Silviculture and Management in Relation to Risk of Windthrow in Northern Ireland

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Assessment of windthrow risk

1. Introduction

In producing a windthrow risk assessment chart (Table 1) the object has been to provide a rational means of deciding what management principles are best suited to any particular site. The degree of risk predicted refers to damage of the kind that can occur under ordinary circumstances.

There are many factors involved in the assessment of wind risk, only some of which are included, and changes in the value of one may alter its relative status with regard to others. Those used are broadly assessed and capable of substantial refinement. For example the gley soil group includes humic gley which is more windthrow prone than gley with a well developed eluviated horizon. Some of the effects are indirect, for example 'geology' combines the effect of land form and exposure, and is also related, by chance, to changing wind speeds over the country. Of the wind itself, its speed, gustiness and turbulence, very little is known, although there are indications that storms may follow a cyclical pattern with 4 or 5 years of high winds being followed by 6 or 7 quieter years, within an 11-year cycle.

The guide must be used with this background in mind and results interpreted and applied in the light of local knowledge and experience.

2. Classification of windthrow risk

Windthrow risk can be assessed for forests in the establishment phase by considering the influence of six site factors. These are: soil type, angle of slope, aspect, altitude, exposure (as measured by the Topex system) and geology. By allocating a degree of risk to each, an overall site assessment can be made as shown in Table 1. It is convenient to recognise four classes of risk:

Very high risk—for sites with a total score of 20 or more points.
High risk—with a score of 16 to 19 points.
Moderate risk—a score of 11 to 15 points.

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TABLE 1
Windthrow Risk Assessment Chart

Score / Factor	0	1	2	3	4	5
Soil	Brown Earth	Ironpan	Valley Peat, Podzol	Climatic Peat	Peaty Gley	Gley
Slope	24°+	15–24°	0–4°	10–14°	5–9°	
Aspect		Flat	S	NE	N	
		E	SW	NW	SE	
			W			
Altitude		0–150′	150′–450′	900′–1,250′	450′–900′	
		1,250′+				
Topex	100+	31–100	11–30	0–10		
Geology	Old Red Sandstone	Granite	Schist, Silurian	Carbon-iferous	Basalt	Triassic Cretaceous

Score: 20 and over—very high risk
16 to 19—high risk
11 to 15—moderate risk
10 and below—low risk.

Low risk—for those sites scoring 10 points or less.
The application of this method to forest inventory plots indicated that about 14% were classified as of very high risk, 54% fell into the high risk class, 27% were in zones of moderate risk and low risk sites accounted for a remaining 5%.

3. Method of risk assessment

Where forests are extensively managed the areas to be assessed for wind risk can be large, either the whole forest or a readily identifiable part such as a catchment area or a system of hills. In intensively managed forests the area assessed may be much smaller—a few compartments or an outlying block. The smallest unit which can be considered is one bounded on all sites by permanent margins or an area having marked changes in site factors influencing stability.

In an area selected for assessment a reasonably dispersed coverage of not less than 20 randomly located sample plots is needed. Soil and exposure maps are available for nearly all state forests, and these, in conjunction with the Ordnance Survey Map, provide nearly all the information needed to make an assessment of risk. If two-thirds of the plots have a score falling into one risk class then it will usually be acceptable to allocate the whole area to that class. However, in some circumstances it may be appropriate to divide the forest into risk classes, and further sampling may be needed. The variability of the samples will be a guide as to whether this is required.

4. Management options

4.1 Stand Structure

Three silvicultural regimes are open to management: high forest, coppice and coppice with standards. Within the high forest two forms of stand structure are distinguished; selection high forest, which is uneven aged; and regular high forest, which is even aged. Further sub-divisions are possible. The selection forest may be either single stem selection or group selection, and the regular high forest may be clear felled or worked on one of the many forms of shelter wood systems. In Northern Ireland the choice lies between group selection or regular high forest with clear felling. In both cases regeneration is normally artificial.

Windthrow is related to the degree and extent of interruptions to the forest canopy. Because of this group selection high forest is suitable only in low risk areas. The practice of regenerating small areas, from which windthrow timber has been cleared, tends to result in a structure approaching that of the group selection high forest, thus increasing windthrow risk. There are only a few locations where the silvicultural system selected can be other than regular high forest with clear felling, with coupes usually at least of compartment size.

4.2 Production Regime

On high and very high risk sites interruptions to the canopy following racking and thinning, and the damage to root systems by extraction operations, can induce an unacceptable risk of wind damage. On these areas all production should, as far as possible, come from clear felling.

On sites having a moderate risk thinning is optional. The decision as to whether to thin or not may depend on factors other than the degree of risk. Most conifers, and all hardwoods, benefit by regular thinning. It may be possible however with some species, to cease thinning at a fairly early age.

All stands on low risk sites may be thinned. The extra production and improved timber quality off-set the slightly increased possibility of windthrow.

4.3 Rotation Lengths

Rotation lengths are usually those which will give the maximum mean annual increment. Attempts to achieve this on sites with high or very high wind risk may result in forest conditions deteriorating as maturity approaches. Mature stands on these sites have usually experienced a good deal of windthrow, resulting in big areas of unstocked ground, increased risk of disease, dangerous working

conditions, high production costs and appreciable timber de-grade with fungal infection. For these reasons shorter rotations, may be recommended as.in Table 2, based on achieving 95% of the maximum mean annual increment.

TABLE 2
Recommended short rotation minimum ages for uniform conifer forest with no thinning, clear felling and artificial regeneration on high and very high wind risk sites

	Local Yield Class									
Species	24	22	20	18	16	14	12	10	8	6
Sitka spruce	36	38	39	41	43	45	47	49	52	54
Norway spruce		47	47	49	51	54	56	60	64	72
Japanese larch						29	30	32	34	36
European larch							35	37	40	44

On sites classified as having a moderate risk there may be a choice as to whether to attempt to achieve the maximum mean annual increment of rotation or not. This decision depends on the state of the stand as it approaches maturity. If there are signs of instability—bent tip in Sitka stands, scattered windthrow, evidence of 'pumping', etc.—then early felling is indicated.

For low risk sites no top height limits need be applied. Rotations will be those of the maximum mean annual increment.

5. Establishment operations

5.1 Layout of Plantations

Turbulence from edge effect is a major cause of damage to plantations, but the risk can be reduced by careful planning.

On very high risk sites roads and rides should be kept to a minimum and, where possible, should be orientated in the direction of the prevailing wind. Roads or rides should not be laid out along contours about one-third down lee slopes. Very high risk sites will not be thinned and racks should not be incorporated in the layout unless associated with main drainage. The same principles should be applied to roads and rides on high risk sites but other racks can be included if required for inspection purposes. They must, however, be no more than 5 m wide so that canopy can close by the time the top

height of the stand reaches about 10 m. The chance of damage on high or very high risk sites can also be reduced by establishing the greatest possible area of plantation in the shortest time and by avoiding big differences in age between adjoining stands. Where this cannot be done then establishment should proceed into the prevailing wind so that the youngest stands are on the windward side of the forest.

On sites of low or moderate risk no modifications are required.

5.2 Ploughing and Planting

Root plant development may be restricted on ploughed ground. This can be an important factor in increasing wind damage.

On very high risk sites ploughing should be restricted to the minimum absolutely necessary to provide a planting medium and remove surface water. Double mould board ploughing is desirable. Plough furrows should be shallow to encounter cross-rooting and, where possible, be parallel to the prevailing wind. Cut and spread turves can be used for planting. The plough ribbon should be as far from the plough furrow as possible. Maximum permissible planting spacings should be used. Wheeled vehicles can destroy top soil structure reducing natural drainage and causing ponding. This effect may persist for very long periods. Tracked machines should be used whenever available.

Modifications are also required when ploughing high risk sites. Turf planting is desirable, but, if not practicable, then the site should be double mould board ploughed, preferably into the prevailing wind, and with the ribbons placed as far from the furrow as possible. Deeper furrows are practicable on some site types if these have improved profile drainage. The use of low ground pressure machines is advisable. Plants are to be widely spaced.

Where the risk of wind damage is classed as low or moderate no particular precautions are required.

5.3 New Main Drainage

Drainage operations can be associated with damage to soil structure and tracked machines should be used for all drainage works except where the impedence results from hard pans.

Drains are likely to restrict root spread and trees on the edges are at greater risk. As drainage intensity increases more trees may be affected, particularly on those sites where sub-soil drainage is impractical. The degree of risk can be reduced by allowing the maximum possible development of root plates, and on high and very high risk sites no trees should be planted within 3 m of the drain centre on the leeward side and 2 m on the windward side. The

effect of increasing drainage intensity on stability is controversial. Current practise is to contour drain wet soils at 50 to 100 m spacing with falls of $\frac{1}{2}$ to $1\frac{1}{2}°$.

5.4 Fertilising

Fertilising does not influence the degree of wind risk very much. As with all other operations involving the use of machinery, ground damage is a danger. On very high risk sites hand or aerial application of fertiliser is recommended. On high or moderate risk sites ground machinery, preferably tracked, can be used. On low risk sites there are no machine constraints.

Canopy irregularities can cause turbulence and may increase instability. Assessment of site fertiliser requirements with a view to obtaining an even canopy is desirable on high and very high risk sites.

5.5 Selection of Species

Selection of species will generally be made on criteria other than stability; but there a differences in rooting and crown characteristics that can have an important effect.

On high and very high risk sites only species having a good tolerance of anaerobic soil conditions, an ability to develop wide, strong root plates, or crown characteristics that reduce wind resistance, are suitable. These are likely to include Sitka spruce, which develops a wide root plate, and Lodgepole pine, which roots deeply in peat and has lower crown wind resistance. Alder can root strongly in clay-rich mineral soils and is leafless in the winter when risk is greatest. Other species will have limited use except for aesthetic purposes. Larches have been widely planted on these sites in the past. Because of their very low tolerance on anaerobic soil conditions and their liability to various root rots they must not be used under any conditions of impeded drainage, and never planted on ploughed ground.

6. Forest improvement

6.1 Roads

Most wind damage associated with roads in established plantations is related to damage to root systems when new roads are made through established crops or to turbulence caused by the edge effect.

On very high risk sites no new road works should be undertaken after canopy has closed. On high risk sites, however, new roads can be made provided the top height of the stand has not passed 7 m and on sites with moderate risk new roads can be made provided a stand top height of 10 m has not been exceeded. When maintaining roads on very high or high risk areas no trees should be removed from road edges nor should new roadsise drains be dug. In areas of

moderate risk roads can be widened, new drainage installed, and edge trees removed if necessary.

6.2 Drains

The risk of wind damage can be increased by cutting through established root systems during maintenance operations or by allowing ponding to occur thus raising water tables and killing roots.

On very high and high risk sites drain maintenance should consist of clearing blockages only. No new drainage systems should be made after top heights reach 5 m. The same constraint applies to new drains in plantations on moderate risk sites although existing drains can be widened and deepened provided damage to root systems is kept to a minimum.

6.3 Fertilising

When fertilising established plantations the constraints are similar to those given above for young plantations (Section 5.4).

6.4 Respacing

Windthrow tends to be more severe in closely spaced crops once the canopy has been broken. Respacing at an early age may help to reduce the extent of the damage.

In young stands in areas of high or very high risk, where the GYC is assessed at 16 or more, and there are at least 3,500 stems per hectare respacing may be considered.

7. Harvesting

Harvesting operations involve creating breaks in the forest canopy making stands liable to edge and turbulence effects. Extraction can cause damage to roots and soil structure.

7.1 Thinning

Stands on high or very high risk sites will not normally be thinned but there will be situations, as in the case on larch, hardwood and some pine plantations, when the silvicultural need to thin may be more important than the increased chance of windthrow that follows. In these circumstances racks, if essential, should if possible be orientated towards the prevailing wind. Line thinning increases wind risk and is not recommended. Stands do not stabilise until about 4 years after thinning. Cycles should not, therefore, be less than this and wherever possible, 5 or 6-year cycles should be adopted.

SUMMARY OF SILVICULTURE AND MANAGEMENT

	Operation	Risk of Low	Moderate
MANAGEMENT	Stand Structure	Regular high forest or group selection.	Regular high forest preferably.
	Production Regime	Thin	Optional depends on stand structure and species.
	Rotation	Max MAI or long	Choice depends on the state of the stand when approaching maturity.
ESTABLISHMENT	Layout of Plantations	No Constraints	No Constraints
	Ploughing	No Constraints	No Constraints
	New Main Drains	Unlikely to be required	Wheeled machines are undesirable.
	Fertilising	No Constraints	
	Selection of Species	No Constraints	There may be some constraints depending on site conditions
IMPROVEMENT	Roads	No Constraints	No roads after stand height 10 m. Widening undesirable.
	Drains	No Constraints	No new drains after 5 m. Do not deepen if cross rooted.
	Fertilising	No Constraints	Wheeled machines undesriable.
HARVESTING	Thinning	No Constraints	Thin before 11 m height. Care with rack directions. Long cycles heavy thinning 4 years minimum for spruces. Avoid line thinning.
	Felling	No Constraints	Fell into wind. Group felling not recommended.
	Windthrow timber	Remove and utilize	Remove and utilize.
	Extraction	No Constraints	No wheeled machines if wet.

IN RELATION TO WINDTHROW RISK

wind Damage

High	Very High
Regular high forest only.	Regular high forest only.
No-thinning	No-thinning
Short	Short
Racks undesirable, if essential then narrow widely spaced. Roads and rides parallel with wind.	Minimum number of racks. Road and rides parallel with wind.
Regenerate large areas over short periods.	
DMB, furrow depth depends on site, ribbon back from score, parallel with wind. Tracked machines best. Wide spacing.	DMB plough, shallow furrow, ribbon back from score, parallel with wind. Consider turfing. Tracked machines. Wide spacing.
Tracked machines. No plants within 2 m windward 3 m leewards.	
Hand or aerial application preferable tracked machines only. Careful application to produce even growth.	
Most spruces, PC. No larches.	SS or Alder only.
No roads after stand height 7 m. No felling edge trees.	No new roads. No felling edge trees.
No new drains after 5 m.	No new drains.
Do not widen or deepen drains—clear blockages only.	
Hand or aerial applications preferable tracked machines only. Desirable to try to bring areas out of check.	
No thinning. Respacing of vigorous stands GYC 16, and over with more than 3,500 stems/ha.	No thinning.
Clear fell or fell into wind.	Clear fell to established margins.
Removal depends on extent of damage.	Do not touch or consider clear felling
Horse, cable or low ground pressure machines only.	Horse or cable only.

On moderate risk sites forests are more likely to be managed within thinning working circles. Rack layout is less important in these circumstances but wide racks should be avoided and line thinning is undesirable. Again cycles should not be less than 4 years.

7.2 Felling

Stands on very high risk sites shoule be felled out to stable margins. On high risk sites similar treatment is desirable, but if whole blocks cannot be completely felled to stable margins, then fellings should be planned to proceed towards the prevailing wind. Advantage should be taken of any zones of stability in locating felling coupes.

On sites of moderate risk felling towards the wind is desirable if the period is likely to extend for more than a few years. In any event felling plans should be prepared for clearing to established edges within a period not exceeding about 10 years. Group fellings are not recommended.

7.3 Dealing with Windthrown Timber

When wind damage has occurred in regular high forest it may be necessary, for economic or biological reasons, to remove the trees involved. On low and moderate risk sites quick utilisation of windthrown timber is likely to be possible under most circumstances. On very high risk sites removal is not recommended. In the case of high risk sites the action will depend upon the extent of the damage; with low levels of damage timber should not be extracted, but where damage has been extensive clear felling should be considered. In intermediate cases felling should proceed either to where changing site conditions improve stability or to the outer edge of the marginal zone of leaning trees on the lee side of the windthrown area, the leaning trees themselves must not be removed.

7.4 Extraction Operations

To avoid damage to soil structure on very high risk sites cable extraction should be used wherever possible. The use of this method is desirable on high risk sites, but low ground pressure machines are acceptable if free operation over the whole area is possible and work is testricted to the drier periods of the year. On both these site types it may be worth considering the use of horses.

There are no constraints on extraction operations in low risk areas, but in moderate risk areas wheeled vehicles should not be used when conditions are wet and rutting is likely to occur.