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Comparison of Sawlog Quantity and Quality Between Sitka Spruce Seedlots Originating from Washington and Queen Charlotte Islands

INFORMATION NOTE

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SUMMARY

A 44-year-old Sitka spruce provenance trial growing in Gwydyr Forest (north Wales) was felled allowing the comparison of various final crop characteristics between selected Sitka spruce seedlots of Washington and Queen Charlotte Islands origins both in the forest and in the sawmill. While there were few statistically significant differences, there was a tendency for the Washington origins to yield a greater volume in the forest and more deals (or battens) satisfying strength class (SC) 3 in the sawmill without a fall in deals satisfying SC4.

INTRODUCTION

1. North Oregon and west Washington origins of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) have been recommended as suitable alternatives to Queen Charlotte Islands (QCI) origin from British Columbia on less exposed sites in south-west England and Wales (Lines, 1987). Although there is a greater risk of autumn or winter frost damage to these more southerly origins, timber production is increased by approximately 10% compared with QCI (Fletcher, 1992). There is now widespread planting of Washington origin Sitka spruce across Wales as managers seek to exploit the increased growth rate.

2. Few studies have assessed the variation in wood quality between different origins of Sitka spruce, although there is known to be an inverse correlation between wood density and rate of increase of stem volume (Broughton, 1962; Brazier, 1972a; Murphy and Pfeifer, 1990). One investigation into wood density examined a wide range of Sitka origins at 9 years of age, and showed the southern origins to be of lower density during the early years of growth (Brazier, 1972b). Fletcher (1992) suggested caution in planting origins from Washington and Oregon across south-west England, Wales and west Scotland because despite the increased growth rate, there is the possibility of some decrease in strength properties of the timber.

3. This study compares the variation in stand volumes and produce out-turn from three Washington origins and one QCI origin growing on one site in Gwydyr Forest, north Wales. In order to assess timber strength, the harvested logs were sawn at a commercial sawmill and the yields of structural grade timber determined by machine stress grading.

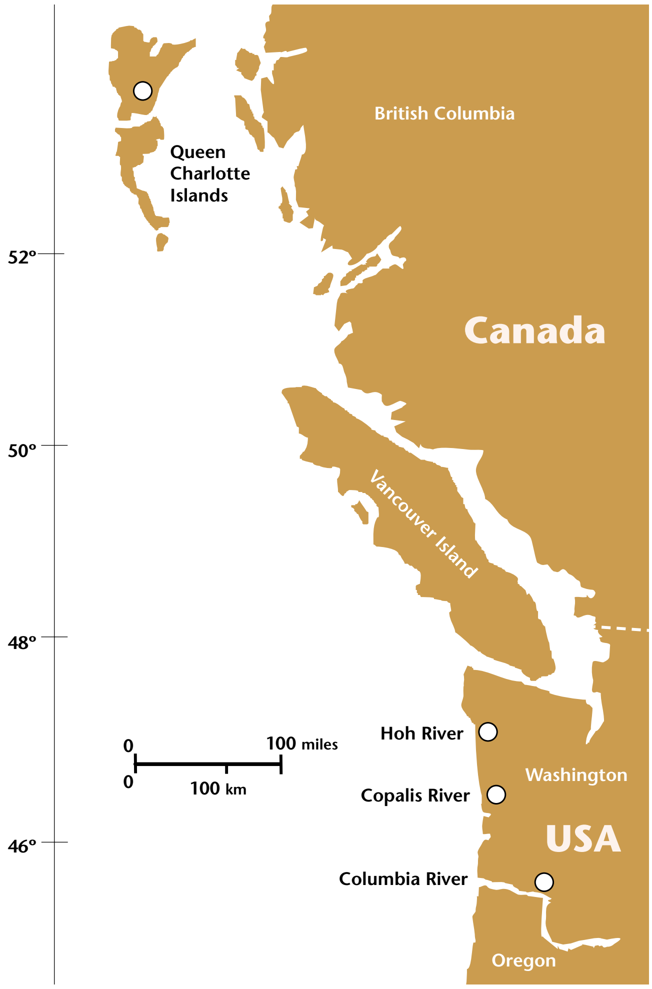
TEST MATERIAL

4. The experiment Gwydyr 1 was planted in 1950 using a 7 x 7 latin square design (49 plots) to compare the variation in survival, growth rate and quality of one QCI and six Washington origins of Sitka spruce. Individual plot size consisted of 10 x 10 trees with an initial spacing of 5 x 5 ft (1.5 x 1.5 m). Thirty-five of the plots were given a light silvicultural thinning (approximately 0.75 Management Tables) in 1986.

5. The study was restricted to the three Washington origins of Hoh River, Columbia River and Copalis River representing the latitudinal spread of the species within Washington state, and the one QCI origin (Figure 1). Three thinned plots, unaffected by windthrow, were selected across the experimental site for each of the four origins of interest; all plots were typical for the site. Using the 12 scattered plots within the Latin square effectively removed any blocking structure so statistical analysis was applied as a one-way analysis of variance. All work took place during the summer of 1994, 44 years after planting.

6. To avoid any 'edge effect' on tree growth, only the inner 8 x 8 trees were assessed. The trees felled were converted using the following product specification, maximising the higher value products:

Figure 1 Map showing relative locations of the four seed origins compared for volume, timber strength and value



- 5 m length sawlogs
  (18 cm minimum top diameter, under bark)

- 3.75 m length sawlogs
  (18 cm minimum top diameter, under bark)

- 2.1 m length bars
  (14–18 cm top diameter, under bark)

- 2.3 m length small roundwood for pulp
  (7–14 cm top diameter, under bark)

- 3.75 m length logs from dead trees
  (7 cm minimum top diameter, under bark)

7. The total volume of each product was recorded for each of the 12 plots, apart from the pulp which was estimated from a random sample of 20 pieces per plot. The out-turn of sawn produce was also recorded separately for each plot during processing in the mill. Finally, the number, dimension and strength class (SC) for sawn timber sections (termed 'deals' or 'battens') was recorded on an individual plot basis.

8. Strength classes (British Standards Institution, 1984) range from SC1 (reject) to SC5 (trussed rafters), SC4 is stronger than SC3 (general structuring) which in turn is stronger than SC2 (general framing; Harding, 1988). Since this study was carried out, a European Standard on the classification of structural timber has been implemented by sawmills (CEN 328, 1995). Under the new standards SC1, 2, 3 and 4 correspond to reject, C14, C18 and C24 respectively.

9. Deals were machine graded to SC4/SC2 and again to SC3/SC1. A few deals were visually rejected prior to machine grading, usually because of wane. Rejected deals were cut back to 15 ft (4.57 m) lengths and visually graded; such deals were not included in the analysis.

RESULTS

10. The variables assessed both in the forest and in the sawmill enabled a comparison across origin for volume, log grade and strength class. Results are presented here in terms of measurements in the forest; and sawmill conversion.

Measurements in the forest

11. In a preliminary analysis, no significant differences were found between top height of the different origins. The calculated mean top height of 25.1 m was assumed to be common to all origins giving a General Yield Class (GYC) of 18. Cumulative volume production was estimated for all plots from the measured felled volume and estimates of thinning volume removed. Local Yield Class (LYC) was determined for each origin using the estimates of cumulative volume production and was found to vary from LYC 20 for QCI to LYC 22 for Hoh River and Columbia River (Table 1).

12. The average values for diameter at breast height (DBH, 1.3 m), basal area and felled volume were consistently higher for the Washington origins compared with QCI (Table 1). However, standard errors (SE) were large, reflecting the high between-plot variation within each origin. Consequently, although the volume of both Hoh River and Columbia River was 19% greater than QCI, this was not quite a

Table 1 Comparisons of stand variables measured in the forest showing mean values for each origin across three plots

Origin	Local yield class	Live trees per hectare	DBH (cm)	Basal area (m^2 ha^{-1})	Basal area as % of QCI	Standing volume (m^3 ha^{-1})	Standing volume as % of QCI
Hoh River	22	1790	25.0	88.1	121	983	119
Copalis River	21	1655	24.8	79.6	110	876	106
Columbia River	22	1766	25.5	89.7	123	987	119
QCI	20	1834	22.4	72.6	100	828	100
Standard error (SE)		±62	±0.43	±3.6		±81.88	

significant difference at the 5% level ($P > 0.2095$). There was no significant difference between the Washington origins for volume or DBH, but Copalis River had a significantly lower basal area due to the smaller number of live trees per hectare.

13. Figure 2 presents a comparison of volumes of felled produce measured for each origin. There was again no significant difference between the origins ($P > 0.05$) for the total volume of produce obtained although Hoh River and Columbia River had respectively 15% and 6% greater total volume than QCI. All three Washington origins exceeded the QCI origin for mean volume and proportion of 5 m logs with a smaller mean volume and proportion of produce composed of pulp.

Sawmill conversion

14. Figure 3 presents a comparison of out-turn achieved for each origin following processing at the sawmill. The greater numbers of 5 m sawlogs available from the Washington origins resulted in greater numbers of deals available for machine stress grading particularly for Hoh River and Columbia River. Interestingly, the percentage of passes at the higher construction grade SC4 was greatest for QCI (31%) while absolute number of SC4 passes varied only slightly between Hoh River (37), Columbia River (41) and QCI (38). In contrast, the percentage and absolute number of deals grading to SC3 was more variable between the origins. For example 63 deals of QCI origins (52% of total) graded to SC3 compared to 100 deals (57%) for Columbia River and 105 deals (64%) for Hoh River. Overall, Copalis River appeared to perform least well, with the largest proportion of rejects (23%) and the lowest number and percentage of deals grading to SC4 (23 deals, 17% of total).

DISCUSSION

15. This is a first reported comparison of end-of-rotation volume and product mix between Washington and QCI origins of Sitka spruce growing in Wales. The trial was not statistically ideal due to differences in thinning regime and incidence of windthrow across the original 49 plots. The breakdown of the blocking structure as three thinned plots unaffected by windthrow were selected for each origin, resulted in loss of experimental precision.

16. The varied number of trees per hectare across origins was a further confounding factor. QCI had the largest number of trees (1834 trees per hectare) and the smallest mean DBH (22.4 cm) which in itself would be sufficient to reduce sawlog out-turn. Also it is difficult to interpret the result in terms of today's silviculture and management when present stocking is ideally 2500 trees per hectare compared to the 4400 per hectare planted at the study site.

17. Despite the general lack of statistical significance for many of the variables assessed it would seem that relative to QCI origin, the Hoh River and Columbia River origins will yield a larger standing volume per hectare at rotation age, with an increase in the proportion of higher value 5 m logs and a decrease in proportion of lower value pulp. Subsequent conversion at the sawmill of the 5 m logs from Hoh and Columbia River should lead to a similar number of higher value SC4 deals and an increase in number of SC3 deals relative to QCI. Selection of either of these two origins should give an increase in value to the forest manager relative to unimproved QCI material without any loss in overall strength for the construction timber market.

Figure 2 Comparison of felled produce measured in the forest showing mean values for each origin calculated across three plots

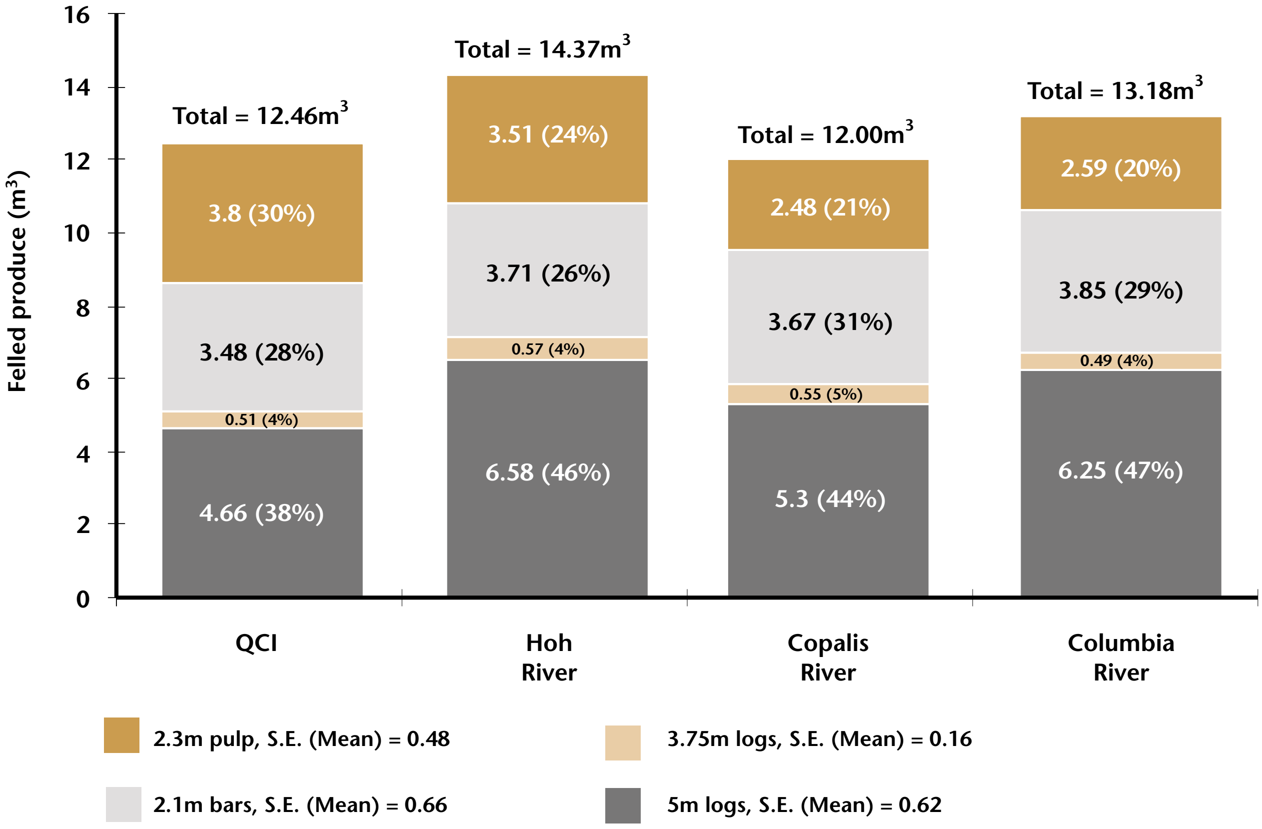
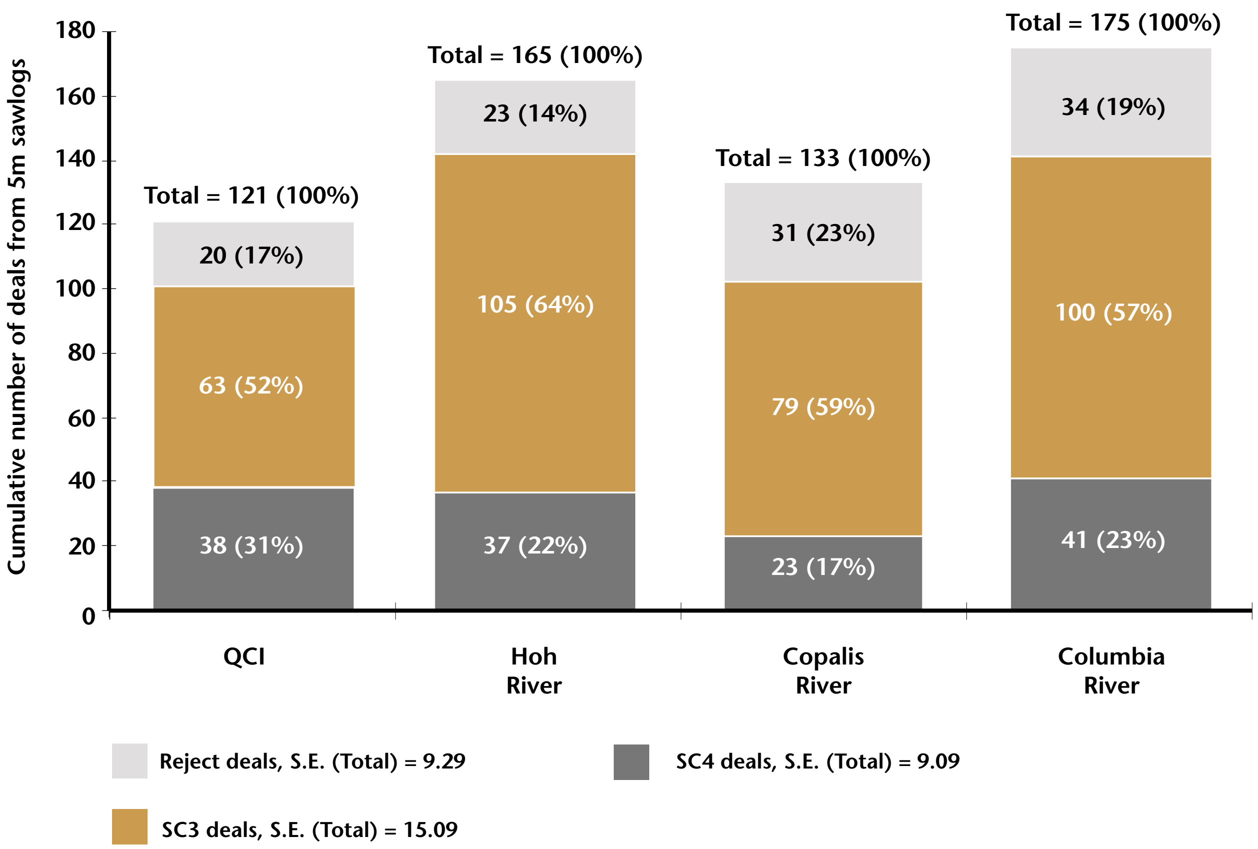


Figure 3 Comparison of out-turn of deals in the sawmill from 5m length logs showing total numbers for each origin over all three plots



18. The poor performance of the Copalis River origin relative to the two other Washington origins is initially surprising but is consistent with the relative 10-year height growth data presented by Samuel (1995). This study confirms that managers should avoid mid-latitude origins from within Washington State when planting Sitka spruce on suitable sites in Britain.

19. The next opportunity to validate this study will be when similar provenance tests planted in 1960 and 1961 are felled. These tests consist of 100 plant plots with two or three replications. Two suitable sites survive in Wales. Thinning regimes have been standard across all origins and windthrow is not currently a problem.

20. This study involved the comparison of genetically unimproved seedlots. Since the Gwydyr trial was planted the genetic improvement of Sitka spruce of QCI origin (selections known to be of QCI origin or thought to be of QCI origin based on the growth characteristics of their progeny) has advanced to the stage that improved material is now available, whereas improved material of Washington origin (WSS) will not be available for another 10 years (Lee, 1997). In the meantime it is recommended that managers in Wales plant unimproved WSS in preference to improved QCI seedlots offering just 15% increase in 10-year height or 15-year diameter (early seed orchards and family mixtures). However more recent family mixtures which predict 20% or more gain for 15-year diameter should be planted on suitable sites in preference to unimproved WSS. Genetic gain trials (Lee, 1994) will be required to compare the relative performance of improved QCI and WSS seedlots on suitable sites in Wales.

CONCLUSIONS AND RECOMMENDATIONS

21. Whilst there are few statistically significant differences for many of the variables measured, and the number of trees per hectare vary across origins it is possible to make the following general conclusions:

- There is a tendency for Sitka spruce of Washington origins to yield an increased volume of sawlogs (after thinning) compared with Queen Charlotte Islands origin, without penalty in terms of the *proportion* of sawn timber satisfying SC3.

- There might be some reduction in the *proportion* of SC4 construction timber from the Washington origins but careful selection of origin should prevent a reduction in absolute number of deals.

- Although managers would have to consider possible future prices available for the potential product out-turn, the study suggests a greater final rotation value for some of the Washington origins (particularly Hoh River and Columbia River), relative to QCI due to a larger proportion of 5 m logs and decrease in proportion of lower value pulp.

- Whilst predicted gains from genetically improved Sitka spruce of QCI origin remain around 15% for 10-year height or 15-year diameter, unimproved WSS should be planted.

- Genetically improved Sitka spruce seedlots of QCI origin offering predicted gains in excess of 20% for 15-year diameter should be planted in preference to unimproved WSS.

- Mid-latitude Washington origins from around the Copalis River area are to be avoided.

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