.7	18.2	21.3	26.4	30.8	34.7	39.1
80	6.0	8.5	12.0	16.9	20.7	23.9	29.3	33.8	37.8	42.3
85	7.3	10.1	14.0	19.3	23.4	26.8	32.4	37.1	41.2	45.8
90	8.7	11.9	16.2	22.0	26.4	30.0	35.9	40.8	45.0	49.7
95	10.4	13.9	18.7	25.0	29.6	33.4	39.7	44.8	49.2	54.0
100	12.3	16.2	21.4	28.2	33.2	37.3	43.8	49.2	53.8	58.8
105	14.4	18.8	24.5	31.8	37.2	41.5	48.4	54.0	58.8	64.0
110	16.8	21.6	27.8	35.8	41.5	46.1	53.4	59.3	64.3	
115	19.5	24.8	31.6	40.2	46.3	51.2	58.9	65.1		
120	22.5	28.4	35.8	45.1	51.6	56.8	65.0			
125	25.9	32.3	40.4	50.4	57.4	62.9				
130	29.7	36.8	45.5	56.3	63.8					

Gross merchantible volume of white and red pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.8	5.7	11.6	23.6	35.8	48.1	73.0	98.2	123.5	155.4
45	4.6	8.6	16.3	30.7	44.4	57.8	83.8	109.0	133.6	163.9
50	7.0	12.3	21.8	38.6	53.9	68.3	95.3	120.8	145.1	174.4
55	10.0	16.8	28.2	47.4	64.2	79.6	107.8	133.7	158.0	186.7
60	13.7	22.1	35.5	57.2	75.5	91.9	121.4	147.9	172.3	200.8
65	18.2	28.3	43.8	68.0	87.8	105.4	136.2	163.4	188.2	216.8
70	23.5	35.4	53.2	79.9	101.4	120.1	152.5	180.6	205.9	234.7
75	29.8	43.6	63.7	93.2	116.4	136.3	170.3	199.4	225.3	254.7
80	37.0	52.9	75.5	107.9	132.9	154.1	189.8	220.1	246.9	276.9
85	45.4	63.5	88.8	124.2	151.1	173.7	211.3	242.9	270.6	301.5
90	55.0	75.5	103.6	142.2	171.2	195.2	235.0	268.0	296.8	328.7
95	65.9	89.0	120.1	162.2	193.3	219.0	261.0	295.6	325.6	358.7
100	78.3	104.2	138.6	184.3	217.8	245.2	289.7	326.1	357.4	391.8
105	92.5	121.3	159.2	208.9	244.8	274.1	321.2	359.6	392.4	428.3
110	108.5	140.6	182.2	236.1	274.7	305.9	356.0	396.5	431.0	
115	126.5	162.1	207.7	266.2	307.8	341.1	394.4	437.1		
120	146.9	186.3	236.2	299.6	344.3	380.0	436.6			
125	169.8	213.3	267.9	336.6	384.6	422.8				
130	195.5	243.5	303.2	377.6	429.3					

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.2	6.5	13.4	27.5	42.0	56.7	86.4	116.6	147.1	185.6
45	5.2	9.9	18.9	35.9	52.2	68.1	99.1	129.3	159.0	195.4
50	8.0	14.2	25.3	45.1	63.3	80.4	112.7	143.2	172.5	207.7
55	11.5	19.4	32.8	55.5	75.4	93.8	127.5	158.5	187.7	222.2
60	15.8	25.6	41.4	67.0	88.7	108.3	143.5	175.3	204.6	238.9
65	21.0	32.8	51.1	79.7	103.4	124.3	161.1	193.7	223.5	257.9
70	27.2	41.1	62.1	93.8	119.4	141.7	180.4	214.1	244.5	279.2
75	34.5	50.7	74.5	109.5	137.2	160.9	201.6	236.5	267.7	303.0
80	43.0	61.7	88.5	126.9	156.8	182.1	224.9	261.2	293.4	329.5
85	52.8	74.1	104.1	146.2	178.4	205.4	250.5	288.4	321.7	358.9
90	64.1	88.3	121.6	167.6	202.2	231.0	278.7	318.4	353.0	391.4
95	76.9	104.2	141.3	191.4	228.6	259.4	309.8	351.5	387.6	427.4
100	91.6	122.3	163.2	217.8	257.8	290.7	344.1	387.9	425.7	467.1
105	108.3	142.6	187.7	247.1	290.2	325.2	382.0	428.1	467.7	511.0
110	127.2	165.4	215.0	279.5	325.9	363.4	423.7	472.4	514.1	
115	148.6	191.0	245.5	315.6	365.5	405.6	469.7	521.3		
120	172.8	219.8	279.5	355.5	409.3	452.2	520.5			
125	200.0	252.0	317.4	399.9	457.7	503.8				
130	230.7	288.0	359.7	449.1	511.4					

White pine working group

Site Class 3 (SI=9.0 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha) 0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.8	1.5	2.7	5.0	7.2	9.3	13.4	17.2	21.0	25.6
50	1.2	2.0	3.5	6.1	8.5	10.7	14.8	18.6	22.3	26.6
55	1.6	2.7	4.4	7.4	9.9	12.2	16.3	20.1	23.7	27.9
60	2.2	3.4	5.5	8.7	11.3	13.7	18.0	21.8	25.3	29.4
65	2.8	4.3	6.6	10.1	12.9	15.4	19.8	23.6	27.1	31.1
70	3.5	5.3	7.8	11.6	14.6	17.2	21.7	25.6	29.1	33.1
75	4.4	6.3	9.2	13.3	16.5	19.2	23.8	27.8	31.3	35.3
80	5.3	7.5	10.7	15.1	18.5	21.3	26.1	30.2	33.7	37.7
85	6.4	8.9	12.3	17.1	20.6	23.6	28.6	32.8	36.4	40.4
90	7.6	10.4	14.1	19.2	23.0	26.1	31.3	35.6	39.3	43.4
95	9.0	12.0	16.1	21.6	25.6	28.9	34.2	38.6	42.4	46.6
100	10.5	13.8	18.3	24.1	28.4	31.8	37.4	42.0	45.9	50.2
105	12.2	15.9	20.7	26.9	31.4	35.0	40.9	45.6	49.7	54.1
110	14.1	18.1	23.3	29.9	34.7	38.5	44.6	49.6	53.8	58.3
115	16.1	20.5	26.1	33.3	38.3	42.3	48.7	53.9	58.2	62.9
120	18.4	23.2	29.3	36.9	42.2	46.5	53.2	58.6	63.1	
125	21.0	26.2	32.7	40.9	46.5	51.0	58.1	63.7		
130	23.8	29.5	36.5	45.2	51.2	55.9	63.4			

Gross merchantible volume of white and red pine (m^3/ha)

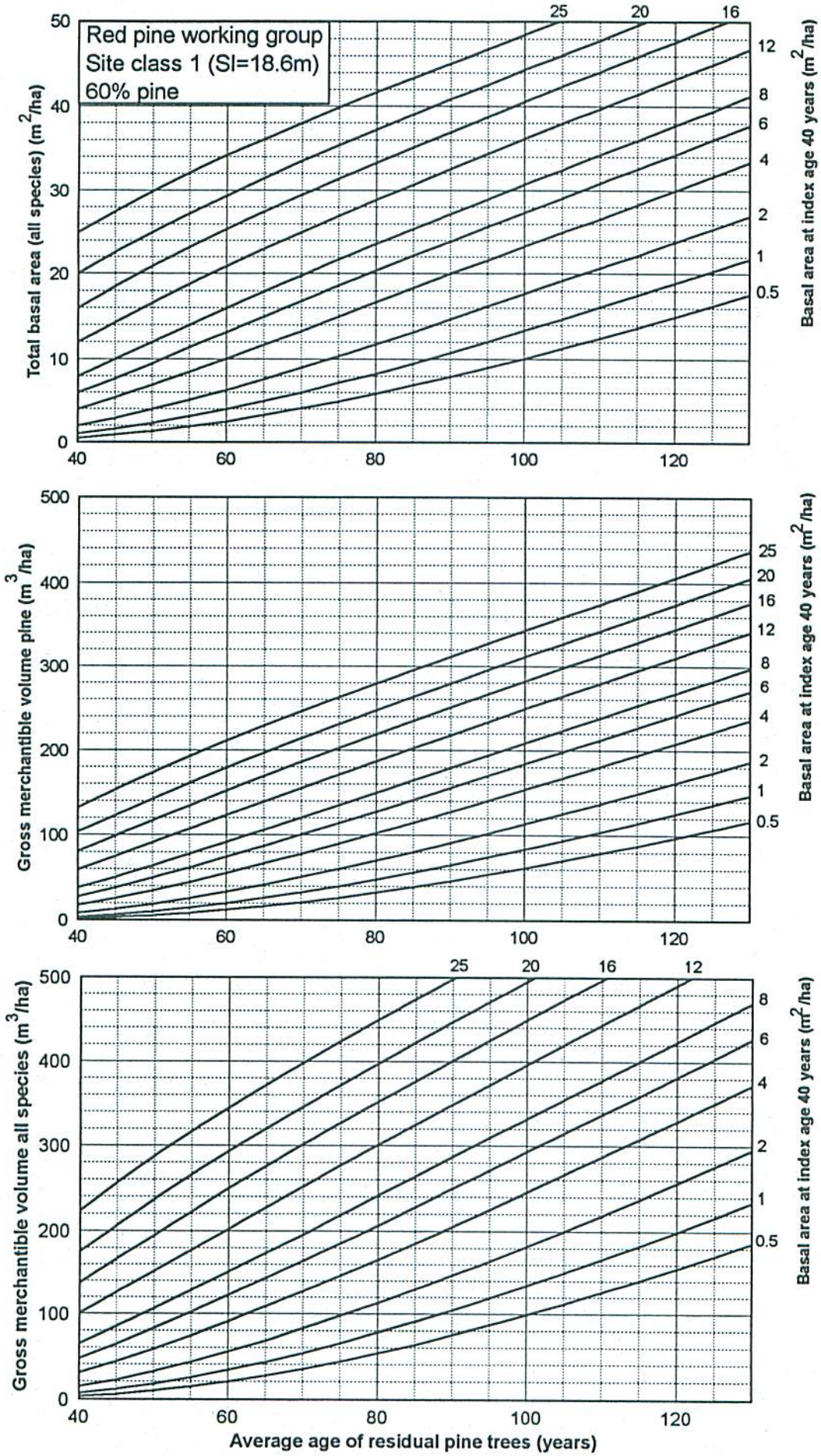
Stand age (years)	Residual total basal area at index age 40 years (m^2/ha) 0.5	1	2	4	6	8	12	16	20	25
40	3.5	7.2	14.7	30.0	45.6	61.3	93.0	125.0	157.2	197.8
45	5.7	10.8	20.3	38.3	55.5	72.3	104.7	136.2	167.0	204.8
50	8.6	15.2	26.8	47.4	66.2	83.9	117.1	148.4	178.3	214.3
55	12.1	20.3	34.1	57.3	77.7	96.3	130.4	161.8	191.2	225.9
60	16.4	26.3	42.4	68.2	90.0	109.6	144.8	176.4	205.5	239.5
65	21.4	33.2	51.6	80.0	103.4	124.0	160.3	192.3	221.5	255.1
70	27.3	41.1	61.8	92.8	117.8	139.5	177.1	209.7	239.1	272.6
75	34.2	50.0	73.1	106.9	133.5	156.3	195.3	228.7	258.4	292.1
80	42.0	59.9	85.6	122.2	150.6	174.6	215.1	249.4	279.7	313.7
85	50.8	71.1	99.4	139.0	169.2	194.4	236.6	272.0	303.0	337.5
90	60.8	83.5	114.6	157.4	189.4	216.1	260.1	296.6	328.5	363.8
95	72.1	97.4	131.5	177.5	211.6	239.6	285.6	323.5	356.4	392.5
100	84.8	112.8	150.0	199.5	235.7	265.3	313.5	352.9	386.8	424.0
105	99.0	129.9	170.4	223.6	262.1	293.4	343.9	384.9	420.1	458.5
110	114.9	148.8	192.9	250.0	290.9	324.0	377.0	419.9	456.4	496.1
115	132.5	169.8	217.7	278.9	322.5	357.4	413.2	458.0	496.1	537.3
120	152.3	193.1	244.9	310.6	356.9	393.9	452.7	499.6	539.3	
125	174.2	218.8	274.9	345.3	394.6	433.8	495.8	545.0		
130	198.5	247.2	307.8	383.4	435.9	477.4	542.8			

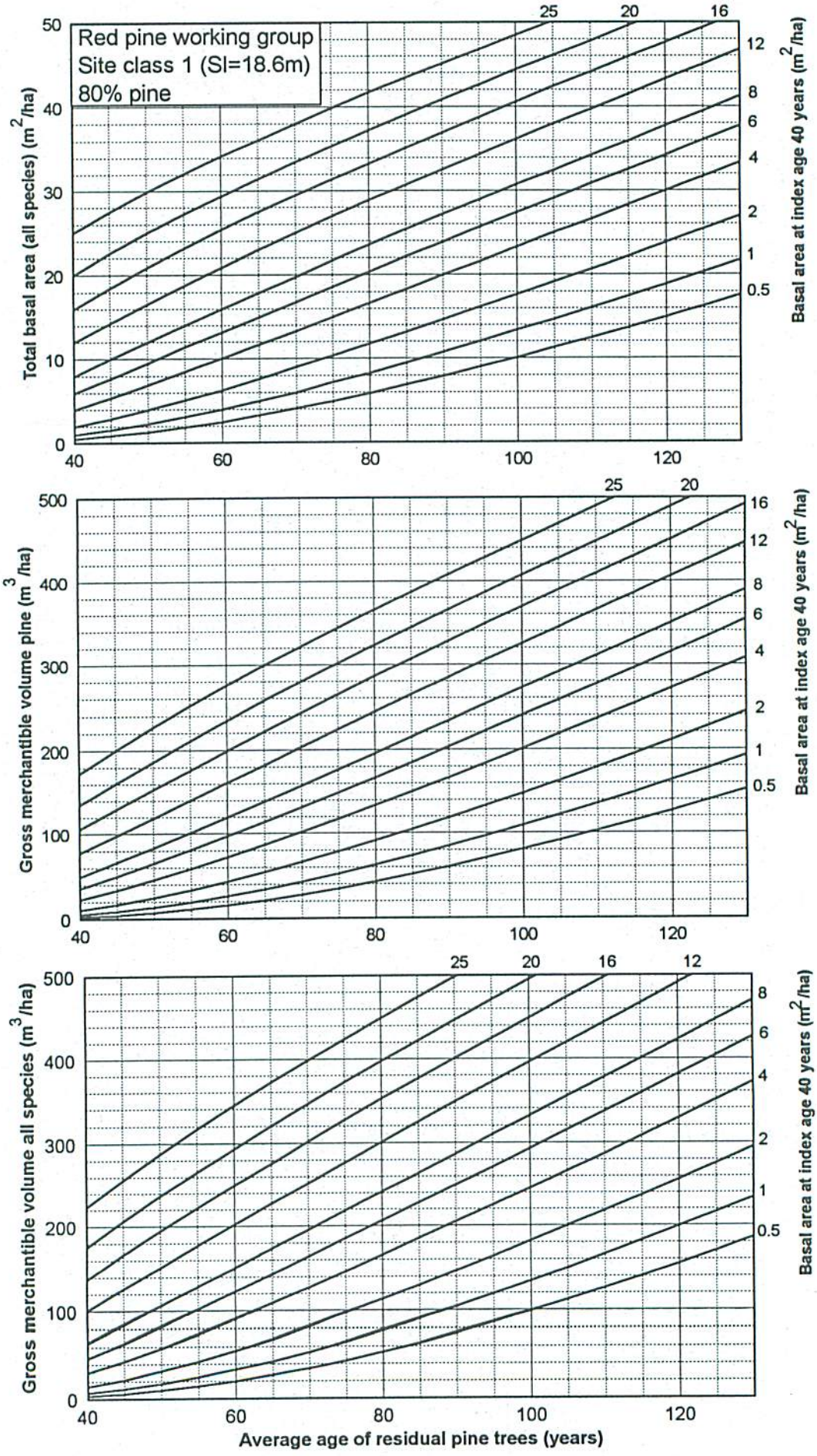
Gross merchantible volume of all species (m^3/ha)

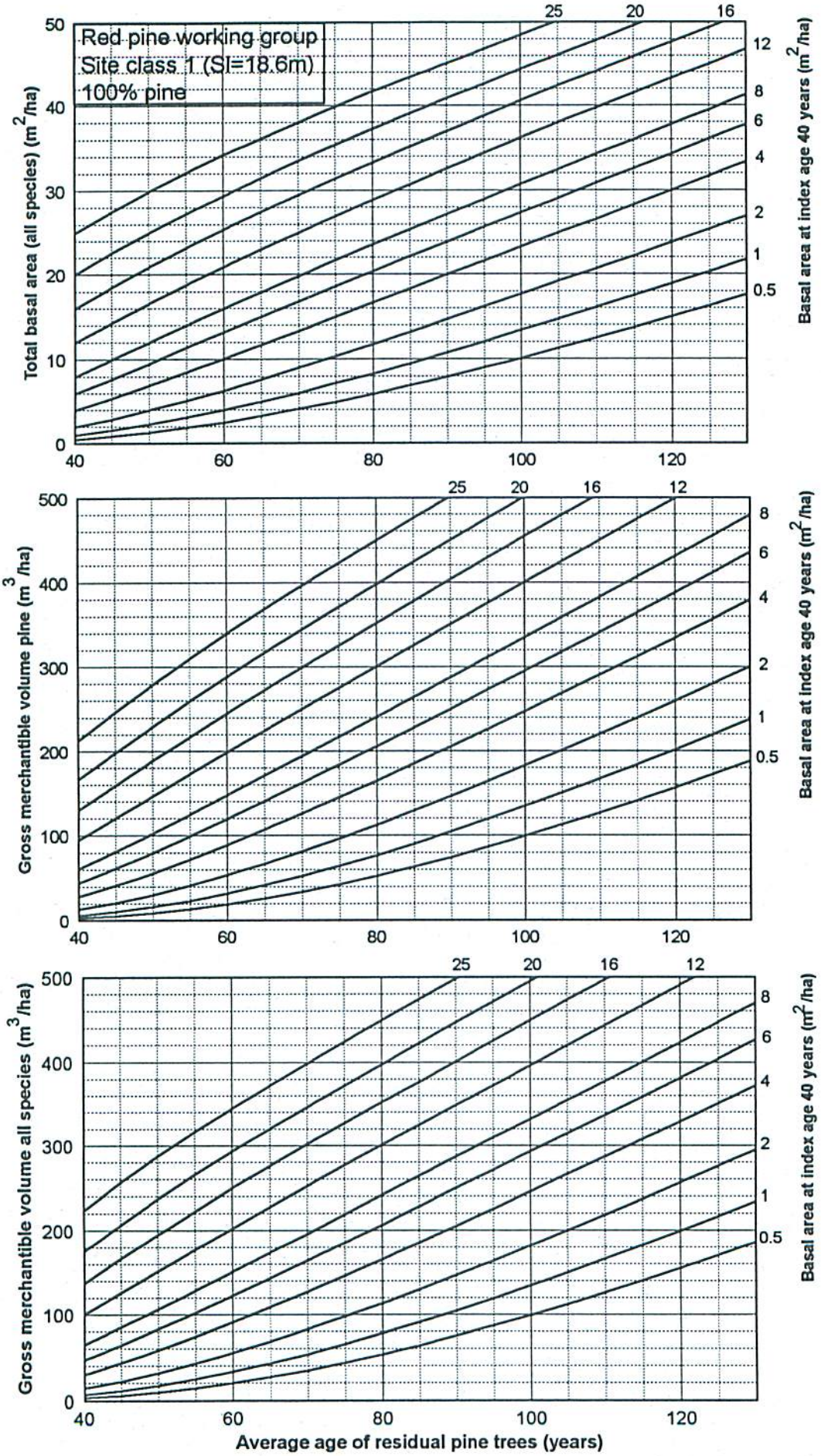
Stand age (years)	Residual total basal area at index age 40 years (m^2/ha) 0.5	1	2	4	6	8	12	16	20	25
40	3.3	6.8	13.9	28.7	43.7	59.0	90.0	121.4	153.1	193.1
45	5.3	10.1	19.3	36.6	53.3	69.5	101.2	132.0	162.3	199.6
50	8.0	14.3	25.4	45.3	63.5	80.7	113.1	143.8	173.1	208.5
55	11.4	19.2	32.4	54.8	74.5	92.7	126.0	156.6	185.5	219.6
60	15.4	24.9	40.3	65.2	86.4	105.5	139.8	170.7	199.3	232.7
65	20.2	31.5	49.1	76.6	99.3	119.4	154.8	186.1	214.7	247.7
70	25.8	39.0	58.9	89.0	113.2	134.4	171.0	202.9	231.8	264.7
75	32.3	47.5	69.8	102.5	128.4	150.6	188.7	221.4	250.6	283.6
80	39.8	57.0	81.8	117.4	144.9	168.3	207.9	241.5	271.2	304.6
85	48.2	67.7	95.1	133.6	163.0	187.6	228.8	263.5	293.9	327.9
90	57.8	79.7	109.8	151.4	182.6	208.6	251.7	287.5	318.8	353.5
95	68.7	93.1	126.1	170.9	204.1	231.5	276.6	313.8	346.0	381.6
100	80.9	107.9	144.0	192.2	227.6	256.6	303.8	342.4	375.8	412.4
105	94.5	124.5	163.8	215.7	253.3	283.9	333.4	373.7	408.3	446.1
110	109.9	142.8	185.7	241.4	281.4	313.8	365.9	408.0	443.9	483.0
115	127.0	163.2	209.7	269.6	312.2	346.5	401.3	445.3	482.8	523.4
120	146.0	185.7	236.2	300.5	345.9	382.2	439.9	486.1	525.3	
125	167.3	210.7	265.5	334.4	382.8	421.3	482.2	530.7		
130	190.9	238.4	297.6	371.6	423.2	464.0	528.4			

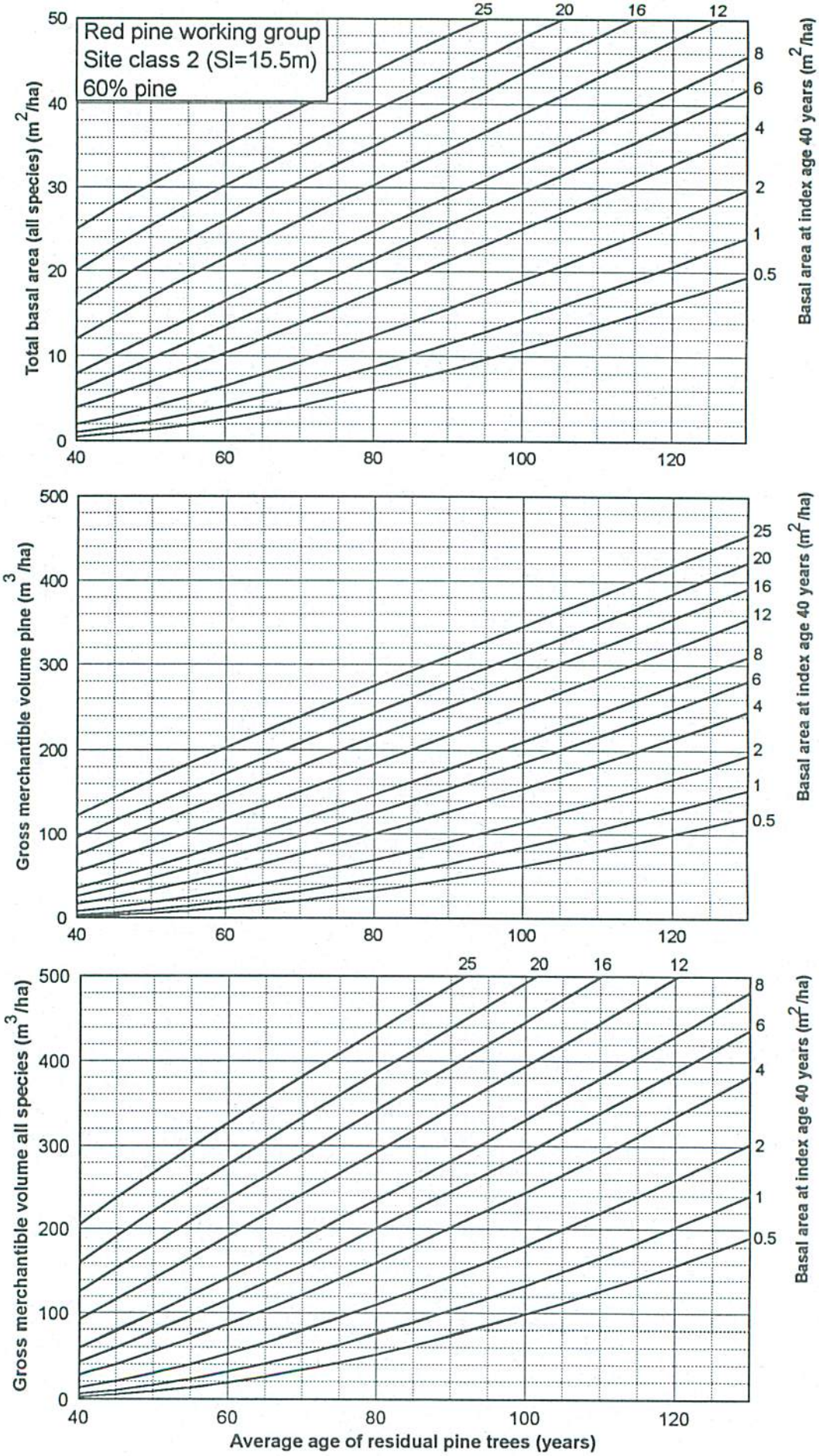
APPENDIX 3

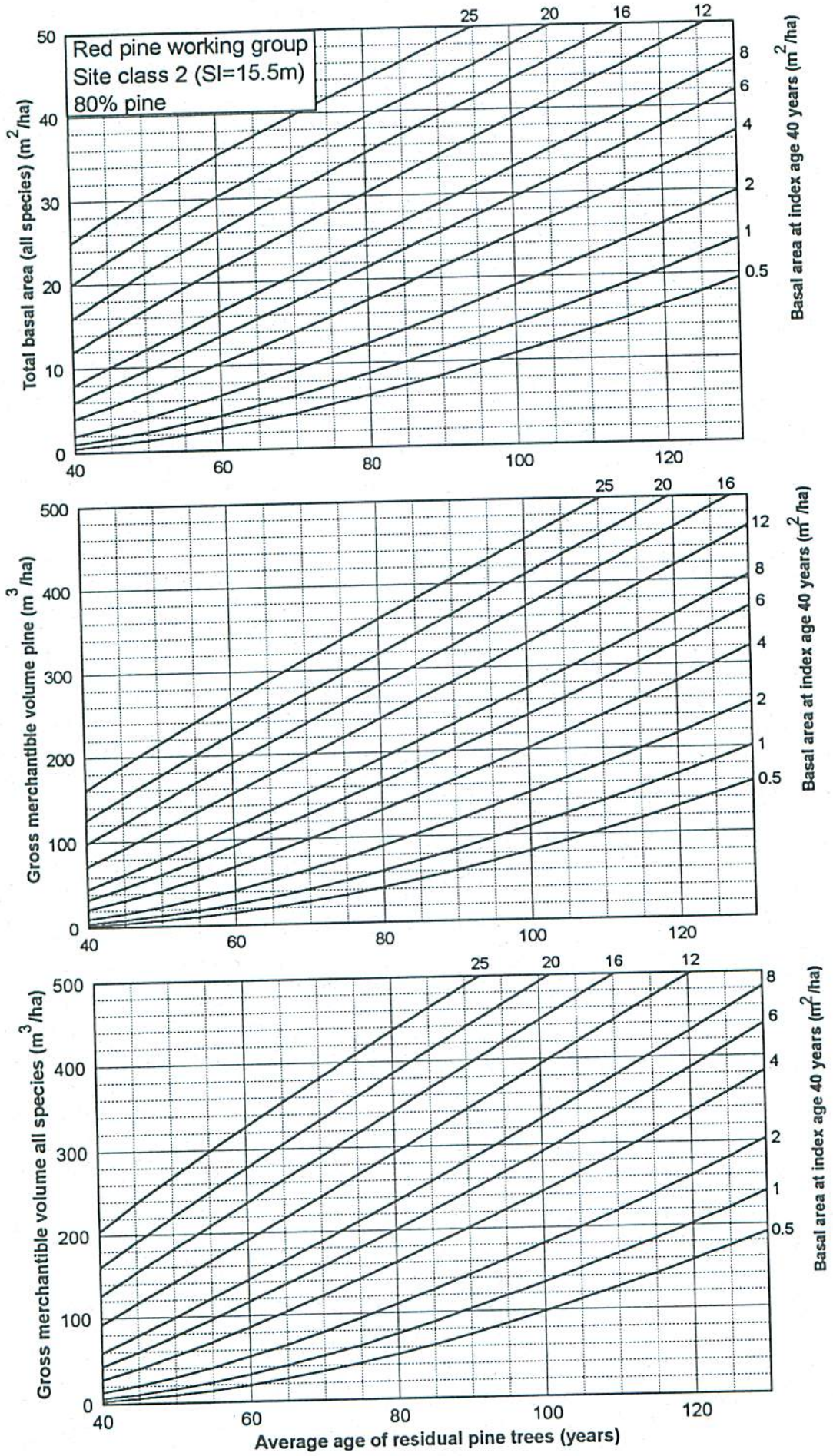
RED PINE WORKING GROUP YIELD CURVES

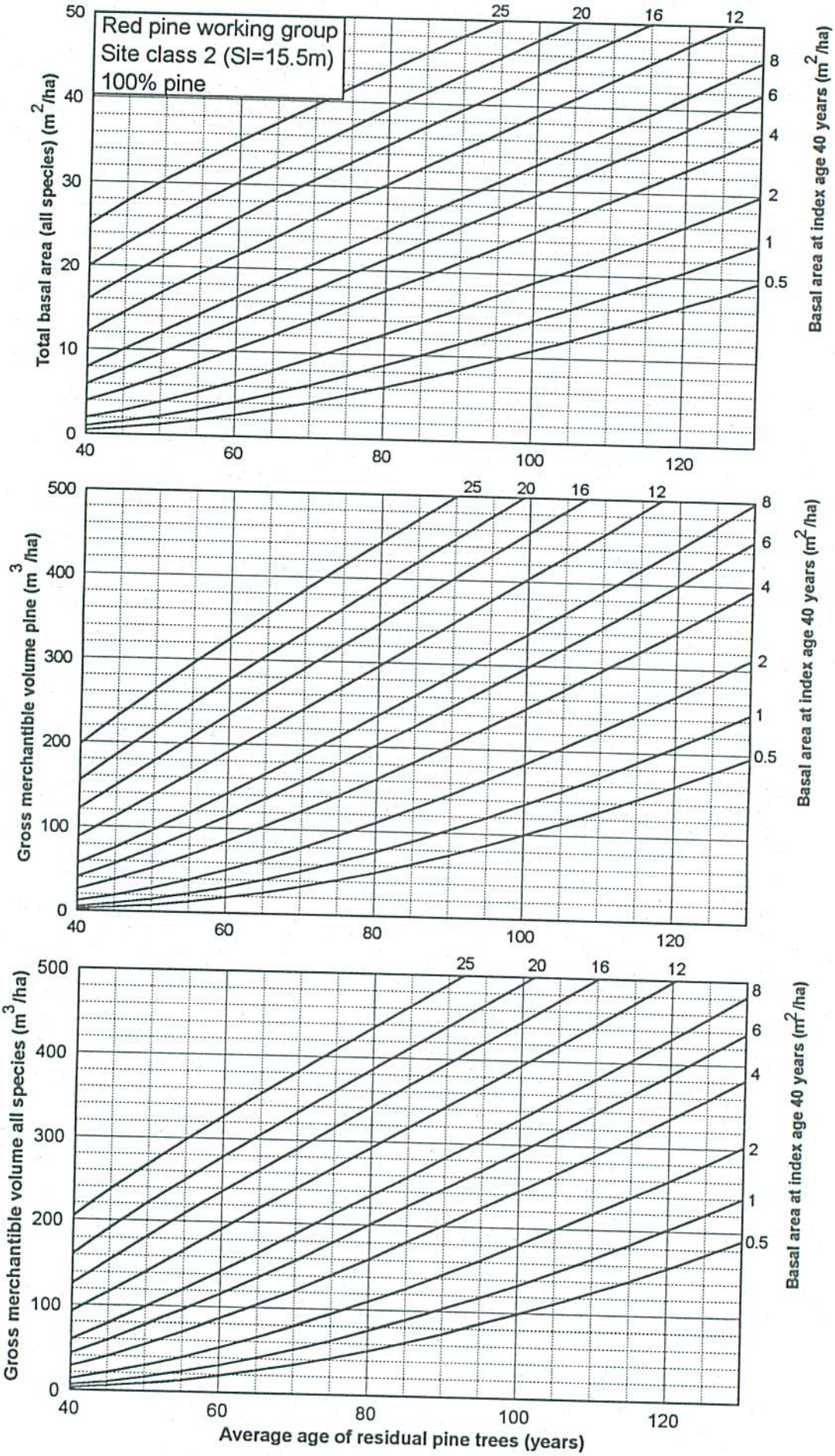

Red pine working group
Site class 1 (SI=18.6m)
60% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Average age of residual pine trees (years)

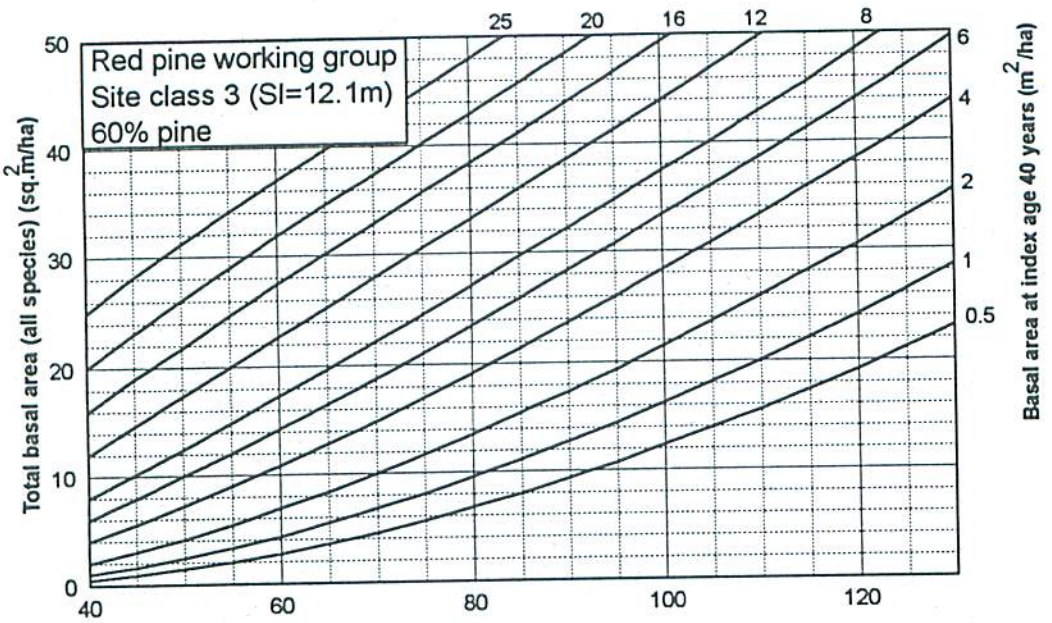

Red pine working group
Site class 1 (SI=18.6m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Average age of residual pine trees (years)

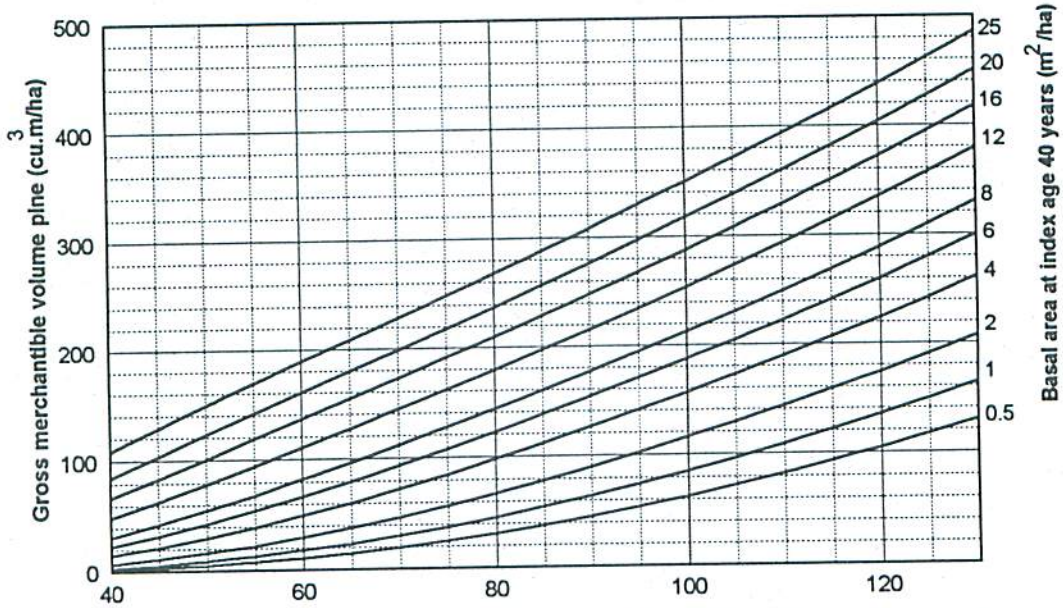

Red pine working group
Site class 1 (SI=18.6m)
100% pine
Total basal area (all species) (m²/ha)
Gross merchantible volume pine (m³/ha)
Gross merchantible volume all species (m³/ha)
Basal area at index age 40 years (m²/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
100
200
300
400
500
60
80
120
Average age of residual pine trees (years)

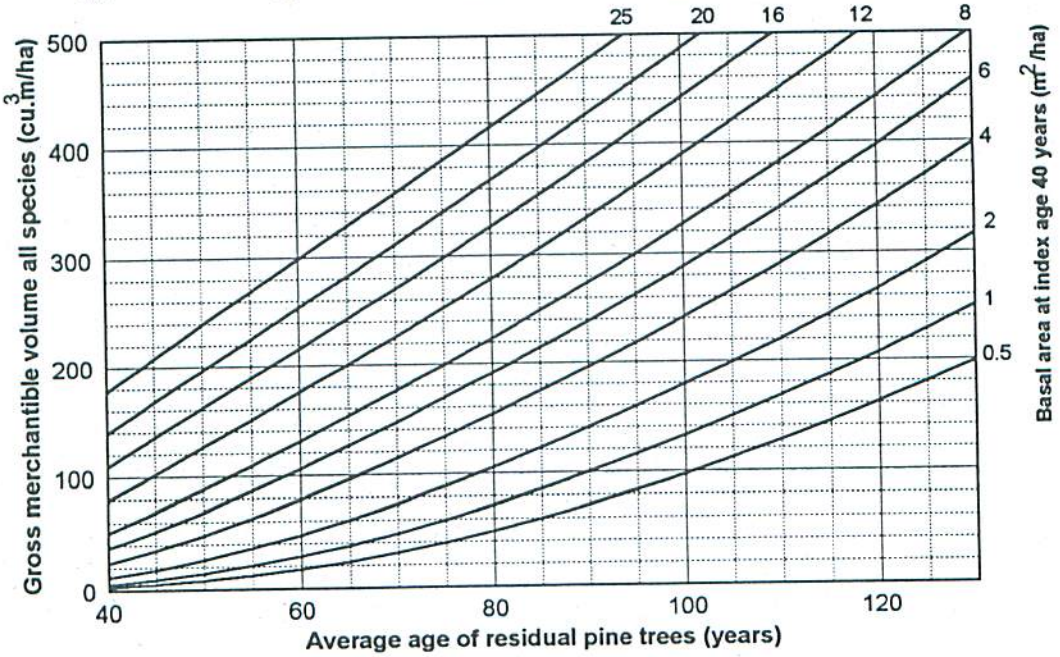

Red pine working group
Site class 2 (SI=15.5m)
60% pine
Total basal area (all species) (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
100
200
300
400
500
40
60
80
100
120
Average age of residual pine trees (years)

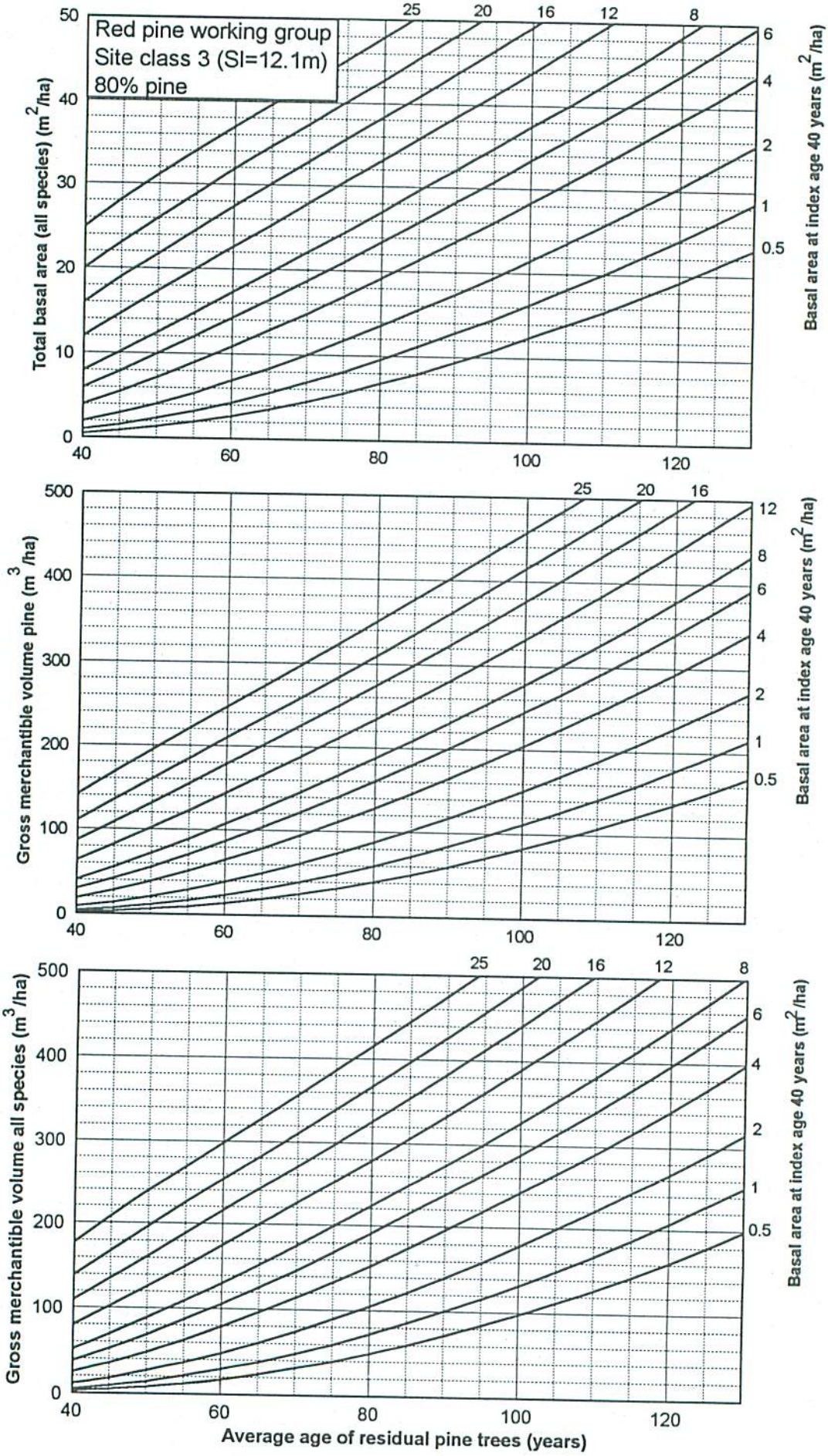

Red pine working group
Site class 2 (SI=15.5m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
60
80
100
120
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
100
200
300
400
500
Average age of residual pine trees (years)

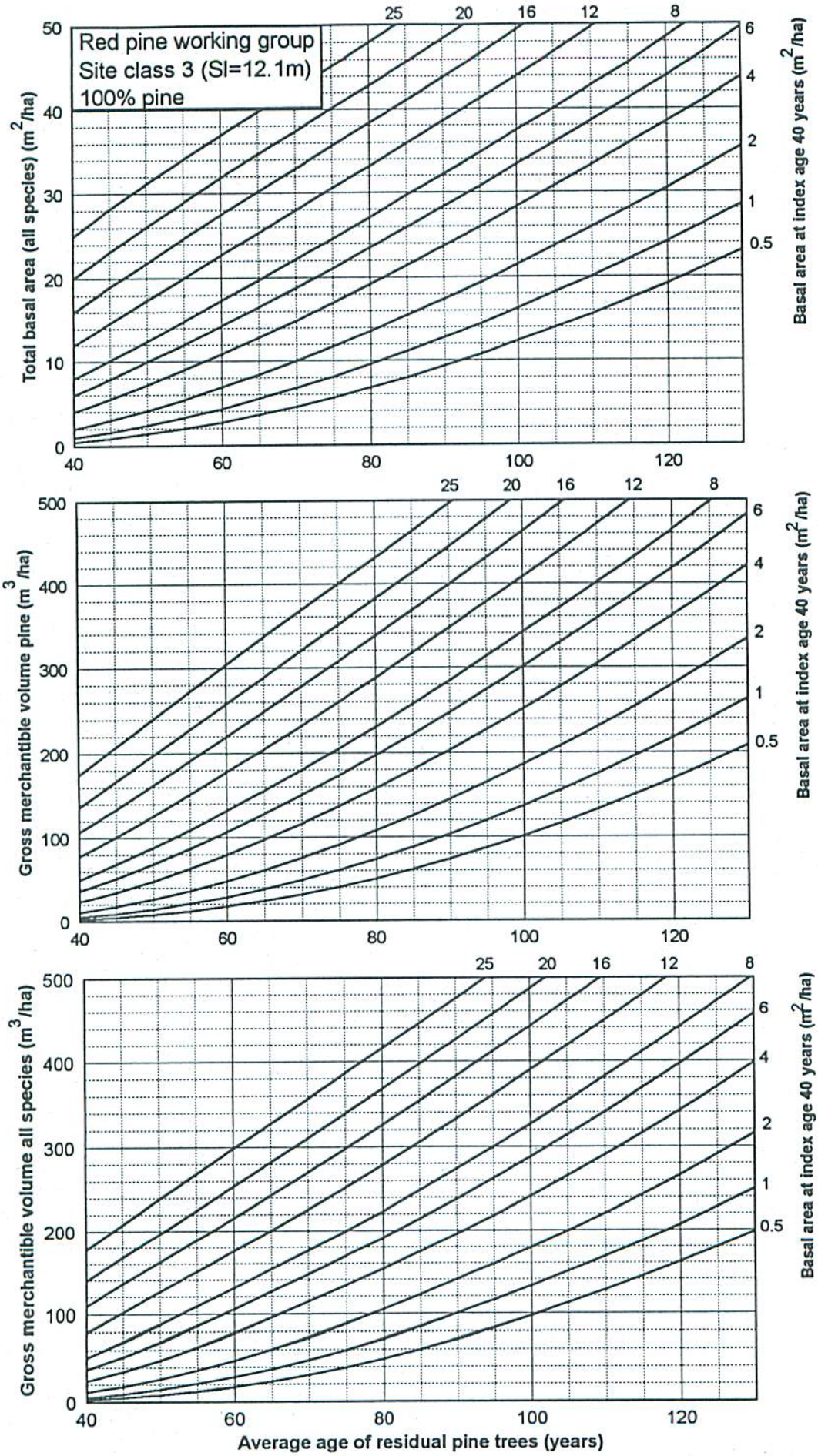

Red pine working group
Site class 2 (SI=15.5m)
100% pine
Total basal area (all species) (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
Average age of residual pine trees (years)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
100
200
300
400
500
60
80
100
120


Red pine working group
Site class 3 (SI=12.1m)
60% pine
Total basal area (all species) (sq.m/ha)
Basal area at index age 40 years (m²/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
40
60
80
100
120


Gross merchantible volume pine (cu.m/ha)
Basal area at index age 40 years (m²/ha)
25
20
16
12
8
6
4
2
1
0.5
0
100
200
300
400
500
40
60
80
100
120


Gross merchantible volume all species (cu.m/ha)
Basal area at index age 40 years (m²/ha)
25
20
16
12
8
6
4
2
1
0.5
0
100
200
300
400
500
40
60
80
100
120
Average age of residual pine trees (years)


Red pine working group
Site class 3 (SI=12.1m)
80% pine
Total basal area (all species) (m2/ha)
Basal area at index age 40 years (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Average age of residual pine trees (years)


Red pine working group
Site class 3 (SI=12.1m)
100% pine
Total basal area (all species) (m2/ha)
Gross merchantible volume pine (m3/ha)
Gross merchantible volume all species (m3/ha)
Basal area at index age 40 years (m2/ha)
25
20
16
12
8
6
4
2
1
0.5
0
10
20
30
40
50
100
200
300
400
500
60
80
100
120
Average age of residual pine trees (years)

APPENDIX 4

RED PINE WORKING GROUP YIELD TABLES

Red pine working group

Site Class 1 (SI=18.6 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.7	10.0	14.3	18.5	22.6	27.5
50	1.3	2.3	4.0	6.9	9.5	12.0	16.6	20.9	25.0	29.9
55	1.9	3.1	5.1	8.5	11.4	14.0	18.8	23.2	27.3	32.1
60	2.5	4.0	6.3	10.1	13.2	16.0	20.9	25.4	29.4	34.2
65	3.3	5.0	7.6	11.7	15.0	17.9	23.0	27.5	31.5	36.1
70	4.1	6.0	9.0	13.3	16.8	19.8	25.0	29.5	33.5	38.0
75	4.9	7.2	10.4	15.0	18.6	21.7	27.0	31.4	35.4	39.9
80	5.9	8.3	11.8	16.7	20.4	23.6	28.9	33.3	37.3	41.7
85	6.9	9.5	13.2	18.3	22.2	25.4	30.7	35.2	39.1	43.4
90	7.9	10.8	14.7	20.0	23.9	27.2	32.6	37.0	40.9	45.1
95	9.0	12.1	16.2	21.6	25.7	29.0	34.4	38.8	42.6	46.8
100	10.1	13.4	17.7	23.3	27.4	30.8	36.2	40.6	44.4	48.5
105	11.3	14.7	19.2	25.0	29.1	32.5	38.0	42.4	46.1	50.2
110	12.5	16.1	20.7	26.6	30.9	34.3	39.7	44.1	47.8	51.9
115	13.7	17.5	22.2	28.3	32.6	36.0	41.5	45.9	49.6	53.6
120	15.0	18.9	23.8	30.0	34.3	37.8	43.3	47.6	51.3	55.2
125	16.3	20.3	25.4	31.7	36.1	39.5	45.0	49.4	53.0	56.9
130	17.6	21.8	27.0	33.4	37.8	41.3	46.8	51.1	54.8	58.6

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.8	3.9	8.3	17.8	27.7	38.0	59.2	81.1	103.6	132.3
45	3.4	6.7	13.1	25.8	38.3	50.6	75.1	99.4	123.5	153.5
50	5.6	10.4	19.0	34.9	49.7	64.0	91.3	117.5	142.8	173.6
55	8.6	14.9	25.8	44.8	61.9	77.9	107.5	135.2	161.5	192.9
60	12.2	20.2	33.5	55.5	74.6	92.0	123.7	152.6	179.6	211.4
65	16.4	26.2	41.8	66.7	87.6	106.4	139.8	169.7	197.2	229.2
70	21.3	32.9	50.8	78.3	100.9	120.9	155.7	186.5	214.4	246.5
75	26.8	40.2	60.3	90.3	114.5	135.4	171.6	202.9	231.2	263.4
80	32.9	48.0	70.2	102.6	128.1	150.0	187.2	219.2	247.7	279.8
85	39.4	56.4	80.6	115.2	141.9	164.6	202.8	235.2	263.9	296.0
90	46.5	65.2	91.3	127.9	155.8	179.2	218.3	251.1	279.9	312.0
95	54.0	74.3	102.3	140.9	169.8	193.9	233.7	266.9	295.8	327.9
100	61.9	83.9	113.7	154.0	183.9	208.6	249.1	282.6	311.6	343.6
105	70.3	93.8	125.3	167.3	198.1	223.4	264.5	298.2	327.3	359.2
110	79.0	104.1	137.2	180.7	212.4	238.2	279.9	313.9	343.0	374.9
115	88.0	114.6	149.3	194.4	226.8	253.1	295.3	329.5	358.7	390.5
120	97.4	125.5	161.6	208.1	241.3	268.0	310.8	345.2	374.5	406.2
125	107.2	136.6	174.2	222.1	256.0	283.1	326.3	360.9	390.3	422.0
130	117.2	148.1	187.0	236.2	270.8	298.3	342.0	376.8	406.2	437.9

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.2	6.7	14.3	30.4	47.3	64.7	100.6	137.6	175.4	223.5
45	5.8	11.4	22.3	43.6	64.5	85.2	126.1	166.5	206.7	256.4
50	9.5	17.5	31.9	58.3	83.0	106.6	151.8	195.0	236.8	287.5
55	14.3	24.8	43.0	74.4	102.5	128.7	177.4	222.7	265.7	317.1
60	20.2	33.4	55.3	91.4	122.6	151.1	202.8	249.8	293.7	345.3
65	27.1	43.2	68.6	109.2	143.2	173.7	227.8	276.2	320.8	372.4
70	35.0	53.9	82.9	127.6	164.2	196.3	252.6	302.1	347.1	398.7
75	43.8	65.5	98.0	146.5	185.4	219.0	277.1	327.5	372.7	424.3
80	53.5	78.0	113.7	165.8	206.7	241.7	301.4	352.4	397.9	449.2
85	63.9	91.2	130.0	185.4	228.2	264.4	325.4	377.0	422.6	473.8
90	75.1	105.0	146.8	205.3	249.8	287.0	349.2	401.3	447.1	498.0
95	87.0	119.5	164.1	225.4	271.5	309.7	372.9	425.4	471.2	521.9
100	99.5	134.5	181.8	245.8	293.3	332.4	396.5	449.4	495.2	545.7
105	112.5	150.0	199.9	266.4	315.2	355.1	420.1	473.3	519.1	569.4
110	126.2	166.0	218.4	287.3	337.2	377.9	443.6	497.1	543.0	593.1
115	140.4	182.4	237.2	308.3	359.4	400.8	467.2	521.0	566.9	616.8
120	155.0	199.3	256.3	329.6	381.8	423.8	490.9	544.9	590.8	640.6
125	170.2	216.7	275.8	351.1	404.3	446.9	514.7	568.9	614.8	664.5
130	185.9	234.4	295.6	372.8	427.0	470.2	538.6	593.0	639.0	688.6

Red pine working group

Site Class 1 (SI=18.6 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.7	10.0	14.3	18.5	22.6	27.5
50	1.3	2.3	4.0	6.9	9.5	12.0	16.6	20.9	25.0	29.9
55	1.9	3.1	5.1	8.5	11.4	14.0	18.8	23.2	27.3	32.1
60	2.5	4.0	6.3	10.1	13.2	16.0	20.9	25.4	29.4	34.2
65	3.3	5.0	7.6	11.7	15.0	17.9	23.0	27.5	31.5	36.1
70	4.1	6.0	9.0	13.3	16.8	19.8	25.0	29.5	33.5	38.0
75	4.9	7.2	10.4	15.0	18.6	21.7	27.0	31.4	35.4	39.9
80	5.9	8.3	11.8	16.7	20.4	23.6	28.9	33.3	37.3	41.7
85	6.9	9.5	13.2	18.3	22.2	25.4	30.7	35.2	39.1	43.4
90	7.9	10.8	14.7	20.0	23.9	27.2	32.6	37.0	40.9	45.1
95	9.0	12.1	16.2	21.6	25.7	29.0	34.4	38.8	42.6	46.8
100	10.1	13.4	17.7	23.3	27.4	30.8	36.2	40.6	44.4	48.5
105	11.3	14.7	19.2	25.0	29.1	32.5	38.0	42.4	46.1	50.2
110	12.5	16.1	20.7	26.6	30.9	34.3	39.7	44.1	47.8	51.9
115	13.7	17.5	22.2	28.3	32.6	36.0	41.5	45.9	49.6	53.6
120	15.0	18.9	23.8	30.0	34.3	37.8	43.3	47.6	51.3	55.2
125	16.3	20.3	25.4	31.7	36.1	39.5	45.0	49.4	53.0	56.9
130	17.6	21.8	27.0	33.4	37.8	41.3	46.8	51.1	54.8	58.6

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.4	5.1	10.9	23.2	36.2	49.6	77.4	106.0	135.4	172.8
45	4.5	8.7	17.2	33.7	50.0	66.1	98.1	129.9	161.4	200.5
50	7.4	13.5	24.8	45.6	65.0	83.6	119.3	153.4	186.6	226.8
55	11.2	19.4	33.7	58.6	80.9	101.7	140.5	176.6	211.0	252.0
60	15.9	26.4	43.7	72.5	97.5	120.2	161.6	199.4	234.7	276.2
65	21.5	34.2	54.6	87.1	114.5	139.0	182.6	221.7	257.7	299.5
70	27.9	43.0	66.3	102.3	131.9	157.9	203.5	243.6	280.1	322.1
75	35.0	52.5	78.7	118.0	149.5	176.9	224.1	265.1	302.0	344.1
80	43.0	62.8	91.7	134.1	167.4	195.9	244.6	286.4	323.6	365.6
85	51.5	73.7	105.3	150.5	185.4	215.0	265.0	307.3	344.8	386.8
90	60.8	85.1	119.3	167.1	203.6	234.2	285.2	328.1	365.7	407.7
95	70.6	97.1	133.7	184.0	221.9	253.3	305.4	348.7	386.5	428.3
100	80.9	109.6	148.5	201.2	240.3	272.5	325.5	369.2	407.1	448.9
105	91.8	122.6	163.7	218.5	258.8	291.8	345.6	389.6	427.6	469.3
110	103.2	136.0	179.2	236.1	277.5	311.2	365.7	410.0	448.1	489.8
115	115.0	149.8	195.0	253.9	296.3	330.6	385.8	430.5	468.7	510.2
120	127.3	164.0	211.1	271.9	315.3	350.2	406.0	451.0	489.2	530.7
125	140.0	178.5	227.6	290.1	334.4	369.9	426.4	471.6	509.9	551.4
130	153.2	193.5	244.3	308.6	353.8	389.8	446.8	492.3	530.7	572.1

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.2	6.7	14.3	30.4	47.3	64.7	100.6	137.6	175.4	223.5
45	5.8	11.4	22.3	43.6	64.5	85.2	126.1	166.5	206.7	256.4
50	9.5	17.5	31.9	58.3	83.0	106.6	151.8	195.0	236.8	287.5
55	14.3	24.8	43.0	74.4	102.5	128.7	177.4	222.7	265.7	317.1
60	20.2	33.4	55.3	91.4	122.6	151.1	202.8	249.8	293.7	345.3
65	27.1	43.2	68.6	109.2	143.2	173.7	227.8	276.2	320.8	372.4
70	35.0	53.9	82.9	127.6	164.2	196.3	252.6	302.1	347.1	398.7
75	43.8	65.5	98.0	146.5	185.4	219.0	277.1	327.5	372.7	424.3
80	53.5	78.0	113.7	165.8	206.7	241.7	301.4	352.4	397.9	449.2
85	63.9	91.2	130.0	185.4	228.2	264.4	325.4	377.0	422.6	473.8
90	75.1	105.0	146.8	205.3	249.8	287.0	349.2	401.3	447.1	498.0
95	87.0	119.5	164.1	225.4	271.5	309.7	372.9	425.4	471.2	521.9
100	99.5	134.5	181.8	245.8	293.3	332.4	396.5	449.4	495.2	545.7
105	112.5	150.0	199.9	266.4	315.2	355.1	420.1	473.3	519.1	569.4
110	126.2	166.0	218.4	287.3	337.2	377.9	443.6	497.1	543.0	593.1
115	140.4	182.4	237.2	308.3	359.4	400.8	467.2	521.0	566.9	616.8
120	155.0	199.3	256.3	329.6	381.8	423.8	490.9	544.9	590.8	640.6
125	170.2	216.7	275.8	351.1	404.3	446.9	514.7	568.9	614.8	664.5
130	185.9	234.4	295.6	372.8	427.0	470.2	538.6	593.0	639.0	688.6

Red pine working group

Site Class 1 (SI=18.6 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.7	10.0	14.3	18.5	22.6	27.5
50	1.3	2.3	4.0	6.9	9.5	12.0	16.6	20.9	25.0	29.9
55	1.9	3.1	5.1	8.5	11.4	14.0	18.8	23.2	27.3	32.1
60	2.5	4.0	6.3	10.1	13.2	16.0	20.9	25.4	29.4	34.2
65	3.3	5.0	7.6	11.7	15.0	17.9	23.0	27.5	31.5	36.1
70	4.1	6.0	9.0	13.3	16.8	19.8	25.0	29.5	33.5	38.0
75	4.9	7.2	10.4	15.0	18.6	21.7	27.0	31.4	35.4	39.9
80	5.9	8.3	11.8	16.7	20.4	23.6	28.9	33.3	37.3	41.7
85	6.9	9.5	13.2	18.3	22.2	25.4	30.7	35.2	39.1	43.4
90	7.9	10.8	14.7	20.0	23.9	27.2	32.6	37.0	40.9	45.1
95	9.0	12.1	16.2	21.6	25.7	29.0	34.4	38.8	42.6	46.8
100	10.1	13.4	17.7	23.3	27.4	30.8	36.2	40.6	44.4	48.5
105	11.3	14.7	19.2	25.0	29.1	32.5	38.0	42.4	46.1	50.2
110	12.5	16.1	20.7	26.6	30.9	34.3	39.7	44.1	47.8	51.9
115	13.7	17.5	22.2	28.3	32.6	36.0	41.5	45.9	49.6	53.6
120	15.0	18.9	23.8	30.0	34.3	37.8	43.3	47.6	51.3	55.2
125	16.3	20.3	25.4	31.7	36.1	39.5	45.0	49.4	53.0	56.9
130	17.6	21.8	27.0	33.4	37.8	41.3	46.8	51.1	54.8	58.6

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.9	6.3	13.4	28.6	44.6	61.1	95.2	130.4	166.5	212.6
45	5.5	10.8	21.1	41.5	61.5	81.4	120.8	159.8	198.5	246.7
50	9.1	16.6	30.6	56.1	80.0	102.9	146.8	188.8	229.6	279.1
55	13.8	23.9	41.5	72.1	99.5	125.2	172.9	217.3	259.6	310.1
60	19.6	32.4	53.8	89.2	119.9	147.9	198.9	245.3	288.7	339.8
65	26.4	42.1	67.2	107.2	140.9	171.0	224.7	272.8	317.0	368.5
70	34.3	52.9	81.6	125.9	162.3	194.3	250.4	299.7	344.6	396.3
75	43.1	64.6	96.9	145.2	184.0	217.6	275.8	326.2	371.6	423.3
80	52.8	77.2	112.9	165.0	206.0	241.1	301.0	352.3	398.1	449.8
85	63.4	90.6	129.5	185.1	228.1	264.6	326.0	378.1	424.2	475.9
90	74.8	104.7	146.8	205.6	250.5	288.1	351.0	403.7	450.0	501.6
95	86.8	119.5	164.5	226.4	273.0	311.7	375.8	429.0	475.5	527.0
100	99.6	134.9	182.7	247.5	295.6	335.3	400.5	454.3	500.9	552.3
105	113.0	150.8	201.4	268.9	318.5	359.1	425.2	479.4	526.2	577.5
110	127.0	167.3	220.5	290.5	341.4	382.9	449.9	504.5	551.4	602.6
115	141.5	184.3	239.9	312.4	364.6	406.8	474.7	529.7	576.7	627.8
120	156.6	201.7	259.8	334.6	387.9	430.9	499.6	554.9	602.0	653.0
125	172.3	219.7	280.0	357.0	411.5	455.1	524.6	580.2	627.4	678.4
130	188.5	238.0	300.6	379.7	435.3	479.6	549.8	605.7	653.0	704.0

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	3.2	6.7	14.3	30.4	47.3	64.7	100.6	137.6	175.4	223.5
45	5.8	11.4	22.3	43.6	64.5	85.2	126.1	166.5	206.7	256.4
50	9.5	17.5	31.9	58.3	83.0	106.6	151.8	195.0	236.8	287.5
55	14.3	24.8	43.0	74.4	102.5	128.7	177.4	222.7	265.7	317.1
60	20.2	33.4	55.3	91.4	122.6	151.1	202.8	249.8	293.7	345.3
65	27.1	43.2	68.6	109.2	143.2	173.7	227.8	276.2	320.8	372.4
70	35.0	53.9	82.9	127.6	164.2	196.3	252.6	302.1	347.1	398.7
75	43.8	65.5	98.0	146.5	185.4	219.0	277.1	327.5	372.7	424.3
80	53.5	78.0	113.7	165.8	206.7	241.7	301.4	352.4	397.9	449.2
85	63.9	91.2	130.0	185.4	228.2	264.4	325.4	377.0	422.6	473.8
90	75.1	105.0	146.8	205.3	249.8	287.0	349.2	401.3	447.1	498.0
95	87.0	119.5	164.1	225.4	271.5	309.7	372.9	425.4	471.2	521.9
100	99.5	134.5	181.8	245.8	293.3	332.4	396.5	449.4	495.2	545.7
105	112.5	150.0	199.9	266.4	315.2	355.1	420.1	473.3	519.1	569.4
110	126.2	166.0	218.4	287.3	337.2	377.9	443.6	497.1	543.0	593.1
115	140.4	182.4	237.2	308.3	359.4	400.8	467.2	521.0	566.9	616.8
120	155.0	199.3	256.3	329.6	381.8	423.8	490.9	544.9	590.8	640.6
125	170.2	216.7	275.8	351.1	404.3	446.9	514.7	568.9	614.8	664.5
130	185.9	234.4	295.6	372.8	427.0	470.2	538.6	593.0	639.0	688.6

Red pine working group

Site Class 2 (SI=15.5 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.8	10.1	14.5	18.7	22.8	27.8
50	1.3	2.3	4.0	7.0	9.7	12.2	16.9	21.3	25.4	30.4
55	1.9	3.2	5.2	8.7	11.6	14.3	19.3	23.7	27.9	32.8
60	2.6	4.1	6.5	10.4	13.6	16.5	21.6	26.1	30.3	35.2
65	3.4	5.2	7.9	12.1	15.6	18.6	23.8	28.5	32.6	37.4
70	4.2	6.3	9.4	13.9	17.5	20.7	26.1	30.7	34.9	39.6
75	5.2	7.5	10.9	15.7	19.5	22.8	28.3	32.9	37.1	41.8
80	6.2	8.8	12.4	17.6	21.5	24.8	30.4	35.1	39.3	43.9
85	7.3	10.1	14.0	19.4	23.5	26.9	32.6	37.3	41.4	46.0
90	8.4	11.5	15.6	21.3	25.5	29.0	34.7	39.4	43.5	48.1
95	9.7	12.9	17.3	23.2	27.5	31.0	36.8	41.5	45.6	50.1
100	10.9	14.4	19.0	25.1	29.5	33.1	38.9	43.7	47.8	52.2
105	12.2	15.9	20.7	27.0	31.5	35.2	41.0	45.8	49.9	54.3
110	13.6	17.5	22.5	29.0	33.6	37.3	43.2	47.9	52.0	56.4
115	15.0	19.1	24.3	30.9	35.6	39.3	45.3	50.1	54.1	58.5
120	16.5	20.7	26.1	32.9	37.7	41.5	47.5	52.2	56.3	60.6
125	17.9	22.4	28.0	34.9	39.8	43.6	49.6	54.4	58.4	62.8
130	19.5	24.1	29.9	37.0	41.9	45.7	51.8	56.6	60.6	

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.7	3.6	7.7	16.5	25.8	35.3	55.0	75.4	96.3	122.9
45	3.2	6.3	12.3	24.2	35.9	47.5	70.5	93.2	115.9	144.0
50	5.3	9.8	18.0	33.0	47.1	60.5	86.4	111.1	135.1	164.2
55	8.2	14.2	24.6	42.7	59.0	74.2	102.5	128.9	153.9	183.9
60	11.7	19.4	32.1	53.3	71.6	88.3	118.8	146.5	172.4	202.9
65	15.9	25.3	40.4	64.4	84.7	102.8	135.1	164.0	190.6	221.5
70	20.7	32.0	49.4	76.2	98.2	117.5	151.5	181.4	208.5	239.8
75	26.3	39.3	59.0	88.4	112.0	132.5	167.9	198.6	226.3	257.7
80	32.4	47.3	69.1	101.0	126.2	147.7	184.4	215.8	243.8	275.5
85	39.1	55.8	79.8	114.1	140.5	163.0	200.9	233.0	261.3	293.2
90	46.3	64.9	90.9	127.4	155.2	178.5	217.5	250.1	278.8	310.8
95	54.1	74.5	102.5	141.1	170.1	194.2	234.1	267.3	296.3	328.4
100	62.4	84.5	114.5	155.1	185.2	210.1	250.9	284.6	313.8	346.0
105	71.2	95.0	126.9	169.4	200.6	226.2	267.8	302.0	331.4	363.8
110	80.4	105.9	139.6	184.0	216.2	242.5	284.9	319.5	349.2	381.6
115	90.1	117.3	152.7	198.9	232.1	259.0	302.2	337.2	367.1	399.7
120	100.2	129.1	166.3	214.1	248.3	275.7	319.7	355.1	385.2	417.9
125	110.8	141.3	180.1	229.6	264.7	292.8	337.4	373.2	403.6	436.4
130	121.8	153.9	194.4	245.5	281.4	310.1	355.4	391.6	422.2	

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.9	6.2	13.1	27.9	43.4	59.4	92.3	126.2	160.9	205.1
45	5.4	10.6	20.6	40.4	59.7	78.9	116.8	154.2	191.4	237.5
50	8.9	16.3	29.8	54.5	77.5	99.6	141.7	182.1	221.1	268.5
55	13.5	23.4	40.4	70.0	96.4	121.1	166.9	209.5	250.0	298.3
60	19.2	31.7	52.4	86.6	116.2	143.2	192.1	236.7	278.3	327.2
65	25.9	41.2	65.5	104.2	136.6	165.7	217.3	263.5	306.0	355.3
70	33.6	51.7	79.6	122.5	157.6	188.5	242.5	290.0	333.2	382.8
75	42.3	63.3	94.6	141.5	179.0	211.6	267.7	316.3	360.0	409.8
80	52.0	75.8	110.5	161.1	200.8	234.9	292.8	342.4	386.6	436.5
85	62.5	89.1	127.1	181.2	223.0	258.4	318.0	368.5	413.1	463.1
90	73.8	103.2	144.3	201.8	245.5	282.1	343.2	394.5	439.4	489.5
95	86.0	118.1	162.2	222.8	268.3	306.1	368.6	420.5	465.7	515.9
100	98.8	133.6	180.7	244.3	291.4	330.3	394.1	446.6	492.2	542.3
105	112.4	149.9	199.7	266.2	314.9	354.8	419.7	472.9	518.7	568.9
110	126.7	166.7	219.3	288.5	338.7	379.6	445.6	499.3	545.4	595.7
115	141.7	184.2	239.5	311.3	362.9	404.7	471.8	526.0	572.4	622.8
120	157.4	202.3	260.1	334.5	387.5	430.1	498.2	553.0	599.6	650.2
125	173.6	221.0	281.4	358.2	412.5	455.9	525.0	580.3	627.2	677.9
130	190.6	240.4	303.1	382.3	437.9	482.1	552.2	608.1	655.2	

Red pine working group

Site Class 2 (SI=15.5 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.8	10.1	14.5	18.7	22.8	27.8
50	1.3	2.3	4.0	7.0	9.7	12.2	16.9	21.3	25.4	30.4
55	1.9	3.2	5.2	8.7	11.6	14.3	19.3	23.7	27.9	32.8
60	2.6	4.1	6.5	10.4	13.6	16.5	21.6	26.1	30.3	35.2
65	3.4	5.2	7.9	12.1	15.6	18.6	23.8	28.5	32.6	37.4
70	4.2	6.3	9.4	13.9	17.5	20.7	26.1	30.7	34.9	39.6
75	5.2	7.5	10.9	15.7	19.5	22.8	28.3	32.9	37.1	41.8
80	6.2	8.8	12.4	17.6	21.5	24.8	30.4	35.1	39.3	43.9
85	7.3	10.1	14.0	19.4	23.5	26.9	32.6	37.3	41.4	46.0
90	8.4	11.5	15.6	21.3	25.5	29.0	34.7	39.4	43.5	48.1
95	9.7	12.9	17.3	23.2	27.5	31.0	36.8	41.5	45.6	50.1
100	10.9	14.4	19.0	25.1	29.5	33.1	38.9	43.7	47.8	52.2
105	12.2	15.9	20.7	27.0	31.5	35.2	41.0	45.8	49.9	54.3
110	13.6	17.5	22.5	29.0	33.6	37.3	43.2	47.9	52.0	56.4
115	15.0	19.1	24.3	30.9	35.6	39.3	45.3	50.1	54.1	58.5
120	16.5	20.7	26.1	32.9	37.7	41.5	47.5	52.2	56.3	60.6
125	17.9	22.4	28.0	34.9	39.8	43.6	49.6	54.4	58.4	62.8
130	19.5	24.1	29.9	37.0	41.9	45.7	51.8	56.6	60.6	

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.2	4.7	10.1	21.6	33.7	46.1	71.9	98.5	125.8	160.6
45	4.2	8.2	16.1	31.6	46.9	62.1	92.1	121.8	151.4	188.1
50	7.0	12.8	23.5	43.1	61.5	79.1	112.8	145.1	176.5	214.6
55	10.7	18.5	32.2	55.8	77.1	97.0	133.9	168.4	201.1	240.2
60	15.3	25.3	42.0	69.6	93.6	115.4	155.2	191.4	225.3	265.1
65	20.7	33.1	52.8	84.2	110.7	134.3	176.5	214.3	249.0	289.4
70	27.1	41.8	64.5	99.5	128.3	153.6	197.9	236.9	272.4	313.3
75	34.3	51.4	77.1	115.5	146.4	173.1	219.4	259.5	295.6	336.7
80	42.3	61.8	90.3	132.0	164.8	192.9	240.9	282.0	318.6	360.0
85	51.0	72.9	104.3	149.0	183.6	213.0	262.4	304.4	341.4	383.0
90	60.5	84.8	118.8	166.5	202.8	233.2	284.1	326.8	364.3	406.0
95	70.7	97.3	133.9	184.3	222.2	253.7	305.9	349.2	387.1	429.0
100	81.5	110.4	149.6	202.6	242.0	274.5	327.8	371.8	410.0	452.1
105	93.0	124.1	165.7	221.3	262.1	295.5	349.9	394.5	433.0	475.2
110	105.0	138.4	182.4	240.4	282.5	316.8	372.2	417.4	456.2	498.6
115	117.7	153.3	199.6	259.8	303.2	338.3	394.8	440.5	479.6	522.1
120	131.0	168.7	217.2	279.7	324.3	360.2	417.7	463.9	503.3	546.0
125	144.8	184.6	235.3	300.0	345.8	382.5	440.9	487.6	527.3	570.1
130	159.2	201.1	253.9	320.7	367.7	405.1	464.4	511.6	551.6	

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.9	6.2	13.1	27.9	43.4	59.4	92.3	126.2	160.9	205.1
45	5.4	10.6	20.6	40.4	59.7	78.9	116.8	154.2	191.4	237.5
50	8.9	16.3	29.8	54.5	77.5	99.6	141.7	182.1	221.1	268.5
55	13.5	23.4	40.4	70.0	96.4	121.1	166.9	209.5	250.0	298.3
60	19.2	31.7	52.4	86.6	116.2	143.2	192.1	236.7	278.3	327.2
65	25.9	41.2	65.5	104.2	136.6	165.7	217.3	263.5	306.0	355.3
70	33.6	51.7	79.6	122.5	157.6	188.5	242.5	290.0	333.2	382.8
75	42.3	63.3	94.6	141.5	179.0	211.6	267.7	316.3	360.0	409.8
80	52.0	75.8	110.5	161.1	200.8	234.9	292.8	342.4	386.6	436.5
85	62.5	89.1	127.1	181.2	223.0	258.4	318.0	368.5	413.1	463.1
90	73.8	103.2	144.3	201.8	245.5	282.1	343.2	394.5	439.4	489.5
95	86.0	118.1	162.2	222.8	268.3	306.1	368.6	420.5	465.7	515.9
100	98.8	133.6	180.7	244.3	291.4	330.3	394.1	446.6	492.2	542.3
105	112.4	149.9	199.7	266.2	314.9	354.8	419.7	472.9	518.7	568.9
110	126.7	166.7	219.3	288.5	338.7	379.6	445.6	499.3	545.4	595.7
115	141.7	184.2	239.5	311.3	362.9	404.7	471.8	526.0	572.4	622.8
120	157.4	202.3	260.1	334.5	387.5	430.1	498.2	553.0	599.6	650.2
125	173.6	221.0	281.4	358.2	412.5	455.9	525.0	580.3	627.2	677.9
130	190.6	240.4	303.1	382.3	437.9	482.1	552.2	608.1	655.2	

Red pine working group

Site Class 2 (SI=15.5 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	2.9	5.4	7.8	10.1	14.5	18.7	22.8	27.8
50	1.3	2.3	4.0	7.0	9.7	12.2	16.9	21.3	25.4	30.4
55	1.9	3.2	5.2	8.7	11.6	14.3	19.3	23.7	27.9	32.8
60	2.6	4.1	6.5	10.4	13.6	16.5	21.6	26.1	30.3	35.2
65	3.4	5.2	7.9	12.1	15.6	18.6	23.8	28.5	32.6	37.4
70	4.2	6.3	9.4	13.9	17.5	20.7	26.1	30.7	34.9	39.6
75	5.2	7.5	10.9	15.7	19.5	22.8	28.3	32.9	37.1	41.8
80	6.2	8.8	12.4	17.6	21.5	24.8	30.4	35.1	39.3	43.9
85	7.3	10.1	14.0	19.4	23.5	26.9	32.6	37.3	41.4	46.0
90	8.4	11.5	15.6	21.3	25.5	29.0	34.7	39.4	43.5	48.1
95	9.7	12.9	17.3	23.2	27.5	31.0	36.8	41.5	45.6	50.1
100	10.9	14.4	19.0	25.1	29.5	33.1	38.9	43.7	47.8	52.2
105	12.2	15.9	20.7	27.0	31.5	35.2	41.0	45.8	49.9	54.3
110	13.6	17.5	22.5	29.0	33.6	37.3	43.2	47.9	52.0	56.4
115	15.0	19.1	24.3	30.9	35.6	39.3	45.3	50.1	54.1	58.5
120	16.5	20.7	26.1	32.9	37.7	41.5	47.5	52.2	56.3	60.6
125	17.9	22.4	28.0	34.9	39.8	43.6	49.6	54.4	58.4	62.8
130	19.5	24.1	29.9	37.0	41.9	45.7	51.8	56.6	60.6	

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.7	5.8	12.4	26.6	41.4	56.8	88.5	121.2	154.8	197.6
45	5.1	10.1	19.8	38.9	57.7	76.4	113.3	149.9	186.2	231.4
50	8.6	15.7	28.9	53.0	75.6	97.3	138.8	178.6	217.1	264.0
55	13.1	22.8	39.6	68.7	94.9	119.3	164.8	207.2	247.4	295.6
60	18.8	31.1	51.6	85.6	115.1	142.0	190.9	235.5	277.2	326.2
65	25.5	40.7	64.9	103.6	136.1	165.3	217.2	263.6	306.4	356.1
70	33.3	51.5	79.4	122.5	157.8	189.0	243.5	291.5	335.2	385.4
75	42.2	63.3	94.8	142.1	180.1	213.0	269.9	319.3	363.7	414.3
80	52.0	76.0	111.1	162.4	202.8	237.4	296.4	346.9	392.0	442.9
85	62.8	89.8	128.3	183.3	225.9	262.0	322.9	374.5	420.1	471.3
90	74.5	104.3	146.2	204.8	249.5	287.0	349.6	402.1	448.2	499.6
95	87.0	119.7	164.8	226.8	273.4	312.2	376.4	429.7	476.3	527.9
100	100.3	135.9	184.0	249.3	297.7	337.7	403.3	457.5	504.5	556.2
105	114.4	152.7	203.9	272.3	322.5	363.6	430.5	485.4	532.8	584.7
110	129.2	170.3	224.4	295.8	347.6	389.7	458.0	513.6	561.3	613.5
115	144.8	188.6	245.5	319.7	373.1	416.3	485.8	542.0	590.1	642.5
120	161.1	207.5	267.3	344.2	399.1	443.2	513.9	570.8	619.3	671.8
125	178.2	227.1	289.6	369.2	425.5	470.6	542.4	600.0	648.8	701.5
130	195.9	247.4	312.5	394.6	452.4	498.4	571.4	629.5	678.7	

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.9	6.2	13.1	27.9	43.4	59.4	92.3	126.2	160.9	205.1
45	5.4	10.6	20.6	40.4	59.7	78.9	116.8	154.2	191.4	237.5
50	8.9	16.3	29.8	54.5	77.5	99.6	141.7	182.1	221.1	268.5
55	13.5	23.4	40.4	70.0	96.4	121.1	166.9	209.5	250.0	298.3
60	19.2	31.7	52.4	86.6	116.2	143.2	192.1	236.7	278.3	327.2
65	25.9	41.2	65.5	104.2	136.6	165.7	217.3	263.5	306.0	355.3
70	33.6	51.7	79.6	122.5	157.6	188.5	242.5	290.0	333.2	382.8
75	42.3	63.3	94.6	141.5	179.0	211.6	267.7	316.3	360.0	409.8
80	52.0	75.8	110.5	161.1	200.8	234.9	292.8	342.4	386.6	436.5
85	62.5	89.1	127.1	181.2	223.0	258.4	318.0	368.5	413.1	463.1
90	73.8	103.2	144.3	201.8	245.5	282.1	343.2	394.5	439.4	489.5
95	86.0	118.1	162.2	222.8	268.3	306.1	368.6	420.5	465.7	515.9
100	98.8	133.6	180.7	244.3	291.4	330.3	394.1	446.6	492.2	542.3
105	112.4	149.9	199.7	266.2	314.9	354.8	419.7	472.9	518.7	568.9
110	126.7	166.7	219.3	288.5	338.7	379.6	445.6	499.3	545.4	595.7
115	141.7	184.2	239.5	311.3	362.9	404.7	471.8	526.0	572.4	622.8
120	157.4	202.3	260.1	334.5	387.5	430.1	498.2	553.0	599.6	650.2
125	173.6	221.0	281.4	358.2	412.5	455.9	525.0	580.3	627.2	677.9
130	190.6	240.4	303.1	382.3	437.9	482.1	552.2	608.1	655.2	

Red pine working group

Site Class 3 (SI=12.1 m)
Composition Index: 60% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	3.0	5.5	7.9	10.2	14.7	19.0	23.1	28.2
50	1.4	2.4	4.1	7.2	10.0	12.5	17.4	21.8	26.1	31.2
55	2.0	3.3	5.4	9.0	12.1	14.9	20.0	24.7	29.0	34.1
60	2.7	4.3	6.9	10.9	14.3	17.3	22.7	27.5	31.9	37.0
65	3.6	5.5	8.4	12.9	16.5	19.7	25.3	30.2	34.7	39.8
70	4.5	6.8	10.0	14.9	18.8	22.2	28.0	32.9	37.4	42.5
75	5.6	8.1	11.8	17.0	21.1	24.6	30.6	35.7	40.2	45.2
80	6.8	9.6	13.6	19.2	23.5	27.1	33.2	38.4	42.9	48.0
85	8.0	11.2	15.5	21.4	25.9	29.7	35.9	41.1	45.7	50.7
90	9.4	12.8	17.4	23.7	28.4	32.2	38.6	43.9	48.4	53.5
95	10.8	14.5	19.4	26.0	30.8	34.8	41.3	46.6	51.2	56.3
100	12.4	16.3	21.5	28.4	33.4	37.5	44.0	49.4	54.0	59.1
105	14.0	18.2	23.7	30.8	36.0	40.1	46.8	52.3	56.9	61.9
110	15.6	20.1	25.9	33.3	38.6	42.9	49.7	55.1	59.8	64.9
115	17.4	22.1	28.2	35.9	41.3	45.6	52.5	58.1	62.8	
120	19.2	24.2	30.5	38.5	44.0	48.5	55.5	61.1		
125	21.2	26.4	33.0	41.1	46.8	51.4	58.5	64.1		
130	23.1	28.6	35.5	43.9	49.7	54.3	61.5			

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	1.5	3.2	6.8	14.6	22.8	31.2	48.7	66.7	85.1	108.7
45	2.9	5.6	11.1	21.7	32.2	42.6	63.3	83.7	104.0	129.2
50	4.9	8.9	16.4	30.0	42.8	55.1	78.6	101.2	123.0	149.5
55	7.5	13.1	22.7	39.4	54.4	68.4	94.5	118.9	142.0	169.6
60	10.9	18.1	30.0	49.7	66.8	82.5	110.9	136.8	160.9	189.4
65	15.0	23.9	38.1	60.8	80.0	97.1	127.5	154.8	179.9	209.1
70	19.8	30.5	47.1	72.7	93.7	112.2	144.6	173.1	199.0	228.8
75	25.3	37.9	56.9	85.3	108.0	127.8	161.9	191.6	218.2	248.6
80	31.5	46.1	67.4	98.4	122.9	143.9	179.6	210.2	237.6	268.4
85	38.4	54.9	78.5	112.2	138.3	160.4	197.6	229.2	257.1	288.4
90	46.0	64.5	90.3	126.6	154.2	177.3	216.0	248.4	276.9	308.7
95	54.2	74.7	102.8	141.5	170.5	194.7	234.8	268.0	297.1	329.3
100	63.1	85.5	115.9	156.9	187.4	212.6	253.9	288.0	317.6	350.2
105	72.7	97.0	129.6	173.0	204.9	231.0	273.5	308.4	338.5	371.5
110	82.8	109.2	143.9	189.6	222.8	249.8	293.6	329.2	359.8	393.3
115	93.7	122.0	158.8	206.8	241.3	269.2	314.2	350.6	381.7	
120	105.1	135.4	174.4	224.6	260.4	289.2	335.3	372.4		
125	117.3	149.5	190.6	243.0	280.0	309.7	357.0	394.9		
130	130.0	164.2	207.4	262.0	300.3	330.9	379.3			

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.5	5.3	11.4	24.2	37.6	51.4	79.8	109.2	139.2	177.4
45	4.7	9.3	18.1	35.5	52.5	69.3	102.6	135.5	168.1	208.6
50	7.9	14.5	26.5	48.5	69.1	88.7	126.3	162.2	196.9	239.2
55	12.2	21.1	36.5	63.1	87.0	109.3	150.6	189.1	225.6	269.1
60	17.5	28.9	47.8	79.1	106.1	130.7	175.4	216.1	254.1	298.7
65	23.9	38.0	60.5	96.2	126.2	153.0	200.7	243.3	282.6	328.1
70	31.4	48.3	74.3	114.4	147.1	176.0	226.4	270.7	311.0	357.3
75	39.9	59.7	89.3	133.5	168.9	199.6	252.5	298.4	339.6	386.5
80	49.5	72.2	105.3	153.5	191.4	223.8	279.0	326.3	368.4	415.9
85	60.1	85.7	122.2	174.3	214.6	248.6	306.0	354.5	397.4	445.5
90	71.7	100.3	140.2	196.0	238.5	274.0	333.4	383.2	426.8	475.4
95	84.3	115.8	159.0	218.5	263.1	300.1	361.4	412.3	456.6	505.8
100	97.8	132.2	178.8	241.7	288.4	326.8	389.9	441.9	487.0	536.7
105	112.3	149.6	199.4	265.8	314.4	354.3	419.1	472.2	517.9	568.1
110	127.7	168.0	221.0	290.7	341.3	382.4	448.9	503.0	549.5	600.2
115	144.0	187.2	243.4	316.4	368.9	411.3	479.5	534.6	581.8	
120	161.3	207.4	266.7	343.0	397.3	441.0	510.8	567.0		
125	179.6	228.6	291.0	370.4	426.6	471.5	543.0	600.2		
130	198.8	250.7	316.2	398.8	456.8	502.9	576.0			

Red pine working group

Site Class 3 (SI=12.1 m)
Composition Index: 80% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	3.0	5.5	7.9	10.2	14.7	19.0	23.1	28.2
50	1.4	2.4	4.1	7.2	10.0	12.5	17.4	21.8	26.1	31.2
55	2.0	3.3	5.4	9.0	12.1	14.9	20.0	24.7	29.0	34.1
60	2.7	4.3	6.9	10.9	14.3	17.3	22.7	27.5	31.9	37.0
65	3.6	5.5	8.4	12.9	16.5	19.7	25.3	30.2	34.7	39.8
70	4.5	6.8	10.0	14.9	18.8	22.2	28.0	32.9	37.4	42.5
75	5.6	8.1	11.8	17.0	21.1	24.6	30.6	35.7	40.2	45.2
80	6.8	9.6	13.6	19.2	23.5	27.1	33.2	38.4	42.9	48.0
85	8.0	11.2	15.5	21.4	25.9	29.7	35.9	41.1	45.7	50.7
90	9.4	12.8	17.4	23.7	28.4	32.2	38.6	43.9	48.4	53.5
95	10.8	14.5	19.4	26.0	30.8	34.8	41.3	46.6	51.2	56.3
100	12.4	16.3	21.5	28.4	33.4	37.5	44.0	49.4	54.0	59.1
105	14.0	18.2	23.7	30.8	36.0	40.1	46.8	52.3	56.9	61.9
110	15.6	20.1	25.9	33.3	38.6	42.9	49.7	55.1	59.8	64.9
115	17.4	22.1	28.2	35.9	41.3	45.6	52.5	58.1	62.8	
120	19.2	24.2	30.5	38.5	44.0	48.5	55.5	61.1		
125	21.2	26.4	33.0	41.1	46.8	51.4	58.5	64.1		
130	23.1	28.6	35.5	43.9	49.7	54.3	61.5			

Gross merchantible volume of red and white pine (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.0	4.2	8.9	19.1	29.8	40.8	63.6	87.1	111.2	142.0
45	3.8	7.4	14.5	28.4	42.1	55.7	82.7	109.4	135.9	168.9
50	6.4	11.7	21.4	39.2	56.0	72.0	102.7	132.2	160.7	195.4
55	9.8	17.1	29.7	51.5	71.1	89.4	123.5	155.3	185.5	221.5
60	14.2	23.6	39.2	65.0	87.3	107.7	144.8	178.7	210.3	247.5
65	19.6	31.2	49.8	79.5	104.5	126.8	166.6	202.3	235.1	273.2
70	25.9	39.9	61.6	95.0	122.4	146.6	188.9	226.1	260.0	299.0
75	33.1	49.6	74.3	111.4	141.1	167.0	211.6	250.3	285.1	324.8
80	41.2	60.2	88.0	128.6	160.6	187.9	234.7	274.7	310.4	350.7
85	50.2	71.8	102.6	146.6	180.7	209.5	258.2	299.4	335.9	376.8
90	60.1	84.2	118.0	165.3	201.4	231.7	282.2	324.6	361.8	403.3
95	70.9	97.6	134.3	184.8	222.8	254.4	306.7	350.2	388.1	430.2
100	82.5	111.7	151.4	205.0	244.9	277.8	331.7	376.3	414.9	457.5
105	94.9	126.8	169.3	226.0	267.6	301.8	357.4	402.9	442.2	485.3
110	108.2	142.6	188.0	247.7	291.1	326.4	383.6	430.1	470.1	513.8
115	122.4	159.3	207.5	270.2	315.3	351.8	410.5	458.0	498.6	
120	137.4	176.9	227.8	293.4	340.2	377.8	438.1	486.6		
125	153.2	195.3	249.0	317.4	365.9	404.7	466.4	515.9		
130	169.9	214.6	271.0	342.3	392.4	432.3	495.6			

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.5	5.3	11.4	24.2	37.6	51.4	79.8	109.2	139.2	177.4
45	4.7	9.3	18.1	35.5	52.5	69.3	102.6	135.5	168.1	208.6
50	7.9	14.5	26.5	48.5	69.1	88.7	126.3	162.2	196.9	239.2
55	12.2	21.1	36.5	63.1	87.0	109.3	150.6	189.1	225.6	269.1
60	17.5	28.9	47.8	79.1	106.1	130.7	175.4	216.1	254.1	298.7
65	23.9	38.0	60.5	96.2	126.2	153.0	200.7	243.3	282.6	328.1
70	31.4	48.3	74.3	114.4	147.1	176.0	226.4	270.7	311.0	357.3
75	39.9	59.7	89.3	133.5	168.9	199.6	252.5	298.4	339.6	386.5
80	49.5	72.2	105.3	153.5	191.4	223.8	279.0	326.3	368.4	415.9
85	60.1	85.7	122.2	174.3	214.6	248.6	306.0	354.5	397.4	445.5
90	71.7	100.3	140.2	196.0	238.5	274.0	333.4	383.2	426.8	475.4
95	84.3	115.8	159.0	218.5	263.1	300.1	361.4	412.3	456.6	505.8
100	97.8	132.2	178.8	241.7	288.4	326.8	389.9	441.9	487.0	536.7
105	112.3	149.6	199.4	265.8	314.4	354.3	419.1	472.2	517.9	568.1
110	127.7	168.0	221.0	290.7	341.3	382.4	448.9	503.0	549.5	600.2
115	144.0	187.2	243.4	316.4	368.9	411.3	479.5	534.6	581.8	
120	161.3	207.4	266.7	343.0	397.3	441.0	510.8	567.0		
125	179.6	228.6	291.0	370.4	426.6	471.5	543.0	600.2		
130	198.8	250.7	316.2	398.8	456.8	502.9	576.0			

Red pine working group

Site Class 3 (SI=12.1 m)
Composition Index: 100% pine

Residual total basal area (m^2/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	0.5	1.0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0
45	0.9	1.6	3.0	5.5	7.9	10.2	14.7	19.0	23.1	28.2
50	1.4	2.4	4.1	7.2	10.0	12.5	17.4	21.8	26.1	31.2
55	2.0	3.3	5.4	9.0	12.1	14.9	20.0	24.7	29.0	34.1
60	2.7	4.3	6.9	10.9	14.3	17.3	22.7	27.5	31.9	37.0
65	3.6	5.5	8.4	12.9	16.5	19.7	25.3	30.2	34.7	39.8
70	4.5	6.8	10.0	14.9	18.8	22.2	28.0	32.9	37.4	42.5
75	5.6	8.1	11.8	17.0	21.1	24.6	30.6	35.7	40.2	45.2
80	6.8	9.6	13.6	19.2	23.5	27.1	33.2	38.4	42.9	48.0
85	8.0	11.2	15.5	21.4	25.9	29.7	35.9	41.1	45.7	50.7
90	9.4	12.8	17.4	23.7	28.4	32.2	38.6	43.9	48.4	53.5
95	10.8	14.5	19.4	26.0	30.8	34.8	41.3	46.6	51.2	56.3
100	12.4	16.3	21.5	28.4	33.4	37.5	44.0	49.4	54.0	59.1
105	14.0	18.2	23.7	30.8	36.0	40.1	46.8	52.3	56.9	61.9
110	15.6	20.1	25.9	33.3	38.6	42.9	49.7	55.1	59.8	64.9
115	17.4	22.1	28.2	35.9	41.3	45.6	52.5	58.1	62.8	
120	19.2	24.2	30.5	38.5	44.0	48.5	55.5	61.1		
125	21.2	26.4	33.0	41.1	46.8	51.4	58.5	64.1		
130	23.1	28.6	35.5	43.9	49.7	54.3	61.5			

Gross merchantible volume of red and white pine (m^3/ha)

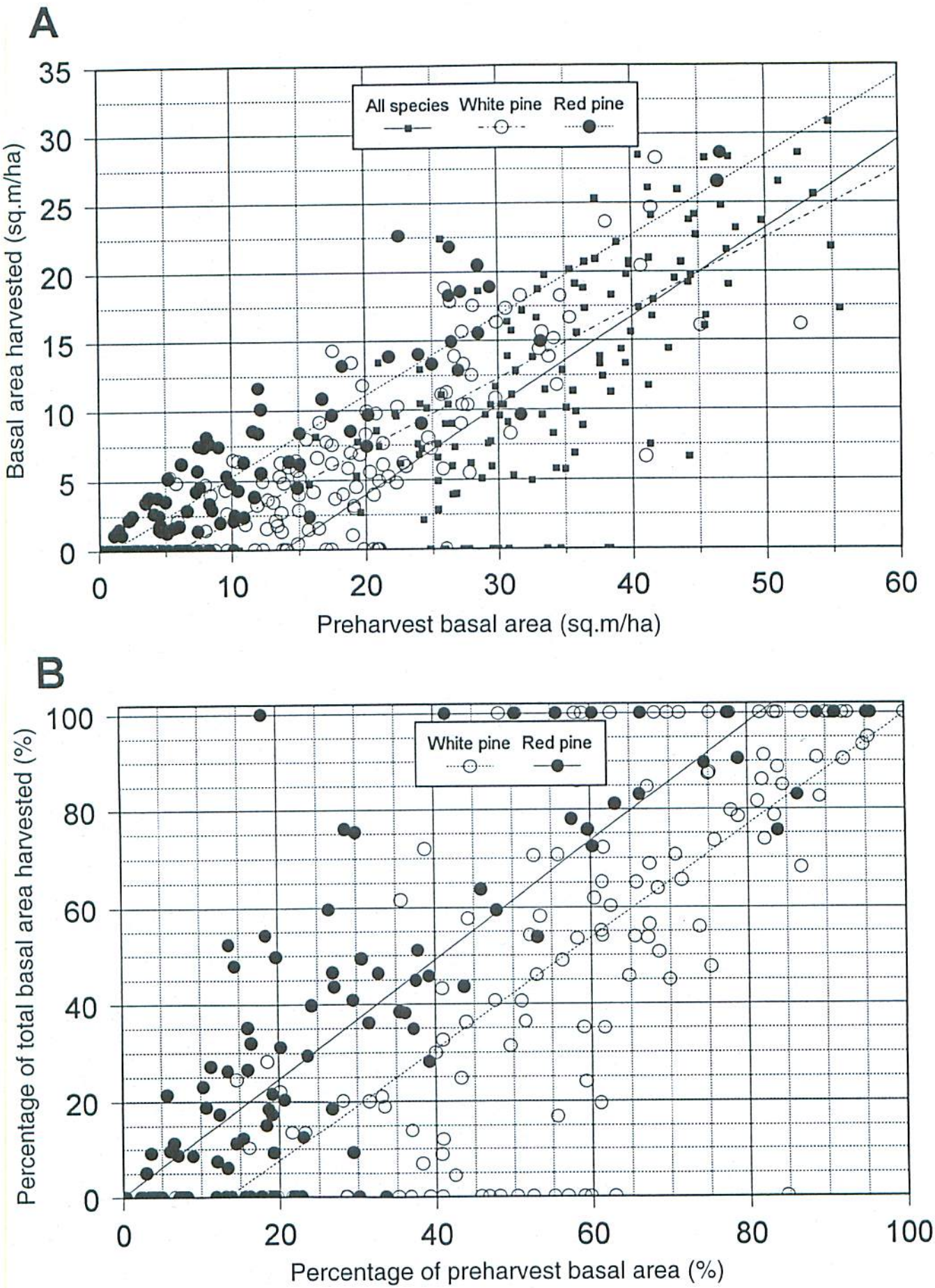
Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.4	5.2	11.0	23.5	36.6	50.2	78.2	107.2	136.8	174.7
45	4.6	9.1	17.8	34.9	51.8	68.6	101.7	134.6	167.2	207.8
50	7.8	14.3	26.3	48.3	68.9	88.6	126.4	162.6	197.7	240.4
55	12.1	21.0	36.5	63.4	87.5	110.0	151.9	191.1	228.2	272.6
60	17.5	29.1	48.2	79.9	107.4	132.6	178.2	219.8	258.7	304.5
65	24.1	38.4	61.3	97.8	128.5	156.0	205.0	248.9	289.3	336.2
70	31.8	49.1	75.8	116.9	150.6	180.3	232.4	278.2	319.9	367.9
75	40.7	61.0	91.4	137.1	173.7	205.4	260.3	307.9	350.8	399.6
80	50.7	74.1	108.3	158.2	197.6	231.3	288.7	338.0	381.9	431.5
85	61.8	88.3	126.2	180.4	222.3	257.8	317.7	368.4	413.3	463.7
90	74.0	103.6	145.2	203.4	247.8	285.0	347.2	399.4	445.2	496.3
95	87.2	120.0	165.2	227.4	274.2	313.0	377.4	430.9	477.6	529.3
100	101.5	137.5	186.2	252.3	301.3	341.8	408.2	463.0	510.5	562.9
105	116.8	156.0	208.3	278.1	329.3	371.3	439.7	495.8	544.1	597.2
110	133.2	175.5	231.3	304.8	358.2	401.6	472.0	529.3	578.4	632.2
115	150.6	196.1	255.3	332.4	387.9	432.8	505.1	563.6	613.5	
120	169.0	217.7	280.3	361.0	418.6	464.9	539.0	598.7		
125	188.5	240.3	306.4	390.6	450.2	497.9	573.9	634.8		
130	209.0	264.0	333.5	421.2	482.8	531.9	609.8			

Gross merchantible volume of all species (m^3/ha)

Stand age (years)	Residual total basal area at index age 40 years (m^2/ha)									
	0.5	1	2	4	6	8	12	16	20	25
40	2.5	5.3	11.4	24.2	37.6	51.4	79.8	109.2	139.2	177.4
45	4.7	9.3	18.1	35.5	52.5	69.3	102.6	135.5	168.1	208.6
50	7.9	14.5	26.5	48.5	69.1	88.7	126.3	162.2	196.9	239.2
55	12.2	21.1	36.5	63.1	87.0	109.3	150.6	189.1	225.6	269.1
60	17.5	28.9	47.8	79.1	106.1	130.7	175.4	216.1	254.1	298.7
65	23.9	38.0	60.5	96.2	126.2	153.0	200.7	243.3	282.6	328.1
70	31.4	48.3	74.3	114.4	147.1	176.0	226.4	270.7	311.0	357.3
75	39.9	59.7	89.3	133.5	168.9	199.6	252.5	298.4	339.6	386.5
80	49.5	72.2	105.3	153.5	191.4	223.8	279.0	326.3	368.4	415.9
85	60.1	85.7	122.2	174.3	214.6	248.6	306.0	354.5	397.4	445.5
90	71.7	100.3	140.2	196.0	238.5	274.0	333.4	383.2	426.8	475.4
95	84.3	115.8	159.0	218.5	263.1	300.1	361.4	412.3	456.6	505.8
100	97.8	132.2	178.8	241.7	288.4	326.8	389.9	441.9	487.0	536.7
105	112.3	149.6	199.4	265.8	314.4	354.3	419.1	472.2	517.9	568.1
110	127.7	168.0	221.0	290.7	341.3	382.4	448.9	503.0	549.5	600.2
115	144.0	187.2	243.4	316.4	368.9	411.3	479.5	534.6	581.8	
120	161.3	207.4	266.7	343.0	397.3	441.0	510.8	567.0		
125	179.6	228.6	291.0	370.4	426.6	471.5	543.0	600.2		
130	198.8	250.7	316.2	398.8	456.8	502.9	576.0			

APPENDIX 5

BASAL AREA HARVESTED vs PREHARVEST BASAL AREA


A
All species
White pine
Red pine
Basal area harvested (sq.m/ha)
Preharvest basal area (sq.m/ha)
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
B
White pine
Red pine
Percentage of total basal area harvested (%)
Percentage of preharvest basal area (%)
0
20
40
60
80
100