Silviculture and Management of high-risk Forests in Great Britain[1]

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Introduction

STABILITY is dependent on such a range of factors that no one person can cover the full field in detail. Although stability as such is one of my projects a lot of what I will be talking about has been gleaned from other people's work at the Northern Research Station on such things as Soils, Drainage, Cultivation and Physiology.

There are 2 points which apply to everything I will be talking about:

a) The wind speeds that I discuss are normal gales, the type that cause sporadic damage every winter, i.e. gusts at about 60 knots and mean hourly speeds around 40 knots. Gales of the hurricane Debbie and the 1968 Glasgow type pay no regard to any of out ministrations.

b) When I talk about the best treatment I mean silviculture and not necessarily economic.

Cultivation and Drainage

There has been a complete change of emphasis and ideas on drainage and cultivation techniques in recent years, due to studies of experiments, root responses to treatment, and the resultant stability. Close spaced moderately deep ploughing on peaty gleys and deep peats has been shown to be detrimental to stability, using the tree pulling technique as used by A. I. Fraser. Fig. 1 shows the differences in turning moment brought about by allowing a wider root plate to develop. Kielder is on a peaty gley, Inchnacardoch is on a deep peat. The following table shows tree dimensions at Kielder.

TABLE 1
MEAN TREE DIMENSIONS KIELDER SS P47

	Total Ht (metres)	Root Wt (Kg)	Mean Root Depth (cm)	Mean Root Plate diam(m)	Angle of Maximum Pull
Plough	13·1	77	59	1·8	5·5
Hand Prep. ...	12·3	68	40	2·0	8·1
Diff. for plough	+0·8	+9	+19	—0·2	—2·6

1. Paper delivered at Wind Risk Symposium, Pomeroy, Co. Tyrone, 1st-3rd May, 1974.
2. Forestry Commission Research Division, Roslin, Midlothian, Scotland.

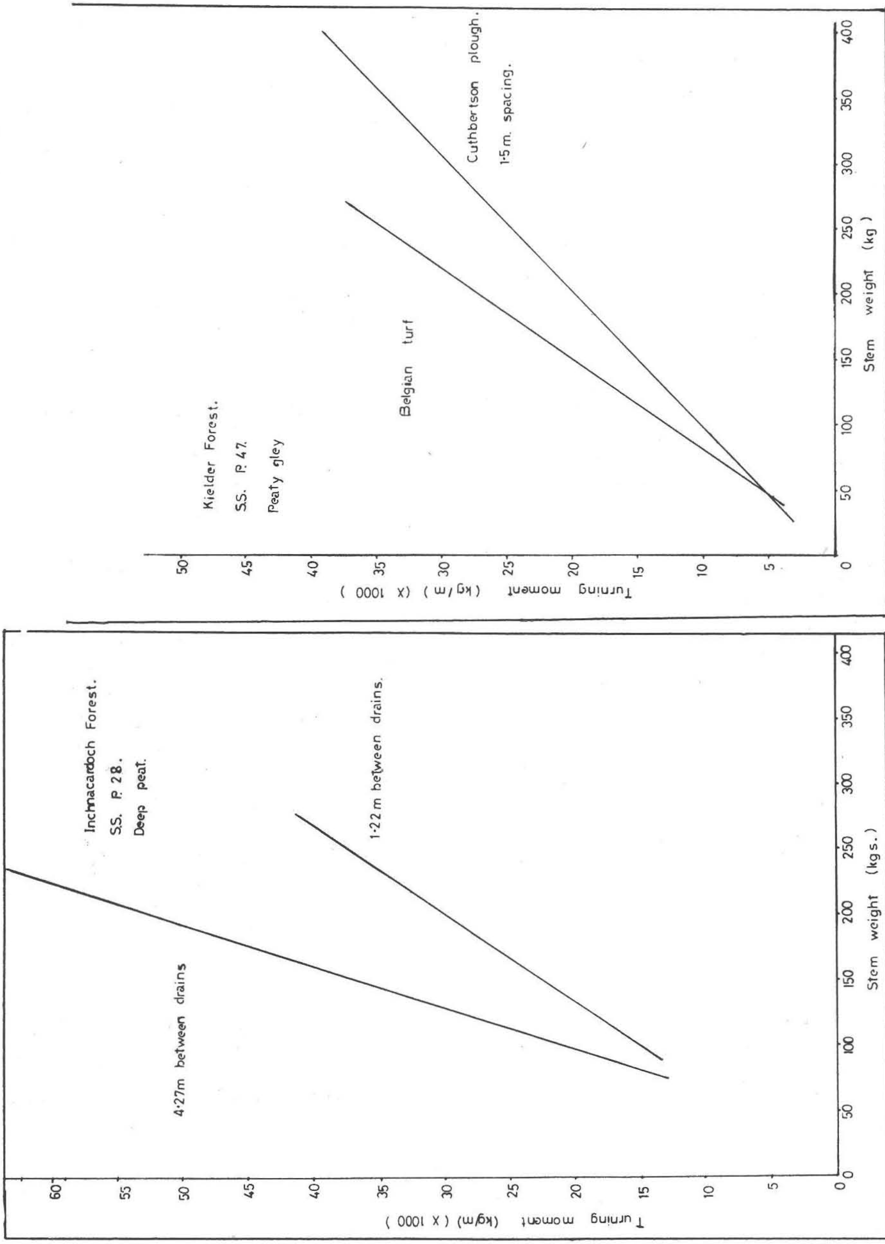

Figure 1: Relationship between turning moment and stem weight in tree-pulling tests in two experiments.

Although the deeper rooting which was advocated in the mid 1960s has been achieved by the ploughing, the reduction in root spread has reduced crop stability. This experimental result is being borne out by the early incidence of wind damage on crops planted on spaced furrow ploughing which are now tall enough to catch the wind. As a result of this, advice on ploughing techniques advocate that wherever spaced furrow ploughing is carried out, a wide platform should be left for root spread (approx. 5m). The Appendix lists the recommended ploughing treatments by soil types.

The lack of benefit from drains dug down to 3' in heavy clay soils either in growth or stability, along with other observations on water movement have led to a policy of strategic drain placing, to intercept surface water and drain wet hollows. The depth of the drain being governed by where the water is flowing, this is usually in the Eg horizon at the peat mineral interface.

Figure 2: Parkgate/Humpy deep double mouldboard tine plough for planting on peat.

Other factors which are influencing drainage techniques are, species behaviour, crop effect, and a greater awareness of climatic factors, all three of which are inter-related. Comparison of Lodgepole pine with Sitka spruce on deep peat has shown that the former has a remarkable capacity for acting as a water pump and drying out the site on which it stands. Rooting down to a metre and drying out the peat to that depth when drains were only 0.15m in depth. On the adjacent plot Sitka spruce rooted to only 50cm with the typical shaving brush root at that depth. The complete reason for this is not clear, but experiments by several University workers have shown that Lodgepole pine is far more tolerant of anaerobic conditions than is Sitka spruce, and also appears to use more water. The practical application of this plus the observed drying out of the soil under Sitka spruce in the Kielder area is,

a) That Lodgepole pine on deep peat does not require such a high drain intensity as Sitka spruce, and

b) If a site has a potential water deficit the drainage intensity is governed by the requirements for crop establishment, and the crop will look after itself in the later stages after canopy closure.

Soil treatments are all based on soil classification as carried out by the Site Survey Teams, a revision contemplated in the soil classification is in the division of gley soils as shown.

Gley Soils	Peaty surface water gley	Clayey Loamy Indurated
	Non-peaty Surface water gley	Clayey Loamy Indurated
	Ground water gley	Peaty Non-Peaty

Loamy and indurated soils being amenable to cultivation and improved drainage in depth compared with clay soils.

Thinning

There are two ways of looking at the effect of thinning, one is to monitor the effect of thinning by counting thrown trees, the second is to measure the effect on the wind itself. The effect on intensity of normal low thinning is illustrated in Fig. 3, a diagram of the pattern of throw in Kielder Experiment 84/86, the heavier the thinning the greater the chance of wind damage. Although the total percentage blow is not yet high enough even in treatment 4 (15%) to cause great economic problems. In order to try and cover the wide range in site types and treatments a second series of experiments were started in 1968 which has a

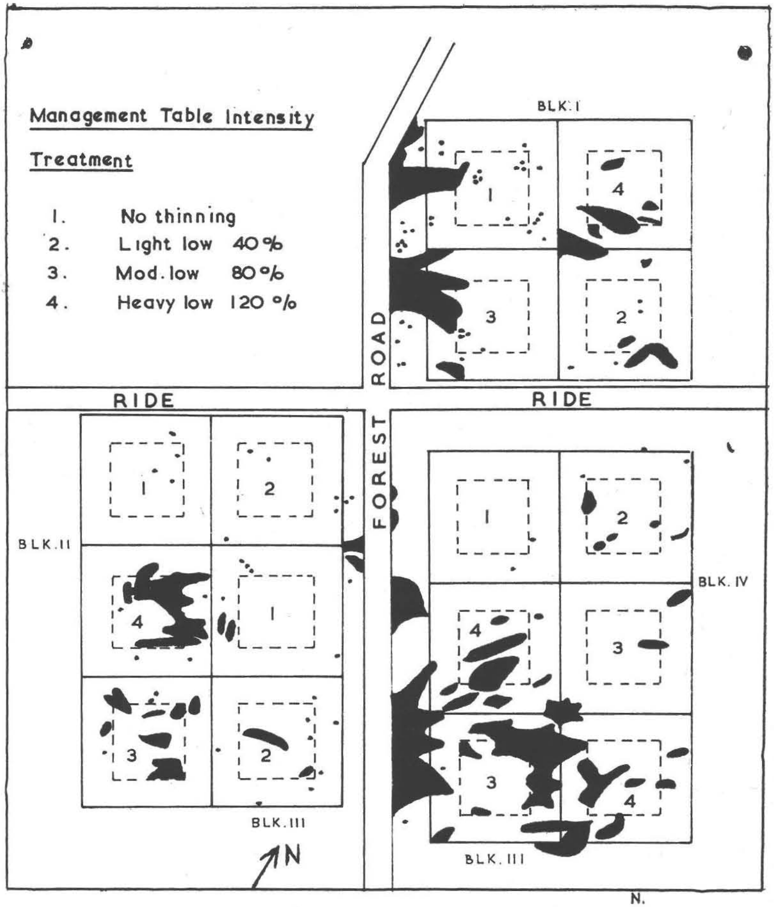

Figure 3: Kielder Expt 84/66. Pattern of Windblow at July 1973. (Plot size 1 acre = ·405 ha.)

total now of 12 experiments scattered from South Scotland to Cornwall and Devon, and new ones are still being laid down. Treatments vary according to local management, but the treatments cover no thin, normal thinning and line thinning. There has been great variation between sites as we expected and also between regions, the means for the Kielder group of experiments are in Table 2.

The Southern experiments do not show anywhere near as much damage, there is a suggestion of more damage in thinned crops

TABLE 2

	No thin	Normal thin	Line thin
No. thrown per ha	8	50	190

except for Margam experiment 4 in South Wales where there is extensive damage across all treatments at a top height of 11.3m, the worst damage being in a small no thin plot 450 stems per ha being thrown. This may well be an example of a wind strength at which no management technique will ever control damage.

There are other examples of tree felling which tend to increase risk, Fig. 3 shows damage extending to the East of the road where two roadside rows were felled to increase air movement to keep the road dry, the increased air movement is certainly reflected in the crop damage. The cutting of rackways for extraction especially if carried out at right angles to line thinning, is a further cause of increased hazard.

Studies of wind flow over a forest at Redesdale compared a thinned crop with a no thinning area. A marked change in the wind structure was measured, an increased turbulence which gave a much greater shaking of individual trees and as a result greater risk of dynamic failure. The tree as a living entity has a delayed response to stimulus, the changes in structure to meet increased exposure take time to occur. It therefore follows that a crop is most susceptible to damage immediately after thinning.

A summary of information to date suggest that the heavier the thinning the more likehood of damage, and that line thinning is worse than normal low thinning. The ideal treatment is the very high risk areas would be to plant at a wide enough spacing to avoid the necessity of thinning. If thinning is a necessity and it is certainly acceptable in lower risk zones, start early enough in the life of the crop, after winter storms are finished, to a light intensity and a high frequency say every 3 years.

In practice very little no thin is applied and a considerable proportion of first thinnings are line thinnings.

Regeneration

A wide field of work in its own right and a far more complex situatiin than afforestation. Stability is brought in where for some reason or another crop manipulation is attempted, either leaving seed trees or natural regeneration or heavy thinnings and strip felling for protection for amenity reasons.

The same rules apply as for thinning, in this case however your working is in a mature crop with taller trees which naturally increases the hazard. Circular groups ranging in size from 0.1 acre to 10 acres were cut in P27 to 31 SS at forest of Ae in 1962, wind speed was measured through the gaps created and damage to the surrounding crop measured, the following table summarises the results.

TABLE 3

OCCURRENCE OF WIND THROW MAY 62–MAY 63 AE 32

Plot size (acres)	10	1·0	0·3	0·1
Wind run as % of 10 acre plot	100	41	28	20
No. of trees thrown per acre	117	145	164	281

Although the windrun is less in the smaller plots the amount of damage per acre felled is larger because of the increased perimeter risk. One 10 acre clear fell will do less damage than 100 x 0.1 acre plots. A follow up experiment to this one at Redesdale was so badly damaged by wind that it was closed three years after starting. Crop manipulation is not a practical possibility in high risk zones on unstable soils. Professor Anderson saw this years ago in Belgium and one of his ideas was that by planting the Anderson group type of system would allow later regeneration planting between the groups. This has possibilities for high amenity areas where it is very necessary to keep the crop on the ground.

Silvicultural ideals have to be balanced against managerial responsibility and the economic realities of each and every situation. I have only touched on the surface of the problem but I hope it provides some food for thought.

APPENDIX

Brown Earth
Podzol
Peaty Podzol
Calcareous Soil

Shallow Spaced Ploughing — For weed suppression and planting position.

A tine will aid mixing in those sites which are degraded and a double mouldboard can reduce costs on those sites which are not degraded.

Ironpan Soils
Peaty Ironpan Soils (without Induration)
Man-made Soils

Spaced Furrow Tine Ploughing — To break impedence. The depth of ploughing will depend on the depth to the B horizon. Although complete ploughing may be best the advantage at the 20 years is not signficant Complete ploughing can give more rapid early growth which may be associated with weed control but this is offset in some cases by slower growth in the first 3 years when plants are growing only in subsoil. Twin tine ploughing appears to be as good as complete ploughing available.

In Dry Uplands and Steep Sloping Wet Uplands both with Induration less than 90 cm (3 ft)
Ironpan Soils
Surface Water Gley
Peaty Gley
Deep Peat

Complete Deep Tine Ploughing — The objective is to increase rooting depth available and maximum benefit will be expected after closure of canopy when drying out of the soil by the crop should become significant.

Evidence suggests that should an alternative be needed it is preferable to plough deep spaced rather than shallow complete.

In Dry Uplands and Steep Sloping Wet Uplands both without Induration less than 75 cm ($2\frac{1}{2}$ ft)
Surface Water Gley (Loamy)
Peaty Gley (Loamy)

Twin Tine Ploughing — Where the structure of 'Loam' includes small pieces of broken rock and clay the mole channel produced by this plough can maintain its shape. The objective is to deepen rooting by aiding the run-off from the site during the period up to closure of canopy; thereafter the site should be influenced by the drying effect of the trees.

In Wet Uplands not on Steep Slopes,

Ironpan Soils
Surface Water Gley (Loamy and Clay)
Peaty Clay (Loamy)

Also
Ground Water Gleys
Deep Peat 45-90 cm ($1\frac{1}{2}$-3 ft)
(without Induration or Ironpan)

Deep Double Tine Ploughing — The objective is to encourage rapid early growth and to permit the development of a wide root plate in order to aid stability. Also to maximise drainage of surface water from the Site.

Peaty Gley (Clay) Deep Peat 45-90 cm (1½-3 ft) with Clay Deep Peat (90 cm 3 ft)	**Deep Double Mouldboard Turf (Drainage) Ploughing** — The objective is to obtain rapid early growth and permit the development of wide root plates for stability. Also it is intended to maximise drainage from the site of surplus water.
Skeletal Soils and Rock	**Very Shallow Double Mouldboard Ploughing** — To allow maximum width of rooting.