

Forest Susceptibility to Windthrow

W.D. Holland

SYNOPSIS

Definition: This paper identifies and assesses physical site factors responsible for forest susceptibility to windthrow and suggest an interpretive method to estimate the windthrow hazard.

Applicable Conditions: The interpretive procedure is valid for edaphic site information such as depth to root restricting layer, soil texture, internal profile drainage, and depth to water table. The procedure can also be applied to physiographic variables such as exposure and aspect, topography, elevation, funneling and shape and landform mass and location.

The data for evaluation of these factors should be available in the landform and physiographic descriptions found in soil survey reports.

Because of limitations to the data contained in soil survey reports, the procedure does not include an evaluation of meteorological factors such as wind direction, speed, or frequency, or quantity and intensity of precipitation and whether it occurs as rain, glaze, or snow. Also excluded are the biological factors of variable stand composition, including root rot, butt rot, poor stocking, open stocking, tree species and root characteristics.

Management practices may also play an important role in windthrow and are considered to be the forester's responsibility for evaluation. The forestry practices include such things as selective versus clear cutting; size, shape, and orientation of cutting; cutting patterns, including thinning, leave strips, borders, seed trees, time since cutting; and fire management.

Classes: Four interpretive classes will be used to express the following degrees of limitations:

none to slight, moderate, severe, and unsuitable.

None to slight - These landforms and soils have properties favorable for the rated use. Limitations are minor and can easily be overcome. Very low losses are expected because of windthrow of trees.

Moderate limitations - Limitations can be overcome or modified with special planning, design, or action. Some soils may require drainage or physical amelioration to increase rooting depth. Forest management may have to be altered in order to protect trees from windthrow.

Severe limitations - Limitations are difficult and costly to overcome or modify. Landforms may preclude most forest management practices that will reduce the susceptibility of trees to windthrow. Soil conditions are too difficult and costly to alter in order to reduce windthrow.

Unsuitable - These landforms and soils have such unfavorable properties that they cannot be used for commercial forest production; e.g. windswept coastal areas or alpine conditions where krummholz, or other treeless vegetation occurs. However, treeless areas resulting from lack of moisture or low temperatures are excluded.

Information Required: The following information is required.

Physiographic -

- 1) exposure
- 2) aspect
- 3) topographic class
- 4) elevation
- 5) funneling and shape
- 6) mass
- 7) mountain location
- 8) plains location

Edaphic -

- 1) depth to root restricting layer
- 2) soil texture
- 3) drainage
- 4) depth to water table

The Interpretive Model: The interpretive model is based on identifying the items affecting windthrow of trees and utilizing those data available (or that can be made available in soil survey reports) to develop criteria defining the limitations that constitute the interpretive classes, and presenting the data in tabular format. However, the interpretive model is constructed in a manner that uses site specific data to estimate the limitations of map units to windthrow hazard.

RATIONALE FOR THE INTERPRETIVE METHOD

The interpretive information is presented in tabular format (Table 1), giving the kind of limitation causing forest susceptibility to windthrow,

as well as interpretive classes that express the degree of limitation, or severity of the windthrow hazard. The methodology is adapted from Coen and Holland (1976) and predecessors, and assumes a forest management level commensurate with present forest management techniques.

Limitation ratings are used to evaluate the mapping units; hence, sufficient site specific data must be collected that representative values may be applied to the map unit ratings.

The following considerations must be examined when using the interpretive ratings:

- 1) Interpretations are based on present knowledge and forest management practices.
- 2) The interpretive ratings do not include any economic or aesthetic values.
- 3) Ratings are based on natural undisturbed landforms and soils.
- 4) Severe ratings express the degree of risk, but do not mean that forests should not be managed or regenerated in such areas. Unsuitable areas are those that are so windswept that trees do not become large enough to be subject to windthrow; e.g. krummholz.
- 5) Interpretations do not eliminate the need for site specific investigations by qualified professionals.
- 6) The number of interpretive classes is restricted at the present time. Ratings are not static. They can be changed as more knowledge becomes available. Similarly, the number of classes can be increased to 5, or even 7 classes, as research provides data enabling greater precision in determining forest susceptibility to windthrow.

Table 1. Guide for assessing physiographic and soil limitations for windthrow hazards

Item affecting	Degrees of limitation			
	None to slight	Moderate	Severe	Unsuitable
<u>Physiographic factors:</u>				
Exposure	Lee side (eastern), transverse valley, valley bottom	Partially sheltered	Windward side, open slopes, narrow valley, valley linear with wind	Krummholz areas
Aspect	Eastern	NNW, N, SSW, S	SW, W, NW	
Topographic class	Level to gentle 0 - 9%	Moderate to strong 10 - 30%	Very strong to very steep; 31 - 100%	Very steep slopes > 100% or > 45
Funneling	Broad, open space	Partial funnel, some restrictions	Unrestricted funnel features	Krummholz areas.
Shape	Regular, subdued	Irregular, abrupt	Cols, cirques, passes	All areas where tree growth is precluded
Mass	Long chain, subdued		Isolated peak, abrupt	
Mountain location	Valley floor, benchland	Valley wall	Peak	
Plains location	Depressional	Rolling	Hills, knolls, ridges	
<u>Edaphic factors:</u>				
Depth to root restricting layer	1 - > 3 m	50 - 100 cm	10 - 50 cm	Nonsoil < 10 cm
Soil texture	l, sil, sl, s, ls	sicl, scl, sc	cl, sic, c	Rock, nonsoil
Drainage	Rapid to moderately well drained	Imperfectly drained	Poorly to very poorly drained	Permanent water or, temporary water if time prevents tree growth
Depth to water table	1 - > 3 m	50 - 100 cm	< 50 cm	

SOURCES OF ERROR

- 1) Soil texture - may not be directly related to forest susceptibility to windthrow. Trees on sandy loam soil, for example, may be quite stable in a sheltered location, but extremely susceptible to windthrow on the same soil if it is located in an exposed location. Soil texture may be more directly related to rooting depth and pedogenic process; e.g. a clay loam soil is more likely to have a compact and cold Bt horizon (thus limiting tree growth) than is a loam or sandy loam. Furthermore, the influence of soil texture - soil water relationships on windthrow is not known; e.g. a SL may have 15% water at field capacity while a CL may have 30%. Certainly a soil with 10% more water than field capacity is probably unstable for trees that are subjected to wind. However, it should be noted that supersaturated soils often support trees, especially when they are on depressional protected sites. Hence, it appears that rating soil texture (and soil moisture) could lead to errors and that emphasis should probably be placed on physiographic factors such as exposure, aspect, and landform shape.
- 2) Elevation - is not always directly related to windthrow susceptibility, as climate and landform exposure may be dominating factors on a specific site. Thus, elevation has not been included in the rated limitations.
- 3) Exposure - has long been recognized as a limitation to forest growth (McCormack, 1965), but definitive methods of measuring the effect of wind on forest growth have not been developed. The same criticism may be applied to the effect of wind on tree windthrow. The mapper is cautioned to carefully define the criteria used to express the varying degrees of limitation that exposure has on forest tree windthrow. The criteria developed in Table 1 for exposure and aspect may prove to be inadequate in the field and may require subsequent modification.

CONCLUSION

The susceptibility of forest trees to windthrow probably results from the combined effects of meteorological, physiographic, edaphic, and biological factors, as well as forest management practices. Soil survey reports can provide data for interpretive evaluation of the physiographic and edaphic factors. It is the forester's responsibility to complete the evaluation of the windthrow hazard by assessing the meteorological and biological factors and the effect of forest management practices. Four interpretive classes are established and a tabular method of evaluation and presentation is suggested. It is suggested that research be conducted into developing a better method of measuring the degrees of limitation causing forest susceptibility to windthrow.

REFERENCES

- Coen, G.M. and W.D. Holland. 1976. Soils of Waterton Lakes National Park, Alberta. Information Report NOR-X-65, Northern Forest Research Centre, Canadian Forestry Service, Environment Canada, Edmonton. 116 p and maps.
- McCormack, R.J. 1965. Outline of the Canada Land Capability classification for forestry. ARDA, Canada Land Inventory, Dept. of Forestry, Ottawa. 10 p.
- McKeague, J.A. and P.N. Sprout. 1975. Cemented subsoils (Duric horizons) in some soils of British Columbia. Can. J. Soil Sci. 55: 189-203.
- Moore, M.K. 1977. Land Management Report No. 3. Factors contributing to blowdown in streamside leave strips on Vancouver Island. B.C. Ministry of Forests, Victoria, B.C.
- Newstein, S.A. 1968. Damage to forests in relation to topography, soil and crops. pp. 42-48. In Forestry Commission Bulletin No. 45. Windblow of Scottish forests in January 1968. Edited by B.W. Holtam, Forestry Commission, Edinburgh.
- Rollerson, T. 1982. Relationships between windthrow and various environmental variables. In Soil interpretations for forestry. APD Technical Paper 6, Thand Management Report No. 10, B.C. Ministry of Environment, Victoria, B.C. pp. 41-62.
- Vold, Terje. 1981. Discussion paper. Soil interpretations for forestry. Terrestrial Studies Branch, B.C. Ministry of Environment, Victoria, B.C.