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Systems of equations for estimating ovendry mass of 18 Canadian tree species

F. Evert

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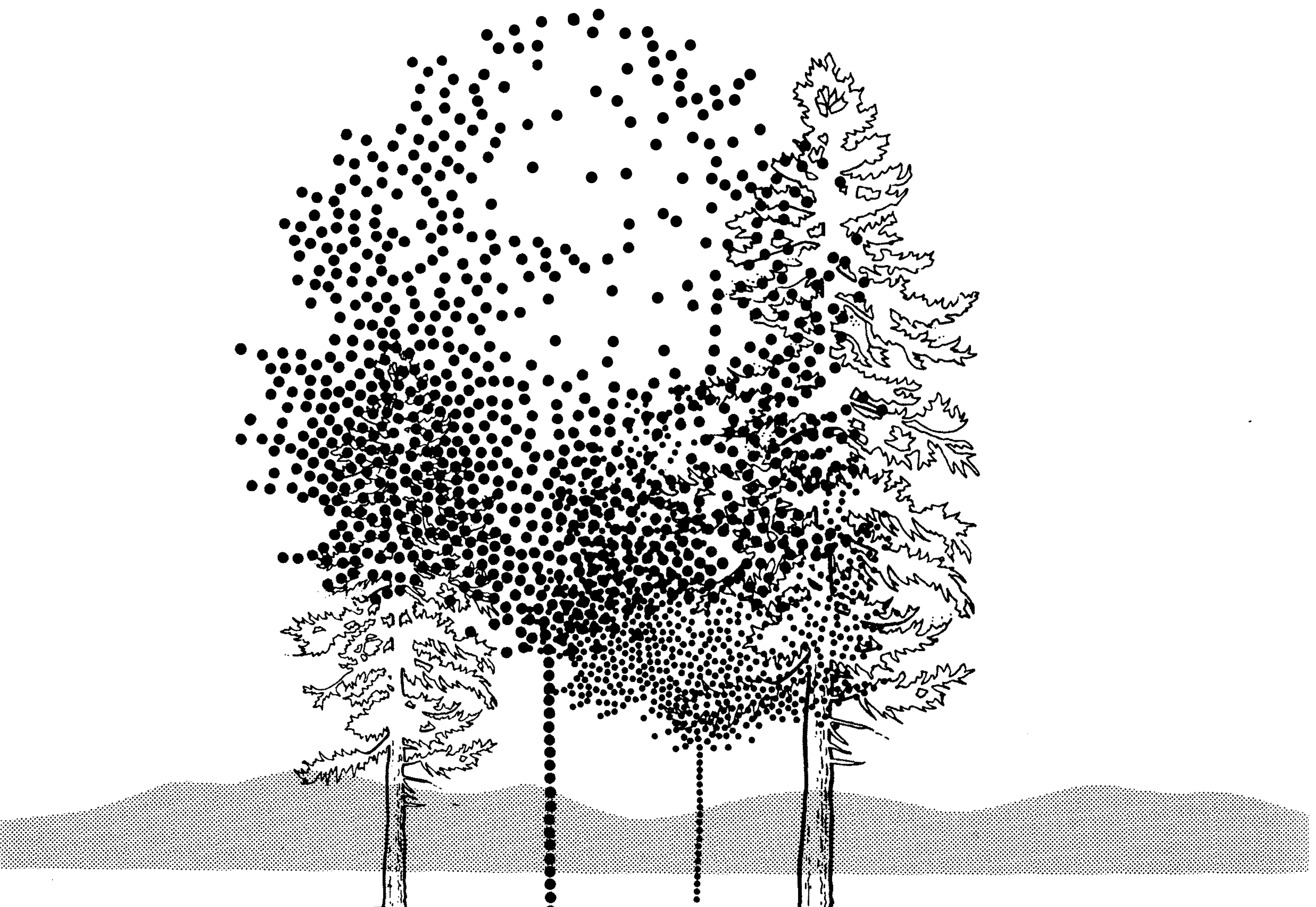
Petawawa National Forestry Institute

PNFI



SYSTEMS OF EQUATIONS FOR ESTIMATING OVENDRY MASS OF 18 CANADIAN TREE SPECIES

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Contents

ABSTRACT

This report presents a single system of standard equations for estimating ovendry mass for each of 18 Canadian tree species. Each system consists of three equations, one for each of total stem wood, total stem bark, and crowns. When applied to the sample data from individual geographic regions, the overall accuracy achieved by the equations for all species was as follows: for total stem wood, 97 per cent of estimates were within 10 per cent of observed values; for total stem bark, 93 per cent of estimates were within 15 per cent of observed values; and for crowns, 86 per cent of estimates were within 30 per cent of observed values.

RÉSUMÉ

Le rapport présente des systèmes uniques d'équations types permettant de calculer, pour 18 essences canadiennes, la masse anhydre. Chaque système comprend trois équations: la première pour tout le bois de fût, la deuxième pour toute l'écorce de fût, et la troisième, pour le houppier. Les données obtenues au moyen d'échantillons prélevés dans différentes régions géographiques ont servi à vérifier la justesse des équations pour toutes les essences. Pour le bois de fût, dans 97 % des cas, l'écart entre les valeurs calculées et les valeurs observées était d'au plus 10 %; pour l'écorce de fût, dans 93 % des cas, l'écart était de 15 %, et pour le houppier, l'écart maximum était de 30 % dans 86 % des cas.

FOREWORD

This study originated in 1981 with a proposal titled 'Ovendry mass and volume equations for Canadian species.' The proposal had, as one of its objectives, the preparation of standard i.e. two-entry (dbh and height) ovendry mass equations.

The timing and the methods proposed, however, did not at the time fit with the PNFI Forestry Statistics and Systems Branchs (FSSB) biomass program. The regional establishments had the mandate to produce biomass equations and it would have been inappropriate to start a study that would have infringed on that mandate.

The timing and methods proposed did become acceptable in 1983 and this publication is the result of that decision. It presents a single system of equations for estimating ovendry mass for each of 18 common Canadian tree species. Each system consists of three equations, one for each of total stem wood, total stem bark, and crowns. Samples for each species contain data from at least two regions, and for all 18 species these samples total about 9000 trees. The present report also presents the first serious attempt to establish the predictive ability of regional and national equations in forestry by testing them on independent data sets. As well, they are tested for combinations of independent variables that may not have been represented in the data used to prepare the equations. The results of this test are significant because the equations will be applied on data that were not a part of the equation-fitting set.

SYSTEMS OF EQUATIONS FOR ESTIMATING OVENDRY MASS OF EIGHTEEN CANADIAN TREE SPECIES

INTRODUCTION

A national system of equations for estimating ovendry mass of trembling aspen (*Populus tremuloides* Michx.) was published in 1983, based on data from six geographic regions across Canada (Evert 1983).

Since then, data collection administered by the Canadian Forestry Service (CFS) for the development of tree biomass relationships for most important Canadian tree species has been completed. The resulting 'data bank' consists of direct measurements on about 11 000 sample trees involving 42 species from eight geographic regions across Canada.

Samples for 18 of these 42 species contain data from at least two regions, and total about 9000 trees. The 18 species are:

Eastern white pine (*Pinus strobus* L.)
Red pine (*Pinus resinosa* Ait.)
Jack pine (*Pinus banksiana* Lamb.)
Lodgepole pine (*Pinus contorta* Dougl.) (inland form)
Black spruce (*Picea mariana* [Mill.] B.S.P.)
White spruce (*Picea glauca* [Moench] Voss)
Balsam fir (*Abies balsamea* [L.] Mill.)
Alpine fir (*Abies lasiocarpa* [Hook.] Nutt.)
Tamarack (*Larix laricina* [Du Roi] K. Koch)
Eastern white cedar (*Thuja occidentalis* L.)
Eastern hemlock (*Tsuga canadensis* [L.] Carr.)
Trembling aspen (*Populus tremuloides* Michx.)
Balsam poplar (*Populus balsamifera* L.)
White birch (*Betula papyrifera* Marsh.)
Yellow birch (*Betula alleghaniensis* Britton)
Sugar maple (*Acer saccharum* Marsh.)
Red maple (*Acer rubrum* L.)
Beech (*Fagus grandifolia* Ehrh.)

The objective of this study was to integrate all available data sets for each of the 18 species into a single national system of standard equations. Each system was to consist of three equations, one for each of total stem wood, total stem bark, and crowns.

The two commonly used components of crowns --- branches, and twigs and foliage --- were not analysed separately because of significant regional differences, particularly in their definitions. There were also regional differences in the methodologies of field sampling and in the definitions of stem wood, stem bark, and crowns; however, in terms of the natural variation of each component, the differences appeared to be minor. Whole tree equations were not prepared because the same model would not fit the equations of all components. Therefore, an independent estimate of the whole tree would not equal the sum of estimated individual components. The preparation of equations for predicting merchantable percentages of the total stem ovendry mass was put on hold because such percentages are already available for predicting merchantable stem volume for most species involved in this study (Honer, Ker, and Alemdag 1983). Perhaps the same percentages could be used for predicting merchantable stem mass.

Each of the 18 systems should basically meet two requirements --- to reflect any genuine patterns that the data may contain, and provide unbiased estimates of mean component mass for trees of all sizes.

METHODS

Data

Source data were (a) computer printouts, storage disks, and computer tapes of individual tree data provided by Canadian Forestry Service Research Centres and, (b) published equations from regional studies. The distribution of sample trees by species, province, or territory and ENFOR project number is shown in Table 1, Appendix 1. For each species, for all regions and projects combined, the distribution of sample tree sizes is shown in Tables 29.1 to 29.18, Appendix 1. Selected regional equations used for testing their applicability throughout the range of the species in question are presented in Tables 5 to 13, Appendix 1.

Analysis

The first step in the analysis involved grouping tree data for each species by diameter and height classes, showing the average mass of stem wood, stem bark, and crowns for each class. The purpose of this grouping was to discover the presence of any genuine patterns that the data might show.

Table 2 to 4, Appendix 1, show the average observed mass of black spruce stem wood, stem bark, and crowns, respectively, by 2 cm dbh and 3 m height classes. Figure 1 to 3 show some of the characteristic patterns present in the above tables. These are:

1) for a given height, mass of both stem wood and stem bark increase with an increase in tree diameter, and for a given diameter, they also increase with an increase in tree height (Figures 1 and 2);

2) for a given height, mass of crowns increases with an increase in dbh, but for a given diameter, it decreases with an increase in tree height (Figure 3).

All 18 species involved in the study show these patterns. Since the underlying purpose of preparing equations is to formulate genuine patterns, two approaches appear possible. Either a model flexible enough to reflect all patterns present in the data would be appropriate, or the choice should involve two models, one for the prediction of mass of stem wood and stem bark, and the other for the prediction of mass of crowns.

Nonlinear models can reflect the two patterns shown to be present in the sample trees of all 18 species. Equations developed by Ouellet (1983a, 1983b), for example, show that for a given height, mass of all three components --- stem wood, stem bark, and crowns --- increases with an increase in

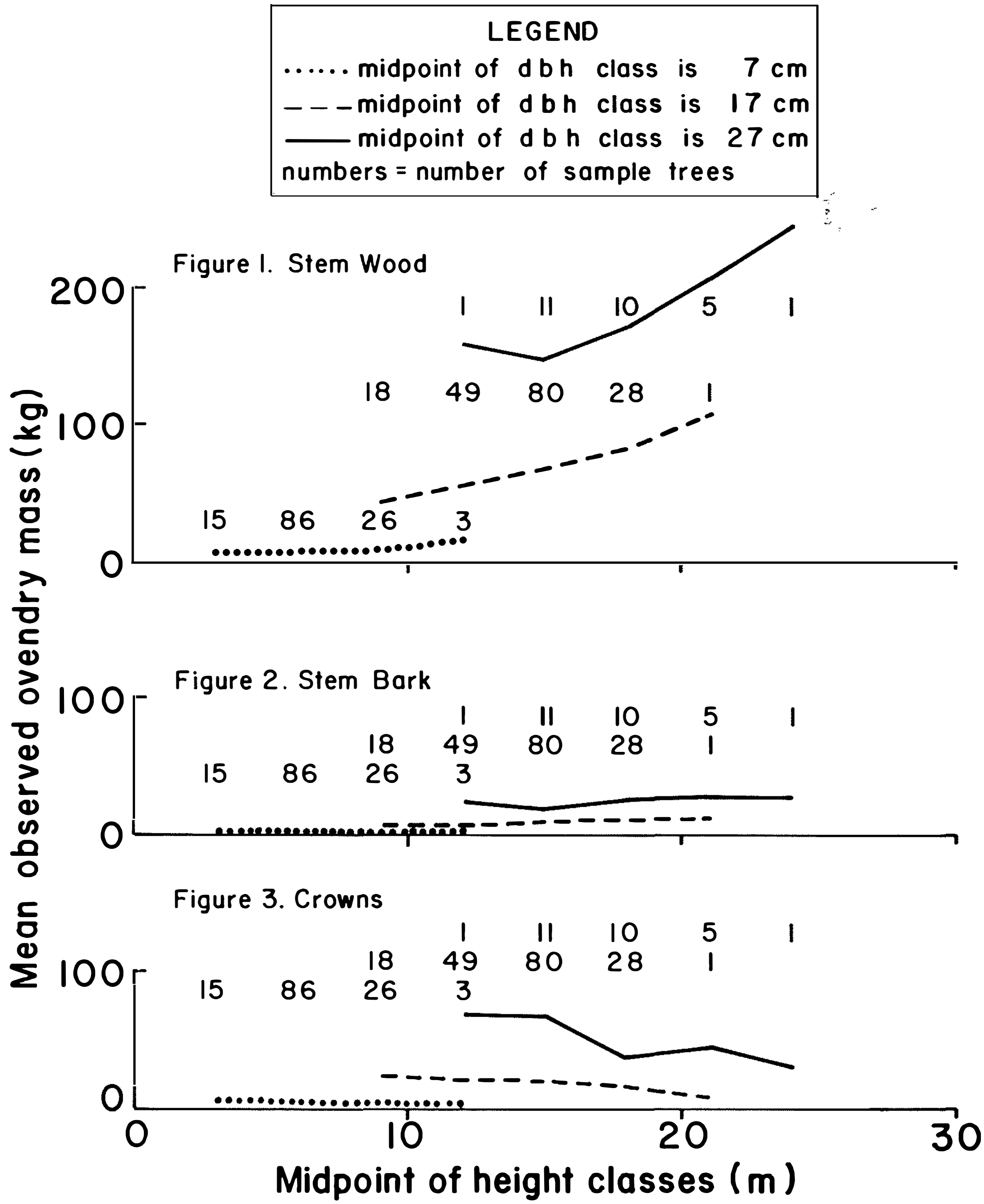

Figure 1. The relationship between ovendry mass of black spruce stem wood and tree height, by dbh classes.

Figure 2. The relationship between ovendry mass of black spruce stem bark and tree height, by dbh classes.

Figure 3. The relationship between ovendry mass of black spruce crowns and tree height, by dbh classes.

tree diameter. These equations also show that, for a given diameter, the mass of two components --- stem wood and stem bark --- increases with an increase in tree height, but the mass of crowns decreases with an increase in tree height in 12 out of 13 commercial species in Quebec. The model used had the form:

$$y = ad^b h^c$$

where y is the mass of a component, d is dbh, and h is tree height. A similar model was chosen for estimating crown mass in the present study.

The linear models used by Alemdag (1983, 1984) and Lavigne (1982), however, cannot reflect the patterns present in the observed data between tree crowns, dbh, and tree height. Both models use d^2h as the sole independent variable. Clearly, if the trend of mass with d^2h is either upward or downward, it must be upward or downward with both dbh and height. Therefore, while these models may be suitable for estimating mass of stem wood and stem bark, they appear unsuitable for estimating crown mass.

Linear models were chosen for estimating mass of stem wood and stem bark because of their proven value in stem volume estimation. Wood density, the link between volume and mass, has not been shown to vary with tree size. Since volume and mass express different but proportional properties of the same object, both should be estimated using the same model.

All equations were fitted by the method of least squares instead of weighted least squares, partly because of the difficulty of selecting appropriate weights to use, in particular for stem bark and tree crowns, and partly because it is the most common method in use for preparing tree volume equations. The remaining steps in the analysis consisted of:

1) Comparing the fit of selected regional versus preliminary national equations.

2) Integrating and regressing all available sample tree data from regional sources into 18 systems of national equations.

3) Verifying the fit of each of the national equations as far as possible.

RESULTS

Selected regional equations versus preliminary national equations

Tables 5 to 7, 8 to 10, and 11 to 13 present selected regional equations for estimating mass of black spruce, white spruce, and trembling aspen, respectively. These equations were chosen for the test because the sample size of each species exceeds 1000 trees, distributed between nine or 10 projects (see Table 1).

The preliminary national equations involved the following models:

1) for estimating mass of stem wood of each of the species

$$om = b_1 d^2 h + b_2 dh$$

2) for estimating ovendry mass of stem bark of:

a) black spruce

$$om = b_1d^2h + b_2dh + b_3d^2$$

b) white spruce

$$om = b_1d^2h + b_2dh$$

c) trembling aspen

$$om = b_1d^2h$$

3) for estimating ovendry mass of crowns of each species

$$om = a_1d^bh^c + a_2(d^bh^c)^2$$

Data for preliminary national equations were split into fitting sets and validation sets (Green 1983) as follows. For each component of a species, equation coefficients were based on data from all projects exclusive of the one to which the equation was to be applied. This procedure resulted in n equations for each component of each species where n is the number of projects, and it allowed testing of all preliminary national equations on n independent data sets.

Tables 14 to 22 show the predictive ability of both regional and national equations when applied to independent data sets, and for combinations of variables that may not be represented in the data sets used to prepare the equation.

The predictive ability of each equation is assessed from two measures --- accuracy, and the mean square error (MSE).

Accuracy expresses the closeness of estimated values to observed values, and it is calculated in this study from the appropriate sums of each sample, or from the grand total of all samples, as follows:

$$\text{Accuracy} = 100\ \Sigma \text{ estimated values}/\Sigma \text{ observed values}$$

Mean square error is the precision statistic used to describe the equation's fit to the basic data but, in this study, it is used to test the predictive ability of a number of equations when applied to independent data sets. It is calculated as follows:

$$MSE = \Sigma\ (\text{observed value} - \text{estimated value})^2/N$$

Every row in each table shows the accuracy of estimates of each equation when applied to a given regional sample. Each column shows the accuracy of estimates of a given equation when applied to each of the regional samples and to the total of all regional samples. The last row in each table shows the MSE derived from the predicted values of each equation when applied throughout the range of the species.

Evidence presented in Tables 14 to 22 part of which is summarized below indicates that the predictive ability of national equations consistently surpassed that of regional equations:

Stem wood:

Over- or underestimate %	Distribution of estimates obtained by: Regional equations from: Alta.	Ont.	Nfld.	Yukon	N.S.-N.B.	National equations
	Cumulative %					
	Black spruce: from Table 14					
0.1 - 5.0	-	20	40	40	80	80
5.1 - 10.0	-	40	60	60	100	100
10.1 - 15.0	-	50	100	90	-	-
15.1 - 20.0	-	60	-	100	-	-
20.1 - 25.0	-	100	-	-	-	-
Σ estim'd mass/Σ obs'd mass		1.125	1.056	1.054	1.015	1.000
Mean square error		315.4	152.7	168.7	59.7	58.2
	White spruce: from Table 17					
0.1 - 5.0	-	20	30	60	60	40
5.1 - 10.0	-	40	30	70	80	90
10.1 - 15.0	-	70	70	90	100	100
15.1 - 20.0	-	90	100	100	-	-
20.1 - 25.0	-	100	-	-	-	-
Σ estim'd mass/Σ obs'd mass		1.133	1.125	1.005	1.046	1.000
Mean square error		1153.2	849.9	369.7	290.8	261.7
	Trembling aspen: from Table 20					
0.1 - 5.0	78	67	-	22	78	78
5.1 - 10.0	89	89	-	89	78	89
10.1 - 15.0	100	89	-	100	100	100
15.1 - 20.0	-	100	-	-	-	-
20.1 - 25.0	-	-	-	-	-	-
Σ estim'd mass / Σ obs'd mass	0.988	1.043	-	0.923	0.975	1.000
Mean square error	224.8	267.0	-	305.0	277.9	221.3

Stem bark:

Over- or underestimate %	Distribution of estimates obtained by: Regional equations from: Alta.	Ont.	Nfld.	Yukon	N.S.-N.B.	National equations
	Cumulative %					
Black spruce: from Table 15						
0.1 - 5.0	-	10	20	-	30	40
5.1 - 10.0	-	30	30	10	60	60
10.1 - 15.0	-	60	60	10	80	70
15.1 - 20.0	-	70	60	10	90	90
20.1 - 25.0	-	90	70	10	100	90
25.1 - 30.0	-	90	80	10	-	90
30.1+	-	100	100	100	-	100
Σ estim'd mass/Σ obs'd mass		0.830	1.099	1.388	0.938	1.000
Mean square error		6.2	10.6	168.7	4.0	3.9
White spruce: from Table 18						
0.1 - 5.0	-	50	20	10	40	50
5.1 - 10.0	-	50	40	20	70	80
10.1 - 15.0	-	70	50	20	80	80
15.1 - 20.0	-	80	70	30	100	90
20.1 - 25.0	-	90	90	50	-	90
25.1 - 30.0	-	100	100	50	-	100
30.1+	-	-	-	100	-	-
Σ estim'd mass/Σ obs'd mass		0.908	1.126	1.233	1.028	1.000
Mean square error		19.8	40.6	76.2	12.3	11.1
Trembling aspen: from Table 21						
0.1 - 5.0	67	22	-	56	33	44
5.1 - 10.0	78	22	-	78	56	67
10.1 - 15.0	78	67	-	100	78	100
15.1 - 20.0	100	78	-	-	100	-
20.1 - 25.0	-	100	-	-	-	-
Σ estim'd mass / Σ obs'd mass	0.981	1.119	-	0.946	0.939	1.000
Mean square error	46.7	46.8	-	35.1	41.4	33.3

Crowns:

Over- or underestimate %	Alta.	Ont.	Nfld.	Yukon	N.S.-N.B.	Que.	National equations
	Distribution of estimates obtained by: Regional equations from: Cumulative %						
Black spruce: from Table 16							
0.1 - 10.0	-	40	20	20	30	20	40
10.1 - 20.0	-	60	30	50	40	50	50
20.1 - 30.0	-	60	40	80	50	90	90
30.1 - 40.0	-	90	60	90	50	90	90
40.1 - 50.0	-	100	70	90	60	90	90
50.1+	-	-	100	100	100	100	100
Σ estim'd mass/Σ obs'd mass		0.934	1.475	1.071	1.377	0.998	1.000
Mean square error		181.5	302.0	187.5	177.6	116.2	117.3
White spruce: from Table 19							
0.1 - 10.0	-	10	10	40	30	10	30
10.1 - 20.0	-	10	20	40	40	30	60
20.1 - 30.0	-	50	30	50	60	60	70
30.1 - 40.0	-	60	40	60	80	90	90
40.1 - 50.0	-	60	40	90	90	100	90
50.1+	-	100	100	100	100	-	100
Σ estim'd mass/Σ obs'd mass		0.631	1.691	0.865	1.113	0.735	100.0
Mean square error		776.5	2564.1	781.2	411.0	516.7	385.0
Trembling aspen: from Table 22							
0.1 - 10.0	11	22	-	22	22	-	22
10.1 - 20.0	33	44	-	44	22	-	44
20.1 - 30.0	56	67	-	67	33	-	78
30.1 - 40.0	78	78	-	78	56	-	89
40.1 - 50.0	89	89	-	89	56	-	89
50.1+	100	100	-	100	100	-	100
Σ estim'd mass / Σ obs'd mass	0.664	1.005	-	1.001	1.403	-	1.000
Mean square error	526.2	416.9	-	416.4	367.9	-	221.3

a) their estimates of mass of regional samples are more accurate than those of regional equations as evidenced by the distribution of over- and underestimates of each equation;
b) their estimates are more precise than those of regional equations as shown by the size of the mean square errors associated with the estimates of each equation; and,
c) perhaps most importantly, most estimates obtained with regional equations are biased to a varying degree, as evidenced by the size of over- or underestimates of the sums of estimates of all regional samples of each equation.

National systems of equations for 18 species

A national system of equations for each of 18 species is presented in Tables 23 to 25, and a test of their application in Tables 26 to 28.

All equations in Tables 23 to 25 were first constrained to pass through the origin. Subsequent testing resulted in the addition of a small intercept to most equations to improve their fit for small trees. All equations have more than one variable mainly on account of the relative height of the dbh measurement --- near the top of short trees and near the base of tall trees.

The mean square errors of black spruce, white spruce, and trembling aspen national equations presented in Tables 23 to 25 are generally somewhat lower than those of preliminary equations whose mean square errors were presented in Tables 14 to 22. They are shown (A) on page 10, with those of preliminary equations in brackets.

Tables 26 to 28 show the accuracy of ovendry mass estimates obtained with the national systems for stem wood, stem bark, and crowns. All estimates are expressed as a per cent of the observed values.

Evidence presented in these tables, partly summarized (B) on page 10, indicates that about 97 per cent of stem wood estimates are within 10 per cent of the observed values; 93 per cent of stem bark estimates are within 15 per cent of observed values; and 86 per cent of crown estimates are within 30 per cent of observed values. These values are higher than the corresponding values for estimates of preliminary equations involving only three species-black spruce, white spruce, and trembling aspen: 93, 83, and 79 per cent.

DISCUSSION AND CONCLUSIONS

On the basis of their predictive ability, national equations consistently outperformed regional equations for each of the three species involved in the comparison --- black and white spruce, and trembling aspen. This was probably so because:

a) all national equations were based on more representative data than their regional counterparts;
b) each regional equation reflected a somewhat different methodology in field sampling; and,
c) national equations for estimating crown mass were based on more flexible models than their regional counterparts. Most of the latter were chosen to meet the requirement that the sum of estimated individual components

A.

Species	Mean square errors: Stem wood	Stem bark	Crowns
Black spruce	54.8 (58.2)	3.4 (3.9)	111.9 (117.3)
White spruce	264.2 (261.7)	10.6 (11.1)	382.9 (385.0)
Trembling aspen	209.7 (221.3)	32.7 (33.3)	169.3 (221.3)

B.

Over- or underestimate %	Distribution of estimates: Stem wood (from Table 26)		Stem bark (from Table 27)		Crowns (from Table 28)	
	N	Cumul. %	N	Cumul. %	N	Cumul. %
0.0 - 5.0	66	76.7	48	55.8	22	25.6
5.1 - 10.0	17	96.5	24	83.7	13	40.7
10.1 - 15.0	2	98.8	8	93.0	13	55.8
15.1 - 20.0	1	100.0	3	96.5	12	69.8
20.1 - 25.0	-		2	98.8	8	79.1
25.1 - 30.0	-		-	98.8	6	86.0
30.1 - 35.0	-		1	100.0	2	88.7
35.1 - 40.0	-		-		4	93.0
40.1 - 45.0	-		-		1	94.2
45.1 - 50.0	-		-		1	95.3
50.1 - 55.0	-		-		1	96.5
55.1 - 60.0	-		-		1	97.7
60.1 - 65.0	-		-		1	98.8
80.1 - 85.0	-		-		1	100.0
All	86		86		86	

must equal the independent estimate of the whole. Therefore, equations for all components had to be based on, and contain, the same variables.

For two-entry equations, representative data implies first of all that sample trees should include the full range of diameters of the species and, within each diameter class, the full range of heights. Such samples also facilitate regression analysis because the variance of the estimated regression coefficients decreases with increase in the range of independent variables (Schumacher and Chapman 1954). Trees of the same dbh and height will, however, vary in their mass, in particular for that of crowns. This is due to variation in the taper or form of boles, in bark thickness, in wood and bark density, in the length and width of crowns, and in the amount of cones or fruit present at the time of measurement. All these variations appear to be largely functions of stand age, site quality, and stand density. Therefore, sample trees for mass equations should also be distributed throughout the full range of stand ages, site qualities, and stand densities.

The idea that equations are most reliable when applied to the area where the data were collected (Lavigne 1982) may or may not, therefore, hold, depending on the distribution of sample trees on which the equations are based. Results based on data for the preliminary national equations which were split into fitting sets and validation sets throw some light on this question. They show that 97 per cent of stem wood estimates were within 10 per cent of observed values. And this despite the fact that the equations involved did not include data from areas where they were applied. It can be concluded, therefore, that the distribution of sample trees may be more important than their geographic location.

The principal independent variable used to estimate mass of stem wood and stem bark was d^2h, and that of crown mass was d^bh^c. Therefore, although one can still obtain a compatible estimate of the whole, it can only be made by summing the estimated individual components.

When applied to each of the regional samples, the overall accuracy achieved by national equations of the three species involved in the comparison was:

a) for stem wood, 97 per cent of estimates were within 10 per cent of the observed values;
b) for stem bark, 93 per cent of estimates were within 15 per cent of the observed values;
c) for crowns, 86 per cent of estimates were within 30 per cent of the observed values.

These figures show the basic limitations of mass equations when they are used to obtain estimates of present stands. The accuracy of an inventory depends on two determinations involving possible errors --- first, the mass of standing trees, and second, the mass of stands of all degrees of stocking. Therefore, the accuracy of an inventory can equal that obtainable with mass equations, but cannot exceed it.

For estimating mass of crowns, nonlinear models proved to be superior to the linear ones. This was demonstrated in their smaller mean squares

(Tables 16, 19, and 22), resulting undoubtedly from greater flexibility of the non-linear models.

SUMMARY OF CONCLUSIONS

Based on evidence presented, the following conclusions seem to be well founded:

1) Well-fitting ovendry mass equations for both regional and national application must

   a) be based on samples that include the full range of diameters of the species and, within each diameter class, the full range of heights, (The sample trees should also be distributed throughout the full range of stand densities, stand ages and site qualities. Size ranges of the sample trees and their distribution throughout the three common forest classifications seem to be more important than their geographic location.)
   b) involve models, either linear or non-linear, that are flexible enough to fit any genuine pattern in the observed data of any of the mass components,
   c) be fitted by the method of least squares or the weighted least squares if appropriate weights can be chosen.

2) Considering both the accuracy and precision of estimates, national equations seem to be able to outperform regional equations, mainly because they would be based on more representative data than would be their regional counterparts.

3) The accuracy obtainable using mass equations is highest for estimates of stem wood and lowest for estimates of tree crowns. (This fact has important implications for inventory planning because the accuracy of an inventory can equal that of mass equations but cannot exceed it.)

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Northern FC	I.E. Bella and T. Singh
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APPENDIX 1:

TABLES

Table 1. The distribution of sample tree data by species, province or territory, and ENFOR project number

Species	N.S. & N.B.			Que.		Nfld.		Ont.				Alta.		B.C.	Yukon	N.W.T.	Total
	P4	P38	P159	P225	P236	P112	P190	P20	P30	P179	P234	P22	P92	P142	P141	P169	No.
20 Eastern white pine		48			56					147							251
30 Red pine	47				53					127							227
40 Jack pine	42		146		134			78					50			56	514
50 Lodgepole pine													60	98	131		289
110 Black spruce	48		153	720		94	234	79					60	58	275	48	1769
130 White spruce	42		152		79	53	114	80					60	105	281	59	1025
210 Balsam fir	49		155		176	72	213	75					59				799
220 Alpine fir													60	89			149
310 Tamarack	46				96	58	177			93			58			51	579
410 Eastern white cedar		48			93					97							238
510 Eastern hemlock		50			88					155							293
610 Trembling aspen	44		156			69			218			278	60	39	196	54	1114
630 Balsam poplar												61	59			53	173
710 White birch	44		150			67	203		132				58	39			693
720 Yellow birch		51					53				98						202
810 Sugar maple		46									117						163
820 Red maple	48		155								65						268
930 Beech		48									80						128
Total number	410	291	1067	720	775	413	994	312	350	619	360	339	592	428	883	321	8874

Table 2. Observed ovendry mass of total stem wood
Average values by tree size

Black Spruce

Diameter class (cm)	Height class (m) 0.0 -1.59	1.6 -4.59	4.6 -7.59	7.6 -10.59	10.6 -13.59	13.6 -16.59	16.6 -19.59	19.6 -22.59	22.6 -25.59	25.6 -28.59	28.6 -31.59	31.6 -34.59	34.6 -37.59	TOTAL
	Average ovendry mass (kg)													
0.1 - 2.0	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
2.1 - 4.0	0.00	0.95	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95
4.1 - 6.0	0.00	2.06	3.09	4.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.57
6.1 - 8.0	0.00	3.54	5.40	8.39	13.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.97
8.1 - 10.0	0.00	0.00	8.47	12.67	18.37	24.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.24
10.1 - 12.0	0.00	0.00	12.93	19.01	25.27	33.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.44
12.1 - 14.0	0.00	0.00	18.67	25.73	33.53	41.64	50.58	0.00	0.00	0.00	0.00	0.00	0.00	32.33
14.1 - 16.0	0.00	0.00	0.00	33.97	44.40	55.14	70.71	0.00	0.00	0.00	0.00	0.00	0.00	48.18
16.1 - 18.0	0.00	0.00	0.00	42.51	55.25	68.41	81.83	99.02	0.00	0.00	0.00	0.00	0.00	64.41
18.1 - 20.0	0.00	0.00	0.00	52.02	67.91	80.82	97.97	121.22	0.00	0.00	0.00	0.00	0.00	80.23
20.1 - 22.0	0.00	0.00	0.00	73.95	76.75	98.65	114.13	132.85	0.00	0.00	0.00	0.00	0.00	104.47
22.1 - 24.0	0.00	0.00	0.00	0.00	92.98	114.45	137.41	155.48	0.00	0.00	0.00	0.00	0.00	125.69
24.1 - 26.0	0.00	0.00	0.00	0.00	113.40	131.68	149.15	171.72	0.00	0.00	0.00	0.00	0.00	141.07
26.1 - 28.0	0.00	0.00	0.00	0.00	159.40	149.44	170.87	208.42	247.29	0.00	0.00	0.00	0.00	171.48
28.1 - 30.0	0.00	0.00	0.00	0.00	137.23	169.46	186.43	218.72	0.00	0.00	0.00	0.00	0.00	183.83
30.1 - 32.0	0.00	0.00	0.00	0.00	159.37	191.49	0.00	292.82	314.85	0.00	0.00	0.00	0.00	261.88
32.1 - 34.0	0.00	0.00	0.00	0.00	0.00	209.19	236.91	302.24	315.30	0.00	0.00	0.00	0.00	254.29
34.1 - 36.0	0.00	0.00	0.00	0.00	0.00	264.47	0.00	332.34	0.00	0.00	0.00	0.00	0.00	312.95
36.1 - 38.0	0.00	0.00	0.00	0.00	0.00	0.00	274.25	382.31	0.00	0.00	0.00	0.00	0.00	346.29
38.1 - 40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	498.49	0.00	0.00	498.49
Total	0.00	1.58	6.08	22.70	46.10	80.22	117.02	201.24	301.42	0.00	498.49	0.00	0.00	53.83

Number of observations: 1769

Table 3. Observed ovendry mass of total stem bark
Average values by tree size

Black Spruce

Diameter range (cm)	Height range (m) 0.0 -1.59	1.6 -4.59	4.6 -7.59	7.6 -10.59	10.6 -13.59	13.6 -16.59	16.6 -19.59	19.6 -22.59	22.6 -25.59	25.6 -28.59	28.6 -31.59	31.6 -34.59	34.6 -37.59	TOTAL
						Average ovendry mass								
0.1 - 2.0	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
2.1 - 4.0	0.00	0.23	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
4.1 - 6.0	0.00	0.45	0.63	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54
6.1 - 8.0	0.00	0.66	1.07	1.34	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
8.1 - 10.0	0.00	0.00	1.70	2.20	2.32	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09
10.1 - 12.0	0.00	0.00	2.62	3.31	3.68	4.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.44
12.1 - 14.0	0.00	0.00	2.86	4.46	5.06	6.07	5.92	0.00	0.00	0.00	0.00	0.00	0.00	5.01
14.1 - 16.0	0.00	0.00	0.00	5.44	6.59	7.75	8.93	0.00	0.00	0.00	0.00	0.00	0.00	6.97
16.1 - 18.0	0.00	0.00	0.00	6.88	8.45	9.72	10.95	11.67	0.00	0.00	0.00	0.00	0.00	9.28
18.1 - 20.0	0.00	0.00	0.00	7.99	9.90	11.57	12.92	14.88	0.00	0.00	0.00	0.00	0.00	11.24
20.1 - 22.0	0.00	0.00	0.00	11.16	10.86	14.26	16.12	16.39	0.00	0.00	0.00	0.00	0.00	14.66
22.1 - 24.0	0.00	0.00	0.00	0.00	13.93	16.29	18.59	21.38	0.00	0.00	0.00	0.00	0.00	17.51
24.1 - 26.0	0.00	0.00	0.00	0.00	18.06	17.73	20.19	19.54	0.00	0.00	0.00	0.00	0.00	18.68
26.1 - 28.0	0.00	0.00	0.00	0.00	23.39	18.56	24.55	27.81	25.41	0.00	0.00	0.00	0.00	22.77
28.1 - 30.0	0.00	0.00	0.00	0.00	20.43	21.88	24.59	27.83	0.00	0.00	0.00	0.00	0.00	24.07
30.1 - 32.0	0.00	0.00	0.00	0.00	24.53	26.92	0.00	30.64	32.38	0.00	0.00	0.00	0.00	29.64
32.1 - 34.0	0.00	0.00	0.00	0.00	0.00	23.20	31.19	36.82	35.09	0.00	0.00	0.00	0.00	30.90
34.1 - 36.0	0.00	0.00	0.00	0.00	0.00	33.84	0.00	36.54	0.00	0.00	0.00	0.00	0.00	35.77
36.1 - 38.0	0.00	0.00	0.00	0.00	0.00	0.00	40.86	43.44	0.00	0.00	0.00	0.00	0.00	42.58
38.1 - 40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.92	0.00	0.00	73.92
Total	0.00	0.35	1.20	3.79	6.84	11.19	15.97	24.28	31.53	0.00	73.92	0.00	0.00	7.57

Number of observations: 1769

Table 4. Observed ovendry mass of crowns
Average values by tree size

Black Spruce

Diameter range (cm)	Height Range (m) 0.0 -1.59	1.6 -4.59	4.6 -7.59	7.6 -10.59	10.6 -13.59	13.6 -16.59	16.6 -19.59	19.6 -22.59	22.6 -25.59	25.6 -28.59	28.6 -31.59	31.6 -34.59	34.6 -37.59	TOTAL
	Average ovendry mass													
0.1 - 2.0	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
2.1 - 4.0	0.00	1.45	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.42
4.1 - 6.0	0.00	2.76	1.71	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
6.1 - 8.0	0.00	5.75	3.82	2.60	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74
8.1 - 10.0	0.00	0.00	6.82	4.95	3.43	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.28
10.1 - 12.0	0.00	0.00	12.35	7.75	5.72	3.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.21
12.1 - 14.0	0.00	0.00	16.49	11.61	9.51	8.00	5.42	0.00	0.00	0.00	0.00	0.00	0.00	10.05
14.1 - 16.0	0.00	0.00	0.00	17.92	14.81	12.00	9.77	0.00	0.00	0.00	0.00	0.00	0.00	13.99
16.1 - 18.0	0.00	0.00	0.00	21.34	20.25	18.45	13.38	7.83	0.00	0.00	0.00	0.00	0.00	18.38
18.1 - 20.0	0.00	0.00	0.00	28.39	28.84	21.68	14.97	18.84	0.00	0.00	0.00	0.00	0.00	22.41
20.1 - 22.0	0.00	0.00	0.00	67.40	33.11	29.59	23.64	16.02	0.00	0.00	0.00	0.00	0.00	27.00
22.1 - 24.0	0.00	0.00	0.00	0.00	48.17	40.33	27.75	31.50	0.00	0.00	0.00	0.00	0.00	35.31
24.1 - 26.0	0.00	0.00	0.00	0.00	60.60	56.44	49.07	45.37	0.00	0.00	0.00	0.00	0.00	53.15
26.1 - 28.0	0.00	0.00	0.00	0.00	68.07	67.94	35.42	43.25	29.52	0.00	0.00	0.00	0.00	50.55
28.1 - 30.0	0.00	0.00	0.00	0.00	98.39	85.44	90.57	48.86	0.00	0.00	0.00	0.00	0.00	76.50
30.1 - 32.0	0.00	0.00	0.00	0.00	84.21	100.69	0.00	77.81	64.22	0.00	0.00	0.00	0.00	80.67
32.1 - 34.0	0.00	0.00	0.00	0.00	0.00	122.79	76.83	111.28	99.92	0.00	0.00	0.00	0.00	100.86
34.1 - 36.0	0.00	0.00	0.00	0.00	0.00	148.46	0.00	117.70	0.00	0.00	0.00	0.00	0.00	126.49
36.1 - 38.0	0.00	0.00	0.00	0.00	0.00	0.00	137.09	123.65	0.00	0.00	0.00	0.00	0.00	128.13
38.1 - 40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	141.36	0.00	0.00	141.36
Total	0.00	2.31	4.61	10.62	16.94	25.31	25.33	49.52	64.42	0.00	141.36	0.00	0.00	16.83

Number of observations: 1769

Table 5. Black spruce - Selected regional equations for estimating ovendry mass of total stem wood

Province or Territory	Project	N	Equation	Reference
Ont.	P-20	74	$om = 0.016625d^2h$	Alemdag 1983
Nfld.	P-112 & 190	318	$om = 0.05935+0.025401d^2h$ if $d^2h \leq -123$	Lavigne 1982
			$om = 0.05935+0.025401(123) + 0.015272(d^2h-123)$ if $d^2h>123$	
Yukon	P-141	302	$om = 0.3170+0.01550d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	195	$om = 0.0275d^{1.7010}h^{1.1058}$	Ker 1984

Table 6. Black spruce - Selected regional equations for estimating ovendry mass of total stem bark

Province or Territory	Project	N	Equation	Reference
Ont.	P-20	74	$om = 0.001726d^2h$	Alemdag 1983
Nfld.	P-112 & 190	318	$om = 0.04401+0.003819d^2h$ if $d^2h \leq 123$	Lavigne 1982
			$om = 0.04401+0.003819(123) + 0.002223(d^2h-123)$ if $d^2h>123$	
Yukon	P-141	302	$om = 0.1696+0.00284d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	195	$om = (0.0358d^{1.7073}h^{1.0468})-(0.0275d^{1.7010}h^{1.1058})$	Ker 1984

Table 7. Black spruce - Selected regional equations for estimating ovendry mass of crowns

Province or Territory	Project	N	Equation	Reference
Ont.	P-20	74	$om = 0.004319d^2h$	Alemdag 1983
Nfld.	P-112 & 190	318	$om = 1.63652+0.009889d^2h$ if $d^2h \leq 123$	Lavigne 1982
			$om = 1.63652+0.009889(123) + 0.005801(d^2h-123)$ if $d^2h>123$	
Yukon	P-141	302	$om = 1.1038+0.00465d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	195	$om = (0.0460d^{2.5410}h^{-0.5032}) + (0.04949d^{1.8761})$	Ker 1984
Québec	P-225	734	$om = 0.085249d^{2.888177}h^{-1.075217}$	Ouellet 1983a

Table 8. White spruce - Selected regional equations for estimating ovendry mass of total stem wood

Province or Territory	Project	N	Equation	Reference
Ont.	P-20	77	$om = 0.014027d^2h$	Alemdag 1983
Nfld.	P-112 & 190	169	$om = 0.37458+0.016216d^2h$ if $d^2h \leq 1342$	Lavigne 1982
			$om = 0.37458+0.016216(1342) + 0.013457(d^2h-1342)$ if $d^2h>1342$	
Yukon	P-141	368	$om = 0.2770+0.01240d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	197	$om = 0.0325d^{1.6447}h^{1.0883}$	Ker 1984

Table 9. White spruce - Selected regional equations for estimating ovendry mass of total stem bark

Province or Territory	Project	N	Equation		Reference
Ont.	P-20	77	$om = 0.001438d^2h$		Alemdag 1983
Nfld.	P-112 & 190	169	$om = 0.14023+0.00213d^2h$	if $d^2h \le 1342$	Lavigne 1982
			$om = 0.14023+0.00213(1342) + 0.001697(d^2h-1342)$	if $d^2h>1342$	
Yukon	P-141	368	$om = 0.1506+0.00193d^2h$		Manning et al. 1984
N.B. & N.S.	P-159	197	$om = (0.0385d^{1.6343}h^{1.0826}) - 0.0325d^{1.6447}h^{1.0883})$		Ker 1984

Table 10. White spruce - Selected regional equations for estimating ovendry mass of crowns

Province or Territory	Project	N	Equation		Reference
Ont.	P-20	77	$om = 0.002754d^2h$		Alemdag 1983
Nfld.	P-112 & 190	169	$om = 1.96037+0.012844d^2h$	if $d^2h \le 1342$	Lavigne 1982
			$om = 1.96037+0.012844(1342) + 0.006076(d^2h-1342)$	if $d^2h>1342$	
Yukon	P-141	368	$om = 1.1784+0.003601d^2h$		Manning et al. 1984
N.B. & N.S.	P-159	197	$om = (0.0445d^{3.0518}h^{-1.1236}) + (0.06373d^{2.5314}h^{-0.8613})$		Ker 1984
Québec	P-236	79	$om = 0.03713d^{2.59633}h^{-0.52236}$		Ouellet 1983b

Table 11. Trembling aspen - Selected regional equations for estimating ovendry mass of total stem wood

Province or Territory	Project	N	Equation	Reference
Alta.-Sask.	P-22	279	$om^* = 0.1814(d^2h)^{0.979867}$	Bella et al. 1980
Ont.	P-30	224	$om = 0.014579d^2h$	Alemdag 1984
Yukon	P-141	201	$om = 0.0983+0.0128d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	197	$om = 0.01511d^{2.1369}h^{0.8147}$	Ker 1984

*om in grams, d and h in cm.

Table 12. Trembling aspen - Selected regional equations for estimating ovendry mass of total stem bark

Province or Territory	Project	N	Equation	Reference
Alta.-Sask.	P-22	279	$^*om = 0.3106(d^2h)^{0.955453}-0.01814(d^2h)^{0.979867}$	Bella et al. 1980
Ont.	P-30	224	$om = 0.003198d^2h$	Alemdag 1984
Yukon	P-141	201	$om = 0.1281+0.0029d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	197	$om = (0.01983d^{2.1551}h^{0.7685})-(0.01511d^{2.1369}h^{0.8147})$	Ker 1984

*om in grams, d and h in cm.

Table 13. Trembling aspen - Selected regional equations for estimating ovendry mass of crowns

Province or Territory	Project	N	Equation	Reference
Alta.-Sask.	P-22	279	*om = $0.1695(d^2h)^{0.848092}$	Bella et al. 1980
Ont.	P-30	224	om = $0.003008d^2h$	Alemdag 1984
Yukon	P-141	201	om = $0.2143+0.0031d^2h$	Manning et al. 1984
N.B. & N.S.	P-159	197	om = $(0.06642d^{2.7190}h^{-0.7639}) + (0.05002d^{2.0766}h^{-0.6540})$	Ker 1984

*om in grams, d and h in cm.

Table 14 - Black spruce total stem wood

Sample location	No. of obs.	Mean mass kg	Equations* (1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Estimated ovendry mass as percent of observed values				
N.S.-N.B.	48	68.8	120.1	112.1	112.4	101.4	100.6
Ont.	79	28.4	98.9	95.3	93.2	99.1	100.6
Alta.	60	130.1	124.1	114.9	115.9	104.8	100.5
Nfld.	94	49.7	101.5	95.8	95.3	91.5	91.3
Yukon	275	36.1	110.7	105.1	104.1	102.7	103.4
B.C.	58	73.2	115.6	107.9	108.2	104.1	101.3
N.S.-N.B.	153	73.7	121.6	113.3	113.8	102.1	101.7
N.W.T.	48	63.7	122.7	114.7	115.0	107.5	105.9
Nfld.	234	36.9	107.9	102.3	101.4	97.6	98.2
Qué.	720	55.6	109.4	102.7	102.5	101.7	99.0
All	1769	53.8	112.5	105.6	105.4	101.5	100.0
MSE	-	-	315.4	152.7	168.7	59.7	58.2

*(1) om = $0.016625d^2h$ (Alemdag 1983)
(2) om = $0.05935+0.025401d^2h$ if $d^2h \leq 123$ (Lavigne 1982)
om = $0.05935+0.025401(123)+0.015272(d^2h-123)$ if $d^2h>123$
(3) om = $0.3170+0.01550d^2h$ (Manning et al. 1984)
(4) om = $0.0275d^{1.7010}h^{1.1058}$ (Ker 1984)
(5) Based on data from all locations except the one for which estimates are sought

Table 15 - Black spruce total stem bark

Sample location	No. of obs.	Mean mass kg	Equations* (1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Estimated ovendry mass as percent of observed values				
N.S.-N.B.	48	8.5	100.5	132.5	167.4	110.4	113.7
Ont.	79	3.2	91.3	125.2	155.5	119.4	136.1
Alta.	60	15.0	111.8	146.0	185.1	102.1	115.8
Nfld.	94	6.9	75.9	101.4	127.4	93.3	97.0
Yukon	275	6.5	64.1	86.4	108.2	79.4	81.8
B.C.	58	10.4	84.5	111.4	140.6	89.4	96.2
N.S.-N.B.	153	9.9	94.4	124.2	157.0	103.0	107.5
N.W.T.	48	9.5	85.2	112.5	142.0	94.2	98.2
Nfld.	234	5.4	77.3	103.9	130.3	97.3	101.9
Qué.	720	7.8	81.3	108.1	136.0	91.9	99.7
All	1769	7.6	83.0	109.9	138.8	93.8	100.0
MSE	-	-	6.2	10.6	168.7	4.0	3.9

*(1) $om = 0.001726d^2h$ (Alemdag 1983)

(2) $om = 0.04401+0.003819d^2h$ if $d^2h \leq 123$ (Lavigne 1982)

$om = 0.04401+0.003819(123)+0.002223(d^2h-123)$ if $d^2h>123$

(3) $om = 0.1696+0.00284d^2h$ (Manning et al. 1984)

(4) $om = (0.0358d^{1.7073}h^{1.0468})-(0.0275d^{1.7010}h^{1.1058})$ (Ker 1984)

(5) Based on data from all locations except the one for which estimates are sought

Table 16 - Black spruce crowns

Sample location	No. of obs.	Mean mass kg	(1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) Qué.	(6) National
			Equations*					
			Estimated ovendry mass as percent of observed values					
N.S.-N.B.	48	32.7	65.6	99.4	74.0	108.4	89.4	93.1
Ont.	79	7.8	92.9	172.8	114.7	142.0	87.3	81.1
Alta.	60	40.6	103.3	147.9	113.9	109.1	73.9	78.0
Nfld.	94	15.3	85.9	139.7	99.4	157.3	126.6	126.3
Yukon	275	10.0	103.7	176.6	122.8	176.4	129.6	129.5
B.C.	58	24.1	109.5	138.4	102.8	115.2	77.1	77.0
N.S. & N.B.	153	36.5	63.8	95.8	71.7	105.8	88.5	93.7
N.W.T.	48	14.3	142.4	217.8	160.7	213.5	160.5	166.7
Nfld.	234	15.3	67.6	114.4	80.0	129.7	104.0	100.9
Qué.	720	13.5	117.0	185.0	134.1	154.8	100.3	98.3
All	1769	16.8	93.4	147.5	107.1	137.7	99.8	100.0
MSE	-	-	181.5	312.0	187.5	177.6	116.2	117.3

*(1) $om = 0.004319d^2h$ (Alemdag 1983)
(2) $om = 1.6365+0.009889d^2h$ if $d^2h \leq 123$ (Lavigne 1982)
$om = 1.6365+0.009889(123)+0.005801(d^2h-123)$ if $d^2h>123$
(3) $om = 1.1038+0.00465d^2h$ (Manning et al. 1984)
(4) $om = (0.0460d^{2.5410}h^{-0.5032})+(0.04949d^{1.8761})$ (Ker 1984)
(5) $om = 0.085249d^{2.88818}h^{-1.07522}$ (Ouellet 1983a)
(6) Based on data from all locations except the one for which estimates are sought

Table 17 - White spruce total stem wood

Sample location	No. of obs.	Mean mass kg	Equations* (1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Estimated ovendry mass as percent of observed values				
N.S.-N.B.	42	64.7	110.2	110.5	97.8	103.1	98.7
Ont.	80	54.1	99.3	101.5	88.3	101.8	93.2
Alta.	60	144.8	118.1	115.6	104.6	107.5	102.6
Nfld.	53	51.2	94.3	96.5	84.0	92.9	87.1
Yukon	281	64.5	116.7	117.2	103.8	113.7	108.7
B.C.	105	162.6	114.8	111.9	101.6	98.2	93.8
N.S.-N.B.	152	72.7	111.4	111.3	98.8	101.4	98.3
N.W.T.	59	121.4	121.5	119.4	107.6	111.7	106.6
Nfld.	114	28.9	97.4	102.3	87.2	98.5	92.5
Qué.	79	123.1	113.9	111.9	100.9	102.1	98.7
All	1025	82.8	113.3	112.5	100.5	104.6	100.0
MSE	-	-	1153.2	849.9	369.7	290.8	261.7

*(1) om = $0.014027d^2h$ (Alemdag 1983)

(2) om = $0.37458+0.016216d^2h$ if $d^2h \leq 1342$ (Lavigne 1982)
om = $0.37458+0.016216(1342)+0.013457(d^2h-1342)$ if $d^2h>1342$

(3) om = $0.2770+0.01240d^2h$ (Manning et al. 1984)

(4) om = $0.0325d^{1.6447}h^{1.0883}$ (Ker 1984)

(5) Based on data from all locations except the one for which estimates are sought

Table 18 - **White spruce total stem bark**

Sample location	No. of obs.	Mean mass kg	Equations* (1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Estimated ovendry mass as percent of observed values				
N.S.-N.B.	42	7.3	100.4	126.3	136.4	118.0	117.0
Ont.	80	6.2	88.4	114.2	121.7	115.7	121.2
Alta.	60	17.2	101.8	123.6	137.7	111.6	105.9
Nfld.	53	5.9	83.4	108.0	115.2	105.4	108.1
Yukon	281	9.9	77.9	97.8	106.1	94.3	91.4
B.C.	105	18.5	103.4	125.0	139.6	103.5	100.1
N.S.-N.B.	152	9.4	87.9	110.0	120.1	99.8	97.2
N.W.T.	59	15.6	97.1	118.7	131.1	108.8	103.9
Nfld.	114	3.9	74.8	100.9	103.3	98.5	104.6
Qué.	79	14.9	96.2	117.4	130.5	104.3	99.3
All	1025	10.6	90.8	112.6	123.3	102.8	100.0
MSE	-	-	19.8	40.6	76.2	12.3	11.1

*(1) om = $0.001438d^2h$ (Alemdag 1983)
(2) om = $0.14023+0.00213d^2h$ if $d^2h \leq 1342$ (Lavigne 1982)
om = $0.14023+0.00213(1342)+0.001697(d^2h-1342)$
(3) om = $0.1506+0.00193d^2h$ (Manning et al. 1984)
(4) om = $(0.0385d^{1.6343}h^{1.0826})-(0.0325d^{1.0447}h^{1.0883})$ (Ker 1984)
(5) Based on data from all locations except the one for which estimates are sought

Table 19 - White spruce crowns

Sample location	No. of obs.	Mean mass kg	(1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) Qué.	(6) National
			Equations* — Estimated ovendry mass as percent of observed values					
N.S.-N.B.	42	28.7	48.7	137.6	67.9	139.0	82.8	124.8
Ont.	80	14.8	71.5	221.4	101.1	134.0	89.7	118.0
Alta.	60	43.1	77.9	193.3	104.6	96.0	70.5	83.4
Nfld.	53	23.2	40.9	127.5	58.5	125.6	74.4	110.4
Yukon	281	21.0	70.5	197.8	97.8	109.1	76.0	95.8
B.C.	105	52.2	70.1	170.5	94.0	79.2	57.6	66.5
N.S.-N.B.	152	45.1	35.2	97.5	48.7	103.9	61.2	90.9
N.W.T.	59	21.6	133.9	339.5	180.8	200.5	140.0	191.9
Nfld.	114	16.5	33.6	118.4	51.0	117.1	66.8	98.5
Qué.	79	29.4	93.5	236.6	126.5	145.2	100.3	134.0
All	1025	29.2	63.1	169.1	86.5	111.3	73.5	100.0
MSE	-	-	776.5	2564.1	781.2	411.0	516.7	385.0

*(1) om = $0.002754d^2h$ (Alemdag 1983)
(2) om = $1.96037+0.012844d^2h$ if $d^2h \leq 1342$ (Lavigne 1982)
om = $1.96037+0.012844(1342)+0.006076(d^2h-1342)$
(3) om = $1.1784+0.003601d^2h$ (Manning et al. 1984)
(4) om = $(0.0445d^{3.0518}h^{-1.1236})+0.06373d^{2.5314}h^{-0.8613})$ (Ker 1984)
(5) om = $0.03713d^{2.59633}h^{-0.52236}$ (Ouellet 1983b)
(6) Based on data from all locations except the one for which estimates are sought

Table 20 - **Trembling aspen total stem wood**

Sample location	No. of obs.	Mean mass kg	(1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Equations* — Estimated ovendry mass as percent of observed values				
N.S.-N.B.	44	82.2	99.1	104.3	92.3	100.2	99.8
Alta.	278	51.8	99.8	104.4	92.5	95.5	102.8
Ont.	218	104.5	93.1	98.5	87.1	89.8	92.7
Alta.	60	147.8	98.9	105.5	93.3	98.4	99.5
Nfld.	69	102.0	96.4	102.0	90.2	96.8	97.0
Yukon	196	45.5	110.6	115.7	102.5	111.0	113.6
B.C.	39	97.0	97.3	102.7	90.9	95.3	98.3
N.S.-N.B.	156	75.2	99.1	104.4	92.4	101.6	99.6
N.W.T.	54	145.2	102.0	108.9	96.3	101.1	103.4
All	1114	79.9	98.8	104.3	92.3	97.5	100.0
MSE	-	-	224.8	267.0	305.0	277.9	221.3

*(1) om** = $0.1814(d^2h)^{0.979867}$ (Bella & De Franceschi 1980)

(2) om = $0.014579d^2h$ (Alemdag 1984)

(3) om = $0.0983+0.0128d^2h$ (Manning et al. 1984)

(4) om = $0.01511d^{2.1369}h^{0.8147}$ (Ker 1984)

(5) Based on data from all locations except the one for which estimates are sought

** om is in grams, d and h are in cm

Table 21 - Trembling aspen total stem bark

Sample location	No. of obs.	Mean mass kg	(1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Equations* — Estimated ovendry mass as percent of observed values				
N.S.-N.B.	44	18.0	101.4	113.7	96.1	98.4	101.7
Alta.	278	12.6	96.4	102.8	87.3	83.4	90.4
Ont.	218	21.8	97.4	112.8	95.3	89.2	101.1
Alta.	60	36.9	81.0	100.9	85.0	82.5	89.0
Nfld.	69	20.1	105.8	123.3	104.1	106.4	111.1
Yukon	196	10.2	115.9	123.5	104.9	111.2	111.7
B.C.	39	20.8	100.0	114.3	96.6	94.4	103.8
N.S.-N.B.	159	17.0	98.2	110.2	93.2	101.3	98.3
N.W.T.	54	31.4	96.4	120.0	101.1	97.3	107.9
All	1114	17.8	98.1	111.9	94.6	93.9	100.0
MSE	-	-	46.7	46.8	35.1	41.4	33.3

*(1) om** = $0.3106(d^2h)^{0.955453} - 0.1814(d^2h)^{0.979867}$ (Bella & De Franceschi 1980)

(2) om = $0.003198d^2h$ (Alemdag 1984)

(3) om = $0.1281+0.0029d^2h$ (Manning et al. 1984)

(4) om = $(0.01983d^{2.1551}h^{0.7685})-(0.01511d^{2.1369}h^{0.8147})$ (Ker 1984)

(5) Based on data from all locations except the one for which estimates are sought

**om is in grams, d and h are in cm

Table 22 - Trembling aspen crowns

Sample location	No. of obs.	Mean mass kg	Equations* (1) Ont.	(2) Nfld.	(3) Yukon	(4) N.S.-N.B.	(5) National
			Estimated ovendry mass as percent of observed values				
N.S.-N.B.	44	24.0	52.0	77.7	77.4	134.3	99.0
Alta.	278	9.1	91.3	129.3	129.7	171.6	120.9
Ont.	218	19.6	74.1	114.0	113.4	122.4	80.8
Alta.	60	24.9	82.6	136.3	135.1	106.4	114.6
Nfld.	69	19.6	74.5	115.3	114.6	169.9	126.8
Yukon	196	12.4	65.3	92.3	92.7	179.3	128.7
B.C.	39	20.5	69.5	105.8	105.2	136.3	96.2
N.S.-N.B.	159	32.9	34.8	51.9	51.8	99.9	68.4
N.W.T.	54	18.6	111.9	184.5	182.8	207.2	151.9
All	1114	18.0	66.4	100.5	100.1	140.3	100.0
MSE	-	-	526.2	416.9	416.4	367.9	221.3

*(1) om** = $0.1695(d^2h)^{0.848092}$ (Bella & De Franceschi 1980)
(2) om = $0.003008d^2h$ (Alemdag 1984)
(3) om = $0.2143+0.0031d^2h$ (Manning et al. 1984)
(4) om = $(0.06642d^{2.7190}h^{-0.7639})+(0.05002d^{2.0766}h^{-0.6540})$ (Ker 1984)
(5) Based on data from all locations except the one which estimates are sought
**om is in grams, d and h are in cm

OVENDRY MASS OF TOTAL STEM WOOD

Table 23. Regression coefficients and statistics of Equation: $om(kg) = b_0+b_1d^2h+b_2d^3h+b_3d^4h(cm,m)$

Species	b_0	b_1	b_2	b_3	SEE %	Mean	N
Eastern white pine	0.10	1.68800×10^{-2}	-1.67924×10^{-4}	9.86055×10^{-7}	20.0	255.4	251
Red pine	0.16	1.64315×10^{-2}	-1.59935×10^{-4}	1.67144×10^{-6}	24.3	179.9	227
Jack pine	0.16	2.09827×10^{-2}	-3.68388×10^{-4}	4.49551×10^{-6}	14.5	108.5	514
Lodgepole pine	-	1.59868×10^{-2}	-9.73653×10^{-5}	3.79331×10^{-6}	20.7	111.7	289
Black spruce	0.20	1.93530×10^{-2}	-2.65000×10^{-4}	2.01300×10^{-6}	13.8	53.8	1769
White spruce	0.40	1.53398×10^{-2}	-1.40177×10^{-4}	1.17719×10^{-6}	19.8	82.8	1025
Balsam fir	0.18	1.51693×10^{-2}	-1.61284×10^{-4}	9.77551×10^{-7}	13.8	64.7	799
Alpine fir	0.40	1.50950×10^{-2}	-1.38717×10^{-4}	7.17706×10^{-7}	13.3	88.7	149
Tamarack	0.08	2.08534×10^{-2}	-3.08371×10^{-4}	2.40107×10^{-6}	18.2	70.1	579
Eastern white cedar	0.18	1.38187×10^{-2}	-1.93302×10^{-4}	1.20723×10^{-6}	19.0	66.4	238
Eastern hemlock	0.14	2.38206×10^{-2}	-6.55681×10^{-4}	9.14408×10^{-6}	23.9	163.8	293
Trembling aspen	0.12	1.22741×10^{-2}	1.60317×10^{-4}	-3.49700×10^{-6}	18.2	79.9	1114
Balsam poplar	0.07	1.21038×10^{-2}	-2.82202×10^{-5}	-1.09056×10^{-6}	18.3	74.0	173
White birch	0.25	1.86697×10^{-2}	-9.48166×10^{-5}	1.54947×10^{-6}	17.2	77.7	693
Yellow birch	0.16	1.69411×10^{-2}	1.08003×10^{-4}	2.42365×10^{-6}	22.6	298.6	202
Sugar maple	0.25	2.17197×10^{-2}	-1.45138×10^{-4}	1.27501×10^{-6}	15.3	277.7	163
Red maple	0.20	1.86811×10^{-2}	-9.77577×10^{-5}	-3.55562×10^{-7}	21.9	95.0	268
Beech	-	3.36988×10^{-2}	-7.97913×10^{-4}	9.30953×10^{-6}	27.5	218.3	128

OVENDRY MASS OF TOTAL STEM BARK

Table 24. Regression coefficients and statistics for estimating ovendry mass of total stem bark

Species	b_0	b_1	b_2	b_3	b_4	b_5	SEE %	Mean	N
			$om(kg) = b_0+b_1d^2h+b_2d^3h+b_3d^4h$ (cm,m)						
Eastern white pine	0.05	3.99162×10^{-3}	-9.68157×10^{-5}	9.31127×10^{-7}	-	-	28.1	37.6	251
Lodgepole pine	0.16	2.49461×10^{-3}	-5.35790×10^{-5}	3.75154×10^{-7}	-	-	27.6	9.5	289
Balsam fir	0.10	2.56937×10^{-3}	-2.59872×10^{-5}	3.21792×10^{-7}	-	-	34.8	11.9	799
Tamarack	0.10	2.81166×10^{-3}	-7.82190×10^{-5}	8.81145×10^{-7}	-	-	26.0	7.0	579
Eastern white cedar	0.07	2.28623×10^{-3}	-5.10385×10^{-5}	5.21122×10^{-7}	-	-	30.9	9.3	238
Eastern hemlock	0.04	4.14217×10^{-3}	-9.04719×10^{-5}	10.65140×10^{-7}	-	-	36.7	29.9	293
Balsam poplar	0.10	3.60554×10^{-3}	-4.62060×10^{-5}	3.79261×10^{-7}	-	-	28.6	18.7	173
White birch	0.06	3.79688×10^{-3}	-4.72790×10^{-5}	4.17481×10^{-7}	-	-	33.0	13.1	693
Yellow birch	0.08	7.23037×10^{-3}	$+9.12222 \times 10^{-5}$	-11.50460×10^{-7}	-	-	41.4	40.4	198
Sugar maple	0.03	4.93256×10^{-3}	-10.85704×10^{-5}	8.09500×10^{-7}	-	-	45.3	30.4	163
Red maple	0.07	3.36872×10^{-3}	-4.84288×10^{-5}	6.45926×10^{-8}	-	-	35.3	12.5	268
Beech	0.08	1.80266×10^{-3}	-2.02888×10^{-6}	4.35852×10^{-7}	-	-	36.5	16.3	128
			$om(kg) = b_0+b_1d^2h+b_2d^{0.5}h+b_3d^2h^2+b_4d_2h^3$ (cm,m)						
Red pine	-	2.72439×10^{-4}	3.69861×10^{-2}	6.78598×10^{-5}	-1.69612×10^{-6}	-	27.6	15.3	227
			$om(kg) = b_0+b_1d^2h+b_2d^3h+b_3d^4h+b_4d^2h^2+b_5d^2h^3$ (cm,m)						
Jack pine	0.10	1.99957×10^{-3}	-5.45714×10^{-5}	6.71624×10^{-7}	3.54819×10^{-5}	1.43675×10^{-6}	21.5	8.9	514
			$om(kg) = b_0+b_1d^2h+b_2d^{1.5}h+b_3d^2h^2+b_4d^2h^4$ (cm,m)						
Black spruce	0.05	1.33576×10^{-3}	7.26787×10^{-3}	-6.97225×10^{-5}	4.30716×10^{-8}	-	24.4	7.6	1769
White spruce	0.06	3.11278×10^{-4}	7.87155×10^{-3}	-1.42708×10^{-5}	4.36050×10^{-9}	-	30.8	10.6	1025
Trembling aspen	0.04	3.57375×10^{-3}	1.76080×10^{-3}	-7.05242×10^{-5}	6.17475×10^{-8}	-	32.3	17.8	1114
				$om(kg) = b_0+b_1d^2h+b_2d^2h^3$					
Alpine fir	0.15	2.45971×10^{-3}	-1.09631×10^{-6}	-	-	-	28.6	15.2	149

OVENDRY MASS OF CROWNS

Table 25. Regression coefficients and statistics of equations for estimating ovendry mass of crown

Species	b_0	b_1	b_2	b_3	b_4	SEE %	Mean	N
$om(kg) = b_0+b_1.d^3/h+b_2(d^3/h)^2+b_3(d^3/h)^3+b_4(d^3/h)^4$								
Eastern white pine	0.10	4.67104×10^{-2}	-2.96865×10^{-6}	2.23786×10^{-10}	-	39.1	61.1	246
Jack pine	0.20	4.28031×10^{-2}	-2.82118×10^{-6}	-	-	59.2	22.9	514
Lodgepole pine	0.30	5.07408×10^{-2}	-6.49132×10^{-6}	-1.25262×10^{-10}	-	64.1	20.5	286
Black spruce	0.80	4.40173×10^{-2}	9.63892×10^{-6}	-2.62080×10^{-9}	-	59.8	16.9	1721
White spruce	1.00	5.25074×10^{-2}	1.09847×10^{-6}	-5.34025×10^{-10}	-	63.7	29.7	966
Balsam fir	0.50	4.17167×10^{-2}	8.83211×10^{-6}	-4.36973×10^{-9}	-	58.7	24.3	799
Alpine fir	2.00	1.57537×10^{-2}	1.47860×10^{-4}	-1.12156×10^{-7}	2.36904×10^{-11}	77.8	38.4	148
Eastern white cedar	0.50	2.76263×10^{-2}	-2.05337×10^{-6}	7.32506×10^{-11}	-	54.0	22.5	235
$om(kg) = b_0+b_1d^{3.1}/h^{1.05}+b_2(d^{3.1}/h^{1.05})^2+b_3(d^{3.1}/h^{1.05})^3$ (cm,m)								
Red pine	-	4.25415×10^{-2}	-1.50318×10^{-6}	2.57971×10^{-11}	-	42.0	54.4	227
$om(kg) = b_0+b_1d^{3.1}/h^{1.4}+b_2(d^{3.1}/h^{1.4})^2+b_3(d^{3.1}/h^{1.4})^3$ (cm,m)								
Tamarack	0.15	8.13195×10^{-2}	4.62608×10^{-5}	-3.51345×10^{-8} (cm,m)		55.0	15.6	579
$om(kg) = b_0+b_1d^{2.4}/h^{0.7}+b_2(d^{2.4}/h^{0.7})^2+b_3(d^{2.4}/h^{0.7})^3$ (cm,m)								
Eastern hemlock	0.10	9.98868×10^{-2}	1.26123×10^{-4}	-5.06674×10^{-8}		51.6	55.9	289
$om(kg) = b_0+b_1d^{2.9}/h^{0.8}+b_2(d^{2.9}/h^{0.8})^2+b_3(d^{2.9}/h^{0.8})^3$ (cm,m)								
Trembling aspen	0.10	3.01651×10^{-2}	4.59525×10^{-6}	-1.18651×10^{-9}	-	74.5	17.4	1112
$om(kg) = b_0+b_1d^{2.5}/h+b_2(d^{2.5}/h)^2+b_3(d^{2.5}/h)^3$ (cm,m)								
Balsam poplar	-	6.67915×10^{-2}	6.57498×10^{-4}	-8.33669×10^{-7}	-	69.7	15.3	170
$om(kg) = b_0+b_1d^{2.5}/h^{0.5}+b_2(d^{2.5}/h^{0.5})^2+b_3(d^{2.5}/h^{0.5})^3$ (cm,m)								
White birch	0.50	5.02611×10^{-2}	5.08551×10^{-5}	-1.49834×10^{-8}		57.8	26.6	693
$om(kg) = b_0+b_1(d^3/h^{0.25})+b_2(d^3/h^{0.25})^2+b_3(d^3/h^{0.25})^3$ (cm,m)								
Yellow birch	0.60	1.06041×10^{-2}	-7.48802×10^{-8}	2.82629×10^{-13}	-	65.3	131.8	202
Sugar maple	0.50	1.34965×10^{-2}	-2.30770×10^{-7}	1.88508×10^{-12}	-	41.1	108.4	163
Beech	0.30	8.69105×10^{-3}	1.54574×10^{-7}	-4.90883×10^{-2}	-	67.6	75.7	125
$om(kg) = b_0+b_1d+b_2d^3$ (cm)								
Red maple	-0.50	4.49842×10	2.78613×10^{-3}	-	-	64.3	34.2	268

OVENDRY MASS OF TOTAL STEM WOOD

Table 26. The fit of national equations for individual projects

Species	Nfld.		N.S.-N.B.			Qué.		Ont.				Alta.		B.C.	Yukon	N.W.T.
	P-112	P-190	P-4	P-33	P-159	P-225	P-236	P-20	P-30	P-179	P-234	P-22	P-92	P-142	P-141	P-169
	Estimated ovendry mass of total stem wood as percent of observed value															
Eastern white pine	-	-	-	109.7	-	-	100.0	-	-	99.6	-	-	-	-	-	-
Red pine	-	-	104.8	-	-	-	91.5	-	-	102.2	-	-	-	-	-	-
Jack pine	-	-	99.4	-	104.2	-	97.9	99.4	-	-	-	-	100.9	-	-	101.0
Lodgepole pine	-	-	-	-	-	-	-	-	-	-	-	-	105.5	96.0	102.5	-
Black spruce	91.9	98.4	101.3	-	102.0	99.6	-	96.2	-	-	-	-	100.7	101.3	102.1	106.6
White spruce	87.4	91.8	99.2	-	98.8	-	98.7	92.5	-	-	-	-	102.6	96.4	105.6	106.6
Balsam fir	96.0	100.3	99.6	-	100.0	-	100.4	99.5	-	-	-	-	101.6	-	-	-
Alpine fir	-	-	-	-	-	-	-	-	-	-	-	-	101.4	98.7	-	-
Tamarack	102.9	97.8	106.4	-	-	-	99.3	-	-	91.3	-	-	103.6	-	-	115.2
Eastern white cedar	-	-	-	101.0	-	-	100.4	-	-	99.3	-	-	-	-	-	-
Eastern hemlock	-	-	-	106.6	-	-	99.7	-	-	99.7	-	-	-	-	-	-
Trembling aspen	97.2	-	100.8	-	100.6	-	-	-	94.3	-	-	100.7	100.5	99.2	111.0	103.4
Balsam poplar	-	-	-	-	-	-	-	-	-	-	-	96.3	100.7	-	-	100.4
White birch	93.1	96.7	92.5	-	101.5	-	-	-	105.7	-	-	-	101.4	101.2	-	-
Yellow birch	-	100.9	-	95.6	-	-	-	-	-	-	100.4	-	-	-	-	-
Sugar maple	-	-	-	102.1	-	-	-	-	-	-	99.8	-	-	-	-	-
Red maple	-	-	95.1	-	100.8	-	-	-	-	-	100.9	-	-	-	-	-
Beech	-	-	-	106.2	-	-	-	-	-	-	99.1	-	-	-	-	-

OVENDRY MASS OF TOTAL STEM BARK

Table 27. The fit of national equations for individual projects

Species	Nfld.		N.S.-N.B.			Qué.		Ont.				Alta.		B.C.	Yukon	N.W.T.
	P-112	P-190	P-4	P-33	P-159	P-225	P-236	P-20	P-30	P-179	P-234	P-22	P-92	P-142	P-141	P-169
	Estimated ovendry mass of total stem wood as percent of observed value															
Eastern white pine	-	-	-	121.1	-	-	96.3	-	-	99.6	-	-	-	-	-	-
Red pine	-	-	86.8	-	-	-	99.4	-	-	102.3	-	-	-	-	-	-
Jack pine	-	-	105.0	-	99.4	-	99.7	106.8	-	-	-	-	96.8	-	-	101.1
Lodgepole pine	-	-	-	-	-	-	-	-	-	-	-	-	106.6	99.0	99.2	-
Black spruce	98.4	102.6	113.4	-	105.6	100.1	-	133.4	-	-	-	-	108.9	98.3	85.1	99.0
White spruce	109.5	104.0	120.0	-	101.1	-	99.8	116.8	-	-	-	-	105.1	95.5	92.4	104.3
Balsam fir	97.1	100.2	109.7	-	96.9	-	95.2	114.4	-	-	-	-	115.1	-	-	-
Alpine fir	-	-	-	-	-	-	-	-	-	-	-	-	99.2	101.9	-	-
Tamarack	91.9	87.7	104.8	-	-	-	105.2	-	-	108.6	-	-	98.8	-	-	91.5
Eastern white cedar	-	-	-	93.2	-	-	97.0	-	-	108.2	-	-	-	-	-	-
Eastern hemlock	-	-	-	106.4	-	-	100.0	-	-	98.7	-	-	-	-	-	-
Trembling aspen	108.7	-	101.0	-	98.4	-	-	-	101.2	-	-	93.9	89.5	101.5	112.3	107.0
Balsam poplar	-	-	-	-	-	-	-	-	-	-	-	99.5	109.4	-	-	92.4
White birch	90.4	95.6	98.1	-	104.0	-	-	-	102.6	-	-	-	103.4	109.7	-	-
Yellow birch	-	78.5	-	84.4	-	-	-	-	-	-	103.8	-	-	-	-	-
Sugar maple	-	-	-	100.1	-	-	-	-	-	-	99.2	-	-	-	-	-
Red maple	-	-	98.2	-	97.4	-	-	-	-	-	105.2	-	-	-	-	-
Beech	-	-	-	107.1	-	-	-	-	-	-	99.4	-	-	-	-	-

OVENDRY MASS OF CROWNS

Table 28. The fit of national equations for individual projects

Species	Nfld.		N.S.-N.B.			Qué.		Ont.				Alta.		B.C.	Yukon	N.W.T.
	P-112	P-190	P-4	P-33	P-159	P-225	P-236	P-20	P-30	P-179	P-234	P-22	P-92	P-142	P-141	P-169
	Estimated ovendry mass of total stem wood as percent of observed value															
Eastern white pine	-	-	-	116.3	-	-	78.0	-	-	104.5	-	-	-	-	-	-
Red pine	-	-	135.6	-	-	-	94.9	-	-	96.5	-	-	-	-	-	-
Jack pine	-	-	91.6	-	93.6	-	100.7	125.7	-	-	-	-	79.2	-	-	136.9
Lodgepole pine	-	-	-	-	-	-	-	-	-	-	-	-	136.4	82.4	101.8	-
Black spruce	124.6	101.3	92.3	-	91.3	99.7	-	86.2	-	-	-	-	80.3	77.5	126.0	163.2
White spruce	110.1	102.3	122.9	-	91.7	-	132.4	119.1	-	-	-	-	88.2	72.5	98.8	182.7
Balsam fir	113.3	94.8	117.4	-	89.0	-	116.4	99.6	-	-	-	-	79.4	-	-	-
Alpine fir	-	-	-	-	-	-	-	-	-	-	-	-	142.3	79.7	-	-
Tamarack	149.8	106.8	130.9	-	-	-	87.3	-	-	88.5	-	-	97.7	-	-	104.9
Eastern white cedar	-	-	-	127.4	-	-	106.6	-	-	85.8	-	-	-	-	-	-
Eastern hemlock	-	-	-	103.4	-	-	93.8	-	-	103.0	-	-	-	-	-	-
Trembling aspen	118.4	-	97.0	-	72.8	-	-	-	84.4	-	-	112.0	117.6	95.6	136.5	152.6
Balsam poplar	-	-	-	-	-	-	-	-	-	-	-	84.5	92.3	-	-	118.1
White birch	119.3	96.0	123.7	-	97.1	-	-	-	109.6	-	-	-	87.4	84.1	-	-
Yellow birch	-	98.5	-	86.3	-	-	-	-	-	-	101.0	-	-	-	-	-
Sugar maple	-	-	-	155.3	-	-	-	-	-	-	97.0	-	-	-	-	-
Red maple	-	-	128.1	-	104.3	-	-	-	-	-	89.8	-	-	-	-	-
Beech	-	-	-	93.2	-	-	-	-	-	-	101.2	-	-	-	-	-

TABLES 29.1 TO 29.18

DISTRIBUTION OF SAMPLE TREE SIZES

Species	Table No.
Eastern white pine	29.1
Red pine	29.2
Jack pine	29.3
Lodgepole Pine	29.4
Black spruce	29.5
White spruce	29.6
Balsam fir	29.7
Alpine fir	29.8
Tamarack	29.9
Eastern white cedar	29.10
Eastern hemlock	29.11
Trembling aspen	29.12
Balsam poplar	29.13
White birch	29.14
Yellow birch	29.15
Sugar maple	29.16
Red maple	29.17
Beech	29.18

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
Table 29.1 EASTERN WHITE PINE							
0.1 - 6.0	27						27
6.1 - 12.0	9	18	3				30
12.1 - 18.0	2	21	13	2			38
18.1 - 24.0		6	15	11			32
24.1 - 30.0			13	11	2		26
30.1 - 36.0		2	7	16	6		31
36.1 - 42.0			6	12	2		20
42.1 - 48.0			1	13	4	2	20
48.1 - 54.0			1	5	2	1	9
54.1 - 60.0				4	4	2	10
60.1 +				3	3	2	8
Total number	38	47	59	77	23	7	251
Table 29.2 RED PINE							
0.1 - 6.0	27						27
6.1 - 12.0	13	16					29
12.1 - 18.0	1	22	17	3			43
18.1 - 24.0		6	11	9			26
24.1 - 30.0		4	19	12			35
30.1 - 36.0			15	15	1		31
36.1 - 42.0			5	8	3		16
42.1 - 48.0			1	9	2	1	13
48.1 - 54.0			2		2	1	5
54.1 - 60.0			1		1		2
Total number	41	48	71	56	9	2	227
Table 29.3 JACK PINE							
0.1 - 6.0	47	3					50
6.1 - 12.0	18	68	12				98
12.1 - 18.0		32	92	7			131
18.1 - 24.0		11	64	25			100
24.1 - 30.0		4	37	29			70
30.1 - 36.0		5	10	38	2		55
36.1 +			2	7	1		10
Total number	65	123	217	106	3		514

Table 29.4 LODGEPOLE PINE

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	31	1					32
6.1 - 12.0	34	39	7				80
12.1 - 18.0	1	30	38	1			70
18.1 - 24.0		2	28	12			42
24.1 - 30.0			13	13	4		30
30.1 - 36.0			3	18	5		26
36.1 +				4	4	1	9
Total number	66	72	89	48			289

Table 29.5 BLACK SPRUCE

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	236	1					237
6.1 - 12.0	155	281	5				441
12.1 - 18.0	6	345	257	1			609
18.1 - 24.0		86	243	26			355
24.1 - 30.0		9	63	21			93
30.1 +		1	13	19	1		34
Total number	397	723	581	67	1		1769

Table 29.6 WHITE SPRUCE

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	140	1					141
6.1 - 12.0	142	101	2				245
12.1 - 18.0	24	156	73				253
18.1 - 24.0	1	59	81	22			163
24.1 - 30.0		14	51	40	1		106
30.1 - 36.0		1	30	42	5		78
36.1 - 42.0			4	14	9	1	28
42.1 +			1	3	3	4	11
Total number	307	332	242	121	18	5	1025

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
Table 29.7 BALSAM FIR							
0.1 - 6.0	112	1					113
6.1 - 12.0	75	92	4				171
12.1 - 18.0	7	136	52				195
18.1 - 24.0		56	97	3			156
24.1 - 30.0		7	80	9			96
30.1 - 36.0		1	27	28			56
36.1 +			1	9	2		12
Total number	194	293	261	49			799
Table 29.8 ALPINE FIR							
0.1 - 6.0	11						11
6.1 - 12.0	36	7					43
12.1 - 18.0	7	19	5				31
18.1 - 24.0		6	17	3			26
24.1 - 30.0		1	5	8			14
30.1 - 36.0			2	15	2		19
36.1 +				5			5
Total number	54	33	29	31	2		149
Table 29.9 TAMARACK							
0.1 - 6.0	99	4					103
6.1 - 12.0	54	91	8	2			155
12.1 - 18.0	1	80	57	4			142
18.1 - 24.0		12	69	10			91
24.1 - 30.0			33	16	5		54
30.1 - 36.0			17	10	3		30
36.1 +			2		2		4
Total number	154	187	186	42	10		579

Diameter class (cm)	1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
			Height class (m)				
Table 29.10 EASTERN WHITE CEDAR							
0.1 - 6.0	34						34
6.1 - 12.0	20	25					45
12.1 - 18.0	2	35	1				38
18.1 - 24.0		31	13				44
24.1 - 30.0		6	18				24
30.1 - 36.0		5	31				36
36.1 +		1	15	1			17
Total number	56	103	78	1			238
Table 29.11 EASTERN HEMLOCK							
0.1 - 6.0	41						41
6.1 - 12.0	16	25	1				42
12.1 - 18.0	1	30	12				43
18.1 - 24.0		13	24	1			38
24.1 - 30.0		7	33	4			44
30.1 - 36.0		3	15	13			31
36.1 - 42.0			2	14			26
42.1 - 48.0			5	12	2		19
48.1 - 54.0			1	7	1		9
Total number	58	78	103	51	3		293
Table 29.12 TREMBLING ASPEN							
0.1 - 6.0	93	23					116
6.1 - 12.0	61	214	49				324
12.1 - 18.0	6	84	179	22			291
18.1 - 24.0		17	109	64	1		191
24.1 - 30.0		3	62	46	6		117
30.1 - 36.0		1	20	30	10		61
36.1 +			4	6	4		14
Total number	160	342	423	168	21		1114

Table 29.13 BALSAM POPLAR

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	21	7					28
6.1 - 12.0	4	33	3				40
12.1 - 18.0		10	19	5			34
18.1 - 24.0			19	9			28
24.1 - 30.0			5	12			17
30.1 +			9	17			26
Total number	25	50	55	43			173

Table 29.14 WHITE BIRCH

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	102	6					108
6.1 - 12.0	48	102	10				160
12.1 - 18.0	2	107	69	3			181
18.1 - 24.0		42	82	32			156
24.1 - 30.0		9	45	11			65
30.1 +		3	11	9			23
Total number	152	269	217	55			693

Table 29.15 YELLOW BIRCH

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	20	5					25
6.1 - 12.0	5	25	3				33
12.1 - 18.0		14	22				36
18.1 - 24.0		7	16	2			25
24.1 - 30.0		1	11	10			22
30.1 - 36.0		1	2	7			10
36.1 - 42.0			5	9	1		15
42.1 - 48.0			1	8			9
48.1 - 54.0				12			12
54.1 +				15			15
Total number	25	53	60	63	1		202

Table 29.16 SUGAR MAPLE

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	11	7					18
6.1 - 12.0		23	8				31
12.1 - 18.0		4	24				28
18.1 - 24.0		1	14	7			22
24.1 - 30.0			8	7			15
30.1 - 36.0			4	7			11
36.1 - 42.0			5	12			17
42.1 - 48.0			2	8	1		11
48.1 +				9	1		10
Total number	11	35	65	50	2		163

Table 29.17 RED MAPLE

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	36	5					41
6.1 - 12.0	11	42	5				58
12.1 - 18.0		42	23				65
18.1 - 24.0		10	25	4			39
24.1 - 30.0		9	24	4			37
30.1 - 36.0		2	11	5			18
36.1 +			1	9			10
Total number	47	110	89	22			268

Table 29.18 BEECH

Diameter class (cm)	Height class (m) 1.6 -7.59	7.6 -13.59	13.6 -19.59	19.6 -25.59	25.6 -31.59	31.6 +	Total
0.1 - 6.0	11	3					14
6.1 - 12.0	1	14	5				20
12.1 - 18.0		7	13	1			21
18.1 - 24.0		2	13	3			18
24.1 - 30.0		2	12	10	1		25
30.1 - 36.0			3	8	1		12
36.1 - 42.0			1	11			12
42.1 - 48.0			1	4	1		6
Total number	12	28	48	37	3		128

APPENDIX 2

ADDENDUM

R.M. Newnham

In November, 1985, a contract was let under the ENFOR program of the Canadian Forestry Service to Sigma Systems and Software Ltd., Deep River, Ontario. The first phase of this contract was to calculate equations for estimating the ovendry mass of stem wood, stem bark, and crown for each of the species in the PNFI biomass data bank not included in the analyses that are described in the main body of this report. These species were generally of less commercial importance and, consequently, their sample sizes were much smaller. The distribution of samples by species, province or territory, and ENFOR project number, is shown in Table A2-1. For several species it can be seen that samples were collected from only one province. Plotted scattergrams of component biomass on d^2h identified possible gross data errors in 26 trees and these trees were discarded from subsequent analyses.

Because of limitations in time and money, no further testing of different models of biomass estimation were undertaken. To maintain as much consistency as possible with Mr. Evert's equations, the following models were used:

1) for estimating ovendry mass of stem wood and of stem bark:

$$om = b_0 + b_1 d^2h + b_2 d^3h + b_3 d^4h$$

2) for estimating ovendry mass of crowns:

$$om = b_0 + b_1 d^3/h + b_2(d^3/h)^2 + b_3(d^3/h)^3 + b_4(d^3/h)^4$$

where om is the ovendry mass of a component in kg, d the dbh in cm, and h the total height in m. For each of the 32 species examined in this supplementary study, the coefficients and appropriate statistics are shown in Tables A2-2 (stem wood), A2-3 (stem bark), and A2-4 (crown). In addition, coefficients are given for the equations for all coniferous species (including those in the main body of the report) and, similarly, for all deciduous species combined.

In phase two of the contract, equations for estimating the ovendry mass of wood of the merchantable portion of the stem were calculated for each species in the data bank using Alemdag's Model 4 (Alemdag 1982):

$$OM\% = b_0 + b_1(dm/d) + b_2(dm/d)^2$$

where OM% is the ovendry mass of the merchantable stem wood (including the stump portion) expressed as a percentage of the total stem + bark ovendry mass and dm is the merchantable top diameter. The merchantable top diameter that was used was the specified diameter limit for the province or territory where the data was collected. It varied between 7 and 10 cm inside bark at the time of sampling. Stump wood mass can be estimated using percentages given by Alemdag (1982) and deducted to give the net merchantable wood mass.

Several problems were encountered in undertaking these analyses. It was found that merchantable mass data were not available in many of the ENFOR project summary data files. As the raw data files, from which the summary files had been produced, differed from project to project and in some cases were poorly documented, there was not time to reprocess the data to a form where it could be used in the analyses. Because of this, the sample size for each species is often less than the corresponding sample size given in Table 1 of the main report. For some species the sample size was reduced to such an extent that it was decided not to calculate regression equations for those species.

An example of the relationship between OM% and the ratio, dm/dbh, is given for white pine in Figure A2-1. Providing the value of dm remains constant (or nearly so), the ratio dm/dbh decreases with increase in tree size. Thus, as would be expected, the values of OM% are greatest for low values of the ratio. The curve for the regression equation

$$OM\% = 78.6 + 41.413\ (dm/dbh) - 85.473\ (dm/dbh)^2$$

reflects the curvilinear trend of the scattergram of points. However, it can be seen that this curve has a maximum, Ymax, at a point, Xymax, within the range of dm/dbh ratios. This would imply that, for larger trees with a ratio less than the value of Xmax, the estimates of percentage of merchantable wood mass would actually decrease, something that could not occur in practice. Similar relationships were found for all of the other species. For all cases, as the proportion of trees that have ratios less than Xmax was relatively small, and the differences between the computed values of OM% for these trees and the values of Ymax were also small, it was decided that all trees with a value of dm/dbh < Xymax would have a value of Ymax for OM%. Expressed mathematically, the model becomes:

$$OM\% = \begin{cases} b_0 + b_1(dm/dbh) + b_2(dm/dbh)^2 & \text{for } dm/dbh \geqq Xymax \\ Ymax & \text{for } dm/dbh < Xymax \end{cases}$$

For each species, values of the regression coefficients, Xymax, and Ymax are given in Table A2-5, together with relevant statistics. The values of R^2 are generally in the range of 0.75 to 0.90 for conifers but are lower for the deciduous species, particularly white and red oaks. For species not included in the table, it is suggested that the appropriate combined equation for either conifers or deciduous species be used.

Because of the problems encountered in processing some of the data files in the PNFI biomass data bank, the third phase of the contract was a detailed examination of these files and the preparation of appropriate documentation that would ensure that future users would know exactly what data were in each file, the formats for reading the data, and any assumptions that had been made in preparing the file. Most of this documentation has now been completed.

Table A2-1. The distribution of sample tree data by species, province or territory, and ENFOR project number.

	N.S.	N.B.	Quebec		Ontario			B.C.	Total
Species	P4	P38	P236	P999	P30	P179	P234	P142	No.
60 Shore pine								40	40
70 Ponderosa pine								43	43
80 Western white pine								40	40
120 Red spruce			55						55
140 Engelmann spruce								43	43
150 Sitka spruce								39	39
230 Grand fir								40	40
240 Amabilis fir								45	45
250 Douglas fir								49	49
251 Blue Douglas-fir								41	41
330 Western larch								41	41
420 Western red cedar								70	70
430 Yellow cypress								41	41
440 Eastern red cedar						35			35
520 Western hemlock								70	70
530 Mountain hemlock								39	39
620 Largetooth aspen					97				97
680 Black cottonwood								40	40
730 Grey birch	44								44
840 Silver maple							40		40
902 Red alder								41	41
911 White ash		48		33			78		159
912 Black ash				42			32		74
913 Red ash							29		29
920 Basswood							80		80
945 Black cherry							79		79
951 White elm							81		81
960 Hickory							79		79
981 White oak							66		66
983 Red oak							119		119
Total number	44	48	55	75	97	35	683	722	1759

OVENDRY MASS OF TOTAL STEM WOOD

Table A2-2. Regression coefficients and statistics for the equation: $om = b_0 + b_1d^2h + b_2d^3h + b_3d^4h$

Species	b_0	b_1	b_2	b_3	R^2	SEE %	Mean	N
60 Shore pine	-0.32	0.220062E-01	-0.444793E-03	0.650619E-05	0.9936	8.5	65.8	40
70 Ponderosa pine	-0.21	0.637524E-02	0.364353E-03	-0.514158E-05	0.9686	22.0	266.3	42
80 Western white pine	-1.29	0.169088E-01	-0.176894E-03	0.171747E-05	0.9958	11.5	127.8	39
120 Red spruce	3.00	0.161688E-01	-0.165896E-03	0.255320E-05	0.9808	11.0	148.0	55
140 Engelmann spruce	-11.42	0.265409E-01	-0.629729E-03	0.645754E-05	0.9858	15.2	190.3	42
150 Sitka spruce	6.55	0.297651E-02	0.540400E-03	-0.862033E-05	0.9615	24.7	56.1	38
230 Grand fir	-19.31	0.310551E-01	-0.911529E-03	0.105126E-04	0.9750	18.4	158.4	39
240 Amabilis fir	-5.09	0.327853E-01	-0.144790E-02	0.262629E-04	0.9663	22.7	54.3	45
250 Douglas fir	-6.87	0.214979E-01	-0.327462E-03	0.261359E-05	0.9961	13.4	260.8	49
251 Blue Douglas-fir	-6.15	0.188567E-01	-0.172161E-03	0.279717E-06	0.9820	17.5	259.9	40
330 Western larch	12.92	0.183411E-02	0.754333E-03	-0.112982E-04	0.9714	21.1	290.4	41
420 Western red cedar	-2.86	0.146624E-01	-0.169380E-03	0.878442E-06	0.9882	21.1	126.5	69
430 Yellow cypress	-5.44	0.410082E-01	-0.169681E-02	0.274132E-04	0.9838	24.5	111.9	41
440 Eastern red cedar	0.41	0.143761E-01	0.209526E-03	-0.104903E-04	0.9815	16.7	20.7	34
520 Western hemlock	4.56	0.686442E-02	0.327054E-03	-0.359338E-05	0.9967	14.9	199.5	70
530 Mountain hemlock	4.00	0.126001E-01	0.267107E-03	-0.496251E-05	0.9882	17.7	125.3	39
620 Largetooth aspen	4.51	0.225107E-02	0.827731E-03	-0.143939E-04	0.9862	12.5	89.1	96
680 Black cottonwood	-2.71	0.121135E-01	0.907019E-04	-0.443452E-05	0.9569	26.6	57.8	39
730 Grey birch	1.00	0.128773E-01	0.753713E-03	-0.245171E-04	0.9856	14.1	28.3	44
840 Silver maple	-2.92	0.234209E-01	-0.391448E-03	0.356480E-05	0.9840	12.5	227.4	40
902 Red alder	-0.82	0.143242E-01	-0.210993E-05	0.221776E-05	0.9975	9.1	44.6	41
911 White ash	-11.84	0.347001E-01	-0.949788E-03	0.112953E-04	0.9656	19.1	158.4	155
912 Black ash	-0.68	0.134331E-01	0.993490E-04	-0.280479E-06	0.9856	15.3	118.7	63
913 Red ash	3.26	0.612565E-02	0.681841E-03	-0.143054E-04	0.9605	18.2	144.1	29
920 Basswood	6.94	0.742139E-02	0.204491E-03	-0.247844E-05	0.9736	17.0	228.2	80
945 Black cherry	-1.68	0.125673E-01	0.530845E-03	-0.120431E-04	0.9412	21.1	193.5	79
951 White elm	2.92	0.135359E-01	0.900408E-04	-0.947944E-08	0.9751	22.1	139.5	81
960 Hickory	-7.61	0.224233E-01	0.792366E-06	-0.417879E-05	0.9668	17.6	222.9	79
981 White oak	2.89	0.233088E-01	-0.267065E-03	0.151028E-05	0.9824	19.8	188.2	65
983 Red oak	13.59	0.764883E-02	0.591214E-03	-0.849065E-05	0.9538	19.5	198.8	119
--- All coniferous	-0.80	0.150905E-01	0.553425E-04	-0.376558E-05	0.8628	52.7	89.3	6856
--- All deciduous	-2.46	0.156714E-01	0.181728E-03	-0.566014E-05	0.8466	51.4	116.6	3750

OVENDRY MASS OF TOTAL STEM BARK

Table A2-3. Regression coefficients and statistics for the equation: $om = b_0 + b_1d^2h + b_2d^3h + b_3d^4h$

Species	b_0	b_1	b_2	b_3	R^2	SEE %	Mean	N
60 Shore pine	-0.37	0.492275E-02	-0.233617E-03	0.378383E-05	0.8875	30.5	7.2	40
70 Ponderosa pine	1.19	0.189336E-02	0.108665E-04	-0.180252E-06	0.9363	31.5	46.1	42
80 Western white pine	-0.29	0.252112E-02	-0.570063E-04	0.584773E-06	0.9659	30.8	12.8	39
120 Red spruce	1.05	0.174678E-02	-0.699329E-05	-0.116437E-07	0.9506	16.6	17.3	55
140 Engelmann spruce	1.83	0.157855E-02	0.393716E-05	-0.384457E-06	0.9476	24.6	20.1	42
150 Sitka spruce	0.57	0.845391E-03	0.727353E-04	-0.155959E-05	0.9339	31.2	7.9	38
230 Grand fir	3.26	0.263973E-04	0.737867E-04	-0.783335E-06	0.8239	54.0	24.6	39
240 Amabilis fir	-0.33	0.569517E-02	-0.292269E-03	0.526673E-05	0.9461	25.7	7.8	45
250 Douglas fir	-0.40	0.285953E-02	-0.252361E-04	0.855488E-07	0.9875	23.2	38.7	49
251 Blue Douglas-fir	-2.34	0.619153E-02	-0.161519E-03	0.158961E-05	0.9628	27.1	51.2	40
330 Western larch	2.04	0.137700E-02	0.131838E-04	-0.194018E-06	0.9726	22.5	38.4	41
420 Western red cedar	0.20	0.623991E-03	0.473930E-04	-0.654084E-06	0.8898	65.0	17.6	69
430 Yellow cypress	-1.13	0.622479E-02	-0.288679E-03	0.396635E-05	0.9306	39.2	8.7	41
440 Eastern red cedar	0.34	0.682829E-04	0.151419E-03	-0.413988E-05	0.9485	25.4	2.2	34
520 Western hemlock	3.71	-0.265814E-02	0.220228E-03	-0.232018E-05	0.9882	26.8	28.1	70
530 Mountain hemlock	2.41	-0.250185E-03	0.187798E-03	-0.273274E-05	0.9524	36.4	23.5	39
620 Largetooth aspen	-1.70	0.701536E-02	-0.279910E-03	0.465782E-05	0.9307	27.0	19.7	96
680 Black cottonwood	-0.18	0.295306E-02	-0.491729E-04	0.359213E-06	0.9069	37.1	10.3	39
730 Grey birch	0.33	-0.109173E-02	0.552359E-03	-0.176912E-04	0.9710	19.4	4.6	44
840 Silver maple	0.43	0.167836E-02	-0.866729E-05	-0.162241E-07	0.9658	18.5	22.1	40
902 Red alder	-0.03	0.112859E-02	0.568821E-04	-0.457960E-06	0.9899	20.2	6.1	41
911 White ash	0.26	0.320319E-02	-0.599818E-04	0.543344E-06	0.8953	31.1	19.2	155
912 Black ash	0.58	0.258436E-02	-0.428366E-04	0.869087E-06	0.9390	30.4	16.5	63
913 Red ash	0.56	0.324913E-02	-0.256623E-04	-0.280298E-06	0.9259	23.4	24.9	29
920 Basswood	2.83	-0.877784E-03	0.169422E-03	-0.236196E-05	0.8758	35.6	38.9	80
945 Black cherry	1.25	0.243496E-02	0.351001E-05	-0.588669E-06	0.8045	37.9	24.1	79
951 White elm	-2.60	0.836719E-02	-0.359993E-03	0.488734E-05	0.9067	50.1	18.7	81
960 Hickory	-1.26	0.641682E-02	-0.231307E-03	0.301798E-05	0.9359	23.4	28.5	79
981 White oak	4.56	0.208504E-03	0.759976E-04	-0.837969E-06	0.9269	38.0	25.2	65
983 Red oak	2.61	0.393549E-02	-0.353778E-04	0.188907E-06	0.8514	33.5	35.4	119
--- All coniferous	1.38	0.141769E-02	0.677791E-05	-0.891979E-07	0.8688	63.6	12.7	6856
--- All deciduous	0.34	0.360306E-02	-0.489182E-04	0.306466E-06	0.8355	53.7	19.6	3746

OVENDRY MASS OF CROWNS

Table A2-4. Regression coefficients and statistics for the equation: $om = b_0 + b_1 d^3/h + b_2(d^3/h)^2 + b_3(d^3/h)^3 + b_4(d^3/h)^4$

Species	b_0	b_1	b_2	b_3	b_4	R^2	SEE %	Mean	N
60 Shore pine	-3.68	0.118753	-0.145739E-03	0.118775E-06	-0.290138E-10	0.9179	32.9	28.2	40
70 Ponderosa pine	-3.34	0.620065E-01	-0.416871E-05	0.144553E-08	-0.128881E-12	0.8656	45.1	112.7	42
80 Western white pine	10.96	-0.917540E-01	0.289018E-03	-0.143989E-06	0.189354E-10	0.7033	85.4	39.9	39
120 Red spruce	-5.59	0.894055E-01	-0.849864E-04	0.426506E-07	-0.595941E-11	0.9246	28.4	38.6	55
140 Engelmann spruce	-12.46	0.173815	-0.133720E-03	0.501452E-07	-0.563268E-11	0.8292	45.0	63.3	42
150 Sitka spruce	5.77	0.212788E-01	0.143485E-03	-0.105941E-06	0.158349E-10	0.9392	33.8	40.4	38
230 Grand fir	-1.21	0.109247	-0.714538E-04	0.328238E-07	-0.495633E-11	0.7561	46.3	57.5	39
240 Amabilis fir	-5.43	0.177169	-0.413148E-03	0.475894E-06	-0.160478E-09	0.9072	32.0	28.9	45
250 Douglas fir	4.06	0.512793E-01	0.454407E-05	0.121177E-08	-0.352394E-12	0.8538	59.0	53.1	49
251 Blue Douglas-fir	-3.00	0.758834E-01	0.495921E-05	-0.411721E-08	0.402119E-12	0.6968	78.6	92.3	40
330 Western larch	11.85	-0.493168E-01	0.137587E-03	-0.503470E-07	0.496413E-11	0.6749	85.7	46.3	41
420 Western red cedar	2.48	0.460083E-01	-0.106356E-05	-0.133785E-08	0.151202E-12	0.9165	43.2	43.8	69
430 Yellow cypress	2.26	0.445005E-01	-0.477678E-04	0.436315E-07	-0.108626E-10	0.8051	47.5	22.1	41
440 Eastern red cedar	-1.52	0.957612E-01	-0.172978E-03	0.173664E-06	-0.450556E-10	0.9469	37.3	18.6	34
520 Western hemlock	-1.75	0.783124E-01	-0.179677E-04	0.520382E-08	-0.443442E-12	0.8465	71.5	46.7	70
530 Mountain hemlock	-13.45	0.940326E-01	-0.889195E-04	0.399736E-07	-0.538905E-11	0.9033	41.8	29.2	39
620 Largetooth aspen	-0.08	0.338415E-01	0.294075E-04	-0.320386E-07	0.829926E-11	0.9399	34.0	13.7	96
680 Black cottonwood	3.19	0.468756E-01	-0.988649E-05	0.538624E-07	-0.238179E-10	0.8827	43.5	26.6	39
730 Grey birch	0.24	0.235953E-01	0.514123E-05	0.256510E-06	-0.287216E-09	0.9585	30.5	6.7	44
840 Silver maple	4.19	-0.322219E-02	0.176774E-03	-0.802507E-07	0.109944E-10	0.9038	44.8	102.2	40
902 Red alder	5.70	-0.209476E-01	0.326784E-03	-0.330112E-06	0.893569E-10	0.8734	39.8	17.3	41
911 White ash	-2.36	0.125749	-0.613103E-04	0.148353E-07	-0.998356E-12	0.8700	53.5	53.9	155
912 Black ash	1.47	0.686494E-01	-0.353061E-04	0.292646E-08	0.100514E-11	0.7497	56.6	21.6	63
913 Red ash	1.78	0.648812E-01	-0.328042E-04	0.186843E-07	-0.363407E-11	0.7862	45.7	32.4	29
920 Basswood	4.84	0.311731E-01	0.653506E-05	-0.208523E-08	0.160385E-12	0.8363	44.7	59.5	80
945 Black cherry	-2.73	0.694253E-01	0.118900E-05	-0.576282E-09	-0.218648E-13	0.6679	82.2	63.7	79
951 White elm	-2.33	0.701520E-01	-0.345801E-05	-0.342853E-08	0.449595E-12	0.8531	39.3	45.3	81
960 Hickory	5.33	-0.204340E-01	0.344820E-03	-0.165311E-06	0.213721E-10	0.7533	67.3	106.6	79
981 White oak	-6.74	0.642583E-01	-0.565354E-05	0.502556E-09	-0.133693E-13	0.9251	51.7	96.3	65
983 Red oak	6.59	0.272990E-01	0.505659E-04	-0.156625E-07	0.126234E-11	0.8073	65.2	85.0	119
--- All coniferous	0.41	0.490137E-01	-0.234327E-05	0.310136E-09	-0.253319E-13	0.7729	74.2	28.6	6733
--- All deciduous	-0.19	0.582004E-01	0.397768E-05	-0.545215E-09	0.132978E-13	0.7261	106.3	42.4	3743

OVENDRY MASS OF MERCHANTABLE STEM WOOD EXPRESSED AS A PERCENTAGE
OF TOTAL STEM WOOD + BARK

Table A2-5. Regression coefficients and statistics for the equation:

$$OM\% = \begin{cases} b_0 + b_1 dm/d + b_2 (dm/d)^2 & \text{if } dm/d \geq Xymax \\ Ymax & \text{if } dm/d < Xymax \end{cases}$$

Species	b_0	b_1	b_2	R^2	SEE %	Mean	Xymax	Ymax	N
20 Eastern white pine	78.6	41.413	-85.473	0.8552	3.9	80.0	0.242	83.7	173
30 Red pine	86.2	26.859	-67.968	0.7720	4.0	84.7	0.198	88.9	143
40 Jack pine	81.6	64.242	-120.409	0.8706	5.7	80.9	0.267	90.1	272
50 Lodgepole pine	87.2	29.972	-68.244	0.8778	4.0	82.9	0.220	90.5	183
70 Ponderosa pine	86.7	2.462	-43.166	0.4816	3.3	83.7	0.029	86.7	24
110 Black spruce	68.1	89.954	-130.444	0.9096	5.5	72.3	0.345	83.6	1070
120 Red spruce	84.9	32.570	-70.079	0.8548	2.4	85.4	0.232	88.7	48
130 White spruce	84.7	26.750	-76.087	0.8833	5.5	76.2	0.176	87.0	452
140 Engelmann spruce	94.4	-8.784	-45.750	0.8014	2.4	86.7	0.000	94.9	21
210 Balsam fir	71.6	62.516	-100.210	0.8692	5.8	73.9	0.312	81.3	235
220 Alpine fir	77.4	38.298	-80.929	0.7821	3.8	77.9	0.237	81.9	74
310 Tamarack	85.9	19.171	-61.422	0.6222	7.6	79.6	0.156	87.4	220
410 Eastern white cedar	64.9	88.836	-132.026	0.9078	3.8	74.1	0.336	79.8	64
420 Western red cedar	86.1	13.053	-57.869	0.6762	2.8	83.0	0.113	86.8	32
510 Eastern hemlock	77.7	23.918	-65.788	0.7686	4.3	76.0	0.182	79.9	116
520 Western hemlock	85.0	22.907	-74.760	0.7647	3.0	81.6	0.153	86.7	27
610 Trembling aspen	70.9	53.352	-93.504	0.7816	7.5	70.2	0.285	78.5	409
620 Largetooth aspen	75.5	29.000	-71.244	0.7888	5.1	70.7	0.204	78.4	70
630 Balsam poplar	80.5	12.458	-63.442	0.6675	8.0	73.0	0.098	81.1	172
710 White birch	67.0	79.554	-125.224	0.8336	4.9	74.0	0.318	79.6	158
720 Yellow birch	78.1	28.674	-78.844	0.6085	6.2	77.9	0.182	80.7	87
810 Sugar maple	88.1	-4.358	-46.622	0.8684	4.2	79.5	0.000	88.1	87
820 Red maple	95.8	-55.172	26.050	0.6893	3.5	80.1	1.000	66.6	74
840 Silver maple	71.9	71.721	-120.596	0.6838	3.7	79.7	0.297	82.6	29
911 White ash	84.0	-4.004	-21.511	0.4873	5.3	78.5	0.000	84.0	62
912 Black ash	87.7	1.380	-52.198	0.7850	8.2	72.3	0.013	87.7	16
913 Red ash	82.0	-0.746	-31.833	0.5335	2.9	77.0	0.000	82.0	20
920 Basswood	79.8	20.638	-71.145	0.6918	5.2	76.7	0.145	81.3	66
930 Beech	86.3	13.973	-50.463	0.7599	3.5	83.6	0.138	87.3	67
945 Black cherry	83.1	11.928	-42.380	0.6885	4.1	80.3	0.141	83.9	58
951 White elm	74.9	30.976	-65.065	0.5080	5.8	74.9	0.238	78.6	66
960 Hickory	76.4	42.981	-82.722	0.7251	5.5	77.0	0.260	81.9	65
981 White oak	79.7	-6.943	-7.063	0.3709	4.6	75.5	0.000	79.7	47
983 Red oak	78.3	1.744	-26.462	0.4187	5.8	74.2	0.033	78.3	98
--- All coniferous	77.5	56.641	-101.938	0.8317	6.3	77.0	0.278	85.3	3322
--- All deciduous	79.2	23.727	-67.603	0.6981	7.0	74.7	0.175	81.3	1631

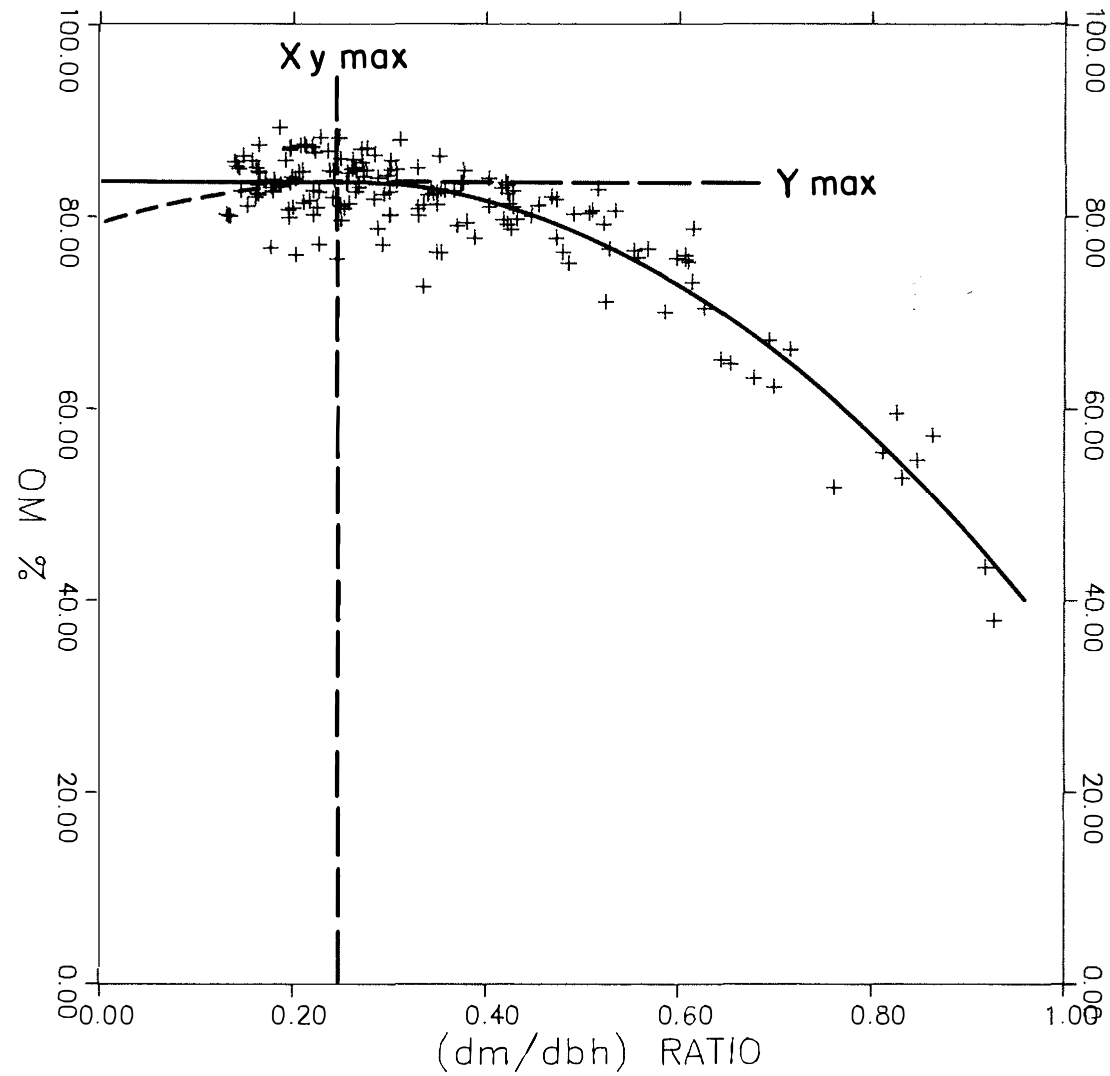

FIGURE A2-1. The relationship between the ovendry mass of merchantable stem wood, expressed as a percentage of total stem + bark ovendry mass, OM%, and the merchantable top diameter/dbh ratio, dm/dbh, for eastern white pine. The curve is for the regression:

$$OM\% = \begin{cases} 78.6 + 41.413\,(d_m/dbh) - 85.473\,(d_m/dbh)^2 & \text{for } d_m/dbh \geq Xymax \\ Ymax & \text{for } dm/dbh < Xymax \end{cases}$$

Reference

Alemdag, I.S. 1982. Biomass of the merchantable and unmerchantable portions of the stem. Environ. Canada, Can. For. Serv., Petawawa Natl. For. Inst., Inf. Rep. PI-X-20.