Growth and yield and wood quality in a SBS mixedwood stand after stand density management

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Annual Operational Report (2002/2003)

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TITLE

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ABSTRACT

Interest in managing broadleaf and mixedwood stands has grown. The alternative to mixedwood management, is the current practice of eliminating the broadleaf stand component. There is little information on how to manage these productive stands. The project will determine the relationship between stand density and i) wood quality, ii) white pine weevil and wood quality, and iii) growth and yield. Results will modify existing policy, provide cost-benefit information by treatment, foster better site utilization, and enhance structural and species diversity. Outcomes should facilitate forest certification. A strategic research management plan for SBS mixedwoods will be available by 31 March/03.

KEY WORDS

Stand density, wood quality, white pine weevil, *Pissodes strobi*, growth and yield, sub-boreal spruce zone, mixedwoods

A. SUMMARY OF ACTIVITIES AND RESULTS

Activities

This project was carried out on the site established under FII project R02-21.

Target trees of both spruce and birch were chosen from various densities of paper birch. The target densities were (<800), (1000-1800), (2000-2800), (3000-3800) and (>3800) SPH. Ten target trees (plots) for each species were obtained from every density category. The target trees were chosen based on crown class; only co-dominant and dominant trees were selected. The height and diameter at breast height (dbh) was measured and then six segments were cut from each of these trees. The segments were cut at the base, dbh, and 20-40-60-80% of total tree height. Where the 20% mark was within 15cm of dbh, only one cookie was cut to represent both sections.

Around each target tree a 3.99 m plot was temporarily established. The species and dbh of each competing tree within the plot was recorded. Additionally, distance and azimuth, from the target tree to each competing tree, was recorded.

Although all six cookies were cut and collected from each target tree in the field, only breast height (dbh) cookies were examined this fiscal year. The breast height cookies were cut in half; half were sent to Forintek for wood quality analysis, the other half was prepared for growth and yield analysis at UNBC.

a) Growth and Yield

The growth and yield cookies were sanded and scanned using a software program called WinDENDRO (6.5a), which allows the user to measure the diameter growth increments of each tree ring. The data is stored in an excel file. Two radii were measured on average, however, when there was compression wood a third radius was included. From this data, tree number/ cookie name, section height, ring count and width of the ring (in mm), was recorded.

b) Wood Quality

"Knot-free discs were sawn from approximately 47 young spruce and 46 birch tree stem segments. Pith-to-bark strips were extracted in a Soxhlet apparatus with ethanol/cyclohexane (1:2 by volume) for 24 hours, and in hot water for a further 24 hours. They were then air dried and sawn to a uniform thickness of 1.57 m on a twin-blade microsaw. The extractive-free radial strips were air-dried to approximately 8 percent equilibrium moisture content. Using a microscope where necessary, the radial strips were marked with calendar year dates and a starting position for pith-to-bark x-ray scanning."[1]

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[1] Munro, B.D. 2003. X-ray Densitometry of Young Interior Spruce and Paper Birch Tree Stem Samples. Forintek Canada Corp. March 2003.

“The prepared samples were scanned on Forintek’s Direct Reading X-Ray Densitometer. The densitometer measures ring density in increments of 0.0254 mm (0.001 inch). Wood density was calculated as the average of the individual ring densities weighted by their estimated cross-sectional area.”[1]

Results

a) Growth and Yield

Forty-seven spruce and 50 paper birch trees were destructively sampled for wood quality and growth analyses.

There was no relationship between individual tree diameter or basal area, for both species, and indicators of stand density, total stems or total basal area per 3.99 m radius plot around the target tree (Figures 1, 2, and 3; Equations 1 to 6). This is surprising as the number of other trees per plot ranged from 2 to 42 (400 to 8400 sph). A similar relationship was found for current tree height in relation to the two indicators of stand density (not presented). These data suggest for this rich site (see below) that neither intra- or inter- specific competition is influencing diameter growth of the sampled trees.

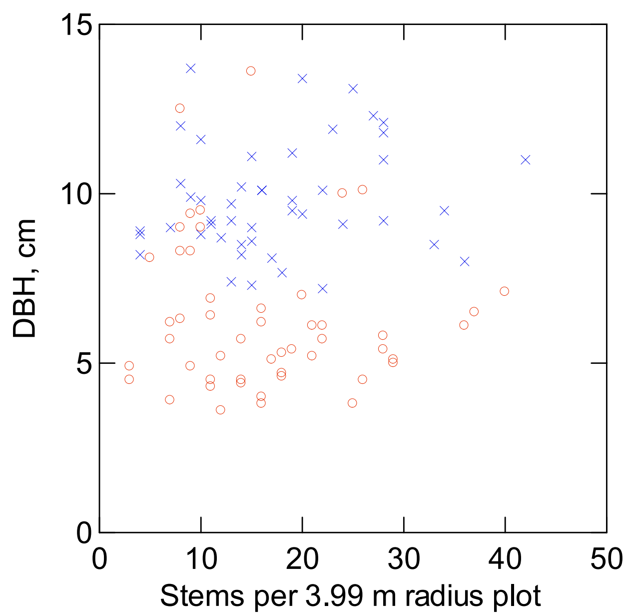

Figure 1. Diameter at breast height (DBH) for spruce (x) and paper birch (o) in relation to the number of total stems within a 3.99 m radius of the target tree.

Regressions were not significant for both species:
Equation 1: Spruce DBH = 9.268 + 0.0312 * $Stem_{plot}$ $r^2 = 0.028$; $P = 0.256$; $df = 45$
Equation 2: Birch DBH = 6.683 - 0.0235 * $Stem_{plot}$ $r^2 = 0.009$; $P = 0.515$; $df = 48$

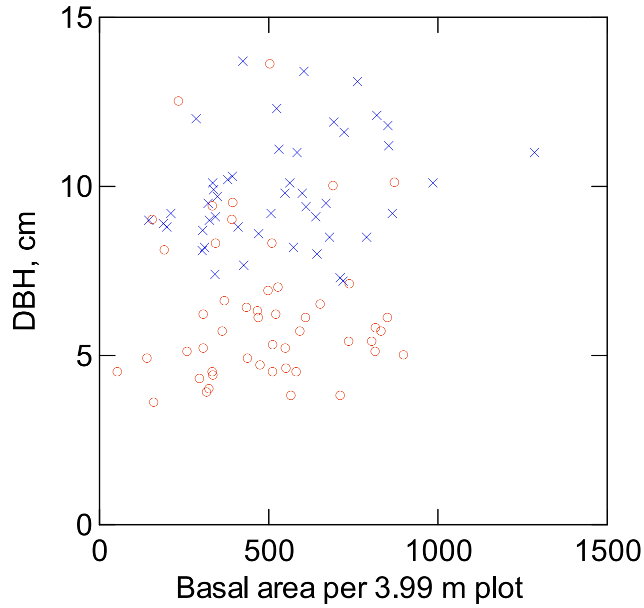

Figure 2. Diameter at breast height (DBH) for spruce (x) and paper birch (o) in relation to the total basal area (cm^2) within a 3.99 m radius of the target tree.

Regressions were not significant for both species:
Equation 3: Spruce $DBH = 8.832 + 0.0018 * BA_{plot}$ $r^2 = 0.071$; $P = 0.070$; $df = 45$
Equation 4: Birch $DBH = 6.366 - 0.0001 * BA_{plot}$ $r^2 = 0.0002$; $P = 0.924$; $df = 48$

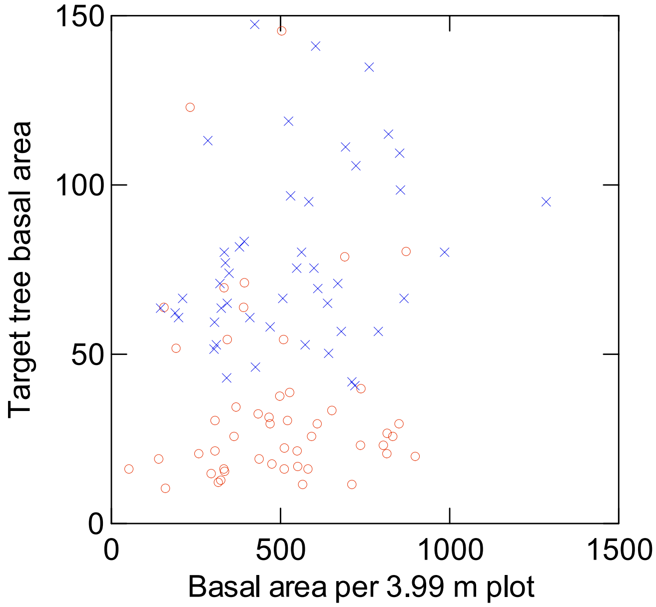

Figure 3. Individual tree basal area (cm^2) for spruce (x) and paper birch (o) in relation to the total basal area (cm^2) within a 3.99 m radius of the target tree.

Regressions were not significant for both species:
Equation 5: Spruce BA = 61.683 + 0.0299 * BA_{plot} $r^2 = 0.072$; P = 0.069; df = 45
Equation 6: Birch BA = 37.601 - 0.0056 * BA_{plot} $r^2 = 0.002$; P = 0.767; df = 48

Spruce site index was about 25 m base age of 50 for the sampled trees using the Growth Intercept Method. Growth intercept tables are not available for paper birch but it appears by interpolating from height over age SI curves birch SI is ≥ 20m. When the spruce was split into trees that were currently tall (6.33 – 7.59 m) medium (5.55 – 6.3 m) or short (≤ 5.5 m) the respective SI's were 26.1, 25.0 and 22.8. The birch was also split into three height classes, tall (7.65 – 10 m), medium (6.5 – 7.5 m) and short (4.3 – 6.4 m). Individual tree height over age growth is shown for the tall and short spruce and birch (Figures 4 to 7). There is much more variation in the growth of the shorter than the tall trees and spruce growth appears to be slowing while birch does not. The three sets of early growth curves for each species will be used to model early growth for the trees receiving dendrometer bands.

The significance of our findings to date is the lack of relationship between tree metrics and stand density of the sampled trees. This aspect will be pursued in the spring of 2003 when approximately 300 dendrometer bands will be placed on trees of both species across the range of density treatments. This may help describe the lack of tree response to density.

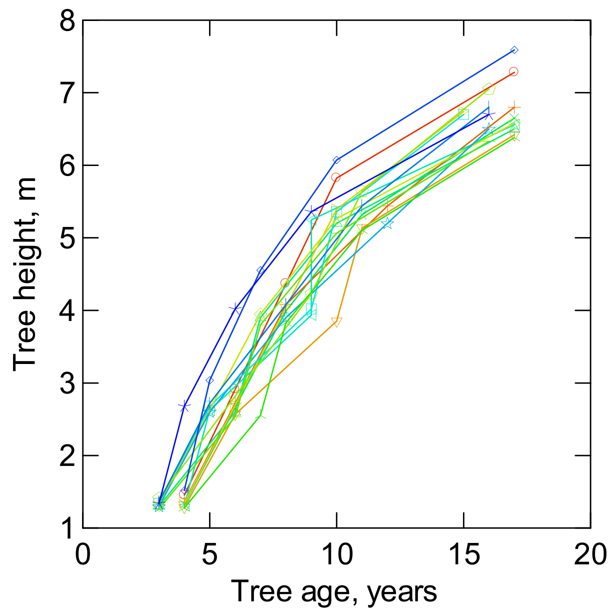

Figure 4. Tall (current height ≥ 6.33 m) individual spruce height over age curves.

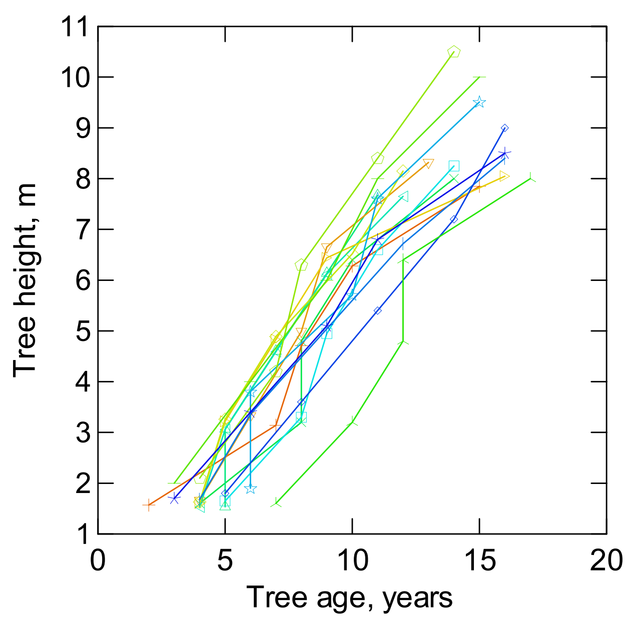

Figure 5. Tall (current height ≥ 7.65 m) individual birch height over age curves birch.

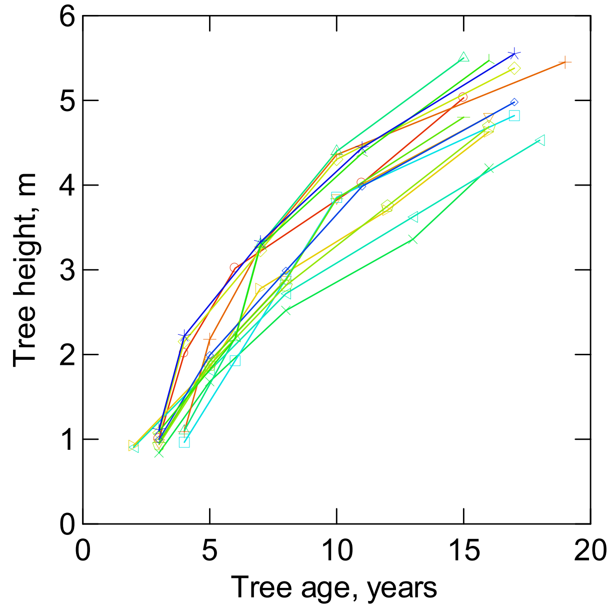

Figure 6. Short (current height ≤ 5.5 m) individual spruce height over age curves.

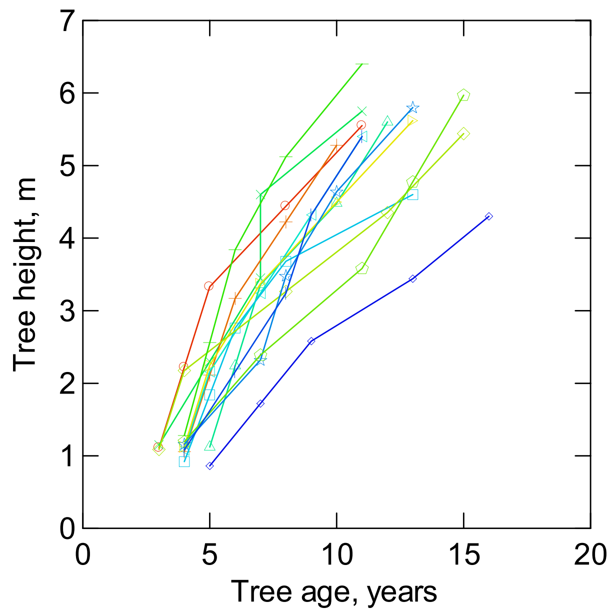

Figure 7. Short (current height ≤ 6.4 m) individual birch height over age curves.

b) Wood Quality

An example of the birch and spruce density scans is shown in Figure 1, where (a) is birch and (b) is spruce. For scanning purposes, and ‘A’ and ‘B’ samples were used from the same disc, where the samples are 180 degrees from each other. In Figure 1(a), the thick solid line is for Ep40A and the thinner solid line is for Ep40B. The smooth thin curves are the averages for earlywood. A distinction between earlywood and latewood could not be made clearly with the scanner. Therefore, only one density was determined for each annual ring. In Figure 1(b), the thick solid line is for Sx40A and the thinner solid line is for Sx40B. The smooth thin curves are the averages for earlywood (lower line) and latewood (upper line). The middle smooth thin curve in Figure 1(b) is the weighted average density.

It is interesting to note and this was present in other spruce samples graphed in a similar manner, that the earlywood density did decrease more than the latewood density as the older the tree developed. However, as a weighted average for the entire disc density, the density decreased as the tree aged.

The summary statistics of densities for birch and spruce are presented in Tables 1 and 2, respectively.

Latewood densities were not determined for birch as it could not be distinguished clearly from the earlywood for scanning purposes; therefore they are not present in Table 1. The average breast-height relative density for paper birch has been documented[2] to have a range of 0.470 to 0.512 (green-volume basis) and 0.620 for ovendry-volume basis. In Table 1, the average disc relative density was determined to be 0.4656, which is similar to the lower part of the range. The spruce disc density was determined to be 0.324 which is similar to the literature[2].

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[2] Gonzalez, J.S. 1990. Wood density of Canadian tree species. Information report NOR-X-315. Forestry Canada.

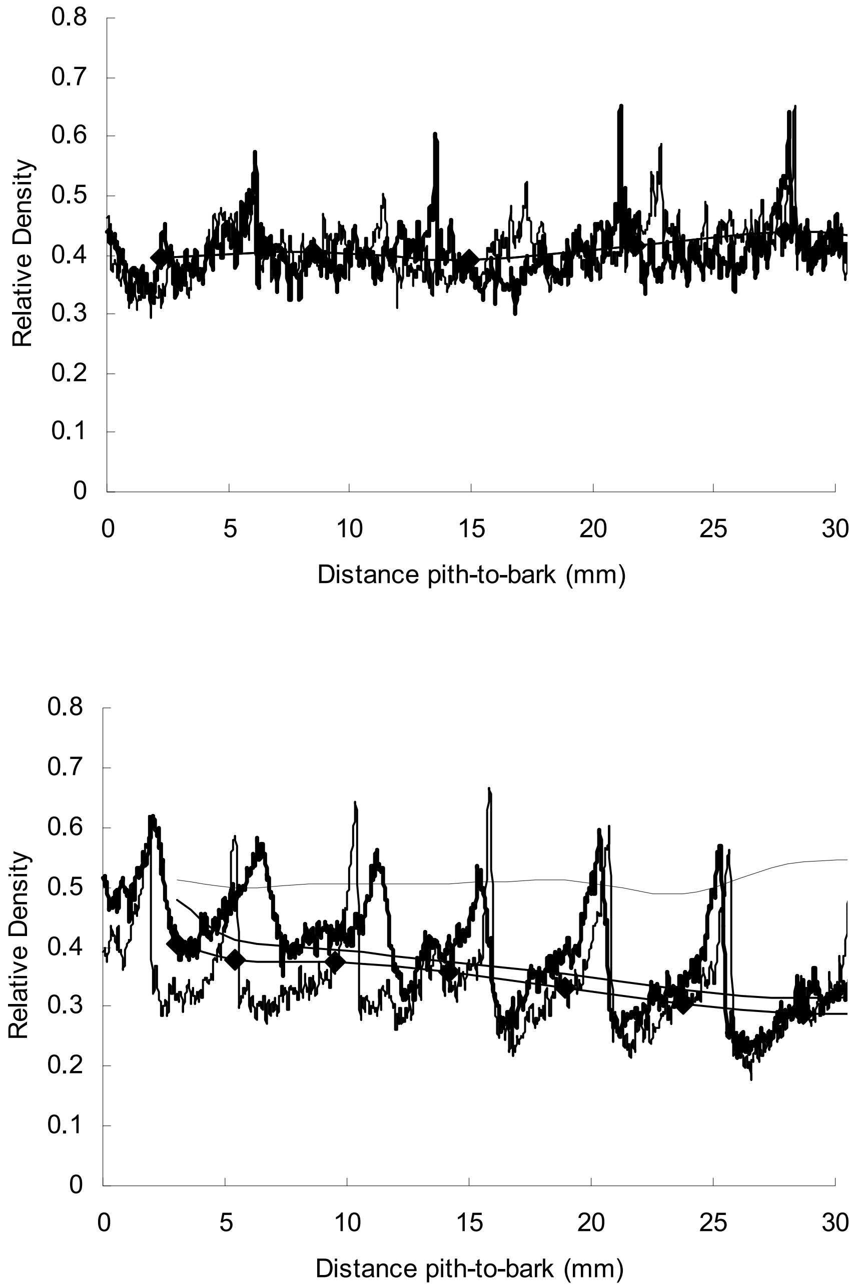

Figure 1. An example of relative density profiles pith-to-bark for (a) birch – Ep40; and, (b) spruce – Sx40.

"Table 1 provides statistics descriptive of wood densities obtained from the young paper birch samples. Table 2 provides similar data for the young spruce."[1]

Table 1. Summary of Paper Birch Densitometry Results[1]

	N	Mean	Std Dev	CV	Min	Max
Disk Age	46	9.04	1.73	19.1	6	14
Disk Diameter (mm)	46	54.70	20.55	37.6	30.22	117.34
Average Ring Width (mm)	46	3.00	0.85	28.4	1.59	5.87
Disk Density	46	0.4656	0.0302	6.5	0.4162	0.5545
Disk Density Earlywood	46	0.4656	0.0302	6.5	0.4162	0.5545
Disk Density Latewood	0	-	-	-	-	-
% Latewood	46	0	0	-	0	0

Table 2. Summary of Interior Spruce Densitometry Results[1]

	N	Mean	Std Dev	CV	Min	Max
Disk Age	47	9.26	1.17	12.6	6	11
Disk Diameter (mm)	47	87.86	18.11	20.6	60.92	140.42
Average Ring Width (mm)	47	4.76	0.83	17.3	3.43	7.80
Disk Density	47	0.3239	0.0221	6.8	0.2731	0.3730
Disk Density Earlywood	47	0.3006	0.0179	5.9	0.2614	0.3401
Disk Density Latewood	47	0.5212	0.0178	3.4	0.4864	0.5619
% Latewood	47	11.56	3.77	32.6	5.5	24.4

B. SUMMARY OF OUTPUTS

Summary, by quarter, of significant outcomes and deliverables for the 2002/2003 fiscal year

Quarter 3

- Strategic mixedwood planning session carried out in November 2002
- Draft strategic plan developed
- Cookie collection for both wood quality and G&Y studies completed

Quarter 4

- Cookies prepared for wood quality and G&Y studies
- Wood quality cookies to FORINTEK
- G&Y cookies scanned
- Data analysis completed
- Strategic plan completed (appendix 1)
- Mixedwoods Presentation to Canfor (appendix 2)
- G&Y report completed – see annual report
- Wood quality report completed – see annual report (Forintek report - appendix 3)
- Year 1 annual report completed

C. EVALUATION OF PROJECT OUTCOMES OR OBJECTIVES

The project was highly successful in achieving the desired outcomes, with all significant outcomes and deliverables for the 2002/2003 fiscal year being achieved. The remainder of the spruce and birch cookies will be sent to Paprican in the spring of 2003. The results will continue to be analyzed and interpreted with respect to their applicability and whether or not they address knowledge gaps.

It is very clear from this project as well as R02-21 that the largest information gaps are associated with mixedwood growth and yield information and mixedwood models. This is being addressed further in the 2003-2004 workplan.

D. ASSESSMENT OF THE APPLICABILITY OF THE RESULTS

The results of this project will supply information from complex stands that will be used to modify existing policy with respect to free growing and stand stocking. They will also provide cost-benefit information to forest operations with respect to stand density, wood quality and expected returns at rotation. This could be incorporated into a silviculture decision matrix. Overall this will enhance the quality of decision making.

The strategic plan for managing mixedwood stands in the SBS is an adaptive process that will support forest certification. The plan should empower resource managers to utilise practical adaptive management approaches. The growth and yield model will allow yields from complex stands to be incorporated, with some degree of confidence, into the TSR process.

By relating wood quality in spruce and birch to stand density and silviculture treatment, resource managers can tailor their management practices to achieve their product goals and desired economic returns on investment. This should enhance timber quality as well. Complex stands have an inherent greater productive capacity than single species stands. Therefore, knowing how to manage complex stands will make better utilization of the site and promote biodiversity.

Additionally, managing stands with significant amounts of deciduous trees may alleviate green-up constraints and thereby reduce access constraints. The deciduous component will reduce or mitigate white pine weevil attack and this too will result in wood quality improvements and better economic returns.

Furthermore, maintaining complex stands on the landscape will enhance structural and species diversity as well as make better use of the site's productive potential. This will lead to a greater public acceptance of management practices. Knowledge of the growth and yield, silviculture impacts on wood quality, and enhanced biodiversity in managed mixedwood stands should facilitate forest certification processes.

Finally, the findings from this study will be directly applicable to complex stands (birch – conifer) across the sub Boreal Spruce Zone. They also should be applicable, with some modification, to complex stands where aspen is the leading deciduous species, such as the Boreal forest. The wood quality relationships to mixed species stand treatments will be unique and may have application beyond the borders of British Columbia. The growth and yield model may also be applicable to other complex stand types and jurisdictions.

The results from this study will be of use to operational foresters, resource managers, planners, policy makers and scientists.

E. IDENTIFICATION OF HOW PROJECT CONTRIBUTED TO KNOWLEDGE GAPS

Some studies indicate that the presence of paper birch in coniferous stands can improve forest productivity (Frivold and Mielikainen 1990, For. Can. NF For. Cent. Inf. Rep. N-X-271. pp. 75-82; Longpre *et al*. 1994, CJFR 24:1846-1853). This has not been documented in BC. This study begins to address this issue in BC.

Since conifer and paper birch mixed species stands have not been managed intensively, it is necessary to collect data in a manner such that growth rates of individual trees, and groups of trees, can be determined to gain insight into interactive mechanisms that could be altered by management. Careful thinning of natural paper birch stands has shown potential for sawlog production in the southern interior of BC. Spacing of dense young paper birch stands has the potential to accelerate growth of the remaining trees or to increase the size of paper birch logs at harvest. Intermediate thinning should shorten sawlog rotations, increase total harvested volume and improve timber quality (Salomon and Leak 1969, Birch Symp. Proc. NE For. Exp. Stn. USDA, For. Ser. pp. 106-118; Hibbs *et al.* 1989, For. Sci. 35:16-29). About 14 ha of a vigorous complex stand, with significant weevil attack, in project R02-21 were thinned in July 2002 to various residual birch densities. Four ha in a second, similar stand were thinned to various residual spruce densities. The downed trees presented an opportunity to look at wood quality and growth and yield characteristics of this stand both with respect to stand density and past weevil attack.

Improved timber quality attributes are represented by the wood relative density, fiber qualities (i.e., length and size) and wood type (i.e., reaction wood, heart/sapwood). Relative density (ratio of the oven-dry weight to green volume or specific gravity) is correlated to strength and stiffness properties, drying characteristics, heating values, machinability and pulping. There is no conclusive evidence from research on fast-growing trees that there is higher or lower wood density. However, it has been demonstrated that a few coniferous species (for example, Douglas-fir) have a negative correlation between growth rate and density (Zobel and van Buijtenen 1989. Wood Variation: Its causes and control. Springer-Verlag, NY). Fiber traits will be important to determine since the fast-growing trees typically have a larger volume of juvenile wood compared to that in mature wood. Juvenile wood impacts several physical properties of wood, namely, pulping and dimensional stability. This project begins to examine these traits.

Managed stand growth models can be developed using pairs of consecutive measurements of stand variables such as basal area per ha, sph, and mean tree height (Garcia 1992, Integrating Forest Information Over Time, ANUTECH, Canberra pp. 110-122). As a result of the spacing in FII project R02-21, an opportunity arose to detail stand growth and wood quality at various densities up until 2002 using the downed trees, to determine basal area increment over the next two to three years at various stand densities, and to project complex stand growth forward. The projections could be checked against existing mixed species growth models (e.g. TWIGS). The output from this area will be used to validate existing assumptions about yields of mixed species stands in the SBS.

When growth results are correlated to the wood quality findings a unique insight into stand development will be detailed.

F. EXPLANATION OF KEY OPERATIONAL VARIANCES AND THEIR IMPACT ON THE PROJECT

Dendrometers were purchased rather than constructed. This will have no impact on the outcome of the project.

Appendix 1

Strategic Mixedwood Plan

Appendix 2

Mixedwoods Presentation for Canfor

Appendix 3

X-ray Densitometry of Young Interior Spruce and Paper Birch Tree Stem Samples (Forintek Canada Corp.)

Filename:	R-0239Ann_rep
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Number of Characters:	15,697 (approx.)