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Timber Quality: A Pilot Study for Assessing Stem Straightness

INFORMATION NOTE

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SUMMARY

Better information on the quality of standing timber in British forests has been highlighted as an urgent requirement of the forest industry. This Information Note reports on an industry-wide initiative to develop a system to assess timber quality of forest stands based on an evaluation of stem straightness. The Note describes the straightness assessment method devised as part of the system. A procedure has been developed for scoring quality of trees and stands. Recommendations are made for future work to develop the method particularly for inventory and production forecasting purposes.

INTRODUCTION

1. Information on the home grown standing timber resource is an essential requirement for the wood processing industry and is used as a basis for major and long-term investment decisions. Forest managers also require information on the timber resource to manage forests sustainably and to maximise economic return. The long-term stability and profitability of the timber industry are dependent on both the availability and the quality of the home grown timber supply.

2. Recent trends in the management of spruce stands have been causing concern over the future of timber supply, notably:

   - the move to wider planting spacing in the late 1960s;
   - the adoption of no-thin management;
   - the preference for mechanised and systematic thinning practices.

   The move to wider planting spacing, in order to reduce establishment costs, would be expected to have a detrimental effect on quality as planting distance affects stem characteristics such as knot and branch size and wood density (Brazier and Mobbs, 1993). The adoption of no-thin management for economic reasons (when markets are limited), or for silvicultural reasons (when risk of windthrow is likely to be high after thinning), provides no opportunity for improving stand quality. Similarly, the use of mechanised and systematic thinning practices reduces options for improving stand quality.

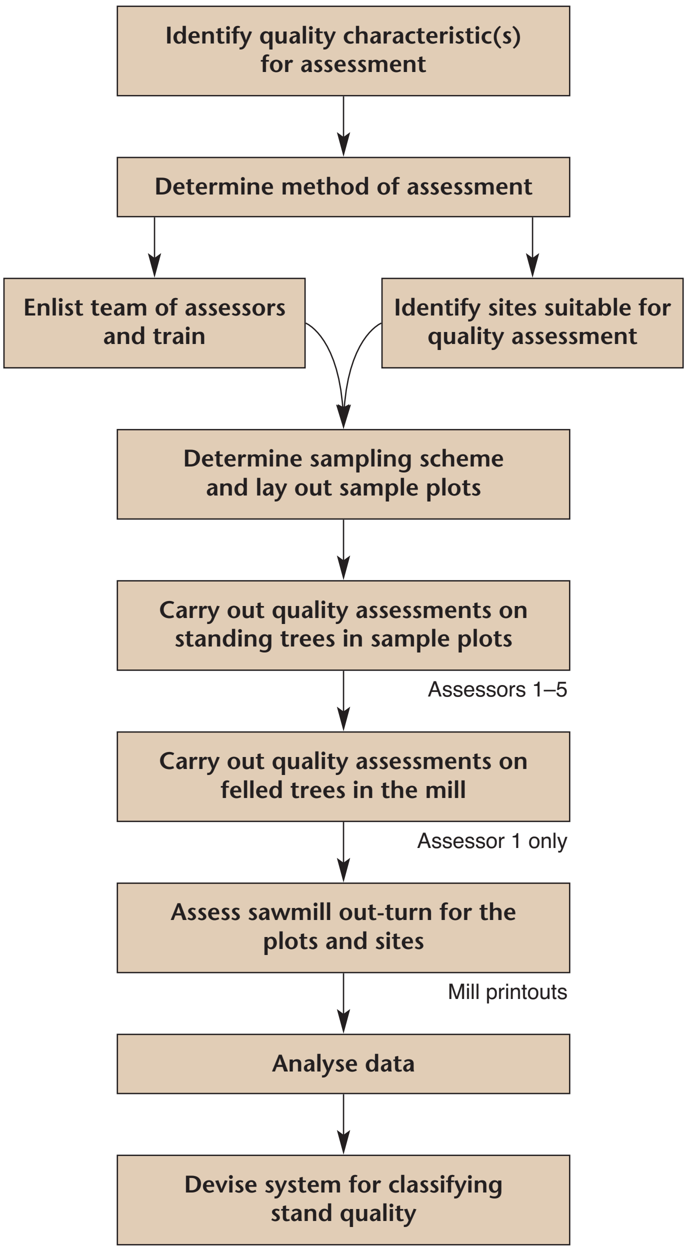
3. Home grown roundwood volume production is expected to increase significantly over the next 25 years (Whiteman, 1996). Good information on the quality of this resource is essential for investment decisions. The national production forecast provides information on the quantity of the timber resource in British forests using a combination of yield models, assortment tables and management assumptions (Rothnie and Selmes, 1996). Yield models and assortment tables (Edwards and Christie, 1981) provide information on potential volume of timber and products assuming no defects. Yield models therefore predict the *maximum* potential wood volume out-turn and adjustments need to be made for any defects.

4. Timber quality was the theme of the April 1993 meeting of the Home Grown Timber Advisory Committee (HGTAC) Technical Sub-Committee (TSC). At the conclusion of the meeting it was acknowledged that a method for assessing timber quality in forest stands was urgently needed. Five forest industry representatives and researchers were asked to form a Steering Group to carry out a pilot study with the core objective:

   '*To establish a system for stand quality classification and to demonstrate its relevance to sawmill output*'.

METHOD AND ASSUMPTIONS

5. At an early stage it was recognised that the pilot study would need to be restricted to spruce species, but the primary aim of the study was to develop a method applicable to a wide range of stands of varying quality and not restricted to particular species, end-uses or regions of Britain. The system needed to be capable of predicting timber quality both immediately prior to harvesting and at least 12 years prior to felling. Initially the method would be developed and tested only on stands due for felling and mill processing, in order to demonstrate that assessors could consistently classify standing trees according to their yield of straight logs and hence sawmill out-turn. The following flowchart outlines the agreed approach.



6. A review of the literature indicated that, for most species, log quality is determined by stem features in the following categories:

• **Stem form**	straightness, sweep, bend, lean.
• **Branchiness**	presence and size of knots, limbs, forks, multistems.
• **Damage**	scar defects, browsing, extraction.

The Steering Group considered these stem features and agreed that for British conditions stem straightness was the most important when assessing quality of spruce logs and the most relevant to product out-turn. Knots were not considered as important, since they were not a primary cause of downgrade of spruce logs from trees grown at initial spacings of up to 2 m. However, knots could be considered in any further evaluation particularly for other species with larger branches such as pine.

Straightness assessment

7. To define straightness the classification used in Field Book 9 *Classification and presentation of softwood sawlogs* (Forestry Commission, 1993) was adopted. This specifies:

Bow not to exceed 1 cm for every 1 m length and this in one plane and one direction only. Bow is measured as the maximum deviation at any point of a straight line joining centres at each end of the log from the actual centre line of the log, as shown in Figure 1.

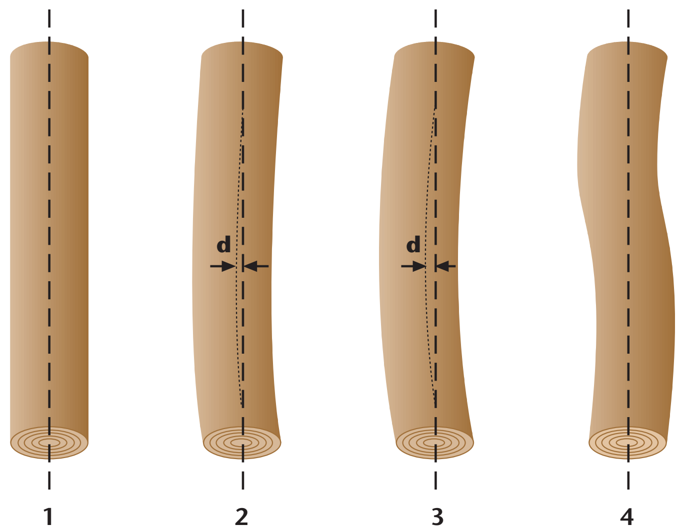


Figure 1
Logs 1 and 2 qualify as straight logs; logs 3 and 4 are not straight. Maximum deviation (d) on log 2 does not exceed 1 cm over 1 m length. Maximum deviation (d) on log 3 exceeds 1 cm over 1 m length. Log 4 shows bow in more than one direction.

8. Assessment of straightness was based on four log length categories, which the Steering Group associated with different value wood products, to ensure the straightness measure would indicate product potential.

- **4 m and longer.** Straight logs of these lengths are important for the structural timber and carcassing market and further penetration of these markets by British grown timber depends on the ability to produce a significant volume of these lengths.

- **3 m+ and less than 4 m.** Straight logs of these lengths can be marketed into the construction market although they are less sought after but they also have market potential in the fencing and packaging sectors.

- **2 m+ and less than 3 m.** The main markets for straight logs of these lengths are fencing, pallet and packaging. They are usually too short for processing into carcassing timber but have some potential for studding.

- **Less than 2 m.** These lengths are generally too short for high volume efficient sawmilling and are more suitable for industrial processing, e.g. pulp and panel board manufacture.

Although this study was concerned primarily with correlating quality assessments of standing trees to sawmill out-turn, the inclusion of four log lengths in the straightness assessment offered scope for interpreting the data in ways that would be of value to all sectors of the wood processing industry.

9. The straightness assessment was restricted to the first 6 m butt section of standing trees because the butt section is the most important for higher value products. In practice it is also difficult to see clearly above 6 m particularly in unthinned, thicket stage crops. The straightness assessment, therefore, was only carried out on trees that would achieve a 6 m length to a minimum sawlog top diameter of 14 cm underbark (ub). Examination of taper data from recently felled permanent sample plots in the Forest of Ae indicated that trees with a breast height diameter (dbh) of 20 cm achieve a 6 m length to 14 cm top diameter ub. This relationship was used to determine the assessable trees within the plots used in this study.

10. To assess straightness on an individual tree the assessor observes the number of straight log lengths in the first 6 m butt portion of the tree. Using this method there are six possible combinations of log lengths as shown in Table 1. Examples of different combinations are shown stylistically in Figure 2.

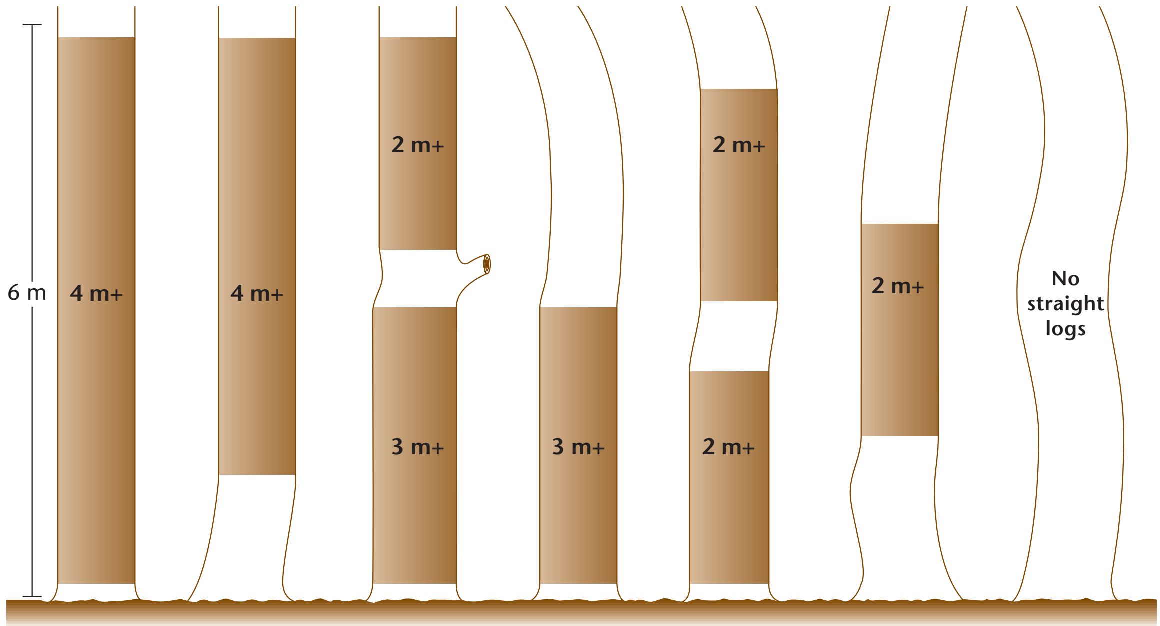


Figure 2 Different combinations of log lengths in first 6 m showing gradual reduction in quality from left to right. A 4 m+ can only occur on its own; a 3 m+ can occur on its own or in combination with a 2 m+; a 2 m+ can occur on its own or in combination with a 2 m+ or a 3 m+.

Table 1 Numbers of straight logs observed in each log length category, indicating possible combinations

Straight log length within first 6 m		
≥ 4 m	≥ 3 m < 4 m	≥ 2 m < 3 m
1	0	0
0	1	1
0	1	0
0	0	2
0	0	1
0	0	0

Field assessments

11. Two unthinned stands due for felling were used in the pilot study. A subjective visual assessment had suggested they differed in quality. The first was Sitka spruce of poor quality; the second was a Norway spruce stand of good quality. Although the stands were of different quality they were very similar in terms of average tree size and details are shown in Table 2.

12. Six industry experts, from sawmilling and forest management backgrounds, with extensive but varying experience in log grading, agreed to participate as assessors in the pilot study. Before the main field trial took place the assessors attended a training day to learn the assessment method.

13. Five sample plots each containing 50 assessable trees were marked out at both sites by Mensuration Branch staff. This level of replication was required to demonstrate the ability of assessors to assess straightness, to measure variation between assessors and to investigate differences between assessments made in the field and the sawmill output.

Combinations of straight log lengths observed in the first 6 m of each standing tree were recorded independently by each assessor. Assessments for both sites were completed by five of the assessors before the trees were felled and not by all six as originally planned. Results for the five assessors only are reported in this Note.

Mill assessments

14. The two stands were felled, and intact log pole lengths (from butt to 14 cm top diameter ub) from the plots at both sites were taken to the BSW Carlisle sawmill. At the mill the poles were laid out, by plot. Three straightness assessments were then carried out on each pole. In the short time between delivery to the mill and processing it was only possible for one assessor based on the mill site to complete all three assessments.

Straight log length to 6 m. The field straightness assessment carried out on the first 6 m of the standing tree was repeated on the felled log poles. The assessment of each standing tree could then be compared with assessment of the same tree as a 6 m long pole.

Millable log length to 6 m. The number of millable log lengths, i.e. includes logs that do not fully meet the Field Book 9 straightness specification but are still considered to be sufficiently straight for sawmill processing. This assessment was carried out to measure differences between normal forest conversion practice and mill practice.

Millable log length to 14 cm top diameter ub. The number of millable logs to 14 cm top diameter ub was assessed to enable comparisons to be made with log scanner results which are presented to 14 cm top diameter ub.

Table 2 Stand details for pilot study sites in Ae Forest District

Species	Age (years)	Yield class	Tariff number	Mean dbh (cm)	Average tree volume (m^3)
Sitka spruce	41	14	30	18	0.20
Norway spruce	41	12	25	19	0.21

RESULTS

15. Data were statistically compared using analysis of variance methods. This revealed that there was variation in the mean number of log lengths estimated by different assessors in the standing trees. For example, Assessor 1 consistently estimated a greater number of logs in all length classes compared with Assessor 2. However, despite this variation, all assessors consistently judged the Norway spruce stand to be of better quality than the Sitka spruce stand.

16. The results of the analysis of the mean number of logs per tree in each length class category proved to be less than ideal as indicators of stand quality. Alternative ways of presenting the data were therefore investigated. First, the scoring system shown in Table 3 based on combinations of log lengths was applied to individual tree data. In terms of straightness a score of 1 indicates a poor quality tree and a score of 6 indicates a very high quality tree. Mean log combination scores can be calculated and used to indicate stand quality.

Table 3 Scores applied to different combinations of log lengths observed for each tree

Score	Number of straight logs counted in butt 6 m		
	≥ 4 m	≥ 3 m < 4 m	≥ 2 m < 3 m
1	0	0	0
2	0	0	1
3	0	0	2
4	0	1	0
5	0	1	1
6	1	0	0

17. The estimates of mean log combination score for both stands fell into two distinct bands as shown in Table 4. The overall mean score for the Sitka spruce stand was about 2, suggesting that this stand contains only short straight lengths suitable for conversion to pulp or similar material. By contrast the overall mean score for the Norway spruce stand was about 4, suggesting that this stand contains reasonable quality butt lengths providing mixed out-turn but predominantly 3 m sawlogs.

18. Second, a scoring system based on the individual log lengths, as shown in Table 5, was applied to the individual tree data.

Table 4 Mean log combination score for Ae timber quality plots by species and by assessor

Species	Assessor number					Overall mean
	1	2	3	4	5	
Sitka spruce	2.3	1.4	2.0	1.7	2.1	1.9
Norway spruce	4.7	3.7	3.3	3.5	4.2	3.9

Table 5 Score applied to different log lengths observed for each tree

Score	Maximum log length observed
1	No straight lengths
2	2 m logs (1 or 2)
3	≥ 3 m < 4 m (1 only)
4	≥ 4 m (1 only)

Table 6 shows the estimates of mean log length score for each assessor. Not surprisingly the variation between assessors was less using the log length score. All estimates of mean log length score for both stands fell into two distinct bands.

Table 6 Mean log length score for Ae timber quality plots by species and by assessor

Species	Assessor number				
	1	2	3	4	5
Sitka spruce	1.9	1.3	1.7	1.6	1.8
Norway spruce	3.1	2.6	2.5	2.5	3.0

19. Comparison of Assessor 1's individual field and mill straightness assessments revealed a consistent pattern for both stands (Table 7). Mean log combination scores based on field and mill assessments of straight logs were almost identical. The mean score for all millable logs showed a slight increase, as would be expected.

All poles, from the assessment plots, were then cross-cut and followed through to the log sorting line. Mill printouts showing the exact combinations of log lengths cut to millable specifications were examined and used to derive individual log combination and log length scores.

Table 7 Field and mill assessments by assessor 1

Species	Mean log combination score		
	Field assessment of straight logs on standing trees	Assessment of straight logs on felled log poles in mill	Assessment of all millable logs on felled log poles in mill
Sitka spruce	2.3	2.2	2.7
Norway spruce	4.7	5.0	5.4

20. For the Norway spruce stand a log combination score of 5 and a log length score of 3 were calculated from the mill printouts of sawlogs cut from the plot trees. The log combination score thus calculated was found to compare extremely well with the field and mill yard assessments made by Assessor 1. Comparison of the printout-derived log length score with log length scores based on field assessments also showed good agreement for all assessors.

21. For the Sitka spruce stand a log combination score of nearly 3 and a log length score of 2 were calculated from the mill printouts of the sawlogs obtained from the plot trees. The log combination score thus calculated was slightly higher than all assessment scores estimated for the stand. The log length score compared well with the mean scores estimated for all assessors with the exception of one assessor score.

Results of field assessments in other stands

22. It was important to establish that the scoring systems described above were able to detect potential quality differences in stands of trees of the same species in different locations. In an extension to the pilot study, further assessments of straightness were carried out in three stands of Sitka spruce in South Scotland, North England and Wales, judged visually to be different in quality. Quality scores of 3, 4 and 6 were derived for these stands, in a pattern consistent with the initial visual inspection. For the stands in South Scotland and North England, a new sampling scheme was devised based on 10 circular or line plots, each containing 10 assessable trees. The appropriate level of sampling for inventory assessment and other surveys has not been determined and further work on sampling is required if the method is to be developed.

DISCUSSION

23. The objective of the pilot study was to develop a method of assessing quality in forest stands which was consistent with sawmill output. A straightness assessment method has been devised and a procedure for scoring quality of trees and stands is proposed. The pilot study showed that for two sites the scores correlated well with the observed output of log lengths at a commercial sawmill.

24. Further training of assessors would deliver a consistent standard of assessment using either of the scoring systems described. The scoring systems allow the data to be interpreted to indicate product potential but more work is required to determine the most useful way of interpreting the data for different applications. Once a consistent standard has been achieved, individual distributions of scores could be used to define a quality index and provide a more detailed analysis of product potential. Interpretation of the scores in terms of volumes by individual product requires more data from field sites and sawmills.

25. The pilot study could not determine how effective the assessment method is in younger stands, where access and visibility are limited. The validity of a quality assessment made on a stand aged 25 years, for predicting its quality when it is 15 years older, has not been established.

RECOMMENDATIONS

26. The method described above has not been fully tested and validated, but in the absence of an alternative, the method (or adaptations) is already being used for a number of quality surveys by the commercial forest industry. However, there is still a need to refine the assessment method and establish:

- the correct levels of sampling and the most cost-efficient survey method;
- whether a quality assessment made in younger stand can provide information on the quality of the stand when it is due to be felled;
- ways of converting quality assessments and scores to predict volumes of different products.

27. Despite these reservations the method can be applied to standing crops to identify the most frequently occurring straight log lengths in a stand due for felling. This would provide valuable information when deciding which product specifications are optimal for a stand.

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