Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
http://www.forestry.gov.uk

Protocol for Stem Straightness Assessment in Sitka Spruce

INFORMATION NOTE

BY ELSPETH MACDONALD, SHAUN MOCHAN AND THOMAS CONNOLLY OF FOREST RESEARCH APRIL 2001

SUMMARY

Information on the quality of standing timber is an important requirement for the British industry. This Note presents details of the testing and validation of a scoring system for the visual assessment of stem straightness in Sitka spruce. The protocol for carrying out the assessment is described together with the estimated time to complete it. The system is based upon a 7-point scale of straightness applied to 10 sample trees per plot and up to 10 plots per stand. This system is recommended whenever a straightness assessment is required in British forestry. A system for grading stands has been proposed based on the distribution of scores within a stand. It is important to note that the classification relates only to the straightness of the first 6 metres of the tree and takes no account of other features which determine log or timber quality.

INTRODUCTION

1. A prototype method of assessing log quality in standing Sitka spruce trees was developed in the early 1990s and is described by Methley (1998). Straightness was identified as the most important single factor affecting log quality in Sitka spruce. Although knots were acknowledged to have a significant impact on log and sawn timber quality, they were not considered the primary cause of downgrade in spruce logs. An assessment method based on a visual estimate of straight log lengths in the first 6 m of the stem was devised.

2. Methley (1998) recommended refinement of the prototype method and further work to establish:

   - the correct levels of sampling and the most cost-efficient survey method;
   - whether a quality assessment made in a 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.

   Details of the refinement and testing of this prototype method are provided in the Appendix. The revised protocol for assessing stem straightness in standing trees is set out below.

PROTOCOL FOR ASSESSING STEM STRAIGHTNESS

Sampling

3. The area of the stand to be assessed should be determined: the stand might be a compartment, sub-compartment, felling coupe or similar. If the stem straightness of a whole forest block is to be assessed, the forest should be broken down into coupes or compartments for assessment purposes. Where there are obvious differences in stem straightness between different parts of a coupe or compartment that can be defined on the ground, the stand should be stratified and each stratum sampled separately.

4. The number of sample plots required should be determined from Table 1, based on the area of the stand to be assessed.

Table 1

Number of sample plots required for stem straightness assessment

Area of stand (ha)	Number of plots
0.5–2	6
2–10	8
Over 10	10

5. For each sample plot a sample point should be randomly located within the stand to be assessed. A simple method for randomly designating the sample points is to overlay a map of the sample stand with a transparent grid on which each intersection can be referenced by numbers along the X and Y axes. Random numbers, which can be generated easily in a Microsoft Excel spreadsheet, are then used to define the intersections. These act as the sample points.

6. The sample plot consists of the first 10 assessable trees (see paragraph 7) within 1.5 m on either side of a random bearing taken from the sample point. Thus in a stand of 7 ha a total of 80 trees would be assessed made up of 8 plots each consisting of 10 trees. To define the random bearing a list of random numbers between 1 and 360 is taken into the field and used sequentially.

7. Only live trees should be assessed and assessment is restricted to those trees that are large enough to produce sawlog dimension material up to 6 m. The minimum diameter at breast height (dbh) for assessable trees is determined by the expected felling date for the stand, as shown in Table 2. These numbers are based on experience of the typical growth of individual Sitka spruce trees and are provided for guidance only.

Table 2

Guideline minimum diameters for assessable trees

Assessment date	Minimum dbh of assessable trees
≤ 5 years before felling	20 cm
6–10 years before felling	17 cm
11–15 years before felling	14 cm
≥ 16 years before felling	10 cm

Straightness assessment of sample trees

8. For each sample tree a visual estimate should be made of the number of straight log lengths in the first 6 m butt portion of the tree.

9. The definition for straightness to be used is that given for green logs in Field Book 9 *Classification and presentation of softwood sawlogs* (Forestry Commission, 1993). 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."

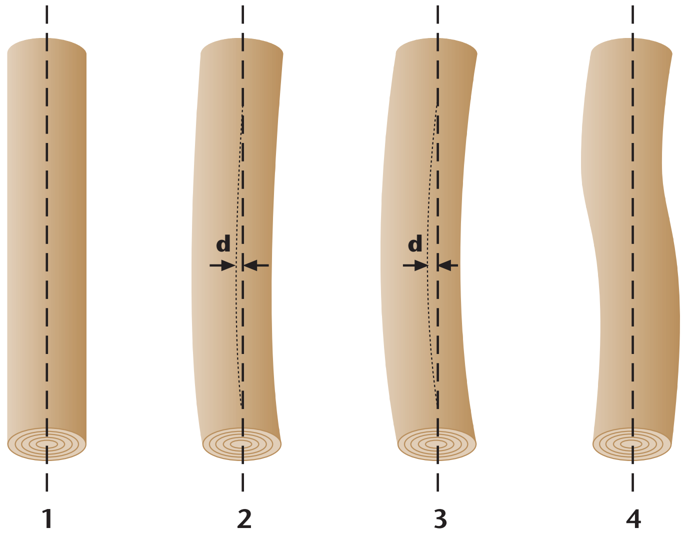

Figure 1

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.

10. The categories of straight log length that should be identified are:

- Greater than or equal to 5 metres.
- Greater than or equal to 4 metres but less than 5 metres.
- Greater than or equal to 3 metres but less than 4 metres.
- Greater than or equal to 2 metres but less than 3 metres.

In theory each of these lengths is therefore a green log or a short green log. However, it should be noted that this protocol does not measure knottiness or other defects and some downgrade may therefore occur (Forestry Commission, 1993).

11. Normal commercial cutting practice must be ignored and no thought given to wastage. For example, if a 3 m straight length is identified in the middle of the first 6 m, no regard is given to the 1.5 m waste above and below the 3 m length.

12. A score should be assigned to each tree according to the scoring system shown in Table 3. Figure 2 illustrates the different possible combinations of straight log lengths that can be identified.

Table 3 Straightness scoring system

Score	Number of straight logs counted in 6 m butt			
	≥5 m	≥4 m <5 m	≥3 m <4 m	≥2 m <3 m
1	-	-	-	-
2	-	-	-	1
3	-	-	-	2
4	-	-	1	-
5	-	-	1	1
6	-	1	-	-
7	1	-	-	-

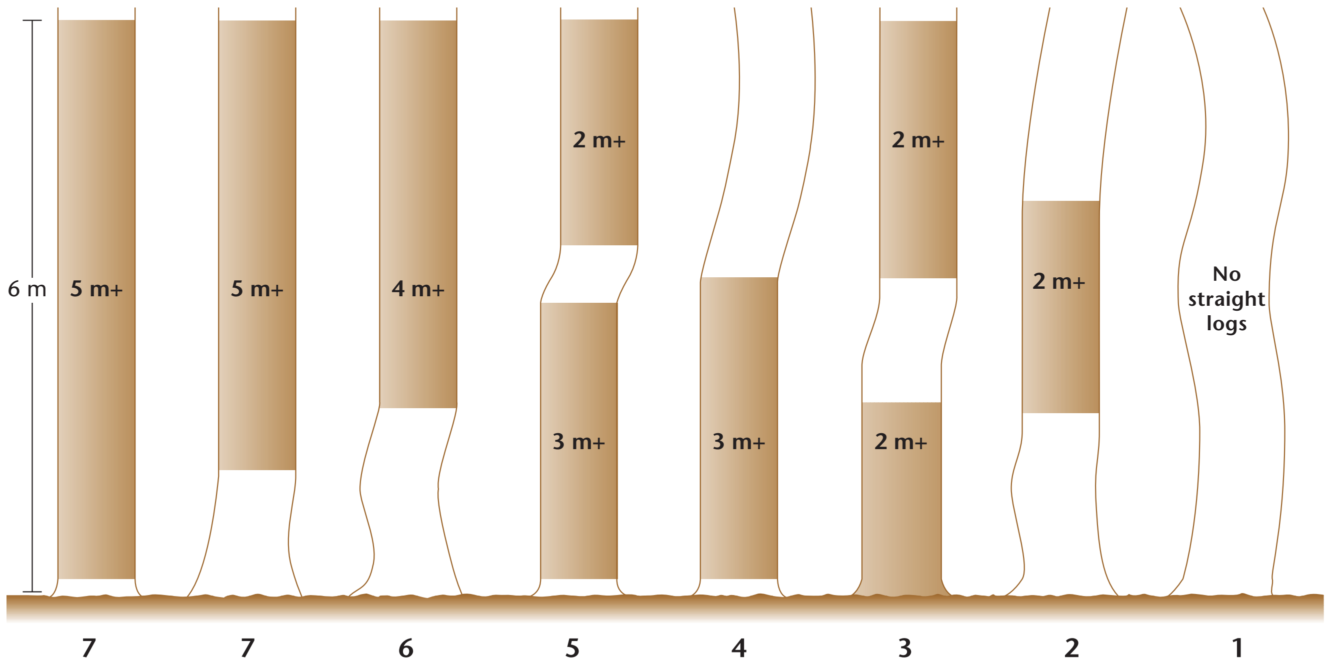

Figure 2

Straightness Score: different combinations of log lengths in first 6 m showing gradual reduction in quality from left to right (after Methley, 1998)

13. Initial estimates by Technical Development Branch based on surveys in two compartments indicate that a 2-man team should be able to measure approximately 13 plots/day. This does not include allowance for any:

- preparatory office planning or post collection data processing;
- travel to and from sites;
- lost time.

The figure is provisional and will be re-evaluated with further work study trials. It is probable, based on the experience of assessors working on a survey of over 270 sites in south Scotland (Stirling *et al.*, 2000), that the number of plots sampled per day will increase with experience.

INTERPRETATION OF STRAIGHTNESS SCORE DATA

14. Stand mean straightness score is the average of all the individual tree scores in a stand. Stand mean straightness scores can be used to rank stands relative to one another. In order to provide more information about the distribution of scores within a stand and hence an indication of the distribution of green log lengths, five quality grades (A–E) have been defined based on the proportion of trees in a stand being assessed in each of the seven straightness score classes:

Grade A – $\geq$ 40% of trees scored 6 or 7

Grade B – > 50% of trees scored 4, 5, 6 or 7 but < 40% score 6 or 7

Grade C – $\geq$ 35% of trees scored 3, 4, 5, 6 or 7 but $\leq$ 50% score 4, 5, 6 and 7

Grade D – < 35% of trees scored 3, 4, 5, 6 and 7 but $\leq$ 50% score 1

Grade E – as for Grade D but > 50% of trees scored 1

For example, a stand with the following score distribution:

Score	% of trees	Cumulative %
7	8	8
6	15	23
5	12	35
4	15	50
3	23	73
2	17	90
1	10	100

would be defined as Grade C, because more than 35% score 3 and over, but only 50% score 4 and over and less than 40 % score 6 or 7. This system has been tested on data from over 270 sites sampled during a straightness survey in south Scotland (Stirling *et al.*, 2000).

The grading score for each site was shown to reflect extremely well the mean straightness score for the site. However, it has the advantage of at the same time providing a measure of the spread in straightness scores within the stand.

APPLICATIONS FOR THE STRAIGHTNESS ASSESSMENT METHOD

15. The stem straightness assessment method described in this Note has only been tested on Sitka spruce, although some of the early work in development of the method included assessment of Norway spruce. In principle, however, the assessment method could be applied equally well to any plantation-grown conifer species in the UK.

16. The assessment can be completed on trees of 20 years old and upwards. In young stands (20–30 years) and in those with heavy branching or where branch whorls are very close together, it can be difficult to see the stem clearly enough to assess straightness and particular care is required. This can be exacerbated if light levels are low, so assessment during late spring, summer and early autumn is recommended. Furthermore, heavy branching may mean that the straightness score alone will not be good enough to identify green logs.

17. A range of applications for the stem straightness assessment method can be envisaged, depending on the individual requirements of forest owners and managers:

- Providing improved information to wood-using industries about the quality of future timber supplies.
- Collection of stand log quality information during inventory, for inclusion in forest databases and linking to Geographic Information Systems.
- Incorporating log quality information into production forecasts.
- Assistance for decision making in forest management, e.g. thinning requirements, rotation lengths, forest design planning.

RECOMMENDATIONS

18. The mean straightness score for a stand provides a method of making comparisons between stands.

19. The scoring system described in this Note is recommended as the provisional standard scoring system for measuring straightness in British forestry. It should be used whenever an assessment of stand stem straightness is required.

20. Straightness quality grade (A–E) provides useful information about the stem straightness distribution within a stand and the likely log assortment in the first 6 metres of the stem. It is recommended as the standard grading system to be applied to stands.

21. Although the straightness assessment was developed for Sitka spruce it is equally appropriate for any other conifer species.

22. The suitability of the provisional standard should be reviewed in the light of experience of its use by the industry over the next 2 years.

ACKNOWLEDGEMENTS

The original efforts towards the development of a prototype system for the measurement of stem straightness by Janet Methley and other members of Forest Research Mensuration Branch were the catalyst for the work presented in this Note. The support of the Scottish Forestry Trust, Scottish Woodlands Ltd, Tilhill Economic Forestry Ltd, the United Kingdom Forest Products Association, Scottish Enterprise Borders and Scottish Enterprise Dumfries and Galloway is gratefully acknowledged.

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APPENDIX: DEVELOPMENT OF STEM STRAIGHTNESS SCORING SYSTEM FOR SITKA SPRUCE

Background

A1. Timber production in the UK is due to rise significantly over the next 20 years, with annual sawlog output forecast to be double current levels by 2020 (Whiteman, 1996). Domestic demand for sawn timber over the same period is forecast to remain relatively static (Whiteman, 1996). Successful marketing of UK sawn timber is, therefore, dependent upon gaining an increased market share over imported timber. Pallet, packaging and fencing markets, which currently absorb more than two-thirds of UK sawn timber production, are likely to become over-supplied (McIntosh, 1997), so that greater penetration of the construction sector will be necessary.

A2. Concerns about the quality of future home-grown sawlog supplies have been voiced throughout the forestry and wood using industries. It is feared that many sawlogs will be of too low a quality to provide material for the construction market. These concerns, which mainly involve Sitka spruce, are based on anecdotal evidence of timber coming on to the market in recent years and on the likely consequences of the changes in silvicultural practice that have taken place over the past 50 years (Brazier, 1977; Mason, 1993).

A3. The investments in sawmilling capacity required to process the increased softwood supply for the construction market are unlikely to take place without improved information about the quality of future sawlog supplies. An assessment of the quality of the standing domestic timber resource, particularly Sitka spruce, is required urgently to enable the sawmilling industry to develop appropriate investment strategies. This requirement was highlighted in a recent market development study (Jaakko Pöyry, 1998).

A4. A forecast of the **quantity** of timber to be harvested from forests in Great Britain is prepared periodically by the Forestry Commission (e.g. Rothnie and Selmes, 1996). To date there has been no comparable estimate of **quality**. An assessment of timber quality at this strategic level requires a standardised method of assessing quality that can be applied to stands throughout Britain.

A5. The refinement and validation of the prototype straightness scoring system developed by Methley (1998) is described below.

Refinement and Testing of the Prototype Method

A6. The original six point scoring system was revised to a seven point scale to allow the identification of a longer straight log length category than in the previous system, i.e. logs greater than 5 metres. These are lengths from which the commonly required log length of 4.9 metres, important for conversion to construction material, could definitely be obtained. The maximum log length identified by the previous method, i.e. logs of greater than 4 metres, did not guarantee that these lengths could be obtained.

A7. Ways in which the objectivity and accuracy of the prototype log quality assessment method might be improved were investigated during a field trial in an unthinned stand of 45-year-old Sitka spruce in Ae Forest District. The use of a hypsometer or a wooden pole to help pinpoint heights on the trees was compared with a purely visual assessment. A team of three observers assessed the same sample of 25 trees nine times using each of the three assessment methods every day for three days. The sample trees were then felled and log quality was assessed on the ground collectively by the team of observers and then by a sawmilling expert. There were no significant differences between-observers or between-methods in the log straightness scores obtained. The use of aids to measurement did not increase the consistency of observations between observers or their accuracy in relation to felled assessments. However, the use of aids to measurement added significantly to the time required to complete the assessment, thereby greatly increasing the cost without any apparent benefit in terms of consistency or accuracy. Therefore, a visual assessment was considered the most cost-efficient method of survey.

A8. To establish appropriate levels of sampling, 17 permanent Sitka spruce sample plots, known to have widely varying form, were studied. The sample included ten unthinned plots, five thinned plots and two plots respaced at 10 years old, and contained between 45 to 263 trees per plot. The plots ranged in age from 28 to 42 years. A log straightness assessment was completed for every tree in each sample plot. Statistical analysis of the data indicated that between 60 and 100 trees, depending on stand area, should be assessed to obtain an acceptable estimate of the mean and the distribution of straightness scores for a stand. Randomly located line plots consisting of ten trees on which assessments could be performed were considered the most appropriate sample unit. The trees to be assessed must be alive and with a sufficiently large dbh (see paragraph A9 below).

A9. Since the aim of the assessment is to give an estimate of the quality of sawlogs, it is important to select sample trees that will be of sufficient dimensions to be cut into sawlogs when they are felled. To achieve this, minimum diameters at breast height for assessable trees have been defined according to the expected felling date of the stand, based on taper and growth data for Sitka spruce (see Table 2).

A10. A small study was undertaken to examine the changes, if any, in stem straightness score that are likely to occur between a mid-rotation assessment and the time of felling (Macdonald and Barrette, 2000). Stem quality data from four Sitka spruce permanent sample plots assessed in 1953 and 1963 were reviewed to determine how stem form varied over time at the individual tree level and at the stand level. In addition, detailed stem analyses were completed for ten Sitka spruce trees planted in 1961 to examine changes in stem profile and straightness score over the life of the trees. The results of these studies suggest that while the profile of individual trees may alter slightly with time, any change in straightness score is likely to be confined to a difference of at most one point and that such a change is uncommon. At the stand level this is unlikely to have a significant effect on the characterisation of the stand. Therefore, a quality assessment made in a stand up to 15 years before the expected felling date can provide a reasonable prediction of the final stand quality.

A11. The use of the straightness assessment method to make meaningful detailed predictions about volumes of different products from a stand is not straightforward, given local variations in market conditions. Making such predictions across a range of stands is likely to require a more detailed method of assessment, such as the MARVL package developed in New Zealand (Deadman and Goulding, 1978), considering the entire merchantable stem of the tree and incorporating product specifications particular to a given location or market.

The straightness assessment method described in this Note is useful for differentiating between stands of differing quality at a strategic level, and in particular for highlighting those of especially high or low log quality.

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Enquiries relating to this publication should be addressed to:

Jason Hubert or Shaun Mochan
Forest Research
Northern Research Station
Roslin
Midlothian
EH25 9SY

Tel: 0131 445 2176
Fax: 0131 445 5124

E-mail: jason.hubert@forestry.gsi.gov.uk
shaun.mochan@forestry.gsi.gov.uk

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