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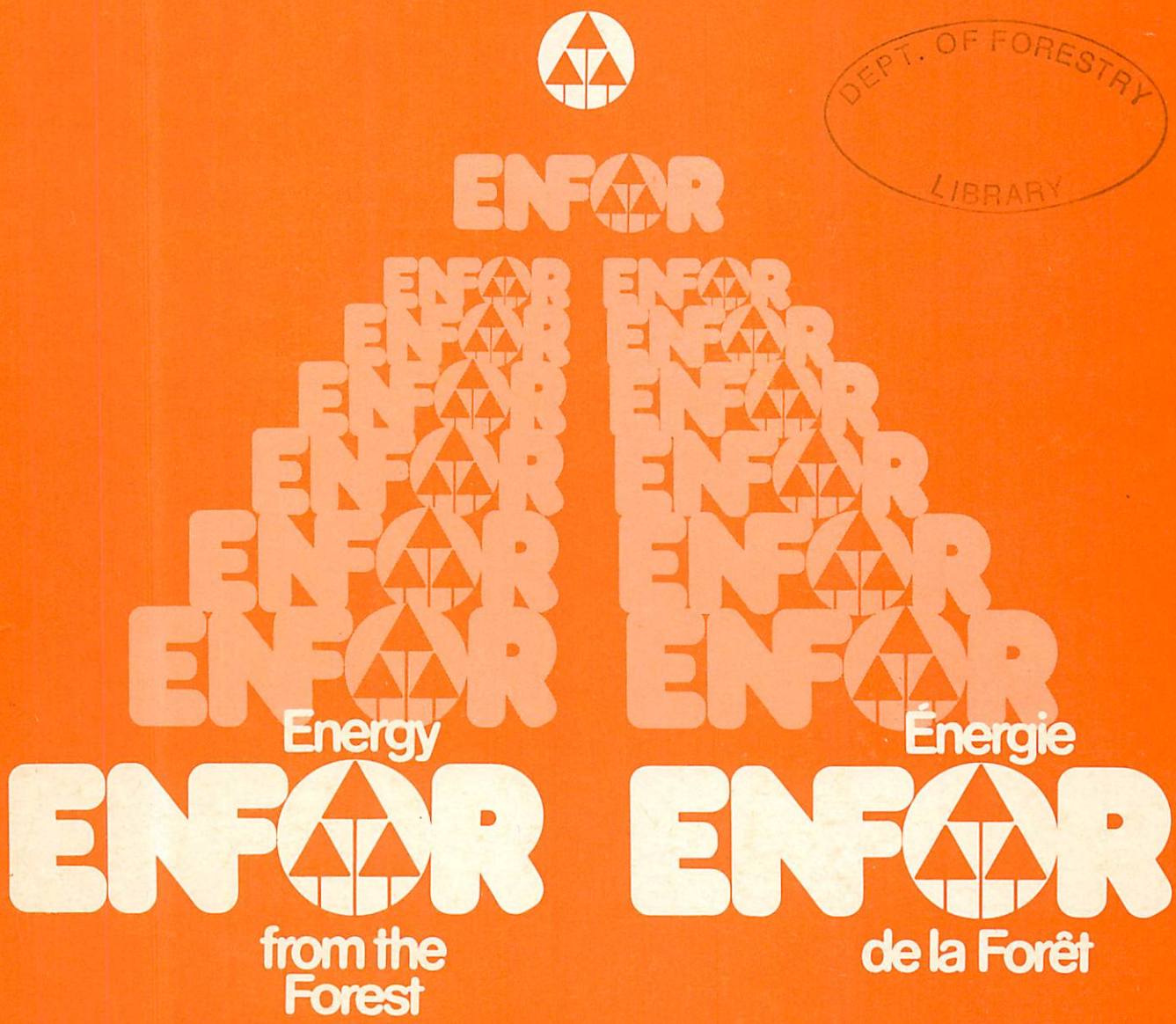
# BIOMASS EQUATIONS
## For Six Tree Species In Central Newfoundland





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# BIOMASS EQUATIONS FOR SIX TREE SPECIES IN CENTRAL NEWFOUNDLAND

by M.B. Lavigne and R.S. van Nostrand

NEWFOUNDLAND FOREST RESEARCH CENTRE
ST. JOHN'S, NEWFOUNDLAND
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May, 1981

## FOREWORD

ENFOR is the bilingual acronym for the Canadian Forestry Service's ENergy from the FORest (ENergie de la FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate in the medium to long-term a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing our dependence on petroleum and other non-renewable energy sources.

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This report, based on ENFOR Project P-112, was prepared by the Canadian Forestry Service. Field data were collected under contract (DSS File No. 07SC. KL001-9-0009) by Northland Associates Limited, of St. John's, Newfoundland.

## ABSTRACT

Biomass data were collected in central Newfoundland for six major tree species. Biomass tables for oven-dried mass of above-ground components and the whole tree were constructed using regression analyses. Five regression models were tested for predicting biomass. The model providing the best fit to date and having satisfactory statistical properties, was a weighted regression using $D^2H$ as independent variable. Sum of predicted masses of components equals the predicted total mass for any combination of breast-high diameter and height.



## RESUME

Des donneés sur la biomasse durent recuillies pour six espèces principales d'arbres de la partie centrale de Terre-Neuve. Des tables de biomasse pour la masse anhydre des composantes de la portion épigée et de la totalité de l'arbre furent construites à l'aide d'analyses de régression. Cinq modéles de régression furent essayés pour prédire la biomasse. Le modèle donnant d'ensemble le meiux déterminé et ayant des propriétés statistiques acceptables, était une régression pondéreé utilisant $D^2H$ comme variable indépendante. La somme des masses prédites des composantes est égale à la masse totale prédite pour n'importe quelle combinaison de diamètre et de hauteur à hauteur de poitrine.

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# BIOMASS EQUATIONS FOR SIX TREE SPECIES IN CENTRAL NEWFOUNDLAND

by

M.B. Lavigne and R.S. van Nostrand

## INTRODUCTION

The development of tree biomass equations is a necessary part of a program of research and development designed to determine the potential of the Newfoundland forest resource as a source of energy (van Nostrand, 1980). The equations can be used with available inventory data to estimate standing crop of biomass. Biomass equations are necessary for evaluating management practices, for example, estimating biomass yields and residues from alternative types of harvesting operations.

This report describes the first work in the province to produce reliable biomass prediction equations. Data was collected for the six major tree species in central Newfoundland: black spruce (Picea mariana (Mill.) B.S.P.), white spruce (Picea glauca (Moench) Voss), balsam fir (Abies balsamea (L.) Mill.), larch (Larix laricina (Du Roi) K. Koch), white birch (Betula papyrifera Marsh.) and trembling aspen (Populus tremuloides Michx.). Equations and tables presented are suitable for use in the region where data was collected.

## METHODS

Data was collected by Northland Associates Limited under a contract supervised by the Newfoundland Forest Research Centre. Terms of the contract specified methods for choosing trees and for collecting data about trees. Since this was the first year for collecting information, difficulties with methods became apparent as work progressed. Northland Associates Limited were helpful in modifying procedures.

The contractor was responsible for performing all field and laboratory work. In the field, total fresh mass of above-ground components of selected trees were measured and samples of each component were collected. In the laboratory, fresh masses of samples were measured, samples were oven-dried and then measured again. A detailed description of field and laboratory procedures is provided in the Appendix. The Newfoundland Forest Research Centre was responsible for computing oven-dried masses of components, and for all analyses.

Procedures for field and laboratory work, and subsequent analyses recognized five components to the total above-ground tree:

1. Stem wood - the woody portion of the central stem, including stump and unmerchantable top,

2. Stem bark - bark of the central stem.

3. Bole - stem wood plus stem bark,

4. Foliage + twigs - foliage and foliage-bearing twigs,

5. Branches - wood and bark of branches, excluding leaf-bearing twigs.

Total mass was determined by summing stem wood, stem bark, branches, and foliage + twigs.

The study area included all productive forest land within 100 km of Grand Falls, which encompasses most of Forest Section B.28a (Rowe, 1972). Trees of each of the six species were collected throughout the study area (Figure 1), and from a wide range of breast height diameters and total heights (Table 1).

Our intention was to have the sample of each species contain a diverse set of combinations of total height and diameter. Trees were collected from stands with a wide variety of particular characteristics to accomplish this objective of sampling. Stands containing a species to be sampled could be stratified according to age class and site quality, using the classification scheme of the Provincial Forest Management Inventory (Anonymous, 1977). Five age classes and two site quality classes were recognized by our sampling scheme (see Appendix). Trees were collected from stands of each stratum. Four trees were usually harvested in a stand. Trees were chosen from the full range of

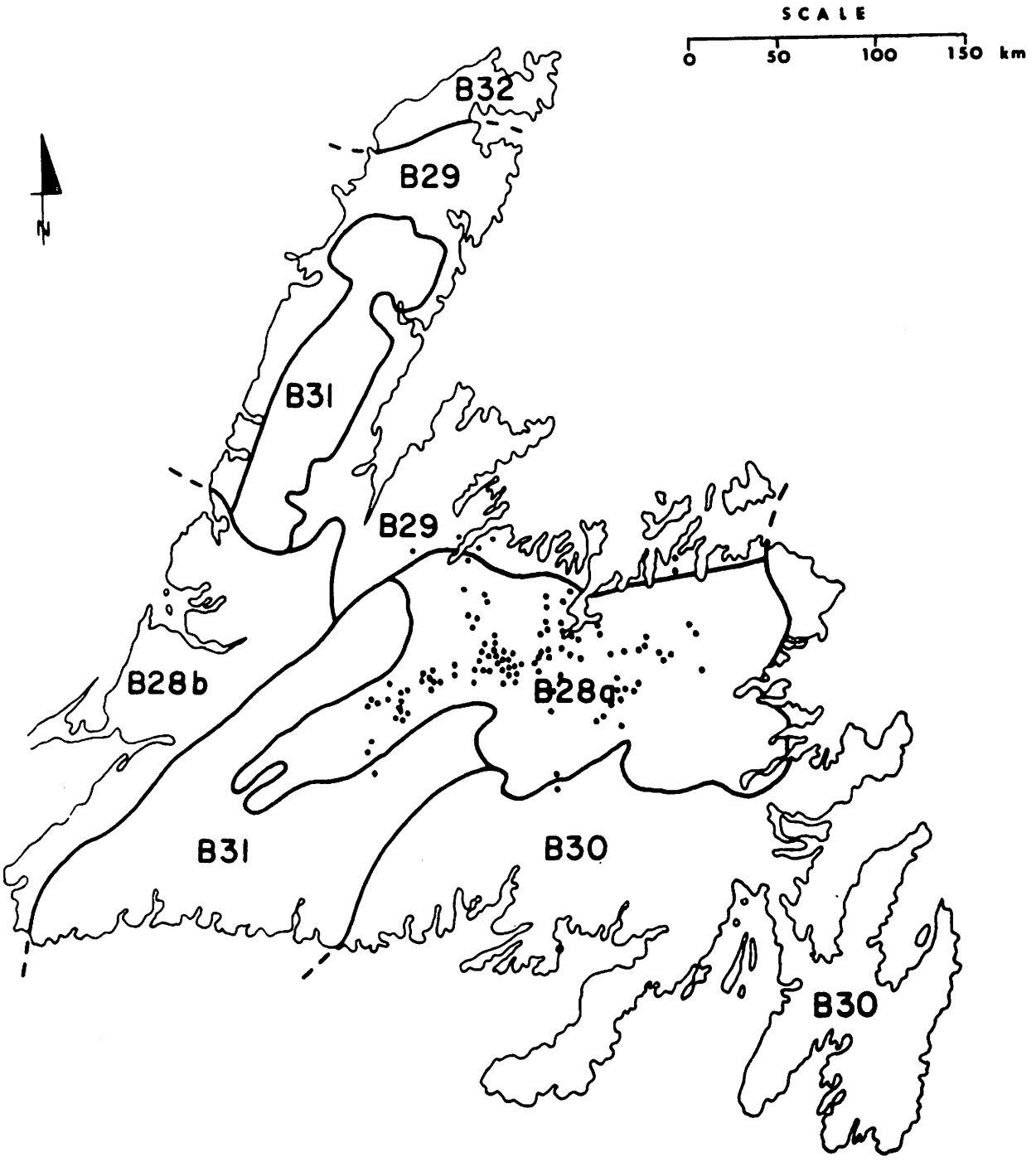


Figure 1. Plot locations for biomass sampling.

Table 1. Ranges of breast height diameter, total height and total oven-dried mass for the sample of each species.

| Species | Number of samples | D[1] (cm) | Height (m) | Total O.D.[2] mass (kg) |
|---|---|---|---|---|
| Balsam fir (*Abies balsamea*) | 73 | 1.5 - 29.7 | 1.9 - 17.9 | .6 - 302.0 |
| Black spruce (*Picea mariana*) | 98 | 2.3 - 28.6 | 1.9 - 18.1 | 2.8 - 277.7 |
| White spruce (*Picea glauca*) | 53 | 3.0 - 30.5 | 2.8 - 18.0 | 1.9 - 347.2 |
| Larch (*Larix laricina*) | 60 | 1.3 - 29.2 | 2.1 - 20.9 | .4 - 273.5 |
| White birch (*Betula papyrifera*) | 68 | 2.1 - 28.1 | 2.6 - 18.9 | .9 - 431.6 |
| Trembling aspen (*Populus tremuloides*) | 70 | 2.2 - 44.7 | 3.3 - 23.4 | .7 - 764.2 |

[1] breast height diameter

[2] oven-dried

diameters found in the stand. These procedures were based on the premise that four trees were sufficient to characterize the height-diameter relationship of a stand, all stands of a stratum had a similar height-diameter relationship and stands from different strata had different height-diameter relationships. The sampling scheme was expected to supply data from a wide range of total heights within each diameter class.

Oven-dried masses of components were calculated from field and laboratory data. Samples carried to the laboratory were used to estimate ratios of oven-dried mass of components to fresh mass of samples. Field measurements of fresh mass were multiplied by average ratios for samples collected from that portion of the tree to estimate oven-dried mass of components for the tree.

Discs collected from boles were measured to calculate two ratios: oven-dried mass of bark to fresh mass of the disc and oven-dried mass of wood to fresh mass of the disc. Fresh masses of stem segments were multiplied by ratios of appropriate discs to estimate oven-dried masses. For the stump and uppermost segment, the ratios calculated from one disc were used to estimate oven-dried masses. For the remaining stem segments, the ratios calculated from discs collected at both ends of the segment were averaged. Estimated oven-dried masses of segments were summed to estimate bole wood mass and bole bark mass.

Procedures for determining oven-dried mass of crown components were slightly different for softwood and hardwood species. For softwood species, the ratios oven-dried mass of branch to fresh mass and oven-dried mass of foliage + twigs to fresh mass were calculated for each branch sample. The ratios were average for samples from each size class of branch. Mean ratios were multiplied with fresh mass of branches of the respective size class and oven-dried masses for size classes were summed to estimate oven-dried masses of crown components. For hardwood species all foliage + twigs were contained in the smallest size class of branches separated in the field. The average ratio of oven-dried mass of foliage + twigs to fresh mass of sample branch was multiplied with fresh mass of branches in the smallest size class to estimate oven-dried mass of foliage + twigs for the tree. Discs were collected for other size classes of hardwood branches and the ratio of oven-dried mass of disc to fresh mass of disc was calculated. Estimated oven-dried mass of branches for all size classes were summed to determine the total for the tree.

Regression analyses were performed to provide equations for predicting oven-dried masses of components from measurements of easily obtained tree characteristics. Breast height diameter (D) and total height (H) were eligible for use as predictor variables since both are measured by current inventory procedures (Anonymous, 1977). For each species and component (Y), five models were tested for utility of predicting oven-dried mass:

$$\hat{Y} = b_o (D^2H)^{b_1} \quad (1)$$

$$\hat{Y} = b_o D^{b_1} H^{b_2} \quad (2)$$

$$\hat{Y} = b_o + b_1 D^2H \quad (3)$$

$$\hat{Y} = b_o + b_1 D^2H + b_2 (D^2H)^2 \quad (4)$$

$$\hat{Y} = \frac{D^2}{b_1 + b_2 \frac{1}{H}} \quad (5)$$

Allometric models (models (1) and (2)) have frequently been used for predicting tree biomass. The logarithimic transformations of these models are linear and can be analyzed by ordinary least squares methods. The conditional variance after transformation is often homogeneous over the range of sizes of trees, satisfying a requirement necessary for least squares calculations to yield maximum likelihood estimates of coefficients (Draper and Smith, 1966). A systematic bias is introduced to predicted values when transforming back to arithmetic units; the bias can be corrected by the method suggested by Baskerville (1972).

The weighted least squares method of regression was used to solve for coefficients of models (3) and (4). The weighted least squares method is used to construct volume tables (Schumacher and Chapman, 1954; Cunia, 1964) and is used, or suggested, for constructing biomass tables (Schreuder and Swank, 1973; Cunia, 1979).

Observations are weighted by a function of the independent variable to make conditional variance homogeneous over the range of sizes of trees. This method of weighting observations assumes that conditional variance before weighting was proportional to a function of the independent variable, such as $\sigma^2(D^2H)^{2k}$. A value for k was est-

imated for each component of each species by subdividing data into $D^2H$ classes, calculating variance and average $D^2H$ for the samples in each class, and regressing logarithm of variance against logarithm of $D^2H$. The slope coefficient of this regression was an estimate of $2k$. This procedure was similar to the method for determining the weighting factor that was used by Schreuder and Swank (1973). Models (3) and (4) were transformed by the weighting function to:

$$Y \quad (D^2H)^{-k} = b_o \cdot (D^2H)^{-k} + b_1 \cdot (D^2H)^{1-k} + \varepsilon \cdot (D^2H)^{-k} \qquad (6)$$

$$Y \cdot (D^2H)^{-k} = b_o \cdot (D^2H)^{-k} + b_1 \cdot (D^2H)^{1-k} + b_2 \cdot (D^2H)^{2-k} + \varepsilon \cdot (D^2H)^{-k} \qquad (7)$$

Coefficients of these models were estimated by using the BMDP1R program of the BMD statistical package (Dixon and Brown, 1977).

Residuals from regression fitted by weighted least squares do not necessarily sum to zero; that is, the sum of values predicted by the equation for trees in the sample does not necessarily equal the sum of observed values of the dependent variable (Furnival, pers comm)*. This discrepancy was removed by applying the correction factor $\Sigma Y/\Sigma \hat{Y}$, as suggested by Professor Furnival.

Model (5) is known as the Honer equation. Coefficients were calculated by least squares methods after rearranging the model to the form:

$$D^2 \cdot Y^{-1} = b_1 + b_2 \cdot H^{-1} \qquad (8)$$

The Honer equation was developed for predicting volume, and had not been tested for predicting biomass.

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*G.M. Furnival, 1981. Personal communication. School of Forestry and Environmental Studies, Yale University. New Haven, Connecticut, U.S.A.

The utility of models was examined by considering coefficients of determination ($R^2$), plots of residuals, prediction intervals and realism of predictions at extremes of the ranges of D and H. Plots of residuals were used to judge whether models fit the data well and to judge whether the requirement for homogeneous variance was satisfied. Prediction intervals and $R^2$ were used to judge the precision of estimates.

After reviewing the results of regression for all models of all components, a single model was chosen for each species. The least squares solutions of the chosen model were used for all components of the species to generate mass tables. It was decided that tables for components should be compatible with the table for total mass; the predicted sum of components must equal predicted total for the same combination of breast height diameter and total height. This was accomplished by adjusting the coefficients of an equation for one component. The adjusted equation was re-evaluated to determine how well the data was fitted.

## BIOMASS EQUATIONS

Equations for predicting biomass are listed in Table 2. Models (3) and (4), using $D^2H$ as the predictor variable and with coefficients estimated by weighted least squares, were chosen for all species. These models fit the data best for most species. Also, making predictions of mass of components compatible with predicted total mass was accomplished with only small adjustments to equations predicting mass of foliage + twigs. Plots of residuals, in Figures 2 to 7, show how well the selected equations fit the data.

For two species, black spruce and larch, the allometric model with $D^2H$ as independent variable (model (1)), fit the data slightly better than the other models. However, sum of predicted mass of components were greatly different from predicted total mass for any combination of breast height diameter and total height, and reasonable adjustment to the coefficients of the equation for one component could not be made.

Table 2. Equations for predicting oven-dried mass for species and components in central Newfoundland.

| Component | Equation | $R^2$ | $S^2$ |
|---|---|---|---|
| | **Balsam fir (n = 73)** | | |
| Total | $1.17894 + .01970\ D^2H$ | .9679 | $.004\ (D^2H)^{1.3244}$ |
| Bole | $.29193 + .01473\ D^2H$ | .9816 | $.0003\ (D^2H)^{1.5016}$ |
| Branches | $-.00182 + .00269\ D^2H$ | .8192 | $.00009\ (D^2H)^{1.5020}$ |
| Foliage + twigs | $.88883 + .00228\ D^2H$ | .7936 | $.006\ (D^2H)^{1.0840}$ |
| | **Black spruce (n = 98)** | | |
| Total | $3.47880 + .02368\ D^2H$ | .9644 | $.014\ (D^2H)^{1.2044}$ |
| Bole | $.68337 + .01844\ D^2H$ | .9865 | $.002\ (D^2H)^{1.2636}$ |
| Branches | $.31072 + .00319\ D^2H$ | .6651 | $.002\ (D^2H)^{1.2592}$ |
| Foliage + twigs | $2.48471 + .00205\ D^2H$ | .6945 | $.085\ (D^2H)^{.7922}$ |
| | **White spruce (n = 53)** | | |
| Total | $2.85965 + .02349\ D^2H$ | .9806 | $.134\ (D^2H)^{.8648}$ |
| Bole | $.60394 + .01633\ D^2H$ | .9795 | $.001\ (D^2H)^{1.3648}$ |
| Branches | $.27815 + .00378\ D^2H$ | .8224 | $.001\ (D^2H)^{1.2850}$ |
| Foliage + twigs | $1.97756 + .00338\ D^2H$ | .8771 | $.347\ (D^2H)^{.5560}$ |
| | **Larch (n = 60)** | | |
| Total | $1.22073 + .02086\ D^2H$ | .9718 | $.075\ (D^2H)^{.9264}$ |
| Bole | $.25838 + .01715\ D^2H$ | .9781 | $.01\ (D^2H)^{1.0896}$ |
| Branches | $.02713 + .00282\ D^2H$ | .7953 | $.001\ (D^2H)^{1.1860}$ |
| Foliage + twigs | $.93522 + .00089\ D^2H$ | .7770 | $.066\ (D^2H)^{.5256}$ |
| | **White birch (n = 68)** | | |
| Total | $1.20385 + .02506\ D^2H + .000000280\ (D^2H)^2$ | .9786 | $.013\ (D^2H)^{1.2070}$ |
| Bole | $.39075 + .02144\ D^2H + .000000063\ (D^2H)^2$ | .9871 | $.002\ (D^2H)^{1.3000}$ |
| Branches | $.24219 + .00223\ D^2H + .000000225\ (D^2H)^2$ | .7383 | $.00003\ (D^2H)^{1.8100}$ |
| Foliage + twigs | $.97091 + .00139\ D^2H - .000000008\ (D^2H)^2$ | .7249 | $.001\ (D^2H)^{1.1380}$ |
| | **Trembling aspen (n = 70)** | | |
| Total | $.54972 + .01987\ D^2H$ | .9858 | $.001\ (D^2H)^{1.4000}$ |
| Bole | $.24198 + .01691\ D^2H$ | .9914 | $.0002\ (D^2H)^{1.5000}$ |
| Branches | $-.04929 + .00242\ D^2H$ | .7909 | $.00001\ (D^2H)^{1.8000}$ |
| Foliage + twigs | $.35703 + .00054\ D^2H$ | .6084 | $.0009\ (D^2H)^{1.0944}$ |

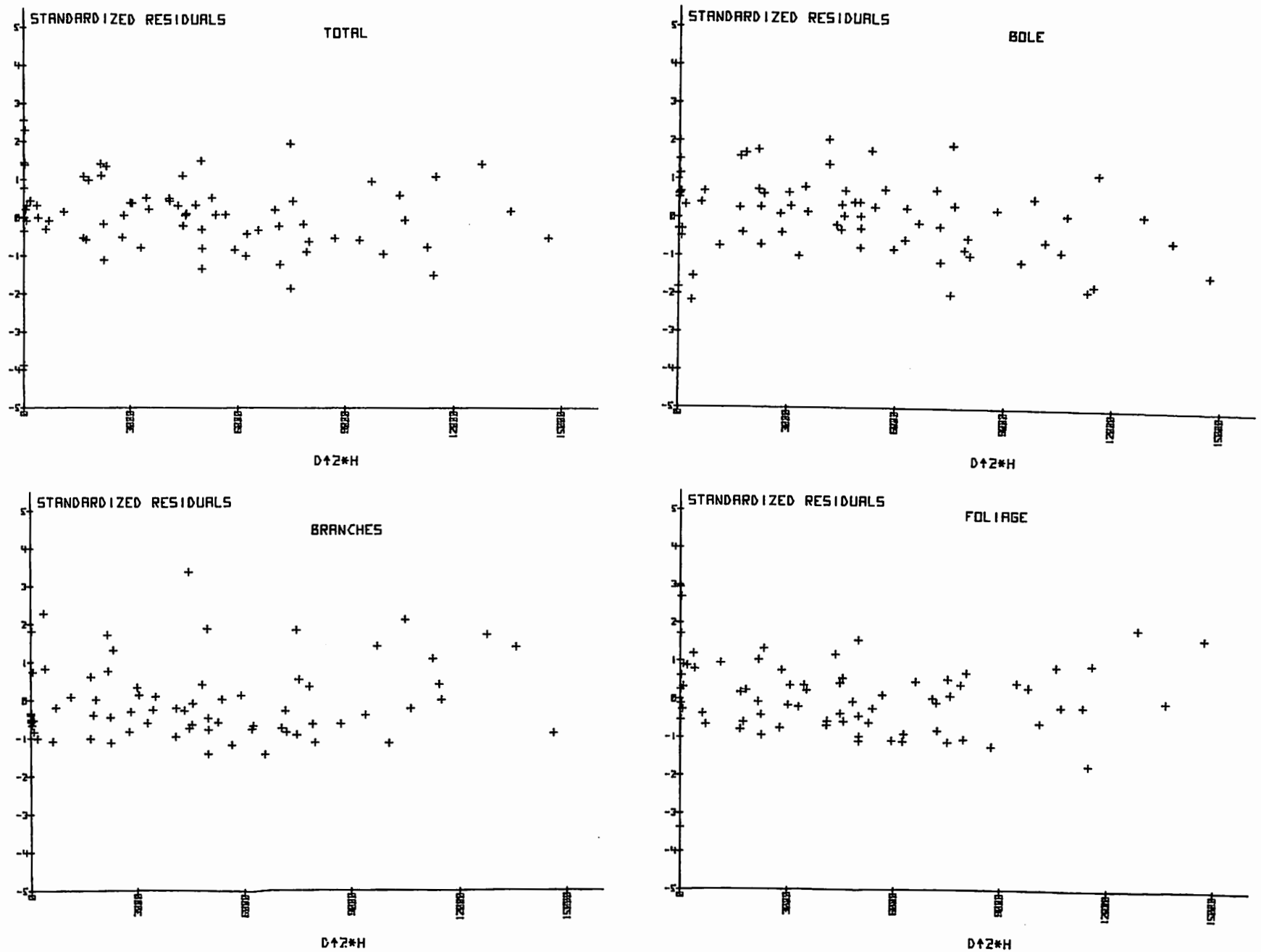



Figure 2. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of balsam fir.

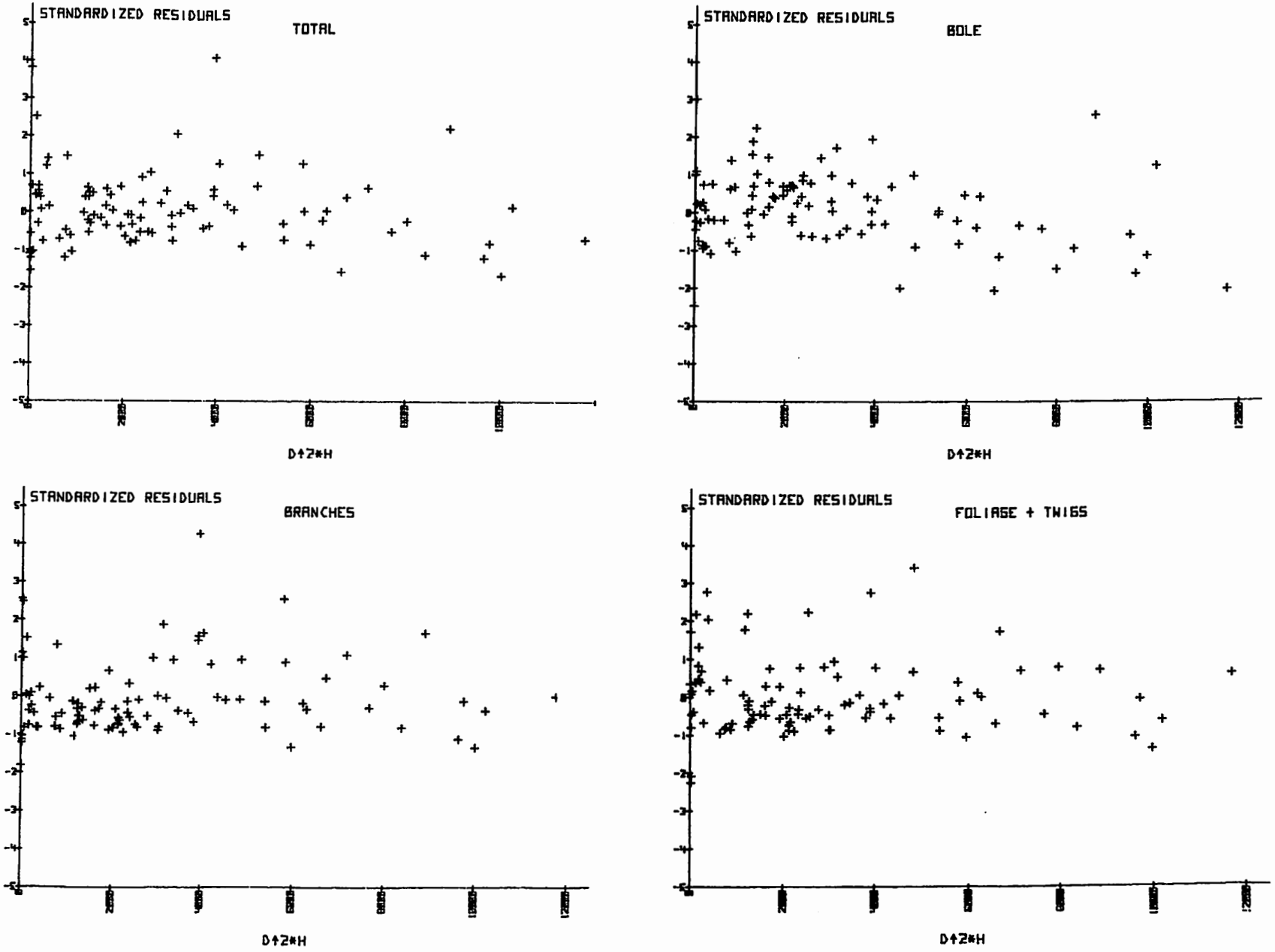



Figure 3. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of black spruce.

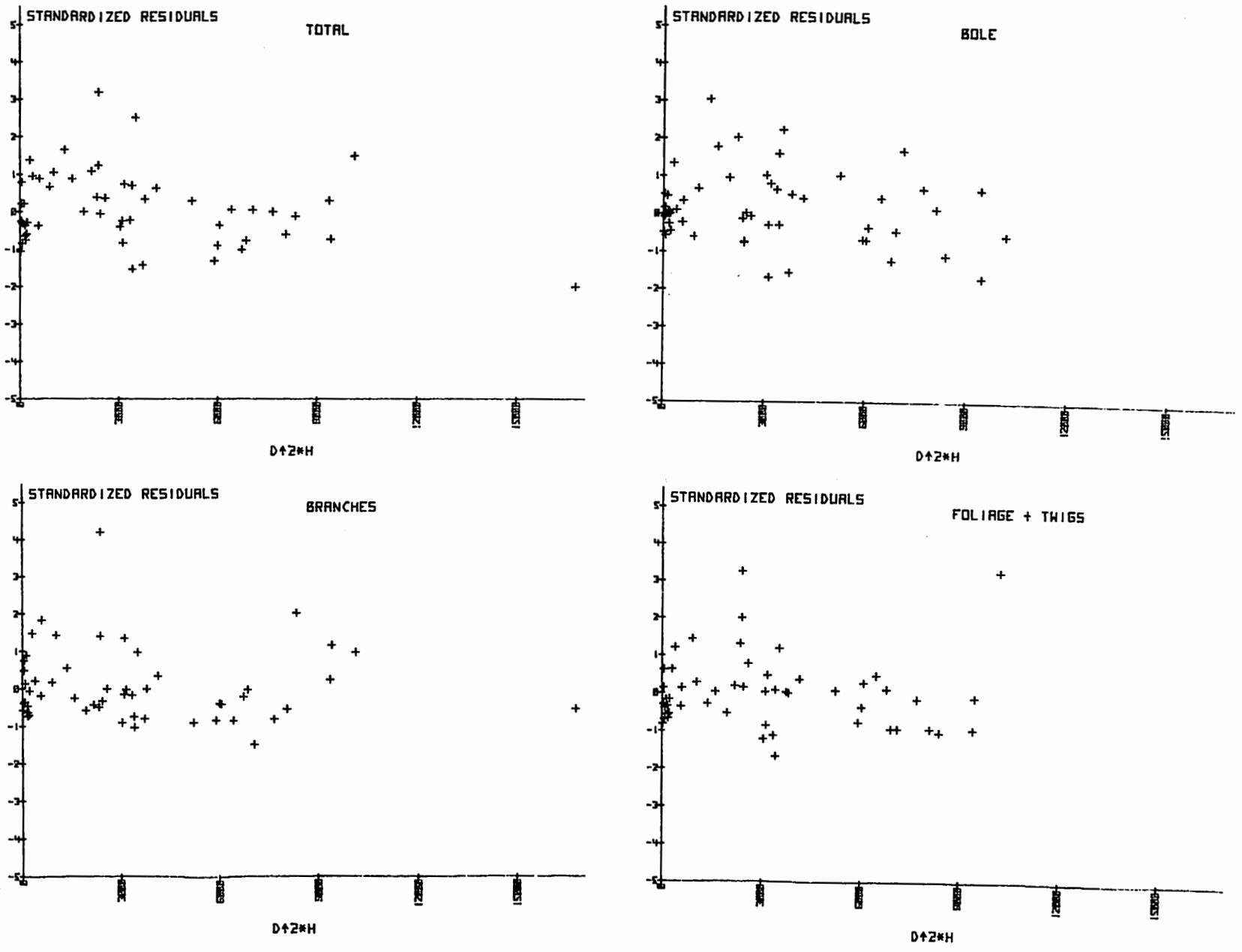
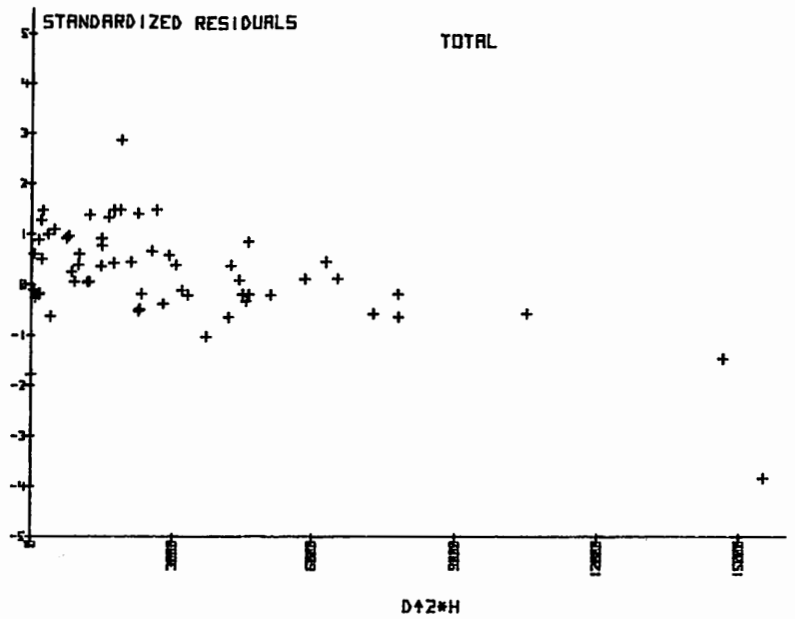
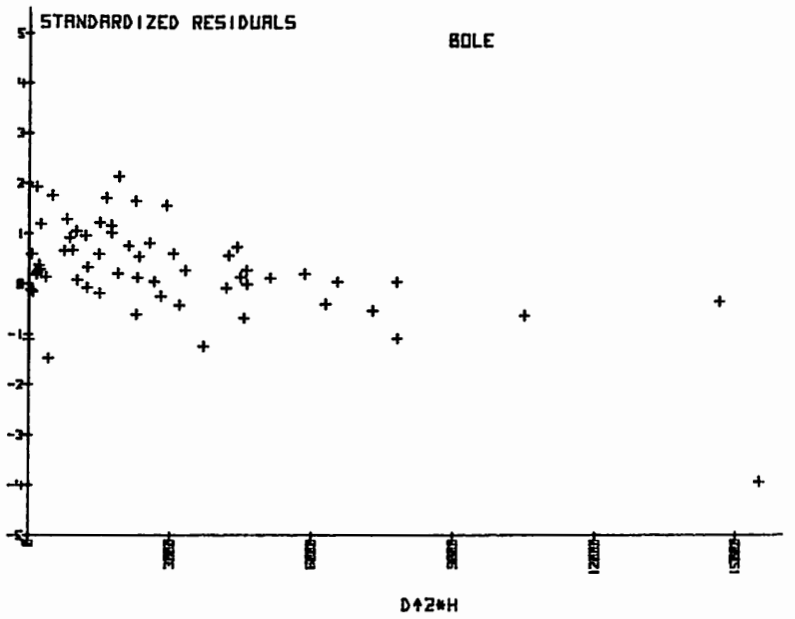
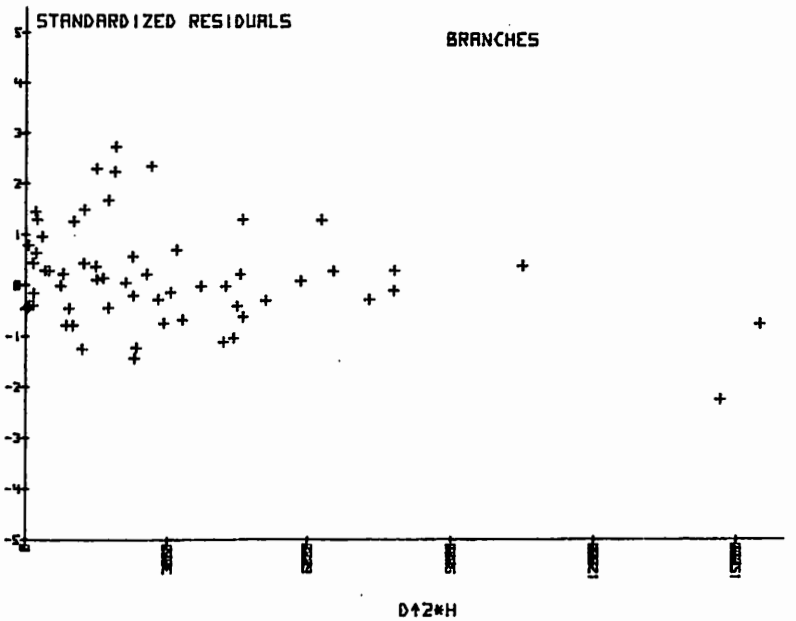



Figure 4. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of white spruce.



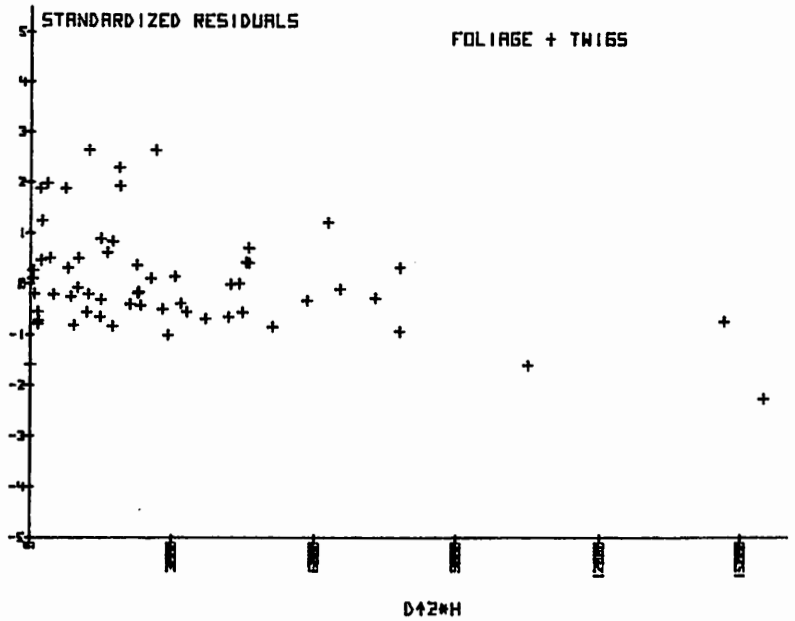




Figure 5. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of larch.

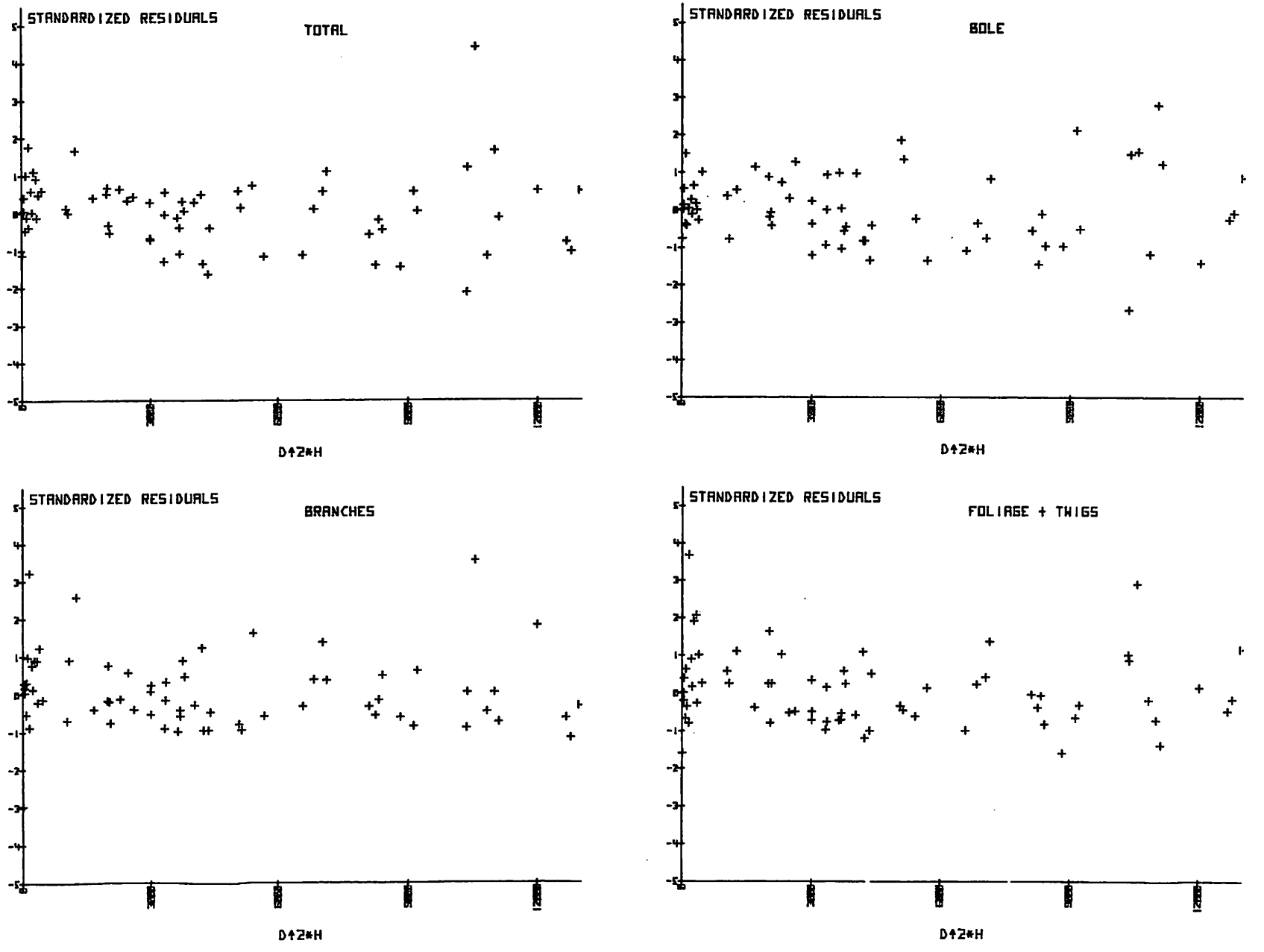



Figure 6. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of white birch.

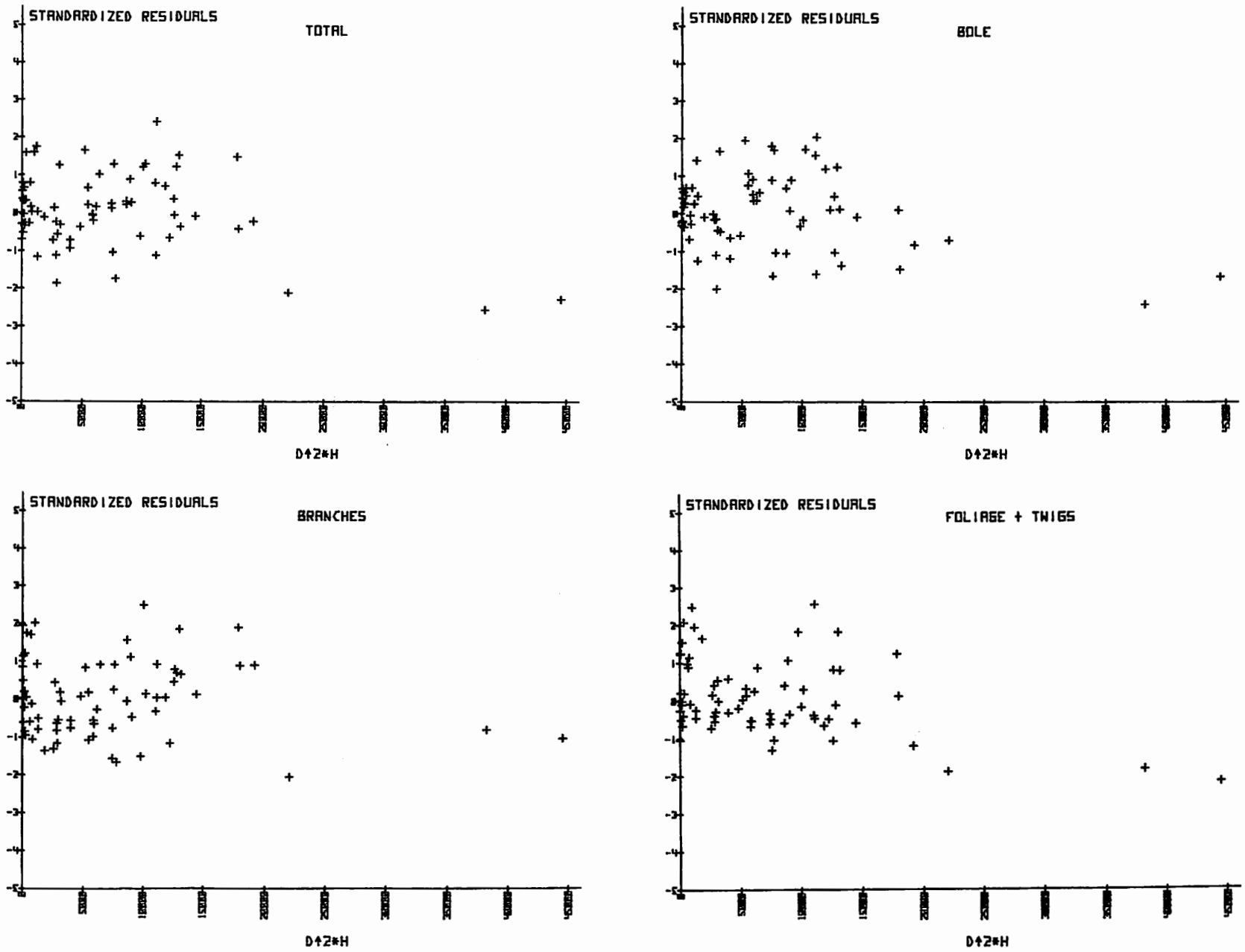



Figure 7. Plots of residuals of data about prediction equations, over the range of the predictor variable, $D^2H$, for components of trembling aspen.

The second allometric model (model 2) was unsatisfactory for all species. For at least one crown component of all species, and often for both crown components, solutions of this model predicted that mass was less for taller trees of a diameter class. Such predictions were considered to be biologically unrealistic. No reason can be offered to explain why unrealistic results of regression were common.

Plots of residuals of allometric models (models (1) and (2)) often revealed that conditional variance was not homogeneous over the range of tree sizes. Heterogenous variance was common for crown components. For best unbiased estimates of coefficients, weighting would be necessary in addition to the logarithmic transformations.

The Honer equation performed poorly for predicting biomass. Variance was often not homogenous and degree of fit was poor for crown components.

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# APPENDIX I

## BIOMASS TABLES

TABLE 3. BALSAM FIR TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 1.34 | 1.49 | | | | | | | | | | |
| 4 | 1.81 | 2.44 | 3.07 | | | | | | | | | |
| 6 | 2.60 | 4.02 | 5.43 | 6.85 | 8.27 | | | | | | | |
| 8 | | 6.22 | 8.74 | 11.27 | 13.79 | 16.31 | | | | | | |
| 10 | | 9.06 | 13.00 | 16.94 | 20.88 | 24.82 | 28.76 | | | | | |
| 12 | | 12.53 | 18.20 | 23.87 | 29.55 | 35.22 | 40.89 | | | | | |
| 14 | | | 24.35 | 32.07 | 39.79 | 47.51 | 55.24 | 62.96 | | | | |
| 16 | | | 31.44 | 41.52 | 51.61 | 61.70 | 71.78 | 81.87 | | | | |
| 18 | | | 39.48 | 52.24 | 65.01 | 77.77 | 90.54 | 103.30 | 116.07 | | | |
| 20 | | | | 64.22 | 79.98 | 95.74 | 111.50 | 127.26 | 143.02 | 158.78 | | |
| 22 | | | | 77.46 | 96.53 | 115.60 | 134.67 | 153.74 | 172.81 | 191.87 | | |
| 24 | | | | | 114.65 | 137.35 | 160.04 | 182.73 | 205.43 | 228.12 | 250.82 | |
| 26 | | | | | 134.35 | 160.99 | 187.62 | 214.25 | 240.89 | 267.52 | 294.16 | |
| 28 | | | | | | 186.52 | 217.41 | 248.30 | 279.19 | 310.07 | 340.96 | |
| 30 | | | | | | 213.94 | 249.40 | 284.86 | 320.32 | 355.78 | 391.24 | 426.70 |
| 32 | | | | | | 243.25 | 283.60 | 323.94 | 364.29 | 404.63 | 444.98 | 485.33 |
| 34 | | | | | | | 320.00 | 365.55 | 411.10 | 456.64 | 502.19 | 547.74 |
| 36 | | | | | | | 358.62 | 409.68 | 460.74 | 511.80 | 562.87 | 613.93 |
| 38 | | | | | | | | 456.33 | 513.22 | 570.11 | 627.01 | 683.90 |
| 40 | | | | | | | | 505.50 | 568.54 | 631.58 | 694.62 | 757.66 |

TABLE 4. BALSAM FIR BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.41 | 0.53 | | | | | | | | | | |
| 4 | 0.76 | 1.23 | 1.71 | | | | | | | | | |
| 6 | 1.35 | 2.41 | 3.47 | 4.53 | 5.59 | | | | | | | |
| 8 | | 4.06 | 5.95 | 7.83 | 9.72 | 11.60 | | | | | | |
| 10 | | 6.18 | 9.13 | 12.08 | 15.02 | 17.97 | 20.91 | | | | | |
| 12 | | 8.78 | 13.02 | 17.26 | 21.50 | 25.75 | 29.99 | | | | | |
| 14 | | | 17.61 | 23.39 | 29.16 | 34.94 | 40.71 | 46.49 | | | | |
| 16 | | | 22.92 | 30.46 | 38.00 | 45.54 | 53.08 | 60.63 | | | | |
| 18 | | | 28.93 | 38.47 | 48.02 | 57.56 | 67.11 | 76.65 | 86.20 | | | |
| 20 | | | | 47.43 | 59.21 | 71.00 | 82.78 | 94.56 | 106.35 | 118.13 | | |
| 22 | | | | 57.33 | 71.59 | 85.84 | 100.10 | 114.36 | 128.62 | 142.88 | | |
| 24 | | | | | 85.14 | 102.11 | 119.07 | 136.04 | 153.01 | 169.98 | 186.95 | |
| 26 | | | | | 99.87 | 119.78 | 139.70 | 159.61 | 179.53 | 199.44 | 219.36 | |
| 28 | | | | | | 138.87 | 161.97 | 185.07 | 208.16 | 231.26 | 254.35 | |
| 30 | | | | | | 159.38 | 185.89 | 212.40 | 238.92 | 265.43 | 291.95 | 318.46 |
| 32 | | | | | | 181.29 | 211.46 | 241.63 | 271.80 | 301.96 | 332.13 | 362.30 |
| 34 | | | | | | | 238.68 | 272.74 | 306.79 | 340.85 | 374.91 | 408.96 |
| 36 | | | | | | | 267.55 | 305.73 | 343.91 | 382.09 | 420.27 | 458.45 |
| 38 | | | | | | | | 340.61 | 383.15 | 425.69 | 468.23 | 510.77 |
| 40 | | | | | | | | 377.38 | 424.52 | 471.65 | 518.79 | 565.92 |

TABLE 5. BALSAM FIR BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.02 | 0.04 | | | | | | | | | | |
| 4 | 0.08 | 0.17 | 0.26 | | | | | | | | | |
| 6 | 0.19 | 0.39 | 0.58 | 0.77 | 0.97 | | | | | | | |
| 8 | | 0.69 | 1.03 | 1.38 | 1.72 | 2.06 | | | | | | |
| 10 | | 1.07 | 1.61 | 2.15 | 2.69 | 3.23 | 3.76 | | | | | |
| 12 | | 1.55 | 2.32 | 3.10 | 3.87 | 4.65 | 5.42 | | | | | |
| 14 | | | 3.16 | 4.22 | 5.27 | 6.33 | 7.38 | 8.43 | | | | |
| 16 | | | 4.13 | 5.51 | 6.88 | 8.26 | 9.64 | 11.02 | | | | |
| 18 | | | 5.23 | 6.97 | 8.71 | 10.46 | 12.20 | 13.94 | 15.69 | | | |
| 20 | | | | 8.61 | 10.76 | 12.91 | 15.06 | 17.21 | 19.37 | 21.52 | | |
| 22 | | | | 10.41 | 13.02 | 15.62 | 18.23 | 20.83 | 23.43 | 26.04 | | |
| 24 | | | | | 15.49 | 18.59 | 21.69 | 24.79 | 27.89 | 30.99 | 34.09 | |
| 26 | | | | | 18.18 | 21.82 | 25.46 | 29.09 | 32.73 | 36.37 | 40.00 | |
| 28 | | | | | | 25.31 | 29.52 | 33.74 | 37.96 | 42.18 | 46.40 | |
| 30 | | | | | | 29.05 | 33.89 | 38.73 | 43.58 | 48.42 | 53.26 | 58.10 |
| 32 | | | | | | 33.05 | 38.56 | 44.07 | 49.58 | 55.09 | 60.60 | 66.11 |
| 34 | | | | | | | 43.53 | 49.75 | 55.97 | 62.19 | 68.41 | 74.63 |
| 36 | | | | | | | 48.81 | 55.78 | 62.75 | 69.72 | 76.70 | 83.67 |
| 38 | | | | | | | | 62.15 | 69.92 | 77.69 | 85.45 | 93.22 |
| 40 | | | | | | | | 68.86 | 77.47 | 86.08 | 94.69 | 103.29 |

TABLE 6. BALSAM FIR FOLIAGE + TWIGS OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.91 | 0.93 | | | | | | | | | | |
| 4 | 0.96 | 1.03 | 1.11 | | | | | | | | | |
| 6 | 1.05 | 1.22 | 1.38 | 1.55 | 1.71 | | | | | | | |
| 8 | | 1.47 | 1.76 | 2.06 | 2.35 | 2.64 | | | | | | |
| 10 | | 1.80 | 2.26 | 2.71 | 3.17 | 3.62 | 4.08 | | | | | |
| 12 | | 2.20 | 2.86 | 3.52 | 4.17 | 4.83 | 5.49 | | | | | |
| 14 | | | 3.57 | 4.46 | 5.36 | 6.25 | 7.15 | 8.04 | | | | |
| 16 | | | 4.39 | 5.56 | 6.73 | 7.89 | 9.06 | 10.23 | | | | |
| 18 | | | 5.32 | 6.80 | 8.28 | 9.75 | 11.23 | 12.71 | 14.19 | | | |
| 20 | | | | 8.18 | 10.01 | 11.83 | 13.66 | 15.48 | 17.30 | 19.13 | | |
| 22 | | | | 9.72 | 11.92 | 14.13 | 16.34 | 18.55 | 20.75 | 22.96 | | |
| 24 | | | | | 14.02 | 16.65 | 19.27 | 21.90 | 24.53 | 27.15 | 29.78 | |
| 26 | | | | | 16.30 | 19.38 | 22.47 | 25.55 | 28.63 | 31.71 | 34.80 | |
| 28 | | | | | | 22.34 | 25.91 | 29.49 | 33.06 | 36.64 | 40.21 | |
| 30 | | | | | | 25.51 | 29.62 | 33.72 | 37.82 | 41.93 | 46.03 | 50.14 |
| 32 | | | | | | 28.91 | 33.57 | 38.24 | 42.91 | 47.58 | 52.25 | 56.92 |
| 34 | | | | | | | 37.79 | 43.06 | 48.33 | 53.60 | 58.87 | 64.15 |
| 36 | | | | | | | 42.26 | 48.17 | 54.08 | 59.99 | 65.90 | 71.81 |
| 38 | | | | | | | | 53.57 | 60.15 | 66.74 | 73.32 | 79.90 |
| 40 | | | | | | | | 59.26 | 66.55 | 73.85 | 81.14 | 88.44 |

TABLE 7. BLACK SPRUCE TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3.67 | 3.86 | | | | | | | | | | |
| 4 | 4.24 | 4.99 | 5.75 | | | | | | | | | |
| 6 | 5.18 | 6.89 | 8.59 | 10.30 | 12.00 | | | | | | | |
| 8 | | 9.54 | 12.57 | 15.60 | 18.63 | 21.67 | | | | | | |
| 10 | | 12.95 | 17.69 | 22.42 | 27.16 | 31.89 | 36.63 | | | | | |
| 12 | | 17.12 | 23.94 | 30.76 | 37.58 | 44.40 | 51.22 | | | | | |
| 14 | | | 31.33 | 40.61 | 49.89 | 59.17 | 68.46 | 77.74 | | | | |
| 16 | | | 39.85 | 51.98 | 64.10 | 76.22 | 88.35 | 100.47 | | | | |
| 18 | | | 49.51 | 64.86 | 80.20 | 95.55 | 110.89 | 126.24 | 141.58 | | | |
| 20 | | | | 79.25 | 98.20 | 117.14 | 136.09 | 155.03 | 173.97 | 192.92 | | |
| 22 | | | | 95.17 | 118.09 | 141.01 | 163.93 | 186.86 | 209.78 | 232.70 | | |
| 24 | | | | | 139.88 | 167.15 | 194.43 | 221.71 | 248.99 | 276.27 | 303.55 | |
| 26 | | | | | 163.56 | 195.57 | 227.59 | 259.60 | 291.62 | 323.63 | 355.65 | |
| 28 | | | | | | 226.26 | 263.39 | 300.52 | 337.65 | 374.78 | 411.91 | |
| 30 | | | | | | 259.22 | 301.85 | 344.47 | 387.09 | 429.72 | 472.34 | 514.97 |
| 32 | | | | | | 294.46 | 342.96 | 391.45 | 439.95 | 488.45 | 536.94 | 585.44 |
| 34 | | | | | | | 386.72 | 441.46 | 496.21 | 550.96 | 605.71 | 660.46 |
| 36 | | | | | | | 433.13 | 494.51 | 555.89 | 617.26 | 678.64 | 740.02 |
| 38 | | | | | | | | 550.58 | 618.97 | 687.36 | 755.75 | 824.13 |
| 40 | | | | | | | | 609.69 | 685.46 | 761.24 | 837.01 | 912.79 |

TABLE 8. BLACK SPRUCE BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.83 | 0.98 | | | | | | | | | | |
| 4 | 1.27 | 1.86 | 2.45 | | | | | | | | | |
| 6 | 2.01 | 3.34 | 4.67 | 5.99 | 7.32 | | | | | | | |
| 8 | | 5.40 | 7.76 | 10.12 | 12.48 | 14.85 | | | | | | |
| 10 | | 8.06 | 11.75 | 15.44 | 19.12 | 22.81 | 26.50 | | | | | |
| 12 | | 11.30 | 16.62 | 21.93 | 27.24 | 32.55 | 37.86 | | | | | |
| 14 | | | 22.37 | 29.60 | 36.83 | 44.05 | 51.28 | 58.51 | | | | |
| 16 | | | 29.01 | 38.45 | 47.89 | 57.33 | 66.77 | 76.21 | | | | |
| 18 | | | 36.53 | 48.48 | 60.43 | 72.38 | 84.33 | 96.28 | 108.23 | | | |
| 20 | | | | 59.69 | 74.44 | 89.20 | 103.95 | 118.70 | 133.45 | 148.20 | | |
| 22 | | | | 72.08 | 89.93 | 107.78 | 125.63 | 143.48 | 161.33 | 179.18 | | |
| 24 | | | | | 106.90 | 128.14 | 149.38 | 170.63 | 191.87 | 213.11 | 234.36 | |
| 26 | | | | | 125.34 | 150.27 | 175.20 | 200.13 | 225.06 | 249.99 | 274.92 | |
| 28 | | | | | | 174.17 | 203.08 | 231.99 | 260.91 | 289.82 | 318.74 | |
| 30 | | | | | | 199.84 | 233.03 | 266.22 | 299.41 | 332.60 | 365.80 | 398.99 |
| 32 | | | | | | 227.27 | 265.04 | 302.80 | 340.57 | 378.33 | 416.10 | 453.86 |
| 34 | | | | | | | 299.12 | 341.75 | 384.38 | 427.02 | 469.65 | 512.28 |
| 36 | | | | | | | 335.26 | 383.06 | 430.85 | 478.65 | 526.44 | 574.24 |
| 38 | | | | | | | | 426.72 | 479.98 | 533.23 | 586.49 | 639.74 |
| 40 | | | | | | | | 472.75 | 531.76 | 590.76 | 649.77 | 708.78 |

TABLE 9. BLACK SPRUCE BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.34 | 0.36 | | | | | | | | | | |
| 4 | 0.41 | 0.51 | 0.62 | | | | | | | | | |
| 6 | 0.54 | 0.77 | 1.00 | 1.23 | 1.46 | | | | | | | |
| 8 | | 1.13 | 1.54 | 1.94 | 2.35 | 2.76 | | | | | | |
| 10 | | 1.59 | 2.22 | 2.86 | 3.50 | 4.14 | 4.78 | | | | | |
| 12 | | 2.15 | 3.07 | 3.99 | 4.90 | 5.82 | 6.74 | | | | | |
| 14 | | | 4.06 | 5.31 | 6.56 | 7.81 | 9.06 | 10.31 | | | | |
| 16 | | | 5.21 | 6.84 | 8.48 | 10.11 | 11.74 | 13.38 | | | | |
| 18 | | | 6.51 | 8.58 | 10.65 | 12.71 | 14.78 | 16.85 | 18.91 | | | |
| 20 | | | | 10.52 | 13.07 | 15.62 | 18.17 | 20.73 | 23.28 | 25.83 | | |
| 22 | | | | 12.66 | 15.75 | 18.84 | 21.93 | 25.01 | 28.10 | 31.19 | | |
| 24 | | | | | 18.69 | 22.36 | 26.03 | 29.71 | 33.38 | 37.06 | 40.73 | |
| 26 | | | | | 21.88 | 26.19 | 30.50 | 34.81 | 39.13 | 43.44 | 47.75 | |
| 28 | | | | | | 30.32 | 35.32 | 40.33 | 45.33 | 50.33 | 55.33 | |
| 30 | | | | | | 34.76 | 40.50 | 46.25 | 51.99 | 57.73 | 63.47 | 69.21 |
| 32 | | | | | | 39.51 | 46.04 | 52.58 | 59.11 | 65.64 | 72.18 | 78.71 |
| 34 | | | | | | | 51.94 | 59.31 | 66.69 | 74.06 | 81.44 | 88.81 |
| 36 | | | | | | | 58.19 | 66.46 | 74.73 | 83.00 | 91.26 | 99.53 |
| 38 | | | | | | | | 74.01 | 83.23 | 92.44 | 101.65 | 110.86 |
| 40 | | | | | | | | 81.97 | 92.18 | 102.39 | 112.60 | 122.81 |

TABLE 10. BLACK SPRUCE FOLIAGE + TWIGS OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 2.50 | 2.52 | | | | | | | | | | |
| 4 | 2.55 | 2.62 | 2.68 | | | | | | | | | |
| 6 | 2.63 | 2.78 | 2.93 | 3.08 | 3.22 | | | | | | | |
| 8 | | 3.01 | 3.27 | 3.53 | 3.80 | 4.06 | | | | | | |
| 10 | | 3.30 | 3.71 | 4.12 | 4.53 | 4.94 | 5.35 | | | | | |
| 12 | | 3.67 | 4.26 | 4.85 | 5.44 | 6.03 | 6.62 | | | | | |
| 14 | | | 4.90 | 5.70 | 6.50 | 7.31 | 8.11 | 8.91 | | | | |
| 16 | | | 5.63 | 6.68 | 7.73 | 8.78 | 9.83 | 10.88 | | | | |
| 18 | | | 6.47 | 7.80 | 9.13 | 10.46 | 11.78 | 13.11 | 14.44 | | | |
| 20 | | | | 9.04 | 10.68 | 12.32 | 13.96 | 15.60 | 17.24 | 18.88 | | |
| 22 | | | | 10.42 | 12.41 | 14.39 | 16.38 | 18.36 | 20.34 | 22.33 | | |
| 24 | | | | | 14.29 | 16.65 | 19.02 | 21.38 | 23.74 | 26.10 | 28.46 | |
| 26 | | | | | 16.34 | 19.11 | 21.89 | 24.66 | 27.43 | 30.20 | 32.97 | |
| 28 | | | | | | 21.77 | 24.99 | 28.20 | 31.41 | 34.63 | 37.84 | |
| 30 | | | | | | 24.62 | 28.31 | 32.00 | 35.69 | 39.38 | 43.07 | 46.76 |
| 32 | | | | | | 27.68 | 31.87 | 36.07 | 40.27 | 44.47 | 48.67 | 52.87 |
| 34 | | | | | | | 35.66 | 40.40 | 45.14 | 49.88 | 54.62 | 59.36 |
| 36 | | | | | | | 39.68 | 44.99 | 50.31 | 55.62 | 60.93 | 66.25 |
| 38 | | | | | | | | 49.85 | 55.77 | 61.69 | 67.61 | 73.53 |
| 40 | | | | | | | | 54.96 | 61.52 | 68.08 | 74.64 | 81.20 |

TABLE 11. WHITE SPRUCE TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3.05 | 3.24 | | | | | | | | | | |
| 4 | 3.61 | 4.36 | 5.11 | | | | | | | | | |
| 6 | 4.55 | 6.24 | 7.93 | 9.62 | 11.32 | | | | | | | |
| 8 | | 8.87 | 11.88 | 14.89 | 17.89 | 20.90 | | | | | | |
| 10 | | 12.26 | 16.95 | 21.65 | 26.35 | 31.05 | 35.75 | | | | | |
| 12 | | 16.39 | 23.16 | 29.92 | 36.69 | 43.45 | 50.22 | | | | | |
| 14 | | | 30.48 | 39.69 | 48.90 | 58.11 | 67.32 | 76.52 | | | | |
| 16 | | | 38.94 | 50.97 | 62.99 | 75.02 | 87.05 | 99.07 | | | | |
| 18 | | | 48.52 | 63.75 | 78.97 | 94.19 | 109.41 | 124.63 | 139.85 | | | |
| 20 | | | | 78.03 | 96.82 | 115.61 | 134.40 | 153.20 | 171.99 | 190.78 | | |
| 22 | | | | 93.81 | 116.55 | 139.29 | 162.03 | 184.77 | 207.50 | 230.24 | | |
| 24 | | | | | 138.16 | 165.22 | 192.28 | 219.34 | 246.40 | 273.46 | 300.52 | |
| 26 | | | | | 161.65 | 193.41 | 225.17 | 256.93 | 288.69 | 320.44 | 352.20 | |
| 28 | | | | | | 223.85 | 260.69 | 297.52 | 334.35 | 371.18 | 408.02 | |
| 30 | | | | | | 256.55 | 298.83 | 341.12 | 383.40 | 425.68 | 467.96 | 510.24 |
| 32 | | | | | | 291.50 | 339.61 | 387.72 | 435.83 | 483.93 | 532.04 | 580.15 |
| 34 | | | | | | | 383.02 | 437.33 | 491.64 | 545.95 | 600.26 | 654.57 |
| 36 | | | | | | | 429.06 | 489.95 | 550.83 | 611.72 | 672.61 | 733.49 |
| 38 | | | | | | | | 545.57 | 613.41 | 681.25 | 749.09 | 816.93 |
| 40 | | | | | | | | 604.20 | 679.37 | 754.54 | 829.71 | 904.88 |

TABLE 12. WHITE SPRUCE BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.73 | 0.87 | | | | | | | | | | |
| 4 | 1.13 | 1.65 | 2.17 | | | | | | | | | |
| 6 | 1.78 | 2.96 | 4.13 | 5.31 | 6.48 | | | | | | | |
| 8 | | 4.78 | 6.87 | 8.96 | 11.06 | 13.15 | | | | | | |
| 10 | | 7.14 | 10.49 | 13.67 | 16.93 | 20.20 | 23.47 | | | | | |
| 12 | | 10.01 | 14.71 | 19.42 | 24.12 | 28.82 | 33.53 | | | | | |
| 14 | | | 19.81 | 26.21 | 32.61 | 39.01 | 45.41 | 51.81 | | | | |
| 16 | | | 25.69 | 34.05 | 42.41 | 50.77 | 59.13 | 67.49 | | | | |
| 18 | | | 32.35 | 42.93 | 53.51 | 64.09 | 74.68 | 85.26 | 95.84 | | | |
| 20 | | | | 52.86 | 65.92 | 78.99 | 92.05 | 105.12 | 118.18 | 131.24 | | |
| 22 | | | | 63.83 | 79.64 | 95.45 | 111.26 | 127.06 | 142.87 | 158.68 | | |
| 24 | | | | | 94.66 | 113.48 | 132.29 | 151.10 | 169.91 | 188.73 | 207.54 | |
| 26 | | | | | 110.99 | 133.07 | 155.15 | 177.23 | 199.31 | 221.39 | 243.46 | |
| 28 | | | | | | 154.24 | 179.84 | 205.45 | 231.05 | 256.66 | 282.26 | |
| 30 | | | | | | 176.97 | 206.36 | 235.76 | 265.15 | 294.54 | 323.94 | 353.33 |
| 32 | | | | | | 201.27 | 234.71 | 268.15 | 301.60 | 335.04 | 368.49 | 401.93 |
| 34 | | | | | | | 264.89 | 302.64 | 340.40 | 378.15 | 415.91 | 453.66 |
| 36 | | | | | | | 296.90 | 339.22 | 381.55 | 423.88 | 466.20 | 508.53 |
| 38 | | | | | | | | 377.89 | 425.05 | 472.21 | 519.38 | 566.54 |
| 40 | | | | | | | | 418.65 | 470.91 | 523.16 | 575.42 | 627.68 |

TABLE 13. WHITE SPRUCE BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.31 | 0.34 | | | | | | | | | | |
| 4 | 0.40 | 0.52 | 0.64 | | | | | | | | | |
| 6 | 0.55 | 0.82 | 1.09 | 1.37 | 1.64 | | | | | | | |
| 8 | | 1.25 | 1.73 | 2.21 | 2.70 | 3.18 | | | | | | |
| 10 | | 1.79 | 2.55 | 3.30 | 4.06 | 4.81 | 5.57 | | | | | |
| 12 | | 2.46 | 3.54 | 4.63 | 5.72 | 6.81 | 7.90 | | | | | |
| 14 | | | 4.72 | 6.21 | 7.69 | 9.17 | 10.65 | 12.13 | | | | |
| 16 | | | 6.08 | 8.02 | 9.95 | 11.89 | 13.83 | 15.76 | | | | |
| 18 | | | 7.63 | 10.08 | 12.53 | 14.97 | 17.42 | 19.87 | 22.32 | | | |
| 20 | | | | 12.37 | 15.40 | 18.42 | 21.45 | 24.47 | 27.49 | 30.52 | | |
| 22 | | | | 14.91 | 18.57 | 22.23 | 25.89 | 29.55 | 33.21 | 36.87 | | |
| 24 | | | | | 22.05 | 26.41 | 30.76 | 35.11 | 39.47 | 43.82 | 48.18 | |
| 26 | | | | | 25.83 | 30.94 | 36.05 | 41.16 | 46.27 | 51.38 | 56.49 | |
| 28 | | | | | | 35.84 | 41.77 | 47.69 | 53.62 | 59.55 | 65.48 | |
| 30 | | | | | | 41.10 | 47.91 | 54.71 | 61.51 | 68.32 | 75.12 | 81.93 |
| 32 | | | | | | 46.73 | 54.47 | 62.21 | 69.95 | 77.69 | 85.43 | 93.18 |
| 34 | | | | | | | 61.45 | 70.19 | 78.93 | 87.67 | 96.41 | 105.15 |
| 36 | | | | | | | 68.86 | 78.66 | 88.46 | 98.26 | 108.05 | 117.85 |
| 38 | | | | | | | | 87.61 | 98.53 | 109.44 | 120.36 | 131.28 |
| 40 | | | | | | | | 97.05 | 109.14 | 121.24 | 133.33 | 145.43 |

TABLE 14. WHITE SPRUCE FOLIAGE + TWIGS OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 2.00 | 2.03 | | | | | | | | | | |
| 4 | 2.09 | 2.19 | 2.30 | | | | | | | | | |
| 6 | 2.22 | 2.46 | 2.71 | 2.95 | 3.19 | | | | | | | |
| 8 | | 2.84 | 3.28 | 3.71 | 4.14 | 4.57 | | | | | | |
| 10 | | 3.33 | 4.01 | 4.68 | 5.36 | 6.03 | 6.71 | | | | | |
| 12 | | 3.92 | 4.90 | 5.87 | 6.84 | 7.82 | 8.79 | | | | | |
| 14 | | | 5.95 | 7.28 | 8.60 | 9.93 | 11.25 | 12.58 | | | | |
| 16 | | | 7.17 | 8.90 | 10.63 | 12.36 | 14.09 | 15.82 | | | | |
| 18 | | | 8.55 | 10.74 | 12.93 | 15.12 | 17.31 | 19.50 | 21.69 | | | |
| 20 | | | | 12.79 | 15.50 | 18.20 | 20.91 | 23.61 | 26.31 | 29.02 | | |
| 22 | | | | 15.06 | 18.34 | 21.61 | 24.88 | 28.15 | 31.42 | 34.70 | | |
| 24 | | | | | 21.45 | 25.34 | 29.23 | 33.13 | 37.02 | 40.92 | 44.81 | |
| 26 | | | | | 24.83 | 29.40 | 33.97 | 38.54 | 43.11 | 47.68 | 52.24 | |
| 28 | | | | | | 33.78 | 39.08 | 44.38 | 49.68 | 54.98 | 60.28 | |
| 30 | | | | | | 38.48 | 44.57 | 50.65 | 56.73 | 62.82 | 68.90 | 74.99 |
| 32 | | | | | | 43.51 | 50.43 | 57.36 | 64.28 | 71.20 | 78.12 | 85.04 |
| 34 | | | | | | | 56.68 | 64.49 | 72.31 | 80.12 | 87.94 | 95.75 |
| 36 | | | | | | | 63.30 | 72.07 | 80.83 | 89.59 | 98.35 | 107.11 |
| 38 | | | | | | | | 80.07 | 89.83 | 99.59 | 109.35 | 119.11 |
| 40 | | | | | | | | 88.51 | 99.32 | 110.14 | 120.95 | 131.77 |

TABLE 15. LARCH TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 1.39 | 1.55 | | | | | | | | | | |
| 4 | 1.89 | 2.56 | 3.22 | | | | | | | | | |
| 6 | 2.72 | 4.22 | 5.73 | 7.23 | 8.73 | | | | | | | |
| 8 | | 6.56 | 9.23 | 11.90 | 14.57 | 17.24 | | | | | | |
| 10 | | 9.56 | 13.74 | 17.91 | 22.08 | 26.25 | 30.42 | | | | | |
| 12 | | 13.24 | 19.24 | 25.25 | 31.26 | 37.27 | 43.27 | | | | | |
| 14 | | | 25.75 | 33.93 | 42.11 | 50.28 | 58.46 | 66.64 | | | | |
| 16 | | | 33.26 | 43.94 | 54.62 | 65.30 | 75.98 | 86.66 | | | | |
| 18 | | | 41.77 | 55.29 | 68.81 | 82.32 | 95.84 | 109.36 | 122.88 | | | |
| 20 | | | | 67.97 | 84.66 | 101.35 | 118.04 | 134.72 | 151.41 | 168.10 | | |
| 22 | | | | 81.99 | 102.18 | 122.38 | 142.57 | 162.76 | 182.95 | 203.15 | | |
| 24 | | | | | 121.37 | 145.41 | 169.44 | 193.47 | 217.50 | 241.53 | 265.56 | |
| 26 | | | | | 142.23 | 170.44 | 198.64 | 226.84 | 255.05 | 283.25 | 311.45 | |
| 28 | | | | | | 197.47 | 230.18 | 262.89 | 295.60 | 328.31 | 361.01 | |
| 30 | | | | | | 226.51 | 264.06 | 301.60 | 339.15 | 376.70 | 414.25 | 451.80 |
| 32 | | | | | | 257.55 | 300.27 | 342.99 | 385.71 | 428.43 | 471.15 | 513.88 |
| 34 | | | | | | | 338.82 | 387.05 | 435.28 | 483.50 | 531.73 | 579.96 |
| 36 | | | | | | | 379.70 | 433.77 | 487.84 | 541.91 | 595.98 | 650.05 |
| 38 | | | | | | | | 483.17 | 543.41 | 603.66 | 663.90 | 724.14 |
| 40 | | | | | | | | 535.24 | 601.99 | 668.74 | 735.49 | 802.24 |

TABLE 16. LARCH BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.40 | 0.53 | | | | | | | | | | |
| 4 | 0.81 | 1.36 | 1.90 | | | | | | | | | |
| 6 | 1.49 | 2.73 | 3.96 | 5.20 | 6.43 | | | | | | | |
| 8 | | 4.65 | 6.84 | 9.04 | 11.23 | 13.43 | | | | | | |
| 10 | | 7.12 | 10.55 | 13.98 | 17.41 | 20.84 | 24.27 | | | | | |
| 12 | | 10.14 | 15.08 | 20.02 | 24.95 | 29.89 | 34.83 | | | | | |
| 14 | | | 20.43 | 27.15 | 33.87 | 40.60 | 47.32 | 54.04 | | | | |
| 16 | | | 26.60 | 35.38 | 44.16 | 52.94 | 61.72 | 70.50 | | | | |
| 18 | | | 33.60 | 44.71 | 55.82 | 66.94 | 78.05 | 89.16 | 100.28 | | | |
| 20 | | | | 55.14 | 68.86 | 82.58 | 96.30 | 110.02 | 123.74 | 137.46 | | |
| 22 | | | | 66.66 | 83.26 | 99.87 | 116.47 | 133.07 | 149.67 | 166.27 | | |
| 24 | | | | | 99.04 | 118.80 | 138.56 | 158.31 | 178.07 | 197.83 | 217.58 | |
| 26 | | | | | 116.19 | 139.38 | 162.57 | 185.75 | 208.94 | 232.13 | 255.31 | |
| 28 | | | | | | 161.61 | 188.50 | 215.39 | 242.28 | 269.17 | 296.06 | |
| 30 | | | | | | 185.48 | 216.35 | 247.22 | 278.09 | 308.96 | 339.83 | 370.70 |
| 32 | | | | | | 211.00 | 246.12 | 281.24 | 316.37 | 351.49 | 386.61 | 421.74 |
| 34 | | | | | | | 277.81 | 317.46 | 357.12 | 396.77 | 436.42 | 476.07 |
| 36 | | | | | | | 311.43 | 355.88 | 400.33 | 444.79 | 489.24 | 533.69 |
| 38 | | | | | | | | 396.49 | 446.02 | 495.55 | 545.08 | 594.61 |
| 40 | | | | | | | | 439.30 | 494.18 | 549.06 | 603.94 | 658.82 |

TABLE 17. LARCH BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.05 | 0.07 | | | | | | | | | | |
| 4 | 0.12 | 0.21 | 0.30 | | | | | | | | | |
| 6 | 0.23 | 0.43 | 0.64 | 0.84 | 1.04 | | | | | | | |
| 8 | | 0.75 | 1.11 | 1.47 | 1.83 | 2.19 | | | | | | |
| 10 | | 1.16 | 1.72 | 2.28 | 2.85 | 3.41 | 3.98 | | | | | |
| 12 | | 1.65 | 2.46 | 3.28 | 4.09 | 4.90 | 5.71 | | | | | |
| 14 | | | 3.34 | 4.45 | 5.55 | 6.66 | 7.77 | 8.87 | | | | |
| 16 | | | 4.36 | 5.80 | 7.25 | 8.69 | 10.13 | 11.58 | | | | |
| 18 | | | 5.51 | 7.34 | 9.16 | 10.99 | 12.82 | 14.65 | 16.47 | | | |
| 20 | | | | 9.05 | 11.31 | 13.56 | 15.82 | 18.08 | 20.33 | 22.59 | | |
| 22 | | | | 10.95 | 13.68 | 16.41 | 19.14 | 21.87 | 24.59 | 27.32 | | |
| 24 | | | | | 16.27 | 19.52 | 22.77 | 26.02 | 29.26 | 32.51 | 35.76 | |
| 26 | | | | | 19.09 | 22.90 | 26.72 | 30.53 | 34.34 | 38.15 | 41.97 | |
| 28 | | | | | | 26.56 | 30.98 | 35.40 | 39.82 | 44.24 | 48.67 | |
| 30 | | | | | | 30.48 | 35.56 | 40.64 | 45.71 | 50.79 | 55.86 | 60.94 |
| 32 | | | | | | 34.68 | 40.45 | 46.23 | 52.01 | 57.78 | 63.56 | 69.33 |
| 34 | | | | | | | 45.67 | 52.19 | 58.71 | 65.23 | 71.75 | 78.27 |
| 36 | | | | | | | 51.19 | 58.50 | 65.81 | 73.12 | 80.43 | 87.74 |
| 38 | | | | | | | | 65.18 | 73.32 | 81.47 | 89.61 | 97.76 |
| 40 | | | | | | | | 72.22 | 81.24 | 90.27 | 99.29 | 108.32 |

TABLE 18. LARCH FOLIAGE + TWIGS OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.94 | 0.95 | | | | | | | | | | |
| 4 | 0.96 | 0.99 | 1.02 | | | | | | | | | |
| 6 | 1.00 | 1.06 | 1.13 | 1.19 | 1.26 | | | | | | | |
| 8 | | 1.16 | 1.28 | 1.39 | 1.50 | 1.62 | | | | | | |
| 10 | | 1.29 | 1.47 | 1.65 | 1.83 | 2.00 | 2.18 | | | | | |
| 12 | | 1.45 | 1.70 | 1.96 | 2.22 | 2.47 | 2.73 | | | | | |
| 14 | | | 1.98 | 2.33 | 2.68 | 3.03 | 3.38 | 3.73 | | | | |
| 16 | | | 2.30 | 2.76 | 3.21 | 3.67 | 4.12 | 4.58 | | | | |
| 18 | | | 2.67 | 3.24 | 3.82 | 4.40 | 4.97 | 5.55 | 6.13 | | | |
| 20 | | | | 3.78 | 4.50 | 5.21 | 5.92 | 6.63 | 7.34 | 8.06 | | |
| 22 | | | | 4.38 | 5.24 | 6.10 | 6.97 | 7.83 | 8.69 | 9.55 | | |
| 24 | | | | | 6.06 | 7.09 | 8.11 | 9.14 | 10.16 | 11.19 | 12.21 | |
| 26 | | | | | 6.95 | 8.15 | 9.36 | 10.56 | 11.76 | 12.97 | 14.17 | |
| 28 | | | | | | 9.31 | 10.70 | 12.10 | 13.49 | 14.89 | 16.29 | |
| 30 | | | | | | 10.55 | 12.15 | 13.75 | 15.35 | 16.96 | 18.56 | 20.16 |
| 32 | | | | | | 11.87 | 13.69 | 15.52 | 17.34 | 19.16 | 20.99 | 22.81 |
| 34 | | | | | | | 15.34 | 17.40 | 19.45 | 21.51 | 23.57 | 25.63 |
| 36 | | | | | | | 17.08 | 19.39 | 21.70 | 24.00 | 26.31 | 28.62 |
| 38 | | | | | | | | 21.50 | 24.07 | 26.64 | 29.21 | 31.78 |
| 40 | | | | | | | | 23.72 | 26.57 | 29.42 | 32.26 | 35.11 |

TABLE 19. WHITE BIRCH TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.40 | 1.60 | | | | | | | | | | |
| 4 | 2.01 | 2.81 | 3.61 | | | | | | | | | |
| 6 | 3.01 | 4.82 | 6.63 | 8.44 | 10.26 | | | | | | | |
| 8 | | 7.64 | 10.87 | 14.11 | 17.36 | 20.62 | | | | | | |
| 10 | | 11.27 | 16.34 | 21.43 | 26.54 | 31.68 | 36.84 | | | | | |
| 12 | | 15.73 | 23.06 | 30.44 | 37.87 | 45.34 | 52.86 | | | | | |
| 14 | | | 31.06 | 41.19 | 51.40 | 61.69 | 72.08 | 82.55 | | | | |
| 16 | | | 40.36 | 53.70 | 67.19 | 80.83 | 94.62 | 108.55 | | | | |
| 18 | | | 50.98 | 68.04 | 85.34 | 102.87 | 120.64 | 138.64 | 156.88 | | | |
| 20 | | | | 84.26 | 105.92 | 127.94 | 150.32 | 173.06 | 196.15 | 219.60 | | |
| 22 | | | | 102.43 | 129.05 | 156.20 | 183.87 | 212.06 | 240.78 | 270.02 | | |
| 24 | | | | | 154.84 | 187.80 | 221.50 | 255.94 | 291.12 | 327.05 | 363.73 | |
| 26 | | | | | 183.40 | 222.92 | 263.45 | 305.01 | 347.59 | 391.20 | 435.83 | |
| 28 | | | | | | 261.75 | 309.99 | 359.62 | 410.61 | 462.99 | 516.74 | |
| 30 | | | | | | 304.51 | 361.41 | 420.13 | 480.66 | 543.00 | 607.16 | 673.14 |
| 32 | | | | | | 351.42 | 418.01 | 486.95 | 558.24 | 631.87 | 707.86 | 786.19 |
| 34 | | | | | | | 480.11 | 560.50 | 643.88 | 730.26 | 819.63 | 911.99 |
| 36 | | | | | | | 548.07 | 641.24 | 738.18 | 838.88 | 943.34 | 1051.56 |
| 38 | | | | | | | | 729.65 | 841.73 | 958.47 | 1079.89 | 1205.97 |
| 40 | | | | | | | | 826.24 | 955.18 | 1089.84 | 1230.25 | 1376.38 |

TABLE 20. WHITE BIRCH BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.56 | 0.73 | | | | | | | | | | |
| 4 | 1.08 | 1.76 | 2.45 | | | | | | | | | |
| 6 | 1.93 | 3.48 | 5.02 | 6.57 | 8.12 | | | | | | | |
| 8 | | 5.88 | 8.63 | 11.38 | 14.14 | 16.89 | | | | | | |
| 10 | | 8.98 | 13.28 | 17.58 | 21.89 | 26.21 | 30.53 | | | | | |
| 12 | | 12.76 | 18.96 | 25.17 | 31.39 | 37.63 | 43.87 | | | | | |
| 14 | | | 25.69 | 34.16 | 42.66 | 51.17 | 59.70 | 68.25 | | | | |
| 16 | | | 33.47 | 44.56 | 55.69 | 66.85 | 78.04 | 89.27 | | | | |
| 18 | | | 42.31 | 56.39 | 70.52 | 84.70 | 98.94 | 113.23 | 127.57 | | | |
| 20 | | | | 69.64 | 87.16 | 104.75 | 122.43 | 140.19 | 158.02 | 175.94 | | |
| 22 | | | | 84.35 | 105.64 | 127.04 | 148.56 | 170.20 | 191.96 | 213.83 | | |
| 24 | | | | | 125.98 | 151.59 | 177.38 | 203.33 | 229.45 | 255.74 | 282.19 | |
| 26 | | | | | 148.20 | 178.46 | 208.94 | 239.66 | 270.60 | 301.78 | 333.18 | |
| 28 | | | | | | 207.67 | 243.31 | 279.25 | 315.50 | 352.06 | 388.93 | |
| 30 | | | | | | 239.29 | 280.54 | 322.19 | 364.25 | 406.72 | 449.60 | 492.89 |
| 32 | | | | | | 273.36 | 320.70 | 368.58 | 416.98 | 465.91 | 515.36 | 565.35 |
| 34 | | | | | | | 363.88 | 418.50 | 473.79 | 529.76 | 586.40 | 643.72 |
| 36 | | | | | | | 410.14 | 472.06 | 534.83 | 598.44 | 662.90 | 728.21 |
| 38 | | | | | | | | 529.37 | 600.22 | 672.12 | 745.08 | 819.08 |
| 40 | | | | | | | | 590.54 | 670.12 | 750.98 | 833.14 | 916.58 |

TABLE 21. WHITE BIRCH BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.26 | 0.28 | | | | | | | | | | |
| 4 | 0.31 | 0.39 | 0.46 | | | | | | | | | |
| 6 | 0.40 | 0.57 | 0.73 | 0.90 | 1.07 | | | | | | | |
| 8 | | 0.83 | 1.13 | 1.44 | 1.76 | 2.09 | | | | | | |
| 10 | | 1.17 | 1.66 | 2.17 | 2.70 | 3.24 | 3.81 | | | | | |
| 12 | | 1.60 | 2.34 | 3.11 | 3.92 | 4.77 | 5.65 | | | | | |
| 14 | | | 3.18 | 4.29 | 5.48 | 6.73 | 8.06 | 9.45 | | | | |
| 16 | | | 4.20 | 5.75 | 7.43 | 9.22 | 11.12 | 13.15 | | | | |
| 18 | | | 5.43 | 7.53 | 9.83 | 12.31 | 14.99 | 17.85 | 20.90 | | | |
| 20 | | | | 9.68 | 12.76 | 16.13 | 19.79 | 23.73 | 27.96 | 32.48 | | |
| 22 | | | | 12.25 | 16.31 | 20.78 | 25.68 | 31.00 | 36.75 | 42.91 | | |
| 24 | | | | | 20.55 | 26.41 | 32.86 | 39.90 | 47.55 | 55.79 | 64.63 | |
| 26 | | | | | 25.60 | 33.14 | 41.50 | 50.68 | 60.69 | 71.52 | 83.17 | |
| 28 | | | | | | 41.14 | 51.82 | 63.62 | 76.52 | 90.53 | 105.64 | |
| 30 | | | | | | 50.57 | 64.06 | 79.01 | 95.42 | 113.28 | 132.61 | 153.39 |
| 32 | | | | | | 61.62 | 78.45 | 97.18 | 117.79 | 140.28 | 164.67 | 190.94 |
| 34 | | | | | | | 95.26 | 118.46 | 144.06 | 172.07 | 202.48 | 235.30 |
| 36 | | | | | | | 114.77 | 143.23 | 174.71 | 209.21 | 246.73 | 287.28 |
| 38 | | | | | | | | 171.87 | 210.21 | 252.31 | 298.16 | 347.76 |
| 40 | | | | | | | | 204.79 | 251.09 | 302.00 | 357.52 | 417.65 |

TABLE 22. WHITE BIRCH FOLIAGE + TWIG OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.98 | 0.99 | | | | | | | | | | |
| 4 | 1.02 | 1.06 | 1.10 | | | | | | | | | |
| 6 | 1.07 | 1.17 | 1.27 | 1.37 | 1.47 | | | | | | | |
| 8 | | 1.33 | 1.50 | 1.68 | 1.86 | 2.03 | | | | | | |
| 10 | | 1.53 | 1.80 | 2.08 | 2.35 | 2.63 | 2.90 | | | | | |
| 12 | | 1.77 | 2.17 | 2.56 | 2.96 | 3.35 | 3.74 | | | | | |
| 14 | | | 2.59 | 3.13 | 3.66 | 4.20 | 4.72 | 5.25 | | | | |
| 16 | | | 3.09 | 3.78 | 4.48 | 5.17 | 5.85 | 6.53 | | | | |
| 18 | | | 3.64 | 4.52 | 5.39 | 6.25 | 7.11 | 7.96 | 8.81 | | | |
| 20 | | | | 5.34 | 6.40 | 7.46 | 8.50 | 9.54 | 10.56 | 11.58 | | |
| 22 | | | | 6.23 | 7.51 | 8.77 | 10.02 | 11.26 | 12.47 | 13.68 | | |
| 24 | | | | | 8.71 | 10.20 | 11.66 | 13.10 | 14.52 | 15.92 | 17.30 | |
| 26 | | | | | 10.00 | 11.72 | 13.41 | 15.07 | 16.70 | 18.30 | 19.87 | |
| 28 | | | | | | 13.34 | 15.26 | 17.15 | 18.99 | 20.80 | 22.57 | |
| 30 | | | | | | 15.05 | 17.21 | 19.33 | 21.39 | 23.40 | 25.36 | 27.26 |
| 32 | | | | | | 16.84 | 19.25 | 21.60 | 23.87 | 26.08 | 28.22 | 30.30 |
| 34 | | | | | | | 21.37 | 23.94 | 26.43 | 28.83 | 31.15 | 33.38 |
| 36 | | | | | | | 23.56 | 26.35 | 29.04 | 31.62 | 34.10 | 36.47 |
| 38 | | | | | | | | 28.82 | 31.70 | 34.44 | 37.05 | 39.53 |
| 40 | | | | | | | | 31.31 | 34.37 | 37.26 | 39.99 | 42.55 |

TABLE 23. TREMBLING ASPEN TOTAL OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.71 | 0.87 | | | | | | | | | | |
| 4 | 1.19 | 1.82 | 2.46 | | | | | | | | | |
| 6 | 1.98 | 3.41 | 4.84 | 6.27 | 7.70 | | | | | | | |
| 8 | | 5.64 | 8.18 | 10.72 | 13.27 | 15.81 | | | | | | |
| 10 | | 8.50 | 12.47 | 16.45 | 20.42 | 24.39 | 28.37 | | | | | |
| 12 | | 11.99 | 17.72 | 23.44 | 29.16 | 34.89 | 40.61 | | | | | |
| 14 | | | 23.92 | 31.71 | 39.49 | 47.28 | 55.07 | 62.86 | | | | |
| 16 | | | 31.07 | 41.24 | 51.42 | 61.59 | 71.76 | 81.94 | | | | |
| 18 | | | 39.18 | 52.05 | 64.93 | 77.80 | 90.68 | 103.56 | 116.43 | | | |
| 20 | | | | 64.13 | 80.03 | 95.93 | 111.82 | 127.72 | 143.61 | 159.51 | | |
| 22 | | | | 77.49 | 96.72 | 115.95 | 135.19 | 154.42 | 173.66 | 192.89 | | |
| 24 | | | | | 115.00 | 137.89 | 160.78 | 183.67 | 206.56 | 229.45 | 252.34 | |
| 26 | | | | | 134.87 | 161.74 | 188.60 | 215.46 | 242.33 | 269.19 | 296.06 | |
| 28 | | | | | | 187.49 | 218.64 | 249.80 | 280.96 | 312.11 | 343.27 | |
| 30 | | | | | | 215.15 | 250.91 | 286.68 | 322.44 | 358.21 | 393.98 | 429.74 |
| 32 | | | | | | 244.71 | 285.41 | 326.10 | 366.79 | 407.49 | 448.18 | 488.87 |
| 34 | | | | | | | 322.13 | 368.07 | 414.00 | 459.94 | 505.88 | 551.82 |
| 36 | | | | | | | 361.07 | 412.57 | 464.08 | 515.58 | 567.08 | 618.59 |
| 38 | | | | | | | | 459.63 | 517.01 | 574.40 | 631.78 | 689.16 |
| 40 | | | | | | | | 509.22 | 572.81 | 636.39 | 699.97 | 763.56 |

TABLE 24. TREMBLING ASPEN BOLE (WOOD + BARK) OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.38 | 0.51 | | | | | | | | | | |
| 4 | 0.78 | 1.32 | 1.87 | | | | | | | | | |
| 6 | 1.46 | 2.68 | 3.89 | 5.11 | 6.33 | | | | | | | |
| 8 | | 4.57 | 6.74 | 8.90 | 11.06 | 13.23 | | | | | | |
| 10 | | 7.01 | 10.39 | 13.77 | 17.15 | 20.53 | 23.92 | | | | | |
| 12 | | 9.98 | 14.85 | 19.72 | 24.59 | 29.46 | 34.33 | | | | | |
| 14 | | | 20.13 | 26.76 | 33.39 | 40.01 | 46.64 | 53.27 | | | | |
| 16 | | | 26.22 | 34.87 | 43.53 | 52.19 | 60.85 | 69.51 | | | | |
| 18 | | | 33.12 | 44.07 | 55.03 | 65.99 | 76.95 | 87.90 | 98.86 | | | |
| 20 | | | | 54.35 | 67.88 | 81.41 | 94.94 | 108.47 | 121.99 | 135.52 | | |
| 22 | | | | 65.72 | 82.09 | 98.46 | 114.82 | 131.19 | 147.56 | 163.93 | | |
| 24 | | | | | 97.64 | 117.12 | 136.60 | 156.08 | 175.56 | 195.05 | 214.53 | |
| 26 | | | | | 114.55 | 137.42 | 160.28 | 183.14 | 206.00 | 228.87 | 251.73 | |
| 28 | | | | | | 159.33 | 185.85 | 212.36 | 238.88 | 265.39 | 291.91 | |
| 30 | | | | | | 182.87 | 213.31 | 243.75 | 274.18 | 304.62 | 335.06 | 365.50 |
| 32 | | | | | | 208.03 | 242.66 | 277.30 | 311.93 | 346.56 | 381.19 | 415.82 |
| 34 | | | | | | | 273.91 | 313.01 | 352.11 | 391.20 | 430.30 | 469.39 |
| 36 | | | | | | | 307.06 | 350.89 | 394.72 | 438.55 | 482.38 | 526.21 |
| 38 | | | | | | | | 390.93 | 439.77 | 488.60 | 537.44 | 586.27 |
| 40 | | | | | | | | 433.14 | 487.25 | 541.36 | 595.47 | 649.59 |

TABLE 25. TREMBLING ASPEN BRANCH OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.00 | 0.00 | | | | | | | | | | |
| 4 | 0.03 | 0.11 | 0.18 | | | | | | | | | |
| 6 | 0.12 | 0.30 | 0.47 | 0.65 | 0.82 | | | | | | | |
| 8 | | 0.57 | 0.88 | 1.19 | 1.50 | 1.81 | | | | | | |
| 10 | | 0.92 | 1.40 | 1.89 | 2.37 | 2.85 | 3.34 | | | | | |
| 12 | | 1.34 | 2.04 | 2.74 | 3.44 | 4.13 | 4.83 | | | | | |
| 14 | | | 2.80 | 3.75 | 4.69 | 5.64 | 6.59 | 7.54 | | | | |
| 16 | | | 3.67 | 4.91 | 6.15 | 7.38 | 8.62 | 9.86 | | | | |
| 18 | | | 4.66 | 6.22 | 7.79 | 9.36 | 10.93 | 12.50 | 14.06 | | | |
| 20 | | | | 7.69 | 9.63 | 11.57 | 13.50 | 15.44 | 17.37 | 19.31 | | |
| 22 | | | | 9.32 | 11.66 | 14.01 | 16.35 | 18.69 | 21.03 | 23.38 | | |
| 24 | | | | | 13.89 | 16.68 | 19.47 | 22.25 | 25.04 | 27.83 | 30.62 | |
| 26 | | | | | 16.31 | 19.58 | 22.85 | 26.13 | 29.40 | 32.67 | 35.94 | |
| 28 | | | | | | 22.72 | 26.51 | 30.31 | 34.10 | 37.90 | 41.69 | |
| 30 | | | | | | 26.09 | 30.44 | 34.80 | 39.15 | 43.51 | 47.87 | 52.22 |
| 32 | | | | | | 29.69 | 34.64 | 39.60 | 44.56 | 49.51 | 54.47 | 59.42 |
| 34 | | | | | | | 39.12 | 44.71 | 50.31 | 55.90 | 61.50 | 67.09 |
| 36 | | | | | | | 43.86 | 50.13 | 56.40 | 62.68 | 68.95 | 75.22 |
| 38 | | | | | | | | 55.86 | 62.85 | 69.84 | 76.83 | 83.82 |
| 40 | | | | | | | | 61.90 | 69.65 | 77.39 | 85.13 | 92.88 |

TABLE 26. TREMBLING ASPEN FOLIAGE + TWIGS OVEN-DRIED MASS (kilograms)

| DBH (cm) | HEIGHT (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 | 0.36 | 0.37 | | | | | | | | | | |
| 4 | 0.37 | 0.39 | 0.41 | | | | | | | | | |
| 6 | 0.40 | 0.43 | 0.47 | 0.51 | 0.55 | | | | | | | |
| 8 | | 0.50 | 0.56 | 0.63 | 0.70 | 0.77 | | | | | | |
| 10 | | 0.57 | 0.68 | 0.79 | 0.90 | 1.01 | 1.11 | | | | | |
| 12 | | 0.67 | 0.82 | 0.98 | 1.13 | 1.29 | 1.45 | | | | | |
| 14 | | | 0.99 | 1.20 | 1.42 | 1.63 | 1.84 | 2.05 | | | | |
| 16 | | | 1.19 | 1.46 | 1.74 | 2.02 | 2.29 | 2.57 | | | | |
| 18 | | | 1.41 | 1.76 | 2.11 | 2.46 | 2.81 | 3.16 | 3.51 | | | |
| 20 | | | | 2.09 | 2.52 | 2.95 | 3.38 | 3.81 | 4.25 | 4.68 | | |
| 22 | | | | 2.45 | 2.97 | 3.49 | 4.02 | 4.54 | 5.06 | 5.58 | | |
| 24 | | | | | 3.47 | 4.09 | 4.71 | 5.33 | 5.96 | 6.58 | 7.20 | |
| 26 | | | | | 4.01 | 4.74 | 5.47 | 6.20 | 6.93 | 7.66 | 8.39 | |
| 28 | | | | | | 5.44 | 6.28 | 7.13 | 7.98 | 8.82 | 9.67 | |
| 30 | | | | | | 6.19 | 7.16 | 8.13 | 9.11 | 10.08 | 11.05 | 12.02 |
| 32 | | | | | | 6.99 | 8.10 | 9.20 | 10.31 | 11.42 | 12.52 | 13.63 |
| 34 | | | | | | | 9.10 | 10.34 | 11.59 | 12.84 | 14.09 | 15.34 |
| 36 | | | | | | | 10.15 | 11.55 | 12.95 | 14.35 | 15.75 | 17.15 |
| 38 | | | | | | | | 12.83 | 14.39 | 15.95 | 17.51 | 19.07 |
| 40 | | | | | | | | 14.18 | 15.91 | 17.64 | 19.37 | 21.09 |

# APPENDIX II

## Field and Laboratory Procedures for Obtaining Data Used in Developing Tree Biomass Equations

### DEFINITIONS AND STANDARDS OF MEASUREMENT

1. Ground level (GL) - top of root collar. On sloping ground this is the level on the up-hill side of the tree.

2. Diameters - measured by diameter tape to nearest 1.0 mm. Where a knot is encountered, the diameter directly below the knot should be recorded, with no length adjustment recorded.

3. Heights and section lengths - measured with metallic or steel tape to nearest 1.0 cm.

4. Tree weights, green - weighed with a suitable scale to nearest 0.1 kg (100 gm) - taken as soon as practicable after felling tree.

5. Sample weights, green and oven-dry (discs, bark, twigs, leaves) - weighed with precision balance to nearest 0.1 gm. Green weights to be taken same day as felling, or at the latest, within 24 hours.

## FIELD PROCEDURES

### Stand Selection

Sampling was confined to the productive forest sites within 100 km of Grand Falls.

Stands were selected using a stratified sampling system, making use of the Newfoundland Forest inventory map sheets and field plots where practical. These stands were within a reasonable distance of a road, unless extreme conditions dictated otherwise, e.g. stands of balsam fir relatively undamaged by budworm were somewhat rare.

Table 27 gives the minimum number of stands and trees sampled for each species. This table was a guideline for the contractor.

Table 27. Sampling distribution.

| Age class | Site[1] class | No. of stands | No. of trees in each diameter class per stand | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | |
| 0-20 | U. | 2 | 1 | 2 | | | | | 6 |
| 0-20 | L. | 2 | 1 | 1 | | | | | 4 |
| 21-40 | U. | 1 | 2 | 1 | 1 | 1 | | | 5 |
| 21-40 | L. | 1 | 2 | 1 | 1 | | | | 4 |
| 41-60 | U. | 2 | | | 1 | 1 | 1 | 1 | 8 |
| 41-60 | L. | 2 | | 1 | 1 | 1 | 1 | | 8 |
| 61-80 | U. | 1 | | | 1 | 1 | 1 | 2 | 5 |
| 61-80 | L. | 1 | | | 1 | 1 | 1 | 1 | 4 |
| 81+ | U. | 1 | | | 1 | 1 | 1 | 2 | 5 |
| 81+ | L. | 1 | | | 1 | 1 | 1 | 1 | 4 |
| Total | | 20 | 8 | 10 | 10 | 9 | 8 | 8 | 53 |

[1] U. site classes high and good of the Provincial Forest Management Inventory. L. site classes poor and medium of the Provincial Forest Management Inventory.

Tree selection

1. Randomly selected a point within the stand.

2. Conducted a prism or relascope sweep and counted trees by species to obtain working group and basal area.

3. Facing magnetic north and moving clockwise with the relascope, selected the first trees of the desired diameter and species included in the count (see Table 27). Not more than one tree of any one species and diameter class was selected from a stand, except as noted. If all required diameters were included in the count, additional points were selected, within the same stand, until the diameter quota was filled. In cases where trees in the largest diameter class were present in the stand, an additional tree was selected from the next lower diameter class. In cases where the age of the selected tree differed by more than 20 years from the stand age, another tree was selected.

White spruce was taken whenever encountered at a point sample. These trees were taken in addition to those of the other species.

Balsam fir, because of the situation with respect to insect attack, was selected on the basis of tree condition. No severely defoliated tree was taken. Balsam fir stands and trees were chosen by deliberate selection, keeping in mind the desirability of a wide distribution of ages, sites, and locations.

Larch stands were selected from plot locations established during the larch survey conducted across the Island during 1976-78.

Deviations from the above sampling procedures and schedule were allowed when it became obvious that certain combinations of species, age, and site could not be located. In such cases, trees of equivalent diameter classes were selected from stands of the more common sites and ages for that species in central Newfoundland.

Sample Tree Procedure

A. For trees > 9.0 cm Dbh

1. Breast height (1.3 m above GL) was marked on the stem. Maximum crown diameter was estimated to nearest 0.1 m.

2. Cleaned area of brush and debris where tree was to fall. Tree was cut at 0.3 m above GL.

3. Measured and recorded height from GL to base of crown.

4. All branches were cut off, leaving tree tip on the stem.

   a. Softwoods:

      (i) Subdivided branches into three groups; (a) dead branches; (b) live branches with basal diameters > 3 cm (measured ob 3 cm from base of branch); and (c) live branches with basal diameters < 3 cm.

      (ii) Weighed and recorded green weights of each group.

      (iii) Randomly selected two branches from each of the three groups, or a minimum of 4 branches when all groups were not represented. Placed in plastic bags separately for each group. These branch samples were used to estimate dry crown component weights.

   b. Hardwoods:

      (i) Live branches were cut into sections 2 m long and sorted into three groups based on the mid-diameter ob of each section; (a) those < 3 cm dob including all foliage; (b) those between 3 and 9 cm dob, and (c) those > 9 cm dob. All dead branches formed a separate fourth group.

      (ii) Recorded green weights for each of the four groups.

      (iii) Randomly selected four branches with leaves from the < 3 cm dob group.

      (iv) Three discs were cut at random from each of the two remaining live-branch groups, and from the dead branches.

(v) Labeled and placed samples in plastic bags separately for each group. These samples were used to estimate dry crown weights.

5. On main stem (softwoods and hardwoods) measured and recorded:

   (a) total length from GL to top of tree;

   (b) length from GL to point on stem where dob was 9.0 cm (merchantable height);

   (c) Dob at breast height.

6. Main stem was cut at each 2 m interval measured from GL.

7. Stump was cut off as close to GL as was practicable and determined age at 0.3 m.

8. Weighed each section and recorded weights separately - stump, first section above stump, etc.

9. Discs were cut 3 to 4 cm thick at each 2 m interval. Disc was taken from the lower end of each section beginning with first section above stump.

10. Labeled and placed in plastic bags. These samples were used to estimate dry stem component weights (wood and bark).

B. <u>For Trees < 9.0 cm Dbh and > 5.0 cm Dbh</u>

1. Marked BH and tree was cut as close to ground as was practicable.

2. Separated branches from stem.

3. Measured and recorded Dbh and total height.

4. Recorded green weights of stem and branches separately.

5. A disc 3 to 4 cm thick was cut from BH and from the middle of the stem.

6. Randomly selected 4 complete branches and placed separately in plastic bags.

C. For Trees < 5.0 cm Dbh to 1.0 cm Dbh

1. As for B.1, 2, 3, 4 and 6.

2. A disc 3 to 4 cm thick was cut from BH.

3. For small trees 1 to 2 cm Dbh, cut up the whole tree and place in plastic bag for processing in the laboratory.

General Stand and Site Descriptions

For each stand from which sample trees were taken the following were determined:

1. Location - latitude and longitude

2. Approximate stand age

3. Basal area of stand using prism or relascope

4. Species composition

## LABORATORY PROCEDURES

Trees

A. Discs

1. Obtained green weight of each disc (bark on). Removed bark and weighed disc again. Green bark weight was the difference between the two weighings.

2. Dried wood and bark at 105°C for 24 hours, or until there was no weight change. Removed from oven, placed in dissicator until cool, and obtained oven-dry weights separately for wood and bark of each disc.

B. Branches, Twigs and Leaves

1. For each branch sample, separated leaf or needle-bearing twigs from rest of branch.

2. Obtained green weights separately for main branch, and twigs plus leaves.

3. Oven-dried as for discs.

4. Obtained oven-dry weights separately for main branch, and twigs plus leaves.

C. Whole Small Trees (1-2 cm Dbh)

1. Separated branches from stem.

2. Separated leaf-bearing twigs from branches.

3. Obtained green weights separately for stem, branches, and twigs plus leaves.

4. Obtained oven-dry weights as above, for stem, branches and twigs plus leaves.

## DATA PROCESSING

All data obtained from the field and laboratory procedures outlined above was key-punched into the computer system at the Newfoundland Forest Research Centre by the contractor for later processing by the Centre.

CODES

Species and Working Groups

| | | |
|---|---|---|
| bS | - | 11 |
| wS | - | 13 |
| bF | - | 21 |
| Larch | - | 31 |
| wB | - | 71 |
| tA | - | 61 |

Site:

| | | | |
|---|---|---|---|
| High | - | H | U = 1 |
| Good | - | G | |
| Medium | - | M | L = 2 |
| Poor | - | P | |

Age Class (Total age):

| | | |
|---|---|---|
| 0-20 | - | 1 |
| 21-40 | - | 2 |
| 41-60 | - | 3 |
| 61-80 | - | 4 |
| 81+ | - | 5 |

Diameter Classes:

| | | |
|---|---|---|
| 0-5 cm | - | 1 |
| 6-10 cm | - | 2 |
| 11-15 cm | - | 3 |
| 16-20 cm | - | 4 |
| 21-25 cm | - | 5 |
| 26-30 cm | - | 6 |

Latitude and Longitude

Recorded in degrees, minutes and seconds.