Forestry Commission

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REVISED WINDINESS SCORES FOR THE WINDTHROW HAZARD CLASSIFICATION: THE REVISED SCORING METHOD

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Abstract

Revised windiness scores for the windthrow hazard classification are presented. Wind zone, elevation and total topex scores have been revised as a result of a new analysis of tatter flag data. The new analysis is the first objective evaluation of the contribution of the different components. An aspect score is introduced and this can be derived in two ways – by selection of a single aspect term eg SW, NE (the Simple Aspect Method of Scoring) or by calculation from topex sector values (the Detailed Aspect Method of Scoring). Recommendations on choice of method are given. The Detailed Aspect Method of Scoring is the preferred option; it includes a measure for wind funnelling and is therefore particularly appropriate in complex terrain.

Introduction

The windthrow hazard classification (Miller, 1985; Booth, 1977) has been widely used by British foresters to identify areas of forest at threat from windthrow. Hazard class is derived by adding scores for three windiness components (ie wind zone, elevation and topex) to a score for soil type. This Research Information Note (RIN) presents revised scores for these three windiness components and scores for a new component (aspect). These revised scores should be used in place of those listed in Forestry Commission (FC) Leaflet 85 (Miller, 1985). Full details of the revision will be published in due course.

The revised windiness scores result from a new form of analysis and an extended dataset. Previous scores have been produced by simple linear regression of rate of tatter against elevation (Miller *et al.*, 1987), and by subjective weighting of the importance of wind zone, elevation and topex. The new analysis uses multiple regression of tatter against location, elevation, topex and aspect in a manner similar to a recent yield prediction study (Worrell, 1987; Worrell and Malcolm, 1990a). This gives objective estimates of the relative contribution of these factors to site windiness. Nevertheless, the overall weight accorded to windiness components as against soil type remains subjective.

The analysis has included data from a tatter flag network that has been substantially extended since previous studies (Miller *et al.*, 1987; Worrell, 1987). Tatter flag data have been used because they remain the best estimates of windiness for upland Britain. Tatter rate has been shown to be well correlated with windspeed, and the topographic coverage is superior to other forms of wind data. In using these estimates for a damage classification it is assumed that the frequency of damaging winds is related to the general windiness at a site.

Analysis of tatter flag data to derive the revised scores

Data from 1173 flag sites were used in the analysis. Two equations were fitted to the data. The first equation explained tatter in terms of location elevation, total topex, and aspect (as identified by one of eight main compass points) and gave an adjusted R^2 of 0.587. This provided a Simple Aspect Method of Scoring (SAMS). The second equation replaced the single aspect term with a weighted average of the eight sector topex values used to form total topex. This gave a Detailed Aspect Method of Scoring (DAMS). The second equation improved the explanation of tatter (adjusted $R^2 = 0.603$), largely because the treatment of aspect through sector values included a measure of funnelling through valleys. The change of R^2 value may seem slight, but it represents a highly significant ($P < 0.001$) improvement over the first equation. The problem of allowing for the effect of funnelling has previously been seen as a problem with the topex system (Worrell and Malcolm, 1990b).

The equations predicted tatter rate in cm^2/day. The range of possible tatter values was less than that used in previous windiness scores: a linear transformation was therefore applied to the tatter values to make the revised range similar to the old range. Without this transformation the hazard class thresholds would have had to be reduced to prevent wholesale hazard class changes. It should be stressed that this transformation is conservative and will tend, if anything, to overestimate windiness scores. The scoring system presented below is, therefore, no longer in units of tatter but in arbitrary units of hazard class windiness score.

The revised scores

The total windiness score is formed by combining scores for wind zone, elevation, topex and aspect (SAMS or DAMS); choice of aspect method involves slight differences to the scale used for elevation and topex scores.

SAMS will be applicable:

- for office revisions where only topex maps or topex totals remain from the previous derivation of hazard class
- for new field surveys where the terrain is relatively simple, eg gently rolling Borders country, flat plateaux and plains
- where the presence of mature forest prevents complete topex sector values being recorded.

Front cover. Windthrow, Brechfa Forest, Wales. Photograph: Angus Mackie

DAMS is preferred, and will be most applicable for:

- office revisions where topex sector values exist
- new field surveys, particularly those in areas of complex terrain, eg western Highlands, valleys
- calculations from digital terrain models (Quine and Wright, 1993).

However, both methods are suitable for automation of scoring through the use of digital terrain models and geographic information systems.

Wind zone score

The wind zone score is read directly from the map (Figure 1). Interpolation is acceptable close to boundaries but will rarely be required as the major steps of the previous map have been removed (eg wind zone D score 7.5 compared with wind zone E score 2.5). The new boundaries give rise to changes in wind zone score of -7 to +6 compared with the previous map.

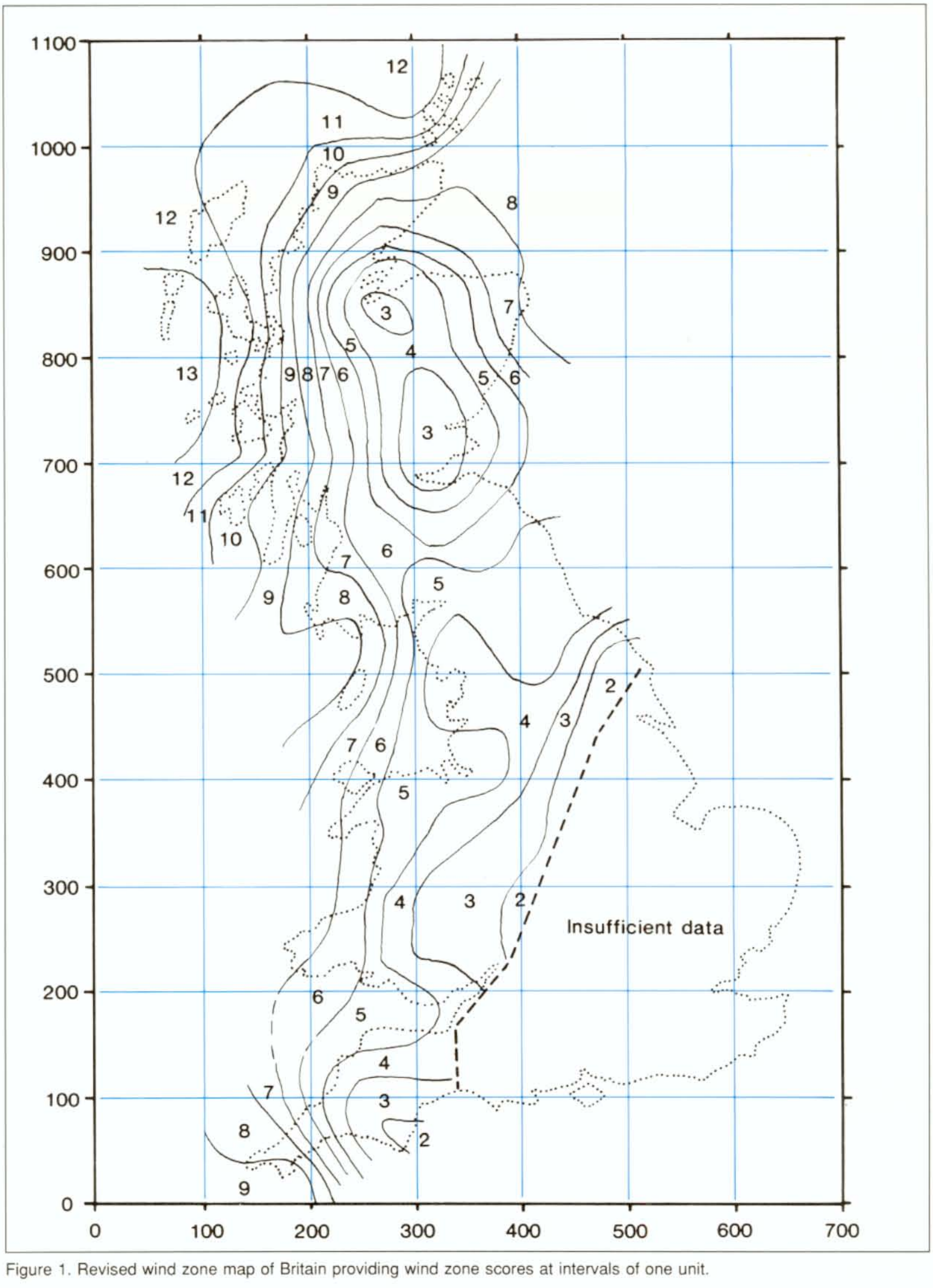

Figure 1. Revised wind zone map of Britain providing wind zone scores at intervals of one unit.

Elevation score

Elevation (m) obtained from map or altimeter is converted to an elevation score using Figure 2. The revised elevation score represents a simple linear increase with increasing height above sea level. Elevations below 340 m score more under the revised system, with a maximum difference of +2.4 at 190 m. There is no consistent change at elevations greater than 340 m.

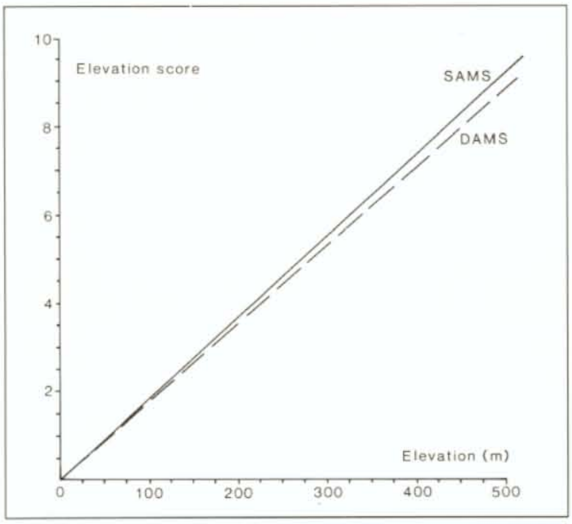

Figure 2. Revised elevation scores – choice of score line depends on choice of aspect scoring method (SAMS or DAMS).

Topex score

The total topex value (ie the sum of the eight principal compass point (sector) skyline angles) obtained for the site is converted to a topex score using Figure 3. Sites with topex values between 0 and 25, and over 40 will generally score less under the revised system. The changes are particularly marked for topex values 5-15 and 60-70, with a maximum difference of -3.4 at a topex of 15.

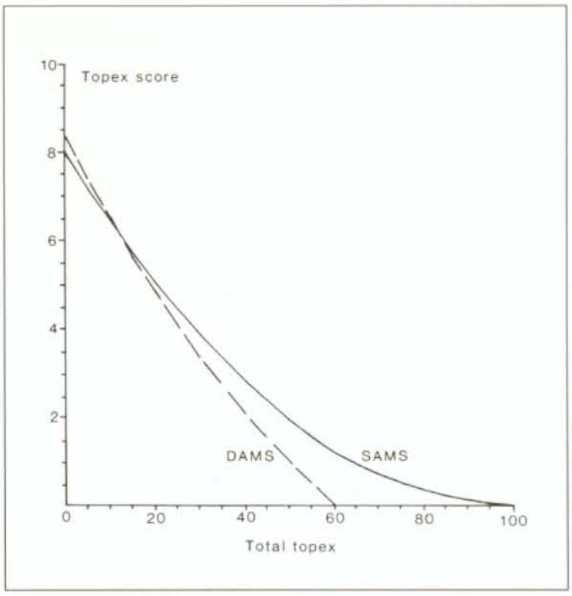

Figure 3. Revised topex scores – choice of score line depends on choice of aspect scoring method (SAMS or DAMS).

Aspect score - SAMS

The aspect obtained for the site as a principal compass point is converted to an aspect score using Table 1. This new score reflects exposure to prevailing winds and has a range of -1 to +1.

Aspect score - DAMS

The aspect effect is derived as a weighted sum of the eight individual sector values using the constants from Table 2, A. In addition, the potential for funnelling is calculated using the equation in Table 2, B. The range of the combined score of aspect and funnelling is dependent on landform, with large values most likely to occur where topex is high. Values between -0.3 and +6.3 have been obtained in early trials.

Table 1. Aspect Scores for the Simple Method (SAMS)

Aspect	ALL	NIL	N	NE	E	SE	S	SW	W	NW
Hazard class score	+1.0	−1.0	0	−0.5	−0.5	0	0	+0.5	+1.0	0

Notes: An aspect of ALL applies to level or gently sloping sites that have no single or defined aspect but are well exposed, eg hilltop or plateau.
An aspect of NIL applies to level or gently sloping sites that have no single or defined aspect but are sheltered, eg valley or basin.

Table 2. Aspect Scores for the Detailed Method (DAMS)

A. Aspect Effect

Aspect	N	NE	E	SE	S	SW	W	NW
Hazard class score	+49	−19	−17	+48	+27	−63	−59	+34

Note: Multiply each topex sector value by the appropriate constant. Sum the results and divide by 1000. The resulting score may be positive or negative and is added to or subtracted from the other windiness scores accordingly.

B. Funnelling Effect

$$\text{Funnelling effect} = 0.1074 \times \sqrt{\left(\begin{matrix}\text{N}\\ \text{sector}\\ \text{value}\end{matrix} - \begin{matrix}\text{E}\\ \text{sector}\\ \text{value}\end{matrix} + \begin{matrix}\text{S}\\ \text{sector}\\ \text{value}\end{matrix} - \begin{matrix}\text{W}\\ \text{sector}\\ \text{value}\end{matrix}\right)^2 + \left(\begin{matrix}\text{NE}\\ \text{sector}\\ \text{value}\end{matrix} - \begin{matrix}\text{SE}\\ \text{sector}\\ \text{value}\end{matrix} + \begin{matrix}\text{SW}\\ \text{sector}\\ \text{value}\end{matrix} - \begin{matrix}\text{NW}\\ \text{sector}\\ \text{value}\end{matrix}\right)^2}$$

Note: Enter the appropriate topex sector values into the equation. The value is always positive.

Windthrow hazard class

The wind zone, elevation, total topex and aspect (SAMS or DAMS) scores are added to the soil score (FC Leaflet 85; Tables, 5, 8 and 9) and converted to a hazard class (FC Leaflet 85, Table 6) in the same manner as before (Miller, 1985). A worked example using SAMS is provided in Table 3, and a worked example using DAMS is given in Table 4. FC Leaflet 85, Tables 5 and 6 are reproduced here as an Appendix for convenience. However, readers are referred to the fuller discussion of soils and use of the hazard classification in the original publication.

Table 3. A Worked Example Using SAMS

A site in the Borders region on a west-facing slope, with a peaty gley soil, scored using SAMS.

Component	Site Value	Source for Score	Score
Wind zone	6	Figure 1	6
Elevation	300 m	Figure 2	5.6
Topex	N NE E SE S SW W NW – Total 4 6 6 6 4 2 0 2 30	Figure 3	3.8
Aspect	W	Table 1	1.0
Soil	Peaty gley	FC Leaflet 85, Table 5 or 8	10
Total hazard class score		Sum of components	26.4
Windthrow hazard class		FC Leaflet 85, Table 6	5

Table 4. A Worked Example Using DAMS

A site in Central Argyll at the base of a valley with axis ENE–WSW, with a brown earth soil, scored using DAMS.

Component	Site Value	Source for Score	Score
Wind zone	8	Figure 1	8
Elevation	150 m	Figure 2	2.6
Topex	N NE E SE S SW W NW – Total 9 11 24 25 7 3 22 16 117	Figure 3	0
Aspect	Aspect effect (sector x constant) N NE E SE +441 −209 −408 +1200 S SW W NW +189 −189 −1298 +544	Table 2, A	
	Sum of sector products = 270 ÷ 1000 = 0.3		
	Funnel effect $= .1074 \times \sqrt{(-15-15)^2 + (-14-13)^2}$ $= .1074 \times 40.4 = \underline{4.3}$	Table 2, B	
	Aspect score (aspect effect + funnel effect)		4.6
Soil	Brown earth	FC Leaflet 85, Table 5 or 8	0
Total hazard class score		Sum of components	15.2
Windthrow hazard class		FC Leaflet 85, Table 6	3

Effect of the revised scores

Comparisons of revised and old scoring methods can be found in Quine and Wright (1993).

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Appendix

FC Leaflet 85, Table 5. Soil scores based on root development and broad soil groups. (See Leaflet 85, Tables 8 and 9 for more detailed soil scores.)

Root Development	Soil group	Score
Unrestricted rooting in excess of 45 cm	Brown earths, podzols, intergrades to ironpan	0
Restricted rooting but some structural root penetration in excess of 25 cm	Deep peats loamy gleys	5
Very restricted rooting under 25 cm deep	Peaty gleys, surface water gleys, deep peats, shallow indurated soils, waterlogged soils	10

FC Leaflet 85, Table 6. Windthrow hazard classes

Windthrow hazard score range	Windthrow hazard class
0 – 7.5	1
8.0 – 13.5	2
14.0 – 19.0	3
19.5 – 24.5	4
25.0 – 30.0	5
30.5 and above	6

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