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Accuracy of Honer Volume Equations for Balsam Fir in Nova Scotia:
Influence of Geographic Location and Pre-Commercial Thinning

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Introduction

Honer et. al. (1983) standard volume equations are frequently used in Nova Scotia to estimate volume when cruising standing timber. There are concerns regarding the applicability of these equations to stands growing on the Cape Breton Highlands Ecodistrict (Neily et. al., 2005), especially when pre-commercially thinned (PCT). It is predicted that PCT balsam fir growing on the Highlands have more stem taper than estimated by Honer, due to harsh winds and growing in more open conditions, resulting in overestimates of volume (Bruchert and Gardner, 2006; Lundqvist and Valiger; 1996 and Weiskittel et. al., 2009). To test this prediction, stem analysis data from PCT and non-PCT Mainland and Cape Breton Highland grown balsam fir (*Abies balsamea* (L.) Mill.) were compared to Honer volume estimates. This report examines stem analysis data collected at 17 locations in pre-commercially thinned (PCT)

balsam fir stands with un-thinned controls (O'Keefe et. al., 2004). Three of these sites were on Cape Breton Highlands (Marianna Road, Warehouse Road and Crowdis Mountain) while the rest were on the Mainland of Nova Scotia.

Results

The data collected for the rot study includes stem analysis taken from 290 balsam fir trees growing in fully stocked conditions at 20 sites. Stem analysis methods are described in O'Keefe et. al. (2004). At these locations, paired plots were located in PCT and un-thinned portions of the same stand. The stands averaged 43 years of age (ranged from 31-66 years).

Table 1. Size Characteristics of Stem Analysis Trees (O'Keefe et. al. 2004).

				Dbh				Height			
				cm				m			
Loc.	Trt.	Cr. Class	Trees	Mean	SD	Min	Max	Mean	SD	Min	Max
Main.	PCT	Dom.	68	19.6	3.5	12.4	26.3	13.4	1.4	10.4	16.2
Main.	PCT	Co-Dom.	50	14.9	2.9	11.0	23.4	11.7	1.1	9.1	13.7
Main.	PCT	Inter.	12	11.3	1.6	9.4	13.8	9.9	0.7	8.9	10.8
Main.	PCT	All	130	17.0	4.3	9.4	26.3	12.4	1.7	8.9	16.2
Main.	CNTRL.	Dom.	62	17.9	3.4	11.2	26.0	13.4	1.5	9.8	17.2
Main.	CNTRL.	Co-Dom.	41	13.2	2.7	9.5	20.8	11.8	1.4	7.8	14.1
Main.	CNTRL.	Inter.	5	10.0	0.7	8.7	10.4	10.0	1.4	7.7	11.1
Main.	CNTRL.	All	108	15.8	4.0	8.7	26.0	12.6	1.7	7.7	17.2
Main.	ALL	All	238	16.4	4.2	8.7	26.3	12.5	1.7	7.7	17.2
C.B.	PCT	Dom.	11	18.3	4.4	11.3	25.5	10.0	1.4	8.3	12.1
C.B.	PCT	Co-Dom.	11	17.8	5.0	11.0	25.4	8.2	1.5	6.6	11.4
C.B.	PCT	Inter.	1	12.3	ND	12.3	12.3	8.8	ND	8.8	8.8
C.B.	PCT	All	23	17.8	4.6	11.0	25.5	9.1	1.7	6.6	12.1
C.B.	CNTRL.	Dom.	11	17.1	2.6	12.5	21.9	10.4	1.7	8.3	13.1
C.B.	CNTRL.	Co-Dom.	7	12.8	2.2	9.8	16.8	9.3	1.4	7.5	12.0
C.B.	CNTRL.	Inter.	0	ND	ND	ND	ND	ND	ND	ND	ND
C.B.	CNTRL.	All	18	15.4	3.2	9.8	21.9	10.0	1.6	7.5	13.1
C.B.	ALL	All	41	16.7	4.2	9.8	25.5	9.5	1.7	6.6	13.1
ALL	ALL	All	279	16.5	4.2	8.7	26.3	12.1	2.0	6.6	17.2

Loc. = Location (***Main.*** =Mainland, ***C.B.*** =Cape Breton Highlands);
Trt. =Treatment (***PCT***=Pre-Commercial Thinning, ***CNTRL***=Control); ***ND*** = No Data
Cr. Class =Crown Class (***Dom*** .=Dominant, ***Co-Dom*** .=Co-Dominant, ***Inter*** .=Intermedite);
Trees = # of trees in sample; ***Dbh*** = Diameter Outside Bark at Breast Height;
Height =Total Tree Height; ***SD***=Standard Deviation; ***Min*** =Minimum; ***Max*** =Maximum

Eleven trees from the rot study were dropped due to damaged tops and being suppressed, leaving 279 for analysis.

One hundred twenty six stems were sectioned (stem analysis methods shown in O'Keefe, 2004) in the un-thinned portions and 153 were sectioned in the PCT areas. The trees averaged 16.5 cm in diameter at breast height and 12.1 m in total height (Table 1). Of the sites studied, three were on Cape Breton Highlands where 23 trees were sectioned in PCT areas and 18 sectioned in control areas. The trees growing on the Highlands were similar in diameter to those grown on the Mainland but were appreciably shorter; averaging only 9.5 m tall compared to 12.5 m for the Mainland (Table 1).

Total Volume

Over all trees, Honer estimates of total volume were not significantly (ns) different than stem analysis (Honer averaged 0.3% higher, Table 2). Further examination of the data shows that the ability of Honer (1983) to estimate volume depends on whether stands were Pre-commercially thinned (PCT) or grown on Cape Breton Highlands. In fact, in the un-thinned stands on the Mainland, Honer (1983) underestimates volume by an average of 2.9% (Honer and stem analysis volumes were significantly different (sig.) at the <0.001 level). On the other hand, in PCT stands on Cape Breton Highlands, Honer (1983) overestimates volume by 6.3% (sig = 0.026). Where stands were PCT on the Mainland or not thinned on the Highlands, more modest variations were found between Honer and stem analysis. Honer over estimated total volume by 1.6 % (sig.<0.001) for Mainland PCTs and 2.5% (ns) for Cape Breton controls.

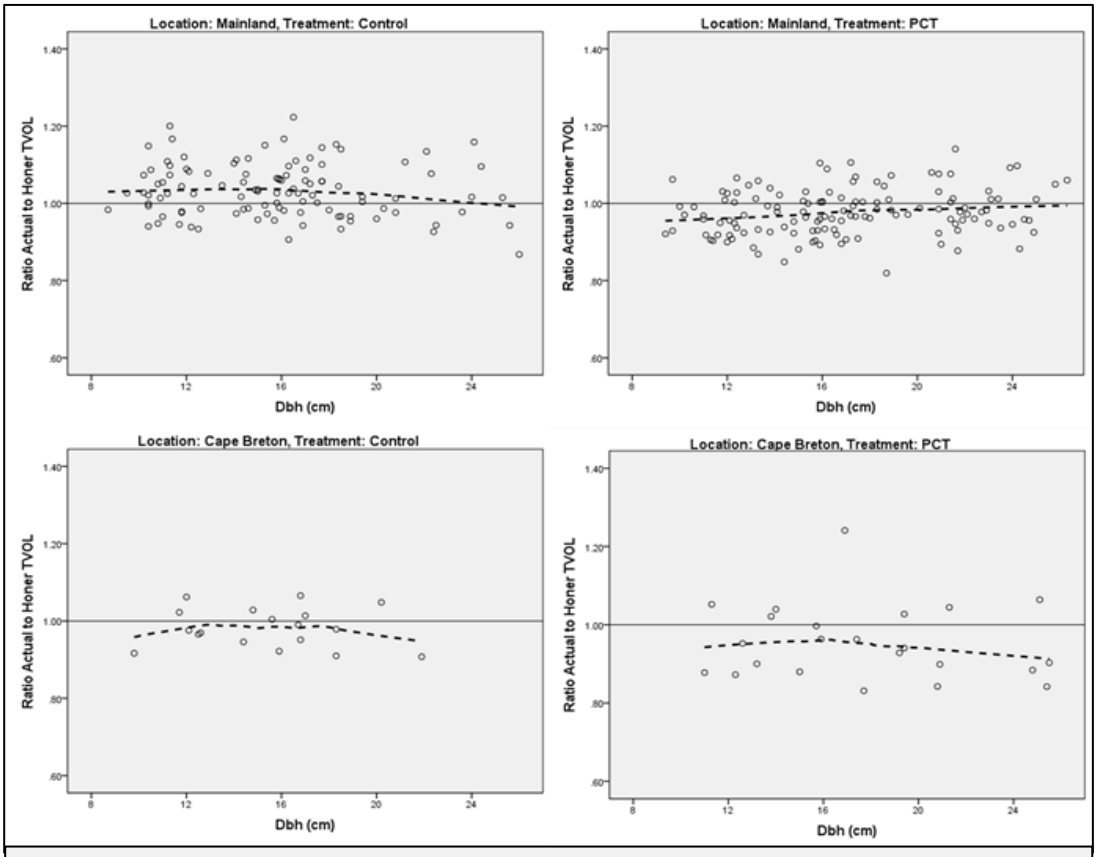

Figure 1. The Ratio of Actual (stem analysis) to Honer (estimated) Total Volume by Region (Mainland Nova Scotia and Cape Breton Highlands), and Treatment (Control and Pre-Commercial Thinning) versus Diameter at breast height outside bark (Dbh) for data from O'Keefe et. al. 2004. The solid line represents when Stem Analysis and Honer volumes are identical. The dotted line represents the results of Loess regression (Cleveland, 1979 and Epanechnikov, 1969) using 80% of the points for localized fit. When regression line is above reference line, Honer is underestimating volume. When regression line is below reference line, Honer is overestimating volume.

The less dominant trees (co-dominant or intermediate crown classes) generally showed less taper and stem analysis volumes were relatively higher than Honer estimates (Table 2, Appendix I). For example on Mainland PCT sites, Honer estimates of total volume were 1.6% (sig.=0.011) higher than stem analysis for dominant trees and only 1.0% (sig.=0.057) higher for co-dominant trees (Table 2). Individual tree results for total volumes from the rot study can be found in Figure 1 and Appendix II.

Table 2. Comparison of Stem Analysis to Honers Estimates of Total Volume (O'Keefe et. al., 2004).

				TVOL, Honer m^3				TVOL, Stem Analysis m^3				TVOL, Honer-Stem Analysis m^3				Wilcoxon RSRT	Bias %	SA:Hon Ratio, TVOL
Loc.	Trt.	Cr. Class	Trees	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Sig,	Mean	Mean
Main.	PCT	Dom.	68	0.1945	0.0782	0.0655	0.3737	0.1914	0.0801	0.0646	0.3961	0.0031	0.0121	-0.0314	0.0361	0.011	1.6	0.984
Main.	PCT	Co-Dom.	50	0.1013	0.0464	0.0466	0.2681	0.1003	0.0491	0.0422	0.2712	0.0010	0.0081	-0.0298	0.0285	0.057	1.0	0.990
Main.	PCT	Inter.	12	0.0497	0.0158	0.0316	0.0766	0.0463	0.0132	0.0291	0.0709	0.0034	0.0033	-0.0020	0.0094	0.006	7.3	0.932
Main.	PCT	All	130	0.1453	0.0830	0.0316	0.3737	0.1429	0.0841	0.0291	0.3961	0.0023	0.0102	-0.0314	0.0361	<.001	1.6	0.984
Main.	CNTRL.	Dom.	62	0.1637	0.0743	0.0496	0.3453	0.1683	0.0759	0.0508	0.3887	-0.0046	0.0144	-0.0533	0.0457	0.007	-2.7	1.028
Main.	CNTRL.	Co-Dom.	41	0.0799	0.0385	0.0348	0.2160	0.0828	0.0389	0.0357	0.2109	-0.0029	0.0060	-0.0261	0.0051	0.006	-3.5	1.036
Main.	CNTRL.	Inter.	5	0.0390	0.0089	0.0233	0.0441	0.0402	0.0100	0.0229	0.0469	-0.0012	0.0034	-0.0061	0.0026	0.686	-3.1	1.032
Main.	CNTRL.	All	108	0.1261	0.0754	0.0233	0.3453	0.1299	0.0770	0.0229	0.3887	-0.0038	0.0115	-0.0533	0.0457	<.001	-2.9	1.030
Main.	ALL	All	238	0.1366	0.0801	0.0233	0.3737	0.1370	0.0811	0.0229	0.3961	-0.0005	0.0112	-0.0533	0.0457	0.870	-0.3	1.003
C.B.	PCT	Dom.	11	0.1387	0.0776	0.0417	0.2885	0.1274	0.0684	0.0439	0.2605	0.0113	0.0128	-0.0045	0.0299	0.026	8.9	0.919
C.B.	PCT	Co-Dom.	11	0.1119	0.0667	0.0367	0.2383	0.1088	0.0612	0.0322	0.2076	0.0032	0.0150	-0.0186	0.0377	0.594	2.9	0.972
C.B.	PCT	Inter.	1	0.0518	ND	0.0518	0.0518	0.0452	ND	0.0452	0.0452	0.0066	ND	0.0066	0.0066	0.317	14.6	0.872
C.B.	PCT	All	23	0.1221	0.0719	0.0367	0.2885	0.1149	0.0644	0.0322	0.2605	0.0072	0.0139	-0.0186	0.0377	0.026	6.3	0.941
C.B.	CNTRL.	Dom.	11	0.1203	0.0483	0.0514	0.2270	0.1165	0.0441	0.0496	0.2060	0.0039	0.0079	-0.0076	0.0210	0.182	3.3	0.968
C.B.	CNTRL.	Co-Dom.	7	0.0607	0.0240	0.0338	0.0968	0.0606	0.0250	0.0310	0.1031	0.0001	0.0038	-0.0063	0.0049	0.735	0.1	0.999
C.B.	CNTRL.	Inter.	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C.B.	CNTRL.	All	18	0.0971	0.0497	0.0338	0.2270	0.0948	0.0464	0.0310	0.2060	0.0024	0.0067	-0.0076	0.0210	0.184	2.5	0.975
C.B.	ALL	All	41	0.1112	0.0636	0.0338	0.2885	0.1061	0.0574	0.0310	0.2605	0.0051	0.0115	-0.0186	0.0377	0.010	4.8	0.954
ALL	ALL	All	279	0.1328	0.0783	0.0233	0.3737	0.1325	0.0787	0.0229	0.3961	0.0004	0.0114	-0.0533	0.0457	0.243	0.3	0.997

Loc. = Location (***Main.*** =Mainland, ***C.B.*** =Cape Breton Highlands); ***Trees*** = # of trees; T***VOL,Honer*** =Honer (1983) Total Volume (inside bark, equation 14) including stump and top.

T***VOL, Stem Analysis*** = Total Volume (inside bark) excluding stump and including all sections. ***TVOL, Honer-Stem Analysis*** =Honer Volume minus Stem Analysis Volume

Wilcoxon =Probabilty that the difference in TVOL between Honer and stem analysis due to chance. ***SA:Hon*** =The sum of the Stem Analysis TVOL divided by the sum of the Honer TVOL

Data not normally distributed, therefore the Wilcoxon related-sample signed rank tests (RSRT) was used (IBM® SPSS® 23) ***Sig.*** =Significance level

Bias =The sum of the differences between Honer and Stem Analysis TVOL divided by the sum of the Actual TVOL multiplied by 100 ***SD*** =Standard Deviation; ***Min*** =Minimum; ***Max*** =Maximum

Highly significant (<0.001) Marginally Significant (<0.15 ***ND*** = No Data ***Cr. Class*** =Crown Class (***Dom*** .=Dominant, ***Co-Dom*** .=Co-Dominant, ***Inter*** .=Intermediate)

Merchantable Volume

In general, Honer underestimates merchantable volume more frequently than for total volume. Over all trees, Honer underestimates merchantable volume by 2.6% (sig.<0.001, Table 3). As with total volume estimates, the ability of Honer (1983) to estimate volume depended on whether a stand is density controlled (PCT) or growing on Cape Breton Highlands. In the un-thinned stands on the Mainland, Honer (1983) underestimates volume by an average of 6.5% (sig.<0.001). On the other hand, in PCT stands on Cape Breton Highlands, Honer (1983) overestimates volume by 4.5% (sig.=0.144). Where stands were treated with PCT on the Mainland, or not thinned on the Highlands, Honer estimated volume to within 1% of actual values (not significantly different, ns). Individual tree results are shown in Figure 2 and Appendix II.

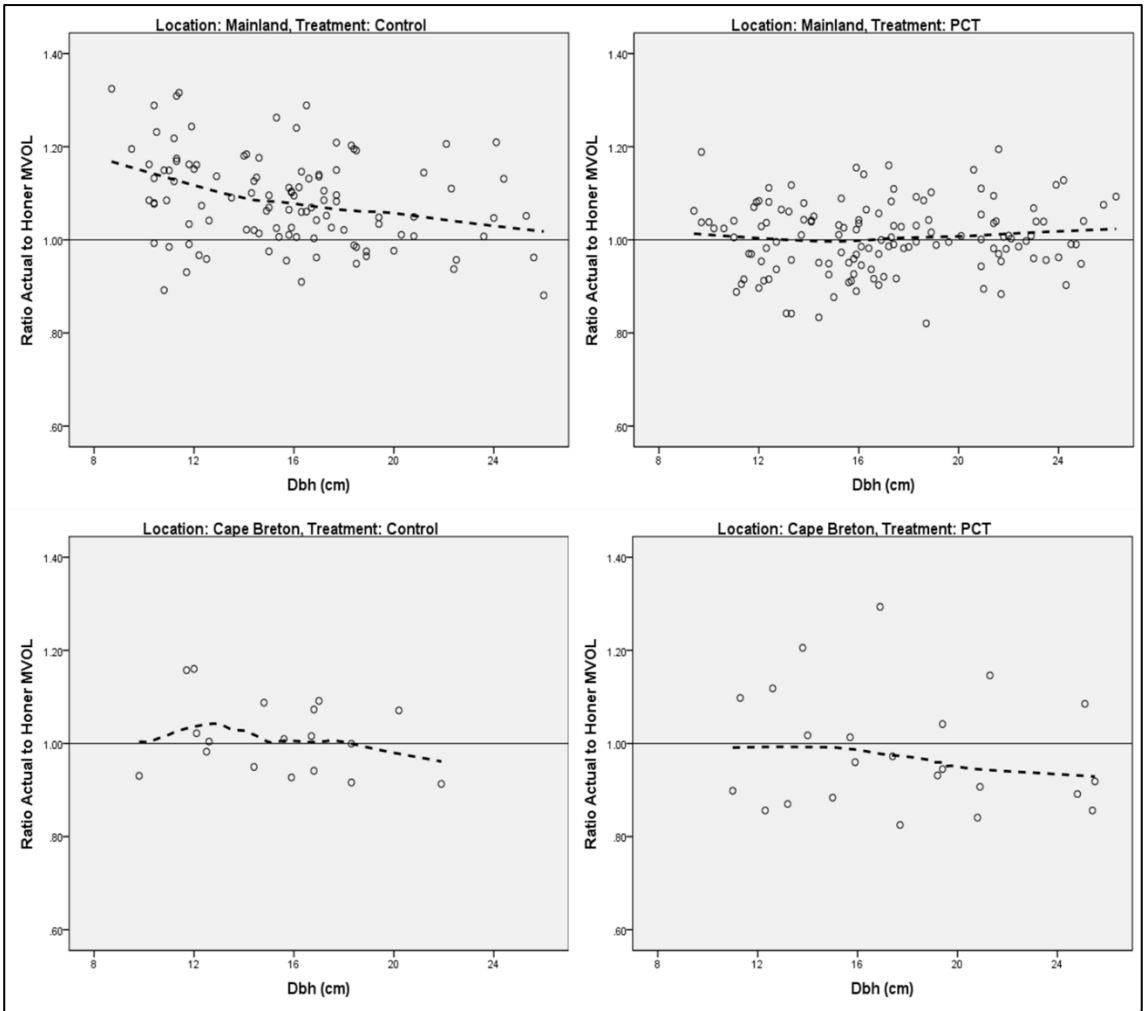

Figure 2. The Ratio of Actual (stem analysis) to Honer (estimated) Merchantable Volume by Region (Mainland Nova Scotia and Cape Breton Highlands), and Treatment (Control and Pre-Commercial Thinning) versus Diameter at breast height outside bark (Dbh) for data from O'Keefe et. al. 2004. The solid line represents when Stem Analysis and Honer volumes are identical. The dotted line represents the results of Loess regression (Cleveland, 1979 and Epanechnikov, 1969) using 80% of the points for localized fit. When regression line is above reference line, Honer is underestimating volume. When regression line is below reference line, Honer is overestimating volume.

Table 3. Comparison of Stem Analysis and Honers Estimates of Merchantable Volume (O'Keefe et. al., 2004).

				MVOL, Honer				MVOL, Stem Analysis				MVOL, Honer-Stem Analysis				Wilcoxon	Bias	SA:Hon
				m^3				m^3				m^3				RSRT	%	Ratio, MVOL
Loc.	Trt.	Cr. Class	Trees	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Sig,	Mean	Mean
Main.	PCT	Dom.	68	0.1762	0.0742	0.0507	0.3448	0.1775	0.0783	0.0505	0.3768	-0.0013	0.0124	-0.0380	0.0274	0.807	-0.7	1.007
Main.	PCT	Co-Dom.	50	0.0864	0.0448	0.0330	0.2458	0.0883	0.0487	0.0299	0.2554	-0.0019	0.0092	-0.0377	0.0257	0.184	-2.1	1.021
Main.	PCT	Inter.	12	0.0358	0.0149	0.0157	0.0568	0.0345	0.0126	0.0167	0.0584	0.0013	0.0041	-0.0040	0.0090	0.530	3.9	0.963
Main.	PCT	All	130	0.1287	0.0795	0.0157	0.3448	0.1300	0.0825	0.0167	0.3768	-0.0013	0.0107	-0.0380	0.0274	0.518	-1.0	1.010
Main.	CNTRL.	Dom.	62	0.1460	0.0705	0.0369	0.3180	0.1550	0.0740	0.0415	0.3717	-0.0090	0.0154	-0.0644	0.0379	<.001	-5.8	1.062
Main.	CNTRL.	Co-Dom.	41	0.0653	0.0369	0.0187	0.1949	0.0714	0.0387	0.0223	0.1964	-0.0061	0.0068	-0.0301	0.0033	<.001	-8.5	1.093
Main.	CNTRL.	Inter.	5	0.0239	0.0086	0.0086	0.0295	0.0276	0.0095	0.0114	0.0344	-0.0037	0.0029	-0.0077	0.0002	0.080	-13.5	1.156
Main.	CNTRL.	All	108	0.1097	0.0722	0.0086	0.3180	0.1174	0.0755	0.0114	0.3717	-0.0077	0.0125	-0.0644	0.0379	<.001	-6.5	1.070
Main.	ALL	All	238	0.1201	0.0767	0.0086	0.3448	0.1242	0.0795	0.0114	0.3768	-0.0042	0.0120	-0.0644	0.0379	<.001	-3.4	1.035
C.B.	PCT	Dom.	11	0.1231	0.0754	0.0304	0.2673	0.1144	0.0669	0.0334	0.2455	0.0088	0.0124	-0.0086	0.0259	0.062	7.7	0.929
C.B.	PCT	Co-Dom.	11	0.0955	0.0607	0.0250	0.2112	0.0951	0.0565	0.0225	0.1837	0.0004	0.0143	-0.0198	0.0304	0.929	0.4	0.996
C.B.	PCT	Inter.	1	0.0400	ND	0.0400	0.0400	0.0342	ND	0.0342	0.0342	0.0058	ND	0.0058	0.0058	0.317	16.8	0.856
C.B.	PCT	All	23	0.1063	0.0682	0.0250	0.2673	0.1017	0.0616	0.0225	0.2455	0.0046	0.0135	-0.0198	0.0304	0.144	4.5	0.957
C.B.	CNTRL.	Dom.	11	0.1057	0.0470	0.0389	0.2085	0.1040	0.0431	0.0382	0.1904	0.0016	0.0082	-0.0100	0.0181	0.722	1.6	0.984
C.B.	CNTRL.	Co-Dom.	7	0.0485	0.0245	0.0190	0.0857	0.0504	0.0248	0.0177	0.0920	-0.0019	0.0040	-0.0063	0.0040	0.237	-3.8	1.039
C.B.	CNTRL.	Inter.	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C.B.	CNTRL.	All	18	0.0834	0.0483	0.0190	0.2085	0.0832	0.0451	0.0177	0.1904	0.0003	0.0070	-0.0100	0.0181	0.777	0.3	0.997
C.B.	ALL	All	41	0.0963	0.0607	0.0190	0.2673	0.0935	0.0551	0.0177	0.2455	0.0027	0.0112	-0.0198	0.0304	0.262	2.9	0.972
ALL	ALL	All	279	0.1166	0.0750	0.0086	0.3448	0.1197	0.0771	0.0114	0.3768	-0.0032	0.0121	-0.0644	0.0379	<.001	-2.6	1.027

Loc. = Location (***Main.*** =Mainland, ***C.B.*** =Cape Breton Highlands); ***Trt.*** =Treatment (***PCT*** =Pre-Commercial Thinning, ***CNTRL*** =Control),

SD =Standard Deviation; ***Min*** =Minimum; ***Max*** =Maximum ***Sig*** .=Significance level ***ND*** = No Data ***Cr. Class*** =Crown Class (***Dom*** .=Dominant, ***Co-Dom*** .=Co-Dominant, ***Inter*** .=Intermediate)

MVOL,Honer =Honer (1983) estimated Tree Length Merchantable Volume (inside bark, equation 22) excluding 15 cm stump and to same top end diameter as stem analysis data for same tree.

MVOL, Stem Analysis = Merchantable Volume (inside bark) excluding stump and including all whole sections up to and including sections with inside bark greater than 7.0 cm.

MVOL, Honer-Stem Analysis =Honer Volume minus Stem Analysis Volume Highly Significant (<0.001) Marginally Significant (<0.15)

Wilcoxon =Probabilty that the difference in MVOL between Honer and stem analysis due to chance. Data not normally distributed, therefore the Wilcoxon related-sample signed rank tests (***RSRT***) was used (IBM® SPSS® 23)

Bias =The sum of the differences between Honer and Actual MVOL divided by the sum of the Actual MVOL multiplied by 100 ***SA:Hon*** =The sum of the Stem Analysis MVOL divided by the sum of the Honer MVOL

Discussion

The total and merchantable volume of Cape Breton Highland grown trees were more frequently overestimated by Honer (1983) than Mainland trees (Figure 3). The rot study data shows that Highland trees were over estimated by 4.8% (sig.=0.010) and 2.9% (ns) respectively for total and merchantable volume. On the other hand, Mainland trees were underestimated by 0.3% (ns) and 3.4% (sig.<0.001) respectively for total and merchantable volume.

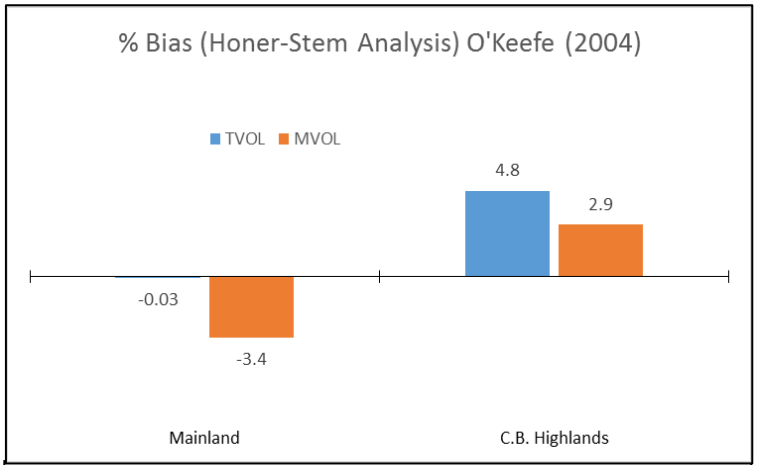

Figure 3. Percent Bias (Tables 2&3) of Honer estimates compared to stem analysis for Total (TVOL) and Merchantable Volume (MVOL) by Region (Mainland and Cape Breton Highlands) for O"Keefe et. al. (2004) data.
% Bias = (Honer-Stem Analysis)/Stem Analysis *100. When bar is below zero, Honer estimates are less than stem analysis, when bar is above zero Honer estimates are more than stem analysis.

Trees grown in PCT stands were also more frequently overestimated by Honer (1983) than those in un-thinned stands (Figure 4). PCT stands on the Highlands were overestimated by 6.3% (sig. =0.026) and 4.5% (sig.=0.144) respectively for total and merchantable volume. In un-thinned Highland stands, Honer overestimated total and merchantable volume by only 2.5% (ns) and 0.3% (ns) respectively. The pattern is repeated for the Mainland, where trees from PCT stands were overestimated by 1.6% (sig.<0.001) for total volume and underestimated by 1% (ns) for merchantable volume. On the other hand, unthinned stands on the Mainland were underestimated by 2.9% (sig.<0.001) and 6.5% (sig.<0.001) respectively for total and merchantable volume.

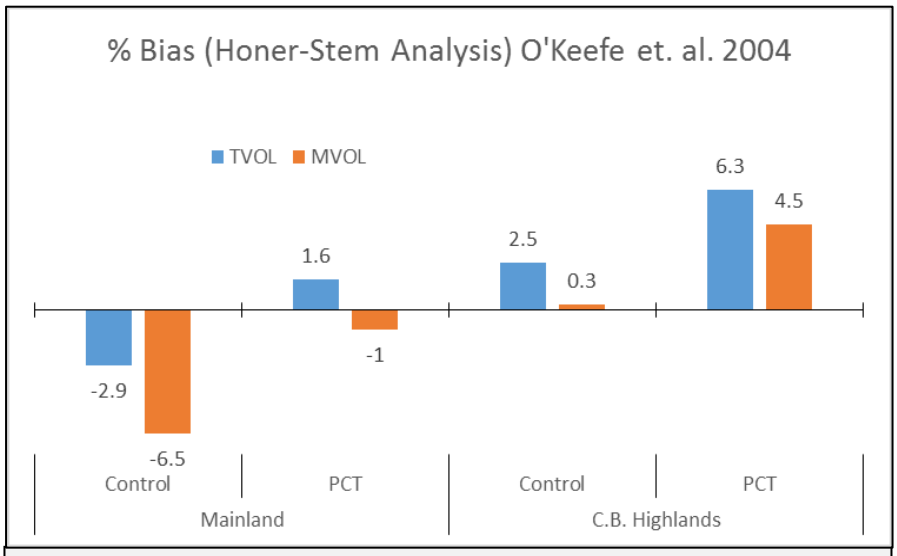

Figure 4. Percent Bias (Tables 2&3) of Honer estimates compared to stem analysis for Total (TVOL) and Merchantable Volume (MVOL) by Region (Mainland and Cape Breton Highlands) and Treatment (Control and Pre-Commercial Thinning) for O'Keefe et. al. (2004) data.
% Bias = (Honer-Stem Analysis)/Stem Analysis *100. When bar is below zero, Honer estimates are less than stem analysis, when bar is above zero Honer estimates are more than stem analysis.

These results show that the accuracy of Honer equations in estimating volume depends on stand and site conditions. Open grown trees or those impacted by exposure to winds such as on the Cape Breton Highlands may have higher taper than those used to derive Honer volume tables and therefore result in overestimates. On the other hand, trees grown in dense stands tend to have less taper and may be underestimated by Honer. It is noted that trees selected for stem analysis in the rot study were from fully stocked, denser portions of stands studied.

Stem analysis data that was used to derive Honer's (1967) does not cover the range of diameter and height combinations evident in PCT stands grown on Cape Breton Highlands (Figure 5). Conditions on the Highlands of Cape Breton have resulted in balsam fir with relatively large

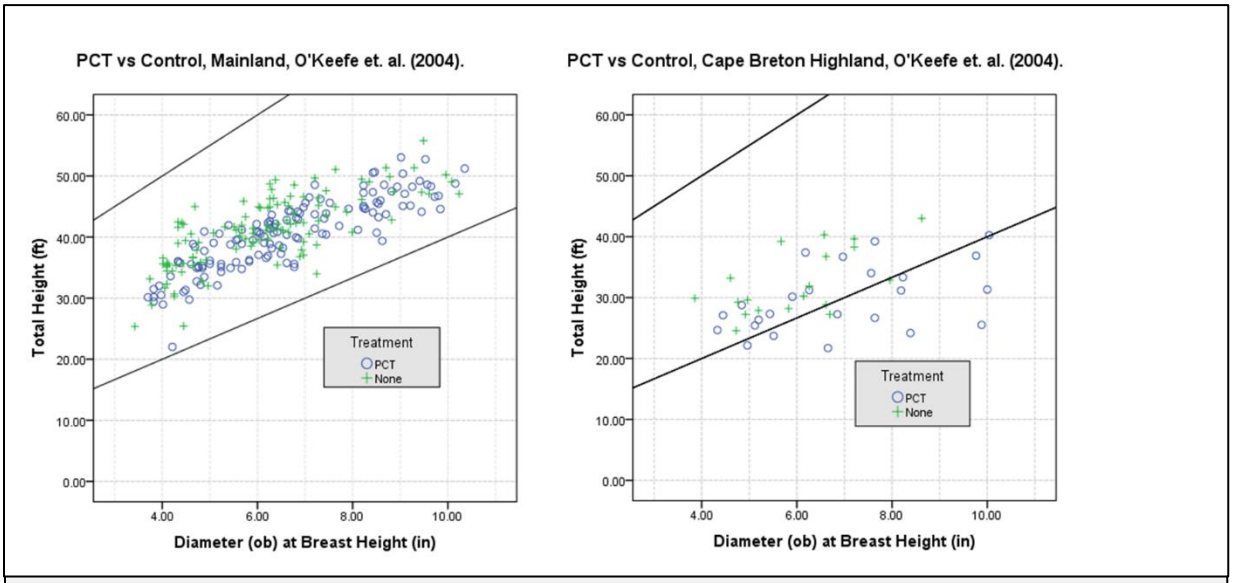

Figure 5. Diameter vs height for stem analysis trees compared to Honer (1967) data range. Lines represent the upper and lower range for data used to derive Honer standard volumes.

diameters for a given height. This is especially evident for PCT stands where density reductions accelerate diameter growth in relation to height growth. It is understandable that stem analysis data for PCTs were not likely available to Honer when deriving his tables during the 1960's.

Despite the pattern of differences between Honer estimates and stem analysis observed in this study, deviations from stem analysis data are relatively small compared to the stated accuracy of the estimates by Honer (1967) of + or – 20.9 %. When all trees are combined from the O'Keefe et. al. (2004) study the differences between Honer and stem analysis total volume averages only 0.3 % (ns). In the case of merchantable volume, estimates are 2.6% low (sig. <0.001).

Recommendations

To adjust Honer (1983) merchantable volume estimates for a dense, non-spaced young balsam fir stand growing on a non-exposed site, Honer estimates could be multiplied by 1.070 (Table 3). For young PCT stands growing on exposed sites similar to the Cape Breton Highlands, Honer merchantable volume estimates could be multiplied by 0.957 (Table 3).

Other Merchantable Volume Estimation Considerations

Users of Honer et. al. (1983) should be aware, that these equations estimate gross merchantable tree length volumes to a given top diameter limit and stump height. Adjustments should be made to these estimates to account for losses due to short wood harvesting methods, waste and cull to accurately estimate the realized volume from harvests or net usable merchantable volume.

Estimates from Keys and McGrath (2002) can be used to estimate the differences between shortwood (8 foot sections) and tree length volume. The loss from tops left on site in shortwood operations makes up a relatively larger portion of the tree length volume for short trees compared to taller trees. For the case where average Dbh is 18 cm and average total height is 9 m (average for the PCT trees sectioned on Cape Breton Highlands in O'Keefe et. al., 2004), shortwood yields are estimated to be 10% lower than tree length volume for a 7.62 cm top diameter limit. If the diameter and height are smaller, relative yields for shortwood would be even lower. For example, for a Dbh of 12 cm and height of 8 m, shortwood volume is 21% lower than tree length volume. Shortwood losses are lower, on a percentage basis, for taller trees. For example, the loss associated with a 18 cm Dbh tree 18 m tall is only 4%.

Reductions to gross merchantable volume also occur from merchantable wood left on site and cull that was not anticipated in the cruise of standing wood. A survey completed by the Nova Scotia Dept of Lands and Forests (Snow and Eddy, 1982) estimated waste including merchantable boles and trees left on sites as 6.5% of net merchantable volume. O'Keefe et. al., (2004) estimated culled volume in young balsam fir stands due to rot as 3.9%.

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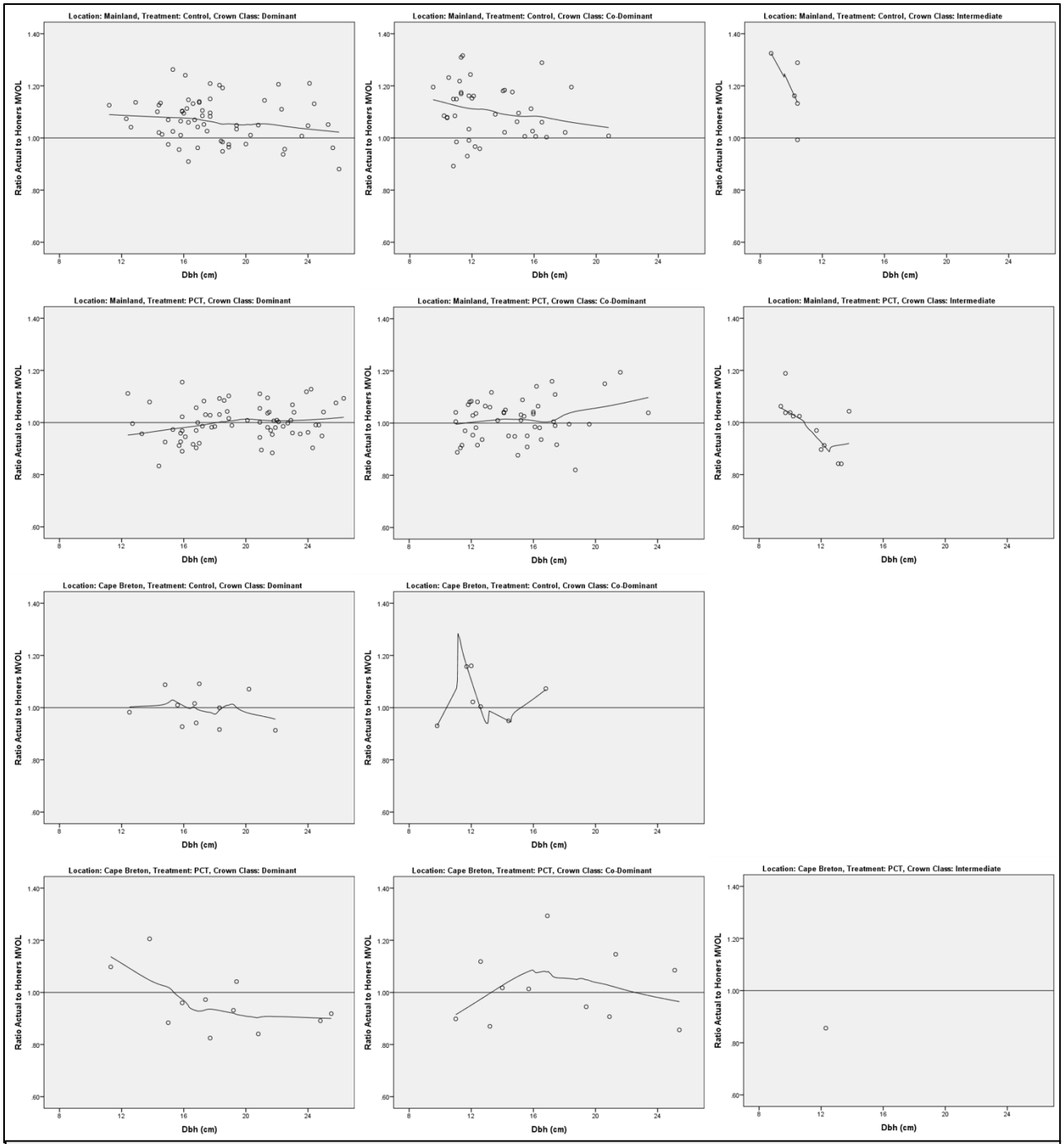

Appendix I. The Ratio of Actual (stem analysis) to Honer (estimated) Merchantable Volume by Regions (Mainland Nova Scotia and Cape Breton Highlands), Treatments (Control and Pre-Commercial Thinning) and Crown Class (Dominant, Co-Dominant and Intermediate) versus Diameter at breast height outside bark (Dbh). The Reference line represents when the stem analysis and Honers estimate are identical. The Regression line represents the results of a Loess regression (Cleveland, 1979) using the Epanechnikov (1969) method using 80% of the points for fit. When regression line is above reference line, Honer is underestimating volume. When regression line is below reference line, Honer is overestimating volume.

Appendix II. Stem Characteristics for Trees from O'Keefe et. al. (2004)

Case #	Location	Location #	Region	Treatment	Tree #	Crown Class	Dbh cm	Height m	Top_{Dib} cm	$TVOL_{stem}$ m^3	$TVOL_{honer}$ m^3	$MVOL_{stem}$ m^3	$MVOL_{honer}$ m^3
1	BARREN HILL	9538	Mainland	PCT	1	Intermediate	9.4	9.22	7.8	0.0291	0.0316	0.0167	0.0157
2	BARREN HILL	9538	Mainland	PCT	2	Intermediate	13.1	9.78	8.3	0.0570	0.0644	0.0423	0.0502
3	BARREN HILL	9538	Mainland	PCT	3	Co-Dominant	16.5	11.36	8.1	0.1074	0.1152	0.0945	0.1009
4	BARREN HILL	9538	Mainland	PCT	4	Dominant	22.7	14.70	8.9	0.2600	0.2659	0.2410	0.2416
5	BARREN HILL	9538	Mainland	PCT	5	Intermediate	11.7	10.84	7.1	0.0530	0.0558	0.0435	0.0449
6	BARREN HILL	9538	Mainland	PCT	6	Co-Dominant	15.4	12.36	7.9	0.1072	0.1072	0.0952	0.0928
7	BARREN HILL	9538	Mainland	PCT	7	Dominant	25.8	14.86	7.1	0.3634	0.3463	0.3452	0.3211
8	BARREN HILL	9538	Mainland	PCT	8	Co-Dominant	16.2	12.85	7.7	0.1332	0.1223	0.1231	0.1079
9	BARREN HILL	9538	Mainland	PCT	9	Dominant	21.4	13.42	8.0	0.2212	0.2206	0.2086	0.2014
10	BLUE MT.	9507	Mainland	PCT	1	Dominant	13.3	10.43	7.7	0.0652	0.0699	0.0552	0.0577
11	BLUE MT.	9507	Mainland	PCT	2	Dominant	12.4	11.45	7.4	0.0698	0.0655	0.0591	0.0532
12	BLUE MT.	9507	Mainland	PCT	3	Dominant	15.3	11.30	7.8	0.0951	0.0987	0.0832	0.0855
13	BLUE MT.	9507	Mainland	PCT	5	Dominant	15.9	11.85	7.8	0.0987	0.1106	0.0862	0.0969
14	BLUE MT.	9507	Mainland	PCT	6	Dominant	15.7	11.15	7.8	0.0929	0.1028	0.0818	0.0897
15	BLUE MT.	9507	Mainland	PCT	7	Co-Dominant	12.4	10.13	7.6	0.0556	0.0594	0.0434	0.0474
16	CROSS BROOK RD	9523	Mainland	PCT	1	Co-Dominant	11.1	10.89	7.2	0.0463	0.0504	0.0343	0.0386
17	CROSS BROOK RD	9523	Mainland	PCT	2	Dominant	14.4	12.55	7.6	0.0805	0.0949	0.0678	0.0814
18	CROSS BROOK RD	9523	Mainland	PCT	3	Dominant	15.9	12.60	7.4	0.1113	0.1160	0.0996	0.1028
19	CROSS BROOK RD	9523	Mainland	PCT	4	Co-Dominant	12.7	10.85	7.4	0.0608	0.0658	0.0507	0.0541
20	CROSS BROOK RD	9523	Mainland	PCT	5	Dominant	21.6	13.91	7.4	0.2187	0.2310	0.2058	0.2122
21	CROSS BROOK RD	9523	Mainland	PCT	6	Dominant	18.6	14.09	8.2	0.1807	0.1729	0.1679	0.1548
22	CROSS BROOK RD	9523	Mainland	PCT	7	Dominant	23.0	13.74	7.5	0.2461	0.2595	0.2295	0.2390
23	CROSS BROOK RD	9523	Mainland	PCT	8	Dominant	22.9	16.17	7.5	0.2850	0.2903	0.2697	0.2674
24	DUNMORE	9512	Mainland	PCT	1	Co-Dominant	16.4	11.76	8.9	0.1123	0.1170	0.0975	0.0993
25	DUNMORE	9512	Mainland	PCT	2	Co-Dominant	19.6	12.77	8.3	0.1730	0.1782	0.1597	0.1604
26	DUNMORE	9512	Mainland	PCT	3	Dominant	21.7	13.19	8.5	0.1964	0.2239	0.1798	0.2035
27	DUNMORE	9512	Mainland	PCT	4	Dominant	18.3	14.87	7.1	0.1840	0.1743	0.1732	0.1586
28	DUNMORE	9512	Mainland	PCT	5	Dominant	24.9	14.25	7.5	0.2891	0.3126	0.2741	0.2890
29	DUNMORE	9512	Mainland	PCT	6	Dominant	22.4	14.45	7.4	0.2453	0.2556	0.2319	0.2353
30	DUNMORE	9512	Mainland	PCT	8	Intermediate	12.2	9.78	7.5	0.0507	0.0559	0.0406	0.0445
31	DUNMORE	9512	Mainland	PCT	9	Intermediate	10.6	10.25	7.2	0.0434	0.0438	0.0329	0.0321
32	EASTVILLE RD	9519	Mainland	PCT	1	Dominant	17.8	13.90	7.8	0.1514	0.1568	0.1379	0.1405
33	EASTVILLE RD	9519	Mainland	PCT	2	Co-Dominant	11.0	10.99	7.9	0.0483	0.0499	0.0356	0.0342
34	EASTVILLE RD	9519	Mainland	PCT	3	Co-Dominant	15.2	12.45	7.5	0.1057	0.1051	0.0948	0.0919
35	EASTVILLE RD	9519	Mainland	PCT	5	Dominant	18.8	13.10	8.5	0.1688	0.1672	0.1553	0.1490
36	EASTVILLE RD	9519	Mainland	PCT	7	Dominant	18.3	13.30	8.3	0.1606	0.1602	0.1471	0.1427
37	EASTVILLE RD	9519	Mainland	PCT	8	Co-Dominant	15.6	12.20	8.5	0.0980	0.1089	0.0839	0.0923
38	EASTVILLE RD	9519	Mainland	PCT	9	Dominant	22.0	14.75	8.4	0.2475	0.2504	0.2302	0.2281
39	HARTLAKE	9501	Mainland	PCT	2	Dominant	20.1	13.57	7.1	0.1938	0.1963	0.1815	0.1800
40	HARTLAKE	9501	Mainland	PCT	3	Co-Dominant	12.3	10.72	7.2	0.0613	0.0612	0.0520	0.0502
41	HARTLAKE	9501	Mainland	PCT	4	Intermediate	12.0	10.27	8.1	0.0506	0.0562	0.0372	0.0415
42	HARTLAKE	9501	Mainland	PCT	6	Dominant	16.8	12.30	7.8	0.1214	0.1272	0.1093	0.1127
43	HARTLAKE	9501	Mainland	PCT	7	Dominant	15.9	12.88	8.2	0.1184	0.1180	0.1042	0.1020
44	HARTLAKE	9501	Mainland	PCT	8	Dominant	21.8	13.98	8.1	0.2308	0.2362	0.2171	0.2157
45	HARTLAKE	9501	Mainland	PCT	9	Co-Dominant	12.3	10.58	7.1	0.0574	0.0605	0.0491	0.0500
46	HARTLAKE	9501	Mainland	PCT	10	Dominant	23.9	14.97	8.4	0.3264	0.2988	0.3064	0.2740
47	HARTLAKE	9501	Mainland	PCT	11	Dominant	19.1	13.88	8.7	0.1749	0.1803	0.1587	0.1605
48	KEMPTOWN	9504	Mainland	PCT	1	Co-Dominant	11.9	11.68	8.0	0.0618	0.0613	0.0491	0.0454
49	KEMPTOWN	9504	Mainland	PCT	2	Co-Dominant	15.0	11.98	7.6	0.0875	0.0993	0.0756	0.0862
50	KEMPTOWN	9504	Mainland	PCT	3	Co-Dominant	14.1	10.95	8.1	0.0809	0.0817	0.0705	0.0677
51	KEMPTOWN	9504	Mainland	PCT	4	Dominant	15.8	12.90	8.6	0.1085	0.1167	0.0949	0.0990
52	KEMPTOWN	9504	Mainland	PCT	5	Co-Dominant	16.3	12.40	8.8	0.1239	0.1205	0.1091	0.1025
53	KEMPTOWN	9504	Mainland	PCT	6	Co-Dominant	15.3	12.50	8.5	0.1100	0.1068	0.0978	0.0898
54	KEMPTOWN	9504	Mainland	PCT	7	Dominant	24.7	14.24	7.8	0.2939	0.3074	0.2809	0.2836
55	KEMPTOWN	9504	Mainland	PCT	8	Dominant	24.0	13.40	7.9	0.2621	0.2772	0.2456	0.2552
56	KEMPTOWN	9504	Mainland	PCT	9	Dominant	20.9	14.42	7.5	0.2391	0.2222	0.2259	0.2035
57	LYNCH RIVER	9536	Mainland	PCT	1	Dominant	23.0	15.36	8.5	0.2910	0.2820	0.2752	0.2577
58	LYNCH RIVER	9536	Mainland	PCT	2	Dominant	18.9	13.34	8.2	0.1837	0.1713	0.1694	0.1537
59	LYNCH RIVER	9536	Mainland	PCT	3	Dominant	21.4	14.42	7.5	0.2507	0.2329	0.2339	0.2137
60	LYNCH RIVER	9536	Mainland	PCT	5	Co-Dominant	17.5	12.39	7.9	0.1261	0.1388	0.1134	0.1237
61	LYNCH RIVER	9536	Mainland	PCT	7	Co-Dominant	17.3	12.12	8.1	0.1324	0.1333	0.1186	0.1180
62	LYNCH RIVER	9536	Mainland	PCT	8	Dominant	26.3	15.64	8.3	0.3961	0.3737	0.3768	0.3448
63	LYNCH RIVER	9536	Mainland	PCT	9	Co-Dominant	13.3	10.85	8.4	0.0764	0.0722	0.0631	0.0565
64	LYNCH RIVER	9536	Mainland	PCT	10	Co-Dominant	14.2	12.06	8.1	0.0914	0.0895	0.0781	0.0744
65	MACULLUMST	9505	Mainland	PCT	1	Intermediate	10.2	8.85	7.2	0.0349	0.0360	0.0258	0.0252

Appendix II. Stem Characteristics for Trees from O'Keefe et. al. (2004)

Case #	Location	Location #	Region	Treatment	Tree #	Crown Class	Dbh cm	Height m	Top_{Dib} cm	$TVOL_{stem}$ m^3	$TVOL_{honer}$ m^3	$MVOL_{stem}$ m^3	$MVOL_{honer}$ m^3
66	MACULLUMST	9505	Mainland	PCT	2	Dominant	18.9	12.31	7.4	0.1582	0.1610	0.1487	0.1464
67	MACULLUMST	9505	Mainland	PCT	3	Dominant	15.9	12.99	7.9	0.1312	0.1188	0.1198	0.1037
68	MACULLUMST	9505	Mainland	PCT	4	Dominant	17.3	13.15	7.9	0.1500	0.1420	0.1367	0.1263
69	MACULLUMST	9505	Mainland	PCT	6	Dominant	21.9	12.05	8.3	0.2034	0.2126	0.1901	0.1939
70	MACULLUMST	9505	Mainland	PCT	7	Co-Dominant	20.6	12.58	9.9	0.2101	0.1945	0.1970	0.1712
71	MACULLUMST	9505	Mainland	PCT	8	Co-Dominant	11.0	10.92	7.8	0.0476	0.0496	0.0348	0.0346
72	MACULLUMST	9505	Mainland	PCT	9	Co-Dominant	12.0	10.65	7.4	0.0594	0.0579	0.0499	0.0460
73	MACULLUMST	9505	Mainland	PCT	10	Dominant	22.1	13.30	7.7	0.2271	0.2337	0.2150	0.2145
74	MCKEEN RD	9510	Mainland	PCT	1	Dominant	16.8	10.90	7.6	0.1035	0.1156	0.0930	0.1030
75	MCKEEN RD	9510	Mainland	PCT	2	Co-Dominant	11.4	9.55	8.0	0.0432	0.0478	0.0309	0.0338
76	MCKEEN RD	9510	Mainland	PCT	5	Dominant	15.8	11.23	7.5	0.0998	0.1047	0.0856	0.0924
77	MCKEEN RD	9510	Mainland	PCT	6	Dominant	17.2	10.70	8.3	0.1156	0.1194	0.1035	0.1050
78	MCKEEN RD	9510	Mainland	PCT	7	Co-Dominant	11.3	9.45	7.9	0.0422	0.0466	0.0299	0.0330
79	MCKEEN RD	9510	Mainland	PCT	9	Dominant	21.7	13.80	8.1	0.2155	0.2317	0.2018	0.2116
80	MCKEEN RD	9510	Mainland	PCT	10	Dominant	23.5	14.65	7.1	0.2661	0.2842	0.2513	0.2628
81	MCKEEN RD	9510	Mainland	PCT	11	Dominant	21.0	13.75	8.3	0.1935	0.2164	0.1758	0.1965
82	NORTH INT	9517	Mainland	PCT	1	Co-Dominant	18.3	12.60	8.8	0.1513	0.1537	0.1347	0.1353
83	NORTH INT	9517	Mainland	PCT	2	Co-Dominant	16.0	11.63	7.4	0.1107	0.1104	0.1014	0.0979
84	NORTH INT	9517	Mainland	PCT	3	Intermediate	13.3	10.70	8.2	0.0620	0.0714	0.0478	0.0568
85	NORTH INT	9517	Mainland	PCT	4	Co-Dominant	16.1	12.70	8.3	0.1156	0.1197	0.1019	0.1034
86	NORTH INT	9517	Mainland	PCT	5	Intermediate	9.7	9.20	7.9	0.0312	0.0336	0.0184	0.0177
87	NORTH INT	9517	Mainland	PCT	7	Intermediate	13.8	10.65	9.4	0.0709	0.0766	0.0584	0.0560
88	OTTERBROOK	9530	Mainland	PCT	1	Intermediate	10.0	9.87	7.5	0.0375	0.0378	0.0251	0.0242
89	OTTERBROOK	9530	Mainland	PCT	2	Dominant	17.7	13.68	8.1	0.1537	0.1532	0.1400	0.1362
90	OTTERBROOK	9530	Mainland	PCT	3	Dominant	20.9	13.65	7.5	0.2100	0.2132	0.1954	0.1952
91	OTTERBROOK	9530	Mainland	PCT	4	Co-Dominant	12.9	11.90	7.4	0.0765	0.0731	0.0645	0.0606
92	OTTERBROOK	9530	Mainland	PCT	5	Co-Dominant	15.2	12.83	8.1	0.1052	0.1075	0.0929	0.0919
93	OTTERBROOK	9530	Mainland	PCT	6	Co-Dominant	17.4	13.11	7.3	0.1384	0.1433	0.1279	0.1292
94	OTTERBROOK	9530	Mainland	PCT	7	Dominant	24.2	16.05	7.7	0.3538	0.3224	0.3354	0.2974
95	OTTERBROOK	9530	Mainland	PCT	8	Dominant	21.4	15.40	7.3	0.2346	0.2446	0.2206	0.2248
96	PLEASENT VALLEY	9526	Mainland	PCT	2	Dominant	17.4	12.11	8.2	0.1353	0.1348	0.1227	0.1191
97	PLEASENT VALLEY	9526	Mainland	PCT	3	Dominant	12.7	11.02	8.3	0.0646	0.0666	0.0505	0.0507
98	PLEASENT VALLEY	9526	Mainland	PCT	4	Dominant	16.1	12.41	7.5	0.1098	0.1176	0.0985	0.1042
99	PLEASENT VALLEY	9526	Mainland	PCT	5	Dominant	16.8	13.06	7.7	0.1351	0.1332	0.1251	0.1184
100	PLEASENT VALLEY	9526	Mainland	PCT	6	Dominant	13.8	11.83	7.1	0.0865	0.0832	0.0776	0.0719
101	PLEASENT VALLEY	9526	Mainland	PCT	7	Co-Dominant	12.1	10.65	7.4	0.0540	0.0589	0.0449	0.0471
102	RIVERSDALE	9525	Mainland	PCT	1	Co-Dominant	12.1	10.73	8.5	0.0566	0.0592	0.0430	0.0418
103	RIVERSDALE	9525	Mainland	PCT	2	Co-Dominant	13.2	12.37	8.0	0.0798	0.0788	0.0673	0.0634
104	RIVERSDALE	9525	Mainland	PCT	4	Dominant	23.1	14.47	7.4	0.2750	0.2721	0.2608	0.2509
105	RIVERSDALE	9525	Mainland	PCT	5	Co-Dominant	14.1	12.03	8.6	0.0861	0.0880	0.0733	0.0705
106	RIVERSDALE	9525	Mainland	PCT	6	Dominant	18.0	14.18	7.3	0.1565	0.1627	0.1451	0.1474
107	RIVERSDALE	9525	Mainland	PCT	7	Dominant	17.0	13.48	7.2	0.1266	0.1397	0.1158	0.1258
108	RIVERSDALE	9525	Mainland	PCT	9	Dominant	16.9	13.52	7.6	0.1357	0.1384	0.1234	0.1234
109	ROUND LAKE	9540	Mainland	PCT	1	Dominant	20.9	14.76	7.1	0.2329	0.2261	0.2191	0.2078
110	ROUND LAKE	9540	Mainland	PCT	2	Co-Dominant	17.4	13.48	7.1	0.1564	0.1464	0.1469	0.1324
111	ROUND LAKE	9540	Mainland	PCT	3	Co-Dominant	17.2	10.86	7.9	0.1336	0.1208	0.1245	0.1073
112	ROUND LAKE	9540	Mainland	PCT	4	Co-Dominant	21.6	12.40	7.7	0.2413	0.2115	0.2315	0.1938
113	ROUND LAKE	9540	Mainland	PCT	5	Dominant	24.5	14.73	8.9	0.2973	0.3102	0.2812	0.2838
114	ROUND LAKE	9540	Mainland	PCT	6	Co-Dominant	23.4	13.71	8.3	0.2712	0.2681	0.2554	0.2458
115	ROUND LAKE	9540	Mainland	PCT	8	Co-Dominant	13.7	12.76	7.1	0.0864	0.0870	0.0758	0.0750
116	ROUND LAKE	9540	Mainland	PCT	10	Co-Dominant	11.8	11.80	7.9	0.0626	0.0607	0.0484	0.0452
117	SOUTH RANGE	9541	Mainland	PCT	2	Co-Dominant	16.0	13.30	8.0	0.1231	0.1225	0.1113	0.1068
118	SOUTH RANGE	9541	Mainland	PCT	3	Dominant	20.9	13.75	7.4	0.1978	0.2144	0.1853	0.1965
119	SOUTH RANGE	9541	Mainland	PCT	5	Co-Dominant	14.8	11.05	7.4	0.0864	0.0907	0.0750	0.0790
120	SOUTH RANGE	9541	Mainland	PCT	6	Dominant	21.5	15.45	8.4	0.2506	0.2475	0.2340	0.2250
121	SOUTH RANGE	9541	Mainland	PCT	7	Co-Dominant	12.4	12.48	7.9	0.0720	0.0701	0.0589	0.0545
122	SOUTH RANGE	9541	Mainland	PCT	8	Dominant	25.0	13.57	9.8	0.3069	0.3037	0.2871	0.2760
123	SOUTH RANGE	9541	Mainland	PCT	9	Co-Dominant	18.7	12.34	7.6	0.1294	0.1579	0.1173	0.1430
124	SOUTH RANGE	9541	Mainland	PCT	10	Dominant	24.3	14.81	8.0	0.2703	0.3064	0.2547	0.2821
125	TRAFALGAR	9514	Mainland	PCT	1	Co-Dominant	11.6	9.07	8.2	0.0436	0.0475	0.0322	0.0332
126	TRAFALGAR	9514	Mainland	PCT	2	Dominant	16.6	11.65	8.1	0.1093	0.1190	0.0956	0.1043
127	TRAFALGAR	9514	Mainland	PCT	5	Co-Dominant	14.4	10.47	7.8	0.0772	0.0822	0.0664	0.0698
128	TRAFALGAR	9514	Mainland	PCT	6	Intermediate	9.7	8.96	7.2	0.0349	0.0329	0.0254	0.0214
129	TRAFALGAR	9514	Mainland	PCT	7	Dominant	14.8	10.95	8.4	0.0831	0.0900	0.0694	0.0750
130	TRAFALGAR	9514	Mainland	PCT	8	Co-Dominant	15.6	11.88	8.5	0.0991	0.1067	0.0860	0.0904
131	BARREN HILL	9539	Mainland	Control	3	Co-Dominant	11.4	12.02	7.3	0.0671	0.0575	0.0586	0.0445
132	BARREN HILL	9539	Mainland	Control	4	Dominant	15.3	13.70	8.6	0.1140	0.1146	0.0983	0.0959

Appendix II. Stem Characteristics for Trees from O'Keefe et. al. (2004)

Case #	Location	Location #	Region	Treatment	Tree #	Crown Class	Dbh cm	Height m	Top_{Dib} cm	$TVOL_{stem}$ m^3	$TVOL_{honer}$ m^3	$MVOL_{stem}$ m^3	$MVOL_{honer}$ m^3
133	BARREN HILL	9539	Mainland	Control	5	Dominant	17.7	14.21	8.0	0.1804	0.1576	0.1698	0.1405
134	BARREN HILL	9539	Mainland	Control	6	Dominant	17.0	14.23	8.3	0.1583	0.1455	0.1455	0.1276
135	BLUE MT	9513	Mainland	Control	1	Dominant	12.6	9.77	8.4	0.0587	0.0595	0.0463	0.0445
136	BLUE MT	9513	Mainland	Control	2	Dominant	12.3	9.97	7.4	0.0591	0.0577	0.0500	0.0466
137	BLUE MT	9513	Mainland	Control	3	Co-Dominant	11.3	7.75	7.2	0.0424	0.0395	0.0358	0.0306
138	BLUE MT	9513	Mainland	Control	4	Dominant	17.3	12.85	9.0	0.1424	0.1395	0.1264	0.1202
139	BLUE MT	9513	Mainland	Control	5	Dominant	17.5	11.20	7.6	0.1284	0.1282	0.1180	0.1150
140	BLUE MT	9513	Mainland	Control	6	Dominant	18.9	13.25	7.7	0.1647	0.1704	0.1488	0.1542
141	CROSS BROOK RD	9522	Mainland	Control	1	Co-Dominant	14.1	11.60	8.1	0.0833	0.0856	0.0724	0.0709
142	CROSS BROOK RD	9522	Mainland	Control	2	Co-Dominant	11.8	11.19	8.2	0.0608	0.0582	0.0484	0.0417
143	CROSS BROOK RD	9522	Mainland	Control	3	Co-Dominant	9.5	10.10	7.7	0.0357	0.0348	0.0223	0.0187
144	CROSS BROOK RD	9522	Mainland	Control	4	Dominant	16.3	12.84	8.5	0.1270	0.1237	0.1129	0.1065
145	CROSS BROOK RD	9522	Mainland	Control	5	Dominant	17.7	12.92	7.5	0.1550	0.1466	0.1429	0.1320
146	CROSS BROOK RD	9522	Mainland	Control	6	Dominant	17.2	13.38	7.9	0.1494	0.1422	0.1371	0.1264
147	DUNMORE	9516	Mainland	Control	1	Dominant	15.0	12.37	7.8	0.1050	0.1018	0.0938	0.0877
148	DUNMORE	9516	Mainland	Control	2	Co-Dominant	10.5	10.85	7.3	0.0489	0.0450	0.0396	0.0322
149	DUNMORE	9516	Mainland	Control	3	Dominant	15.8	12.75	8.4	0.1187	0.1156	0.1053	0.0989
150	DUNMORE	9516	Mainland	Control	4	Dominant	20.0	13.45	8.1	0.1853	0.1930	0.1707	0.1748
151	DUNMORE	9516	Mainland	Control	5	Dominant	17.7	11.95	8.0	0.1519	0.1380	0.1414	0.1230
152	DUNMORE	9516	Mainland	Control	6	Dominant	22.4	12.95	7.8	0.2179	0.2352	0.2023	0.2159
153	DUNMORE	9516	Mainland	Control	8	Dominant	14.3	12.25	8.4	0.0934	0.0918	0.0828	0.0752
154	EASTVILLE RD	9520	Mainland	Control	1	Dominant	17.2	14.80	8.5	0.1715	0.1534	0.1483	0.1342
155	EASTVILLE RD	9520	Mainland	Control	3	Dominant	16.0	14.54	7.6	0.1388	0.1310	0.1266	0.1156
156	EASTVILLE RD	9520	Mainland	Control	5	Co-Dominant	13.5	12.70	7.5	0.0881	0.0842	0.0772	0.0708
157	EASTVILLE RD	9520	Mainland	Control	6	Intermediate	10.4	9.85	7.7	0.0469	0.0408	0.0344	0.0267
158	EASTVILLE RD	9520	Mainland	Control	7	Dominant	15.9	14.84	7.9	0.1398	0.1314	0.1264	0.1147
159	EASTVILLE RD	9520	Mainland	Control	8	Co-Dominant	10.2	10.84	7.4	0.0436	0.0424	0.0311	0.0287
160	HARTLAKE	9502	Mainland	Control	2	Dominant	20.3	12.45	7.7	0.1849	0.1874	0.1727	0.1708
161	HARTLAKE	9502	Mainland	Control	3	Intermediate	8.7	7.70	7.7	0.0229	0.0233	0.0114	0.0086
162	HARTLAKE	9502	Mainland	Control	4	Co-Dominant	10.8	9.35	7.5	0.0400	0.0422	0.0269	0.0302
163	HARTLAKE	9502	Mainland	Control	7	Dominant	14.6	12.07	7.2	0.0934	0.0946	0.0839	0.0828
164	HARTLAKE	9502	Mainland	Control	8	Dominant	17.7	11.27	8.3	0.1393	0.1318	0.1278	0.1166
165	HARTLAKE	9502	Mainland	Control	9	Dominant	16.9	12.47	8.9	0.1307	0.1300	0.1163	0.1116
166	KEMPTOWN	9506	Mainland	Control	1	Dominant	11.2	10.42	7.5	0.0508	0.0496	0.0415	0.0369
167	KEMPTOWN	9506	Mainland	Control	2	Dominant	14.4	12.51	7.5	0.0932	0.0947	0.0832	0.0815
168	KEMPTOWN	9506	Mainland	Control	3	Co-Dominant	11.8	11.11	7.8	0.0565	0.0579	0.0451	0.0436
169	KEMPTOWN	9506	Mainland	Control	4	Dominant	18.5	13.06	7.6	0.1561	0.1615	0.1437	0.1460
170	KEMPTOWN	9506	Mainland	Control	5	Dominant	22.5	14.40	8.0	0.2427	0.2572	0.2256	0.2357
171	KEMPTOWN	9506	Mainland	Control	6	Dominant	15.8	12.05	7.4	0.1108	0.1107	0.0990	0.0980
172	KEMPTOWN	9506	Mainland	Control	7	Dominant	15.0	11.95	8.1	0.0949	0.0991	0.0822	0.0843
173	LYNCH RIVER	9537	Mainland	Control	1	Co-Dominant	14.9	11.74	8.1	0.0998	0.0964	0.0869	0.0818
174	LYNCH RIVER	9537	Mainland	Control	2	Co-Dominant	10.8	9.22	7.3	0.0438	0.0417	0.0353	0.0307
175	LYNCH RIVER	9537	Mainland	Control	5	Co-Dominant	16.5	12.54	8.4	0.1292	0.1245	0.1145	0.1080
176	LYNCH RIVER	9537	Mainland	Control	6	Co-Dominant	12.5	11.05	7.6	0.0604	0.0647	0.0498	0.0519
177	LYNCH RIVER	9537	Mainland	Control	7	Dominant	16.6	12.60	8.5	0.1404	0.1265	0.1239	0.1095
178	LYNCH RIVER	9537	Mainland	Control	8	Dominant	25.3	15.32	7.2	0.3456	0.3406	0.3317	0.3155
179	LYNCH RIVER	9537	Mainland	Control	9	Dominant	25.6	14.95	7.7	0.3229	0.3424	0.3046	0.3166
180	MACULLUMST	9508	Mainland	Control	2	Intermediate	10.4	10.65	7.9	0.0409	0.0435	0.0270	0.0272
181	MACULLUMST	9508	Mainland	Control	3	Dominant	14.4	12.83	7.6	0.1018	0.0965	0.0932	0.0828
182	MACULLUMST	9508	Mainland	Control	4	Co-Dominant	14.1	12.53	7.4	0.1011	0.0909	0.0924	0.0781
183	MACULLUMST	9508	Mainland	Control	5	Dominant	17.0	12.85	8.8	0.1426	0.1347	0.1320	0.1162
184	MACULLUMST	9508	Mainland	Control	6	Dominant	19.4	13.70	8.2	0.1873	0.1842	0.1739	0.1659
185	MACULLUMST	9508	Mainland	Control	8	Dominant	16.1	14.20	8.3	0.1521	0.1303	0.1397	0.1126
186	MACULLUMST	9508	Mainland	Control	9	Dominant	22.3	15.20	8.4	0.2833	0.2631	0.2664	0.2400
187	MACULLUMST	9508	Mainland	Control	10	Dominant	22.1	16.13	10.9	0.3061	0.2699	0.2847	0.2361
188	MACULLUMST	9508	Mainland	Control	12	Dominant	24.4	14.33	8.4	0.3302	0.3014	0.3131	0.2768
189	MCKEEN RD	9511	Mainland	Control	1	Co-Dominant	11.7	12.30	7.5	0.0583	0.0617	0.0444	0.0477
190	MCKEEN RD	9511	Mainland	Control	2	Co-Dominant	15.4	13.65	8.0	0.1126	0.1157	0.1004	0.0998
191	MCKEEN RD	9511	Mainland	Control	3	Co-Dominant	11.2	12.85	7.7	0.0648	0.0585	0.0516	0.0424
192	MCKEEN RD	9511	Mainland	Control	4	Dominant	18.9	14.55	8.5	0.1745	0.1829	0.1591	0.1632
193	MCKEEN RD	9511	Mainland	Control	5	Dominant	15.7	12.53	7.3	0.1077	0.1127	0.0954	0.0999
194	MCKEEN RD	9511	Mainland	Control	6	Dominant	16.9	13.75	7.7	0.1321	0.1402	0.1200	0.1247
195	MCKEEN RD	9511	Mainland	Control	7	Dominant	26.0	14.50	8.5	0.2996	0.3453	0.2801	0.3180
196	NORTH INT	9518	Mainland	Control	1	Co-Dominant	15.0	12.63	8.3	0.1072	0.1035	0.0955	0.0872
197	NORTH INT	9518	Mainland	Control	3	Co-Dominant	14.6	13.20	7.7	0.1132	0.1014	0.1023	0.0870
198	NORTH INT	9518	Mainland	Control	4	Dominant	24.0	14.43	8.1	0.2979	0.2931	0.2822	0.2695
199	NORTH INT	9518	Mainland	Control	7	Co-Dominant	18.0	12.35	7.6	0.1439	0.1464	0.1347	0.1319

Appendix II. Stem Characteristics for Trees from O'Keefe et. al. (2004)													
Case #	Location	Location #	Region	Treatment	Tree #	Crown Class	Dbh cm	Height m	Top_{Dib} cm	$TVOL_{stem}$ m^3	$TVOL_{honer}$ m^3	$MVOL_{stem}$ m^3	$MVOL_{honer}$ m^3
267	CROWDIS MTN	9529	Cape Breton	Control	6	Dominant	21.9	13.11	7.5	0.2060	0.2270	0.1904	0.2085
268	CROWDIS MTN	9529	Cape Breton	Control	7	Co-Dominant	14.4	11.95	7.4	0.0864	0.0913	0.0750	0.0790
269	MARIANNA	9533	Cape Breton	Control	1	Dominant	14.8	8.58	9.1	0.0759	0.0738	0.0639	0.0587
270	MARIANNA	9533	Cape Breton	Control	2	Co-Dominant	12.0	7.48	7.2	0.0459	0.0432	0.0405	0.0349
271	MARIANNA	9533	Cape Breton	Control	3	Dominant	20.2	10.04	8.4	0.1640	0.1564	0.1512	0.1412
272	MARIANNA	9533	Cape Breton	Control	4	Co-Dominant	16.8	8.76	7.8	0.1031	0.0968	0.0920	0.0857
273	MARIANNA	9533	Cape Breton	Control	6	Dominant	17.0	8.29	10.6	0.0959	0.0946	0.0814	0.0746
274	WAREHOUSE ROAD	9534	Cape Breton	Control	1	Dominant	12.5	8.33	8.2	0.0496	0.0514	0.0382	0.0389
275	WAREHOUSE ROAD	9534	Cape Breton	Control	2	Co-Dominant	12.1	8.96	7.6	0.0499	0.0511	0.0410	0.0401
276	WAREHOUSE ROAD	9534	Cape Breton	Control	3	Co-Dominant	12.6	9.05	7.8	0.0542	0.0559	0.0445	0.0443
277	WAREHOUSE ROAD	9534	Cape Breton	Control	4	Dominant	15.6	9.22	7.5	0.0874	0.0870	0.0773	0.0766
278	WAREHOUSE ROAD	9534	Cape Breton	Control	5	Dominant	16.8	11.19	7.6	0.1123	0.1180	0.0990	0.1052
279	WAREHOUSE ROAD	9534	Cape Breton	Control	6	Dominant	15.9	9.99	7.3	0.0890	0.0965	0.0795	0.0858