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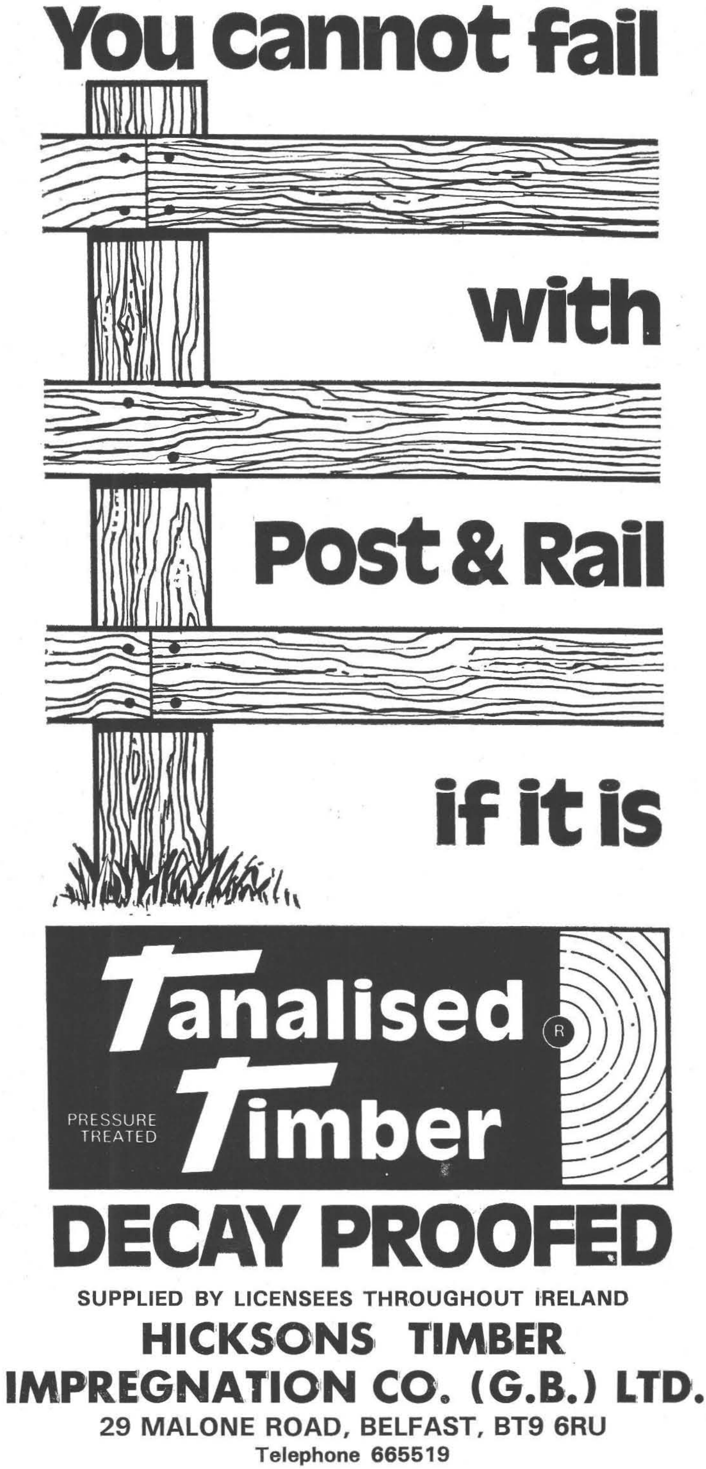

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#IRISH FORESTRY

Vol. 31 1974 No. 2

Don't Slaughter your Horses Yet

ON page 171 we print a comment by an executive of the huge American Weyerhaeuser Company. While this statement was made before the recent multiplication of the price of oil and fertilizers, it still holds true, although possibly its interpretation may now be somewhat different in practice from what it might once have been.

We still need the sense of urgency, but now the emphasis may be rather less on the move towards a high level of technology in forestry work, such as has been reached in other countries. The general move in that direction in all fields is so massive and has gained such momentum that any change in its motion will be difficult to achieve. While this momentum may still lead to disaster there are signs at least of a move towards the brake lever. There are indications that people may wish for a lower level of change, for a quieter life style.

In our relatively undeveloped state we still have time to consider our options. Perhaps we might examine the so-called "intermediate technology", with equipment designed to use the minimum of energy required to get the job done, and at the same time provide more employment of a varied and rewarding nature.

Some factors influencing the stability of Sitka in Northern Ireland[1]

R. F. MacKenzie[2]

1. Introduction

1.1 In 1969 forest management in Northern Ireland was still influenced by the aftermath of the catastrophic winds which had occurred 10 years earlier. Although the number and volume of trees wind damaged was substantially diminished there was still an important proportion of the total production which could be attributed to these phenomenal conditions. Because of this it was decided that a survey should be conducted with a view to identifying and evaluating those site factors which pre-disposed stands to risk of wind damage. An examination of existing sample plots provided the readiest means of assessing damage and recording the appropriate site factors. The effective period covered was probably from 1965 to 1969. Some supplementary evidence was gathered following the gales of January 1974 and is included where appropriate.

1.2 During that period the annual summaries of the monthly weather reports of the Meteorological Office (Anon 1968, 1969, 1970, 1971) indicated that the number of gales and the maximum wind speeds recorded were not abnormal. Nor did any catastrophic amount of wind damage occur. The survey was, therefore, concerned with the attritional damage of the type that can continue from year to year within stands on sites that are susceptible, rather than with the dramatic and extensive damage that results from catastrophic winds occurring at long intervals of time.

1.3 The survey was of an observational character. This was because, while man power resources were available the laboratory facilities which would have been required for detailed scientific examination of, for example, soil physical and chemical characteristics were then unable to cope with this volume of work. At the same time the amount of data that could be analysed was limited by the capacity of existing computer services. It was, however, fortunate that Dr. Michael Kennedy (M. S. O Cinneide) of University College, Galway, was able to undertake a sophisticated

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1. Paper delivered at Wind Risk Symposium, Pomeroy, Co. Tyrone, 1st-3rd May, 1974.
2. Forestry Division, Ministry of Agriculture, Belfast.

statistical analysis of the data and his paper is one of those presented in this issue.

2. Stand Management

2.1 Although it was not possible to obtain reliable information about the relationship between thinning practice and wind damage the survey was able to produce information on certain other management aspects. The amount of damage recorded in relation to these factors is given in Table 1. Along with the other site factors discussed in the following sections a chi-squared test was applied to this information and a figure of 2943.51 was obtained which, on the face of it, would indicate a high degree of relationship between these management aspects and the amount of windthrow recorded. In this particular case the test is not valid as the results may indicate only that there is, say, a high proportion of edge relative to the total area of plantation or that the plantations are intensively drained. However a subsequent investigation, following the storm of January 1974, into the causes of windthrow of single trees on 85 sites in the North and West of the Province indicated that only 11% of the throw could not be attributed to direct association with artificial features such as drains, racks, plough scores on roads, which accounted for 77%, and natural features such as flush areas or rock outcrops which accounted for the remainder. In these circumstances it was considered that there was a validity in the findings of the survey even though strict statistical testing was not possible.

2.2 Of the factors recorded in Table 1 the most important is that of windthrow-creep. This term signifies the gradual increase in extent of a windthrow area that occurs from year to year, and

TABLE 1
NUMBERS AND PROPORTIONS OF WINDTHROWN TREES IN RELATION TO CERTAIN MISCELLANEOUS SITE FACTORS

Factor	No. of trees thrown	No. of trees not thrown	Total Number	Proportion thrown %	No. of plots
Exposed edge	63	879	879	7·16	19
Drain edge ...	217	26,729	26,946	0.18	291
Road edge ...	15	493	508	2.·95	15
Rack or ride ...	24	1,618	1,642	1·46	21
Windtrhrow creep	307	1,971	2,278	13·48	59
Springs or flush	12	1,119	1,131	1·06	4
Any combination	115	3,060	3,175	3·62	29
No abnormality	14	31,298	31,312	0·04	483

the implication is that once the canopy of the forest has been broken by windthrow the chances of further damage occurring in the same area are considerably increased. Future management of any stand which has had the canopy broken by windthrow must take into account this very substantial increase in the probability of further damage — it is unlikely that remedial measures regarding the basic site factors can be taken at this stage but it may be possible to lengthen thinning cycles, or to stop thinning altogether, or to bring forward the date of felling.

2.3 The second most important factor is that of proximity to plantation edges. Sample plot location instructions require that plots which fall on the edge of plantations are in fact sited there and are, if need be, semi-circular in shape. In practice this is very seldom done and it is more usual for plots to be located 10 metres approximately from the actual edge of the plantation. The windthrown trees recorded in the survey are not therefore those of the actual edge of the plantation but of a belt about 20 metres or so in width along the edge. In fact it would seem from observation that the actual edge trees are more stable than those to the immediate interior of the plantation. This may be due to the alteration of wind patterns at the edge of the forest — the windthrow resulting from the eddy caused by this disturbance.

2.4 To a certain extent this suggestion is supported by observational evidence in edge zone windthrown areas where the direction of fall is frequently variable indicating a downward rather than a horizontal wind movement. In general it may be concluded that the edge zone is more vulnerable than elsewhere and management should take account of this susceptibility.

2.5 For the reasons given in paragraph 2.1 it is less easy to assess the influence of the next group of factors — that including drains, roads, racks and rides. The survey recorded whether or not any one of these factors was present in the plot, it did not record whether there was a direct relationship with windthrown trees although subsequent observation tends to confirm that such a direct relationship does exist.

2.6 As it is the information available is only sufficient to say that these factors do have an effect on increasing the susceptibility of any site to wind damage, and that there would seem to be a strong indication that the major interruption in the canopy resulting from the presence of a road would be twice as dangerous as the minor interruption caused by racks or rides. This would, however, be influenced to a large extent by the date of construction of the road relative to the age of the plantation and the information gathered regarding the causes of damage to single trees following the gales of January 1974 indicated that only 3% of thrown trees were associated with roads. This compared with 35% of thrown trees which were on rack sides.

2.7 The presence of drains, which do not usually affect the form of the canopy, is less serious and in this instance the increase in instability can be attributed to the interference with the root system. This is to a certain extent confirmed by the 1974 survey which showed that 22% of all single trees that were thrown were on drain edges and 20% were directly associated with plough scores. In both cases the development of eccentric root systems was very marked. A general conclusion from this would be that, given that the rooting system is such that the stand is inherently unstable, then the canopy form is of very great importance and the greater the interruption in the canopy the greater will be the amount of windthrow that can be expected.

2.8 Finally it is worth noting that the presence of springs or flush areas are of importance. There is no evidence to indicate that the presence of springs or flush areas have any influence on rooting patterns although it may be so. Observation would suggest that if there is an influence it is not great. It is suggested that the likeliest reason for the increase in windthrow on these areas is the difference in growth pattern found on them. Flushes and spring lines are frequently associated with increased growth rate which involves a substantial and usually abrupt change in the canopy form presenting an increase in resistance to wind; and, because of increased stem length, causing relatively greater bending moments (with less mutual support) than is experienced by trees in the matrix of the stand. If this assumption is correct then remedial treatment must be aimed at producing as regular a canopy as possible within the stand and this may be achieved by judicious use of fertilisers over the non-flushed areas.

3. The Influence of Soil Type

3.1 The amount of damage recorded in the various plots is given in Table 2. When the number of windthrown trees is compared with the number not affected, in relation to the various soil types recognised, a chi-squared figure of 116.23 is arrived at which is sufficiently high to indicate that damage varies significantly with soil type.

3.2 The main reason for this would appear to lie in the rooting patterns developed on the various soils. On brown earths and podzols Sitka roots are abundant to depths in excess of 50 cm although, because most of these soils are shallow, it is not usual

TABLE 2
NUMBERS AND PROPORTIONS OF WINDTHROWN TREES IN RELATION TO THE MAJOR SOIL TYPES

Soil Type	No. of trees thrown	No. not thrown	Total	Proportion thrown %	No. of Plots
Brown Earth ...	1	2,056	2,057	0·05	28
Podzol	4	1,209	1,213	0·33	32
Iron Pan ...	2	1,193	1,195	0·17	27
Gley	223	12,558	12,781	1·74	239
Peaty Gley ...	395	30,604	30,999	1·27	379
Valley Peat ...	2	691	693	0·29	22
Blanket Peat ...	139	18,284	18,423	0·75	177
TOTALS	766	66,595	67,361	1·14	904

to find much rooting beyond 1m. On gleys root penetration is common to a depth of 35 cm but diminishes rapidly below that and on peaty gleys the abundance of roots diminishes after 30 cm is reached — Table 3 refers. Iron pan soils are usually characterised by the presence of a discontinuous pan and most trees have root systems which can penetrate this at one or more points. The pans are usually at depths of around 25 to 35 cm which would make them comparable in terms of stability with the gleys were it not for this characteristic.

3.3 Rooting development may be restricted either physically or chemically. In the first instance soil bulk densities of over 1.5 have been shown to prevent root penetration. The pan horizon of an iron pan soil would have a density in excess of this but for most other forest soils of Northern Ireland the normal density range would be from approximately 0.6 to 1.3 — well below the range in which root growth might be inhibited. Chemical impedance is possible and some evidence of what may be manganese toxicity has been found in the more acid soils although a similar effect could be caused by the inhibition of growth hormones in flooded roots as suggested by Phillips (1964).

3.4 However the most likely cause of this variation in rooting pattern is the retardation of root growth by inadequate oxygenation. As Sutton (1969) records in a review of literature ". . . inadequate oxygenation is well known (c.f. Barker, 1919; Heinicke, 1932; Leyton and Rousseau, 1958). Aeration was shown by Loehwing (1931) to influence total root surface area, size of root hair zone, degree of vascular differentiation, and fibrousness in roots of several aquatic and terrestrial species. Gail and Long

(1935) demonstrated that distribution of main laterals, number of laterals, and length of tap root of Pinus contorta and P ponderosa were influenced strongly by degree of aeration. Elongation of roots of P sylvestris and Picea abies grown in aerobic unsterilised distilled water or peat extracts from various bogs was ten times that of plants grown in unaerobic conditions (Huikari, 1959) . . . Such evaluations of soil aeration based on gas-phase composition fail to allow for the effect of any liquid surrounding the root. Water thicknesses of 0.08 to 0.35 mm around a root will be sufficient to limit oxygen supply at soil porosities between 0.2 and 0.5 when the oxygen concentration in the pores is in equilibrium with atmospheric oxygen (Letey and Stolzy, 1967)." It would seem, therefore, that rooting is likely to be more closely related to profile drainage characteristics than to other factors.

TABLE 3
NUMBER OF PLOTS SHOWING WIND DAMAGE ON CERTAIN SOIL TYPES AND THE DEPTH OF ROOT PLATES OF WINDTHROWN TREES

Soil Type	Rooting Depth (cm)								
	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50+
Brown Earth			3	3	4	2	1	6	11
Gley	5	8	3	11	12	9	9	7	5
Peaty Gley	2	6	13	21	17	13	10	4	10
TOTAL	7	14	16	32	29	22	19	11	15

3.5 The principal effect of this restriction is to produce a set of circumstances in which the liability to damage increases rapidly for unstable trees and less quickly for deep rooting trees. Broadly speaking this means that for any given wind force the poorer the profile drainage the greater will be the extent of damage and, with increasing wind force, the rate of damage on the unstable site will increase much faster than will the rate of damage on the stable site. Returning to Table 2 it will be seen that we can divide the Northern Ireland forest soils into four broad groups for the purpose of classification of wind damage risk. The first group, where the risk is outstandingly great, is that comprising the gleys and the peaty gleys. The indication is that the gleys with a proportion damaged of 1.74% present a greater problem from the point of view of stability than do the peaty gleys, with a proportion damaged of 1.27%.

3.6 The second broad grouping of soil types are the various climatic peats referred to under the general heading of blanket peat in Table 2. The indication here is that with a proportion damaged of 0.75% the risk is only half that of the gleys and peaty gleys. It is unlikely that this increased stability on the blanket peats can be attributed to deeper rooting although there is some evidence that horizontal systems are more extensive. The prime cause may lie in the complex interlocking of the peat fibre at all levels from the mineral soil upwards combined with the extensive development of a fine root system for the Sitka under the highly acid conditions of the peat. This contrasts sharply with the characteristic separation of the top soil — which is usually about 25 cm in depth — from the sub-soil on gleys.

3.7 The third grouping of soil types, which include the valley peats, podozols and iron soils, show proportions damaged of 0.29%, 0.33% and 0.17% respectively — in effect this group can be expected to show approximately half the amount of damage relative to the climatic peats. In this group improved stability is related to the improved rooting conditions. The valley peats are usually highly eutrophic and the water supply is normally telluric — both factors contributing to the development of a stable root system. Podozols are free draining and would normally be highly stable but tend under Northern Ireland conditions to be shallow and weakly developed manganese pans are not uncommon. As has been mentioned in Paragraph 3.3 the iron pan soils usually have discontinuous pans and some degree of through rooting is possible.

3.8 The fourth group, that of the brown earth, has a proportion damaged of 0.05% which may be considered negligible and consequently forest management need not be concerned with wind risk on this type. The low level of windthrow on these soils can be attributed to the development of a deep and stable root system and it is worth noting that the proportion of wind break is highest on this soil type.

4. The Influence of Slope

4.1 The amount of damage recorded in relation to the slope of the ground, as measured from a height of 1.4 m on the highest tree to the same height on the opposite tree on the plot margin through the plot centre, is given in Table 4. Application of the chi-squared test to this table gives a result of 238.77 which is sufficiently high to indicate that there is a significant statistical relationship between the angle of slope and the amount of windthrow that has occurred.

4.2 An examination of the data indicates that by far the largest proportion of damage occurs on slopes between 5 and 9 degrees — there being approximately twice as much damage here as there is to be found on level ground or on the next steeper class of slope, that from 10 to 14 degrees. The amount of damage occurring on slopes in excess of 14 degrees is negligible and windthrow does not appear to be a risk that would normally influence management decisions in areas with steep slopes but it is worth noting that topographical influences can be of considerable importance and land form is most likely to be a factor in wind damage where the terrain is steepest.

TABLE 4

NUMBER AND PROPORTION OF WINDTHROWN TREES IN RELATION TO THE GROUND SLOPE OF THE SAMPLE PLOTS

Slope (in degrees)	No. of trees thrown	No. not thrown	Total	Proportion thrown %	No. of plots
0– 4	226	31,765	31,991	0·71	349
5– 9	461	23,217	23,678	1·95	347
10–14	75	7,352	7,427	1·01	128
15–19	3	2,981	2,984	0·10	52
20–24	2	1,282	1,284	0·16	31
24+	0	507	507	0·00	14
Total	767	67,104	67,871	1·13	921

4.3 In broad terms, therefore, it is possible to divide the forest into three risk classes from the point of view of slope: with the reservation that there may be topographical influences of which account should be taken. The first class in which the risk is as high as it is on gleysols, is represented by slopes of 5 to 9 degrees. The second group, with a degree of risk approximately half that of the first, is represented by relatively level ground and slopes from 10 degrees to 14 degrees. The third group, in which the risk appears very small (but where the influence of topography may be large), is represented by all steeper slopes.

4.4 In attempting to attribute the wind risk characteristics of various slopes to environmental factors one must return to the basic mechanics of windthrow which requires that the centre of gravity of the tree be displaced beyond the base before the tree can fall. The extent of the base is determined by the rooting system which in turn is influenced by the physical nature of the soil and the effect that has upon the soil hydrology. As has already been suggested it is the water in the soil that controls root development and under the limiting conditions imposed by high winter water tables deep rooting is prevented on most forest soils. On steeper slopes drainage is improved through the natural downhill movement of water and soil depths are frequently increased through the process of solifluction from upper slopes. These factors together contribute to lessening the restrictions on root development and hence increasing stability.

4.5 This may appear to be a somewhat contradictory statement in view of the substantial increase in stability of trees on more or less level ground compared with those on slopes of 5 to 9 degrees. There are, however, two reasons for this increase in stability; both based on the profile drainage characteristics of the site. In the first instance, at higher elevations, iron pan formation is common, following leaching of the better drained soils, and elsewhere unsorted and unstratified glacial deposits inhibit water movement down the profile. Under these conditions of poor drainage, and with the deterioration of climate at higher elevations, peat formation can be expected to proceed at a rapid rate and bogs are likely to be deeper here than lower down the hill. It has already been shown (Paragraph 3.6) that there appears to be characteristically more stability on deep peats than on the closely related peaty mineral soils.

4.6 The second probable reason for the increase in stability on relatively level ground may be attributed to the existence of limited areas of deep, well-drained lowland soils which would not normally form part of the forest estate but were acquired along with the more extensive areas of hill land usually purchased.

4.7 Because of the close relationship between the rooting pattern and stability, and the fact that root development is substantially influenced by profile drainage it would be reasonable to expect to find a relationship between soil type — which is determined to a great extent by profile drainage — and most other factors which are significantly related related to windthrow. An examination of the data given in Table 5 and the application of a chi-squared test to the observed and expected frequencies of soil types within each slope class indicates that there is a highly significant relationship between soil type and slope. The number of gleyed plots diminishes directly and rapidly with increasing slope. Peaty gleys are most common on slopes of 5 to 9 degrees and there are more peaty plots on the more or less level sites. In contrasting the freely drained soils with those characterised by impeded drainage — the brown earths with the gleys and peats — 74% of the plots on the latter types fell on slopes of less than 9 degrees compared with 44% of the former.

TABLE 5

NUMBER OF PLOTS OF FOUR MAJOR SOIL TYPES IN RELATIONSHIP TO SLOPE OF THE GROUND WITHIN THE PLOT

Slope (in degrees)	Brown earth	Gley	Peaty gley	Peat	Total
0– 4	118	250	164	164	696
5– 9	216	225	206	106	753
10–14	149	67	121	52	389
15–19	100	26	50	12	188
20–24	112	13	13	5	143
25–29	49	5	3	10	67
30–34	17	1	1		19
35–39	4	2	1		7
40–44					0
45–49	1				1
Totals	766	589	559	349	2,263

4.8 Reference now to Table 2 shows that of all Sitka spruce production forest in 1969 68% was planted on gleys and peaty gleys, 20% on blanket peats and the remainder (including 3% on brown earths) on other soil types. Given that increasing peat depth appears to have a favourable influence on stability then the reduction in windthrow on level ground as compared with the moderate slopes can be attributed to the higher proportion of deeper peats on these sites.

5. The Influence of Aspect

5.1 The amount of damage recorded in relation to the aspect of the plot assessed from a central position and taking into account the general topography of the vicinity is given in Table 6. When the number of trees windthrown is compared to the number unaffected by wind a chi-squared figure of 264.66 is derived indicating a highly significant statistical relationship between aspect and wind damage.

5.2 Examination of this table indicates that two broad risk classes are discernible. The least risk is encountered on slopes

TABLE 6
NUMBERS AND PROPORTIONS OF WINDTHROWN TREES IN RELATION TO THE ASPECT OF THE PLOT

Aspect	No. of trees thrown	No. not thrown	Total	Proportion thrown %	No. of plots
N	180	7,200	7,380	2.44	123
NE	223	17,361	17,584	1·27	179
E	50	14,885	14,935	0·33	136
SE	116	5,864	5,980	1·94	86
S	34	4,341	4,375	0·78	74
SW	26	3,801	3,827	0·68	78
W	38	5,563	5,601	0·68	81
NW	98	7,378	7,476	1·31	141
Flat	2	713	713	0·28	23

facing the south, south-west and the west; and there would appear to be twice as much chance of windthrow occurring on slopes with aspects ranging from north-westerly through north to south-easterly. There are anomalies within this range. The northerly aspect would appear to be twice as risk prone as the rest of the group and, if the figures are to be taken literally, there would appear to be virtually no risk from wind if an easterly aspect is chosen for planting. However the assessment of espect is essentially based on a broad subjective judgement with some assistance from the compass and any grouping of aspects with a view to allocation to risk classes must be made with this in mind.

TABLE 7
RELATIONSHIP BETWEEN THE DIRECTION OF THE WIND AND THE NUMBER OF PLOTS WITH DAMAGE

Wind from	Number of plots with damage	Proportion of total (%)
S	7	2·8
SW	41	16·6
W	70	28·3
NW	54	21·9
N	39	15·8
NE	6	2·4
E	4	1·6
SE	10	4·1

5.3 If these broad groups are considered in relation to the information concerning wind direction given in Table 7 it will be seen that there is a general relationship between the aspect factor and wind direction. Winds from north through west to south-west account for 88% of all damage — and 87% of all damage occurs on slopes with aspects from north-west through north to south-east. If it is suggested that there is a relationship between damage and lee slopes then a contingency table, Table 8 can be constructed. Application of the chi-squared test to these figures gives a result of 187.88 which would suggest that the relationship is a real one.

TABLE 8
RELATIONSHIP BETWEEN WIND DIRECTION AND LEE SLOPE DAMAGE

Wind from	S	SW	W	NW	N	NE	E	SE
Number of plots damaged	7	41	70	54	39	6	4	10
Number of trees damaged	180	223	50	116	34	26	38	98
Aspect	N	NE	E	SE	S	SW	W	NW

5.4 Gloyne (1968) has suggested that the obstruction to flow of wind by the major geographic features of the Earth's surface, such as the Rocky Mountains, can impose recognisably distinct readjustments of the pressure field but in the British Isles the only such case of importance is the now well documented lee-wave phenomenon. This arises when an air-stream of particular velocity and temperature structure in the vertical blows across a range of suitably spaced hills which may be only a few hundred feet in height. Sympathetic undulations are set up in the upper current and strong surface winds are induced which blow down lee slopes. In more mountainous country, where the lee-wave phenomenon is absent, damage may still be markedly associated with lee slopes (Aanensen, 1965). In these circumstances it is not uncommon to find that a point about one third of the way down the lee-slope experiences more severe damage than elsewhere. This is generally attributed to the effects of turbulence. In either event lee slopes are more susceptible than windward slopes.

5.5 In addition to the influence of wind there are two other factors that can be taken into account when attempting to explain the greater susceptibility to wind damage of trees on northern and eastern slopes. The first is that the total solar daily energy available is limited and the net amount received by unit area of ground is related to the angle of incidence of the suns rays. In broad terms south facing slopes can be expected to receive substantially more energy than north facing slopes. Most of the energy received is dissipated in the evaporation of water but insufficient energy is available to evaporate all water at all times and north slopes are less favoured in this respect than others, and there is therefore a greater tendency for peat formation to occur there. As has been shown peaty mineral soils are likely to be inherently unstable.

5.6 The second factor which renders lee-slope forest unstable is related to the positive geotropism shown by most roots. By the concentration of growth hormones, through grativational influence, in the lower parts of meristematic regions roots grown downwards. Where the development of the vertical system is inhibited through the presence of a restricting sub-stratum, the horizontal system may demonstrate the same characteristic, but to a lesser extent, by the downhill orientation of roots on slopes. Scale drawings of typical root systems are given in Fig 1. In terms of susceptibility to wind damage this means that lee-slope trees are generally inefficiently anchored to the soil on the uphill side and are there-

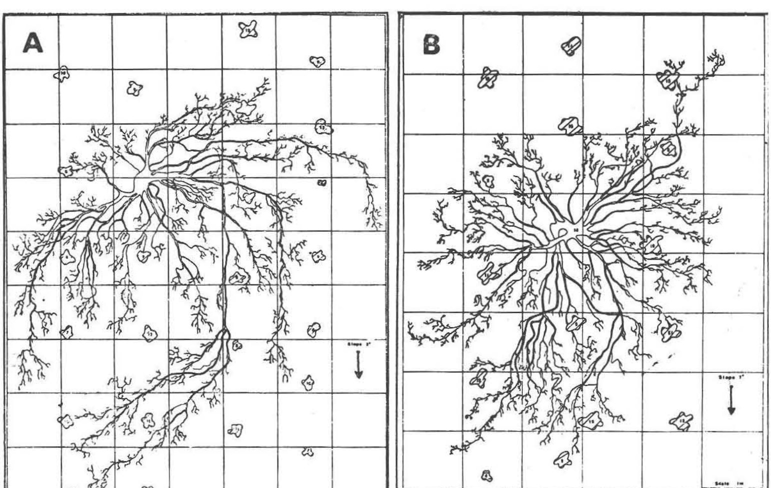

Figure 1: Plans of the horizontal rooting systems of Sitka spruce, aged 21 yeare in Lisnaskea Forest. A on 3° slope, B on 7° slope. The plans ars divided into 1 m. squares.

fore inherently more unstable than those on the windward slope which have improved anchorage.

6. Influence of Altitude

6.1 The amount of damage recorded in relation to the altitude of the plot as estimated from the 6" Ordnance Survey map is given in Table 9. When the number of trees thrown is compared with the number unaffected by wind for each altitudinal class a chi-squared figure of 84.97 is derived indicating that there is a significant statistical relationship.

TABLE 9
RELATIONSHIP BETWEEN THE NUMBER AND PROPORTION OF WINDTHROWN TREES IN RELATION TO THE ESTIMATED ALTITUDE

Altitude above OD	No. of trees thrown	No. of trees not thrown	Total	Proportion thrown %	No. of plots
0 - 150′	1	805	806	0·12	25
151′- 300′	16	2,085	2,101	0·76	62
301′- 450′	2	3,581	3,583	0·06	48
451′- 600′	81	4,487	4,568	1·77	113
601′- 750′	182	12,733	12,955	1·40	187
751′- 900′	412	34,789	35,210	1·17	265
901′-1,050′	56	5,893	5,949	0·94	136
1,051′-1,200′	17	1,888	1,905	0·89	60
Above 1,200′	0	794	794	0·00	25

6.2 Examination of the data in Table 9 indicates that, with the exception of the anomaly in the 300' to 450' zone (which may be fortuitous and ascribed to the small number of plots), the proportion of damage increases with increasing altitude reaching a maximum at between 451' and 600' and thereafter decreasing until a point is reached at the highest elevations where no damage at all occurs. In general terms this trend follows expected soil development patterns with the better drained soils, usual at lower elevations, giving way to gleys and then to shallow peaty mineral soils and finally, on the highest regions, to deep peat. Again, as with aspect, the role of climate is important. Increasing elevation brings in turn decreasing temperatures and increasing rainfall — both factors which play a predominant part in the processes of peat formation.

6.3 Although it is suggested that soil type is a better indicator of site susceptibility to wind change than altitude it is worth noting that elevation and wind strength and gustiness are related. At altitudes of 2,000 to 3,000 feet winds are governed by pressure gradients and by the rotation of the earth (Gloyne 1963). Below that level friction, and other forces, reduce wind speed but increase gustiness. At the lowest levels, below 450', a degree of shelter exists and in forests at these levels the effect of gustiness is reduced. Because of this, and the generally better rooting conditions at these lower altitudes, risk of wind damage is reduced. At the highest elevations gustiness is reduced and wind speed increased. Trees tabituated to high wind speeds tend to develop root systems adapted to their habitat and this, combined with a greater stability found on deep peat — which is more common at high elevations — would explain the reduction in damage.

7. The Influence of the Solid Geology

7.1 The amount of damage recorded in relation to the parent material from which the soil of the plots was derived, as determined by an examination of the stones found in the plot area, is given in Table 10. When the number of windthrown trees is compared with the number of unaffected in relation to parent material a chi-squared figure of 914.70 is derived indicating a highly significant statistical relationship between windthrow and the solid geology.

TABLE 10
RELATIONSHIP BETWEEN THE NUMBER AND PROPORTION OF WINDTHROWN TREES IN RELATION TO THE PARENT MATERIAL FROM WHICH THE PLOT SOIL WAS DERIVED

Parent Material	No. of trees damaged	No. of trees not damaged	Total	Proportion damaged	No. of plots
Basalt	560	44,991	45,551	1·23	396
Triassic associates of Basalts ...	113	998	1,111	10·17	35
Schists	37	8,748	8,785	0·42	242
Carboniferous ...	48	8,713	8,761	0·55	159
Old Red sandstone	0	181	181	0·00	6
Granite	4	2,231	2,235	0·18	57
Silurian	5	1,242	1,247	0·40	36

7.2 If the results for the Triassic soils and the Old Red Standstone are set aside — the number of plots are small and they are concentrated largely in two separate forests where the management may have influenced the degree of risk — then three broad risk classes can be identified. The lowest is represented by those soils derived from granites of South Down. The next class, where the risk is apparently twice as great, is formed from soils derived from schists, Silurian rocks, and the wide variety of Carboniferous strata. The highest rick class is on soils formed from basalts.

7.3 At first sight this would appear to be a reasonable conclusion. Basalts tend to weather to fine particles which might be expected to produce a heavy soil. The sedimentary and metamorphic rocks contain a proportion of hard quartzitic materials which should improve soil structure, and hence drainage, and the crystalline structure of the granites usually produces sandy, well drained soil. However these statements imply normal particle sorting such as occurs under the usual conditions of profile development. This is not the case with most of the Northern Ireland forest soils where the parent material is in the form of glacially deposited, unsorted and unstratified rock fragments. The granitic soils were furthest from the centres of distribution of the last ice advance and are least affected, most other soils are very widely evolved from glacial till which, because of its structure, is inherently poorly drained. This being the case we must look further to explain the apparent difference in susceptibility to windthrow of forests on soils derived from various parent materials.

7.4 In the early days of forestry in Northern Ireland, prior to 1930, acquisitions were limited mainly to old woodland sites associated with the larger estates. These were mostly well drained, lowland soils. During the 1930-1940 period further acquisitions were made in what was then marginal agricultural land on the poorer drained sites at higher altitudes. For historical reasons these acquisitions were largely concentrated on the basalt plateaux of Antrim and Derry, and, to a certain extent, the schistoze soils of the Sperrins. The first major acquisitions of carboniferous soils were made after 1940.

7.5 Historically the acquisition of forest land in all of the major geological regions has shown much the same pattern — well drained sites are acquired first, then gleyed soils, followed by the peaty soils of the upper middle slopes and finally the deep peats of the high elevations. This pattern has meant that the forests of the basalt plateaux were at a stage of growth and management which rendered them highly susceptible, and it is this factor of age (or more properly of height) rather than the nature of the parent material, which may influence the analysis.

7.6 Table 11 shows the relative proportion of the major soil groups in relation to parent material of those plots that were included in the survey. As only production forest was involved this reflects the position about 1955. The current position will indicate little change in the basalts, schists and pranites but soils of the Silurian, and in particular the Carboniferous series, will show a substantial increase in the peaty gleys and the peats. This trend has been accentuated in the last 20 years as techniques have been developed that make afforestation, and hence acquisition, of high altitude peats possible.

TABLE 11
RELATIVE PROPORTION OF SOIL TYPES FOR THE MAJOR GEOLOGICAL ZONES

	Parent Material				
Soil Type	Basalt	Schist	Carbon-iferous	Silurian	Granite
Brown earths and other well drained soils	14	13	38	80	44
Gleys	35	15	49	8	12
Peaty gleys ...	31	51	6	7	11
Peats	20	20	6	5	33

8. The Relationship Between Site Fertility and Windthrow

8.1 The amount of damage recorded in relation to the fartility of the site as measured by the estimated yield in cubic metres per hectare per annum for the rotation of the maximum mean annual increment and determined from the top-height/age relationships of the Forestry Commission Management Tables (Forestry Commission Booklet No. 34 HMSO 1971) is given in Table 12. Application of a chi-squared test to this information gives a result of 1192.79 which indicates that there is a very significant statistical relationship between the amount of damage and the yield class.

8.2 The 1970 Inventory Survey of Northern Ireland's State Forests indicated that the mean yield class for Sitka spruce on peat soils was 9.3, for peaty-gleys the mean was 11.8 and on gleys yield averaged 14.6. As has already been shown in Section 4 there is a strong relationship between soil type and stand stability, with the peats being substantially more stable than the peaty-gleys which are marginally more stable than the gleys. This finding would confirm the general trend of Table 12 up to yield class 16. On the more fertile sites in yield classes 16 to 20 productivity can be associated with the existence of spring lines or extensive flushes and these have been shown, in paragraph 2.8 to be among the sites with a greater susceptibility to wind damage.

TABLE 12
NUMBERS AND PROPORTION OF TREES WINDTHROWN IN RELATION TO THE YIELD CLASS

Yield class	No. of trees thrown	No. not thrown	Total	Proportion thrown %	No. of plots
0	0	104	104	0	5
2	0	446	546	0	18
4	0	826	826	0	32
6	16	1,482	1,498	1·07	52
8	0	1,193	1,193	0	35
10	8	1,802	1,810	0·44	53
12	180	9,802	9,982	1·80	251
14	152	5,513	5,665	2·68	145
16	239	6,160	6,399	3·73	152
18	139	3,695	3,836	3·62	79
20	22	1,050	1,072	2·05	33
22	6	718	724	0·83	17
24	0	74	74	0	5

8.3 The highest yielding trees have two characteristics which may make a material contribution to the apparent increase in stability. The first is that for physiological reasons needles are seldom retained on the most vigorous trees beyond three years whereas on slower growing trees retention periods can be as much as 10 years and this combined with the characteristic production of two whorls of branches every year, more or less irrespective of vigour, means that the fast growing tree presents a much lower degree of wind resistance than does the slower growing trees. If this conclusion is valid it is another indication of the importance of the form and structure of the forest canopy.

9. The Relationship Between Exposure and Windthrow

9.1 The amount of damage recorded in relation to the exposure of the site as measured by the sum of the angles of inclination to the horizon at the eight main points of the compass from the plot centre (the Topex system) is given in Table 13. Application of a chi-squared test to this information gives a result of 1192.79 indicating a significant relationship between the topex rating and the amount of windthrow.

9.2 No measurement of topography was made during the survey owing to the practical difficulties involved in classification and assessment; but the Topex measure of exposure would perhaps be more correctly considered a measure of the relative topography. Exposure is compounded of many factoes and there are as many

TABLE 13

NUMBER AND PROPORTION OF WINDTHROWN TREES IN RELATION TO THE EXPOSURE OF THE PLOTS AS MEASURES BY THE TOPEX SYSTEM

Exposure (degrees)	No. of trees thrown	No. not thrown	Total	Proportion thrown %	No. of plots
Severe (0–10)	37	1,252	1,289	2·87	40
Very exposed (11–30)	693	53,839	54,532	1·27	630
Moderate (31–60)	33	10,910	10,943	0·30	220
Sheltered (61–100) ...	4	1,103	1,107	0·36	31
Totals	767	67,104	67,871	1·13	921

opinions regarding the degree of exposure of a site as there are factors involved. It is therefore useful to have a basic reference point and the Topex system does provide this although it has obvious faults — a site at the base of a cliff exposed to westerly gales could be rated as 'sheltered' when, from the point of view of tree growth, the only sensible classification would be 'severely exposed'. This would be a major drawback under certain conditions; but in Northern Ireland this problem does not arise with the exception of the escarpment faces of the basalt and Carboniferous plateaux. In most other areas of the country the system probably provides a fair evaluation of the relative topography and as such may be of value in site assessment.

9.3 Table 13 indicates that a Topex rating of 'severe' is likely to indicate a high degree of windthrow risk, sites in this class being more than twice as prone to damage as sites in the next class — 'very exposed'. 'Moderately exposed' sites and 'sheltered' sites are substantially less liable to damage. However, a significant proportion of trees are thrown in these areas and they cannot be accounted 'safe' from the point of view of stability. It is only in the 'very sheltered' sites — those with a Topex rating of over 100° — that wind risk might be considered negligable and as none of the plots examined fell into this class no firm conclusions can be drawn.

9.4 As well as being a measure of land form the Topex system is also related to altitude. With higher elevations the chances of a Topex rating for a plot to approach zero will become greater. It follows that there will be an increased proportion of peats and gleys in the lower ratings with an additional possibility of damage occurring. At the same time the lower Topex ratings indicate a low relief topography and, as has been shown, this characterises the type of country in which the lee-wave phenomenon is most marked with the consequential increase of wind damage risk on lee slopes. It would seem, therefore, that assessment of Topex ratings, while of doubtful use as a measure of exposure, can nevertheless serve a useful purpose in the estimation of wind risk.

10. The Assessment of Windthrow Risk

10.1 The survey gathered information on eight groups of factors which it was thought might influence the degree of risk of windthrow. The application of statistical tests to this data has shown that, with certain reservations, significant relationships exist, thus justifying the use of this type of site and management information in the assessment of that risk. A means of doing this is given in Dr. Kennedy's paper.

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Topography and Wind Risk[1]

T. C. BOOTH[2]

Introduction

SOME two years ago we tried to account for the distribution of wind throw in Kershope Forest, a forest on carboniferous gleys where sporadic damage is the accepted rather than the rare occurrence. Only 10% of the variation was accounted for by the normal site survey factors, i.e. tree height, topex, aspect. The soils were all high risk soils surface water gleys and peaty gleys and were not mapped. As we felt sure that relative exposure was an important factor and topex had accounted for little of the variation we decided to have a look at other methods of exposure zonation.

Method of Measuring Exposure

a) *Subjective scoring using local knowledge.* A method to which all foresters are accustomed, using deformation of trees in the area and years of experience regarding damaging winds and affects of topography on wind flow. The faults of the method are also well known, it is subjective and therefore not strictly repeatable, it does not lend itself to analysis and is very time consuming if required over a large forest area, etc.

b) *Measurement by a series of anemometers.* Either a set of permanent anemometers recording full time, or a set of mobile anemometers with which you rush out and measure wind speeds when you have strong winds. At least a three year study is called for, it is extremely expensive to mount and is not practical for large scale work.

c) *Crude assessment by "tatter flags".* A good method of measuring exposure and has its uses for comparison of specific sites, it is however non-directional and the logistics and cost of running the large numbers of flags to enable you to map a forest area put tatter flags out as a possibility.

d) *Topex (topographic shelter).* Sometimes known as sky line angles, this was the method used in the basic study and had contributed little. Correlation of topex has only been carried out with tatter flags previously and this was the first attempt to tie in with wind damage.

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1. Paper delivered at Wind Risk Symposium, Pomeroy, Co. Tyrone, 1st-3rd May, 1974.
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There are limitations to all of the above methods as planning aids, principally because of the large areas we operate as planning units, but also because of the time scale of some of the methods and the vagaries of the wind. In order to control the wind and reduce both the time scale and the land area we considered the possible use of topographic models in wind tunnels. Feelers had been put out regarding using this method in 1966 but the experts made disparaging noises and the estimated cost of the model was £800. This time the model was a do-it-yourself and we found a friendly wind tunnel owner.

Method

The models were built of ¼" sheets of polythene and polyfilla, to a horizontal scale of 6" to 1 mile (1 : 10,560) and three vertical scales 1.1, 2.5 and 4.0 x the horizontal as little was known about the effect of vertical exaggeration. After gaining experience in the method, a 6' x 4' model with sampling points marked out sufficient detail to help mapping later, cost £8 in materials and 3 man weeks work. The first wind tunnel we used was at Edinburgh University, and had been used to study airflow around buildings. It was an open ended tunnel and the model was placed on a table at the end of the tunnel and a simulated natural wind was blown over it. Wind speeds were measured by a hand held hot wire anemometer at preselected points on the model, by moving the model we were able to obtain winds from any direction over the model.

In order to test the technique we modelled an area of Wauchope Forest (Whitrope) where numerous methods of exposure had already been tested. This was a 600 acre site (240 ha), 11" x 3" on the model scale with data from a 3 year run of tatter flags, topex and subjective scoring for 40 stations.

Results and Further Work

The wind tunnel results and the other methods of zoning exposure were tested against flag tatter which we considered the most reliable method and some extremely satisfactory results were obtained (see Appendix 1). Although not the best of the methods used at Whitrope the wind tunnel method had so many points in its favour for large scale mapping that further tests were carried out. Using the vertical exaggeration of x 2.5 which gave by far the best results and reducing the unassessed surround we have since carried out a series of studies both at Edinburgh and at Bristol University Department of Aeronautics.

1. *Kershope Forest.* An attempt to improve the explanation of

wind throw distribution. Although good exposure maps were obtained, and the effects of wind direction were clearly illustrated by increased wind speeds in valleys and funnel features open to the wind, there was little improvement in explaining the actual distribution of windthrow. A hazard rating compiled from tree height, altitude tunnel wind score, weighted by % area thrown did appear to have possibilities.

2. *Bristol University*. Because of doubts cast on the validity of what we were doing a further series of tests were carried out at Bristol using more sophisticated technique. Using a closed circuit tunnel and a natural wind profile calculated to suit the scale of the model the Whitrope x 2.5 model was tested. This time 12 wind directions were used in order to marry the wind tunnel speeds with the long term wind speed averages from Eskdalemuir. A further improvement was the feeding of the signal from the hot wire anemometer directly into the computer. This enabled a sampling of the signal to be carried out to give 6 sec (gust speed) and 30 min (average hourly speed approx) to see if these gave any improvement on the somewhat crude Edinburgh results.

The results supported and improved slightly on the Edinburgh results for correlation with field measurements. However no advantage was obtained by the use of long term averages from Eskdalemuir expressed either as hours of wind above certain levels of Beaufort or as total run, or from the more detailed analysis of the 6 sec and 30 min averages. A highly significant degree of correlation was found between the two wind tunnel sets of results.

3. *Kintyre Forest*. In order to test the method on a slightly different type of topography and examine the problems of mapping, 48 sq. miles of Kintyre peninsular were studied. From the beginning of construction of the models to the drawing of the maps a total time of 6 man weeks were used. Exposure was expressed in four zones and maps drawn for "Westerly" and "Total" exposure using the basic eight wind directions and contours as aid lines. A limited number of tatter flags and pilot plots provided the only check on accuracy. Scrutiny by the field staff of the maps found no flaws, and they thought them a considerable improvement on previous aids to exposure classification. As a test of a new technique computer mapping of the wind tunnel data was attempted (Fig. 1). Although the outlines differed from the hand drawn which had used contours as an aid, the areas of the four zones only differed by at most 1%.

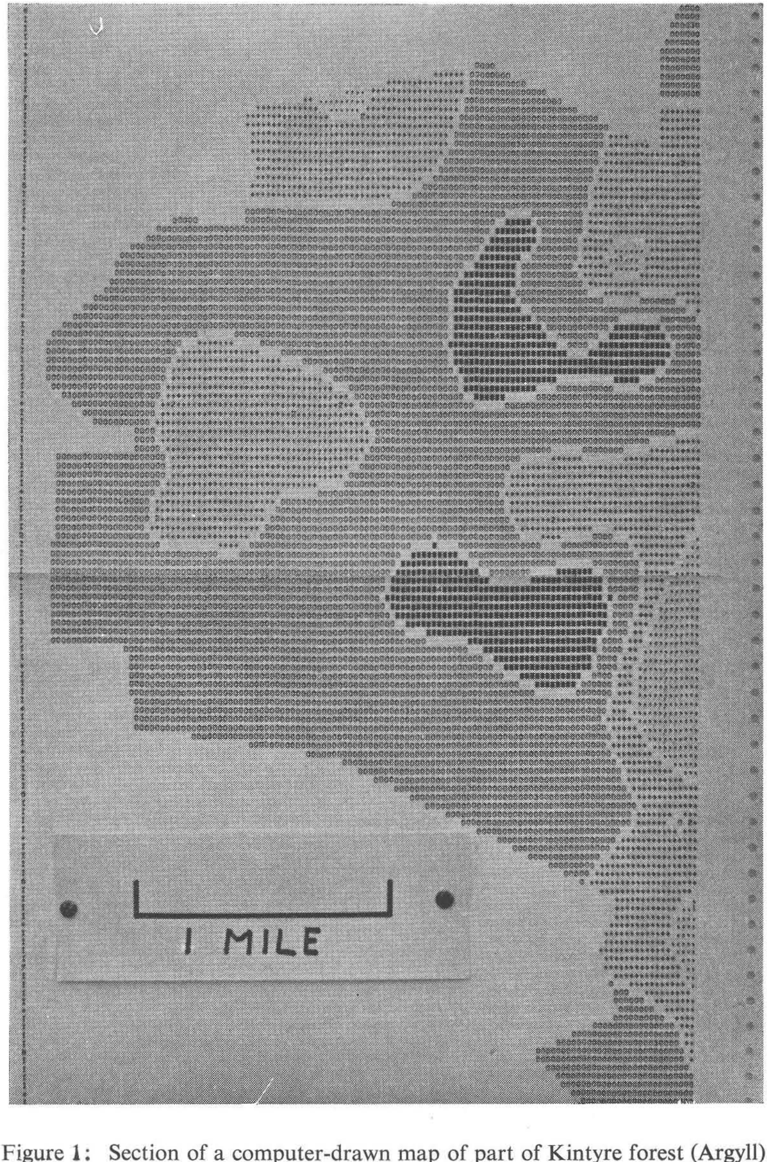

Figure 1: Section of a computer-drawn map of part of Kintyre forest (Argyll). Four zones of relative windspeed, the darker the printing the higher the windspeed. (Photo: A. J. Low.)

Conclusions and Future Work

It is possible to map relative exposure to wind using a wind tunnel and topographic models with a considerable saving in time and cost over other methods. There are probably limits on the complexity of terrain that can be modelled and we hope to prove this on a recent test carried out on an area of S. Wales. We have not yet proved conclusively that exposure zonation is a help to stability zonation, but there are suggestions that as with tatter flags a close correlation with tree growth is possible. While a good correlation with "tatter flags" has been proved we are not as yet sure of the technique as regards the higher wind speeds which cause crop damage and a project to test this is in the early planning stage.

APPENDIX I

CORRELATION COEFFICIENTS FOR WIND TUNNEL WORK

Experiment at Edinburgh		
Wauchope (Whitrope)	*Correlation with tatter flag. 3 year average*	
Vertical Scale 1·1 x horizontal	·1108	not sig.
Vertical Scale 2·5 x horizontal	·4256	***
Vertical Scale 4·0 x horizontal	·1924	not sig.
Foresters subjective score Total	0·776	***
Topographic Shelter (topex)	—0·696	***
Wind tunnel score full model	0·660	***
Wind tunnel score cut down model	0·660	***
Experiment at Bristol		
Bristol Total 6 sec. (gusts)	0·759	***
Bristol Total 30 mins. (hr. average)	0·745	***
Hours of wind per annum in Beaufort Classes	(6 sec.) 0·757	
Hours of wind per annum in Beaufort Classes.	(30 min.) 0·769	
Best correlation at Beaufort 5–6 and above (20–25 knots).		
Total annual wind run	0·76	

OTHER CORRELATIONS

Total Edinburgh/Bristol	6 sec.	·890
Total Edinburgh/Bristol	30 min.	·892

For individual wind directions intercorrelations were all highly significant except for North where correlation is virtually zero.

Bristol 6 sec./Bristol 30 min. ·996

Repeat run of 64 points at Bristol Set I/Set II	6 sec.	0·993
	30 min.	0·992

Significance levels * 5%
** 1%
*** ·1%

Quantitative assessment of the relative importance and cooperative effects of factors influencing forest instability[1]

M. S. O CINNEIDE[2]

1. Introduction

CONSIDERABLE progress has been made in recognising the factors that lead to windblow in forest plantations. These may be classified into three broad groups, (a) those relating to characteristics of individual tree species, (b) those relating to composition and structure of forest plantations, and (c) environmental variables. The first two groups are largely the concern of the botanist and the silviculturist and are not considered in this paper. Environmental variables shown to be significant to windblow processes include bedrock, soil-type, slope, altitude, exposure, and aspect. This paper assesses the relative importance of these variables and explores their co-operative effects on forest instability.

2. Approaches to the Study of Windblow

Research on windblow has been carried out along two distinct but complementary lines. One has dealt primarily with the factors affecting the resistance of trees to wind damage. The second line pursues the processes of windthrow, such as the forces that wind applies to trees and the forces that a tree can resist. The latter approach has the advantage of being a direct observational or experimental method and is consequently more focussed on the processes *per se*, whereas the former generally is circumstantial and comes after the processes have occurred. The direct observational method is, however, wrought with many difficulties including the inconvenience of having to observe the study area during storms. Because of this, much work along this line has retreated from the forest to the greater comfort of laboratories where an effort is made to simulate natural conditions. This research has been executed along the first of these lines as it is by

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far the best method for the individual researcher with limited resources, while capable of yielding valuable insights as to the nature of windblow.

3. Field Investigations

Choice of a suitable field study area was guided by the foslowing criteria: (a) wind damage should be a frequent occurrence; (b) forests established on sites that exhibit a wide range of the environmental variables affecting windthrow should exist; (c) existence of data on wind damage was deemed highly desirable. The coniferous plantations of Northern Ireland met these criteria well and were chosen without hesitation.

Windblow data collerted in 1969 by the Ministry of Agriculture, Northern Ireland were made available to this author. A total of 2,590 sample plots, 0.04 hectares (one-tenth acre) in size, were investigated. Intensity of windthrow and windsnap together with the level of variables believed to be significant to wind damage were recorded. Data for 33 of these plots were unacceptable because of incompleteness and ambiguity. Because of the huge sample size it was deemed unnecessary to substitute for these plots. Consequently, a total of 2,557 plots were available for analysis.

4. Analytical Difficulties

A great number of variables are involved in the processes of windthrow. The major difficulty is one of determining which variables are most functionally related to the phenomenon and under what conditions and through which intervening processes do these functional relationships find their greatest manifestation. This research is primarily associated with the inductive phase of model development in as much as *ex post facto* explanations of the relationships found within the data form the basis for developing much more specific hypotheses (middle-range theory) to be tested later.

Because of the large number of potential explanatory variables the task of isolating the relationships within the data is not easy. Among the complicating factors are:

(a) Interactions and intercorrelations between the causal variables. Many of the factors involved do not produce their effects simply. Rather, interaction of a high order with those of other factors are involved. Thus some factors tend to augment the effects of other factors in such a way that the combined effects are greater than the sum of the individual effects. This phenomenon is known in ecology parlance as synergism. Some factors tend to nullify the effects of other factors thus making detection difficult. Because of intercorrelations between the causal variables it is difficult to establish to which variable can variation in the dependent variable be rightly attributed.

(b) Measurability difficulties. Some of the variables involved cannot be quantitatively measured on a continuous scale, but at best on an ordinal scale and in some cases on a purely nominal scale. The nonparametric nature of these variables defies the fruitful application of many conventional mathematical models to the problem.

(c) Stratification in sampling. To ensure reasonable representation of minority conditions it was necessary to stratify the original sample despite its huge size. This renders the significance tests usually employed in multivariate analysis models inapplicable.

(d) Nonlinearity. The absence of linear relationships between many of the causal variables and the dependent variables all but eliminates the possibility of devising a simple model that adequately explains the dependent variables.

(e) Spatial autocorrelation. This makes void the assumption of independence between observations.

(f) The highly skewed nature of the dependent variables. As most parametric statistical models assume normality they could not be properly applied to the present data without considerable transformations inevitably resulting in information loss.

(g) The meristic nature of the dependent variable. As windthrow could only assume integer values it does not meet the assumptions of many statistical models.

These difficulties led to a search for a model capable of (a) handling a large number of explanatory variables, (b) showing how these variables interacted with one another to determine the distribution of the dependent variable, and (c) doing (a) and (b) with nonparametric data and without the assumptions of normality, homoscedacity, linearity, and additivity. Conventional multivariate models such as those employed in regression and factor analysis clearly do not meet the criteria. The Automatic Interaction Detection (AID) model developed at the Institute for Social Research, The University of Michigan (Sonquist and Morgan, 1964), was designed specifically for this type of problem. The basic idea in the model is the sequential identification and segregation of subgroups one at a time, nonsymmetrically, so as to select the set of subgroups that will reduce the error in predicting the dependent variable as much as possible relative to the number of groups. The model is described briefly by Sonquist (1970, p. 20):

The technique is a step-wise application of a one-way analysis of variance model. Its objective is to partition the sample into a series of non-overlapping sub-groups whose means explain more of the variance in the dependent variable than any other such set of subgroups. The algorithm actually implemented is as follows:

1. Select that as yet unspilt and untried sample group, group i, which has the largest total sum of squares. (The total input sample is considered the first, and indeed only, group at the start).

2. Fnd the division of the Ck classes of any single predictor Xk such that combining classes to form the partition p of this group i into two non-overlapping sub-groups on this basis provides the largest reduction in the unexplained sum of squares. Consider all possible binary splits on all predictors with the restrictions that (a) the classes of each predictor are ordered into descending sequence, using their means as a key and (b) observations belonging to classes which are not contiguous (after sorting) are not placed together in one of the new groups to be formed. Restriction (a) may be removed, by option, for any predictor Xk.

3. For a partition p on variable k over group i actually to take place after completion of step 2 it is required that the between group sum of squares associated with this partition be larger than an arbitary constant Q. It is also required that the total sume of squares for group i be larger than an arbitrary constant P. If neither of these criteria are met, group i is not capable of being split and the next most promising group (having the maximum total sum of squares) is selected via step 1.

4. If there are no more unsplit groups such that requirements P and Q are met or if the number of currently unsplit groups exceeds an arbitrary integer R, the process terminates.

This model was deemed appropriate and has been employed in the following analysis.

5. Analysis and Findings

Parent material, soil-type, slope of terrain, altitude, exposure, aspect, species, and age of trees were employed as predictor variables in the AID analysis. Slope, altitude, exposure, and age of trees were monotonically constrained; all possible splits based on the remaining four variables were permissable. For a split to occur, a reduction in the unexplained sum of squares amounting to one per cent of the initial total sum of squares had to be achieved. Splits resulting in group membership of less than 10 were prohibited. Groups with less than $1x10^{-5}$ of the initial total sum of squares were not considered eligible for splitting.

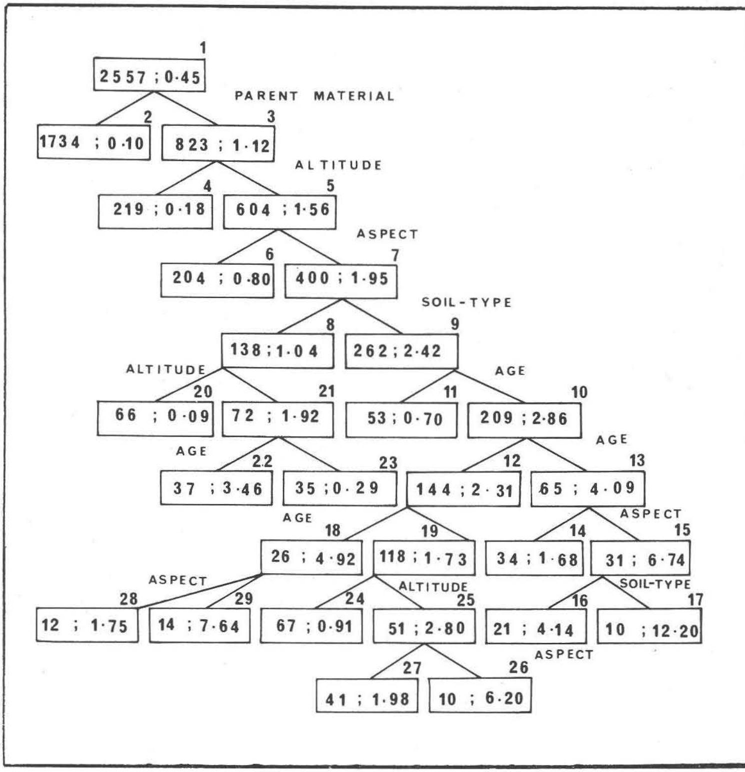

Figure 1: Summary of AID analysis of windthrow. The entry on the left in each box refers to the number of sample quadrats; the entry on the right is the mean number of trees thrown in these quadrats. The group number is listed beside each group. The variable used to perform each binary split is also shown.

Figure 1 summarizes the results of the AID analysis. The parent group, i.e. the total sample, has 2557 sample quadrats with a mean of 0.45 thrown trees per quadrat. The most efficient single predictor is parent material. With the aid of that variable a binary split was performed which isolated all quadrats with basalt and all basaltic "associates" into group 3 and all remaining quadrats into group 2. The mean number of thrown trees per quadrat in the latter was only 0.10 while damage in the former group was 11 times greater with a mean of 1.12 thrown trees per plot.

Group 3 had the greatest total sum of squares after the first split. In the next iteration this group was subdivided with the aid of altitude. The 219 cases that constitute group 4 had an altitude of 137 metres or less. The mean number of thrown trees in this group was 0.18. Group 5, which consists of all cases of group 2 with an altitude greater than 137 metres, has 604 members with a mean of 1.56 thrown trees per plot. Plantations on basalt and basaltic "associates" situated at altitudes greater than 137 metres are approximately 9 times more vulnerable to windthrow than plantations on the same rocks at lower altitudes and almost 16 times more vulnerable than plantations on all other rock types irrespective of altitude.

Of the 3 candidate groups available for splitting at the end of the second iteration group 5 had the largest total sum of squares and was successfully split using aspect as the predictor variable. Quadrats with eastern, southern and southwestern aspects were isolated into group 6 while all remaining quadrats were placed in group 7. Group 6 consists of 204 cases with a mean of 0.80 thrown trees per quadrat. Group 7 is composed of 400 cases with a mean of 1.95 thrown trees per plot. Plots on basalt and basaltic "associates" at altitudes greater than 137 meters with northern, northeastern, southeastern, western and northwestern aspects experienced over twice as much windthrow as those on the same parent materials, at the same elevations, but with eastern, southern and southwestern aspects and almost 10 times as much windthrow as plots on parent materials other than basalt and basaltic "associates" irrespective of altitude or aspect.

Of the four candidate groups available for splitting at the end of the third iteration group 7 had the greatest total sum of squares. The most efficient predictor variable was soil-type and was used to subdivide group 7 into groups 8 and 9. Group 8 has 138 quadrats, 98 of which are peat and 40 of which are brown earths. The mean number of trees thrown per plot is 1.04. Group 9 has 262 members, 172 of which are peaty gleys, 80 of which are non-peaty gleys, and 10 of which are iron pan soils. The mean number of thrown trees per quadrat in this group is 2.42. Thus, plantations on basalt or basaltic "associates", at altitudes greater than 137 metres with northern, northeastern, southeastern, western and northwestern aspects, with gleys and iron pan soils were more than twice as heavily damaged as plantations on the same rocks, at the same altitudes, with the same aspects, but with peaty or brown earth soils. The intensity of damage in group 9 is over 24 times greater than that in group 2.

Of the five candidate groups available for splitting at the end of the fourth iteration, group 9 was found to have the greatest total sum of squares. The most efficient variable at reducing the sum of squares in a binary split was age of trees. Thus group 9 was subdivided into groups 10 and 11. Plantations 20 years old or more were classified in group 10 while plantations less than 20 years old were classified in group 11. The mean number of trees thrown in group 10 was 2.86 while a mean of 0.70 was thrown in group 11. Thus plantations on basalt or basaltic "associates", at altitudes greater than 137 metres, with northern, northeastern, southeastern, western and northwestern aspects, with gley and iron pan soils, and 20 years old or more are over four times as vulnerable to damage as plantations on same rocks, altitudes, aspects, and soils, but less than 20 years old. The intensity of damage in group 10 is 28 times greater than that in group 2.

At the end of the fifth iteration group 10 had the largest total sum of squares. The binary split which most successfully reduces the sum of squares was accomplished using age of trees as the independent variable. Thus group 10 was subdivided into groups 12 and 13. All quadrats aged between 20-24 years inclusive were isolated in group 13 with a mean of 4.09 thrown trees per quadrat. Plots 25 years old or more are classified in group 12 with an appreciably lower rate of damage than their younger counterparts.

At the end of the sixth iteration group 13 was the candidate group which qualified for splitting. The variable employed in the splitting was aspect; plots with a northern or northeastern aspect were classified in group 15 while the remaining plots, with south-east, west, and northwest aspects, were entered in group 14. Damage in the former was 4 times greater than that in the latter and over 57 times greater than that in group 2.

At the end of the seventh iteration group 15 had the greatest unexplained total sum of squares. The most efficient variable in reducing this variation proved to be soil-type which was therefore employed to divide group 15 into groups 16 and 17. Group 16 consists of 21 quadrats all of which have peaty gley soils with a mean of 4.14 thrown trees per quadrat. Group 17 is composed of 10 quadrats all of which have nonpeaty gleys with a mean of 12.20 thrown trees per quadrat. The intensity of damage in group 17 is approximately 3 times that in group 16, 27 times that for the total sample, and 122 times that of group 2. It has by far the highest rate of damage of all the subgroups identified. Thus the most precarious position for a tree is (a) on a nonpeaty gley, (b) on a north or northeast facing slope, (c) in the 20-24 year age group, (d) at an altitude of 138 metres or greater, and (e) with a basaltic or basaltic "associate" parent material.

The ninth split resulted in the division of group 12 into groups 18 and 19 on the basis of age. All plots in group 18 were 35-44 years old. They experienced a mean of 4.92 thrown trees per plot which is actually higher than that among the 45-49 age-group previously segregated into group 13. The 118 members that constitute group 19 were aged 25-34 years and had experienced a mean of 1.73 thrown trees per plot.

The next iteration resulted in the subdivision of group 8 into groups 20 and 21 on the basis of altitude. The 66 plots in group 20 are at altitudes of 138-229 metres and had a mean of only 0.09 thrown trees per plot. Group 21 is composed of 72 quadrats, 69 of which are at altitudes of 230-320 metres and the remaining 3 having greater altitudes, with a mean of 1.92 thrown trees per quadrat.

The subdivision of group 21 into groups 22 and 23 using age as the discriminating variable constituted the next step. Group 22 is composed of plots in the 25-39 age-group while all 35 plots in group 23 were in the 15-24 age-group. The mean windthrow of 3.46 trees per plot in the former is over 11 times that of the latter, with a windthrow of 0.29 trees per plot.

The twelfth split was on group 19 and employed elevation as the predictor variable. Group 24 consists of 67 plots between 138 and 229 metres altitude and has a mean windthrow of 0.91 trees per plot. Group 25, with 51 plots situated between 230 and 320 metres altitude, had a mean of 2.80 thrown trees per plot.

The thirteenth successful iteration resulted in the division of group 25 into groups 26 and 27. Aspect was used as the discriminating variable. In group 26 are 41 plots having northeasterly, northerly, and northwesterly aspects and a mean windthrow of 1.98 thrown trees per plot. A mean windthrow of 6.20 trees per plot was recorded in the 10 plots that constitute group 27. These plots have southeasterly and westerly aspects.

The final split to occur was the segregation of group 18 into groups 28 and 29 on the basis of aspect. The 12 plots in group 28 have either northerly or southeasterly aspects and experienced a mean of 1.75 thrown trees per plot. In group 29 are 14 plots with northeasterly, northwesterly, and westerly aspects and having a mean windthrow of 7.64 trees per plot.

6. Conclusions

The more outstanding results of these splits include: (a) plots at higher altitudes are more vulnerable to windthrow than are those at lower levels; (b) plots on lee slopes are appreciably more vulnerable to windthrow than are those on windward sides; (c) plantations on gleyey soils are more prone to windthrow than are those on other soils; (d) although older plantations experience more windthrow than younger plantations, damage peaks in the middle part of the age range examined; (e) windthrow is not merely more intense but is found in younger plantations (i) at higher than at lower elevations, (ii) on leeward than on windward slopes, and (iii) on gleyey than on other soils; (f) advantages of favoured edaphic conditions are partly offset by disadvantages associated with high elevation; (g) high elevation plantations face less risk on windward than on leeward slopes; and (h) high elevation plantations on leeward slopes are much less liable to windthrow if established on brown earths, peats, or podzols than when on peaty and nonpeaty surface water gleys.

Parent material is the single most efficient discriminating variable between heavily and lightly damaged plantations. This does not imply that parent material is the primary causal factor in the determination of windthrow. Rather, its great predictive power is attributable to its spatial correspondence with a high incidence of (a) gleyey soils, (b) middle and high altitudes, (c) plantations on north, northeast, and east slopes, and (d) middle-aged plantations (Kennedy, 1973).

The analysis suggests that altitude is strongly related to windthrow, with plantations on middle slopes (138-274 m) being exceptionally vulnerable. Aspect is the next most significant variable with plantations on north, northeast and east slopes having heavy wind damage. Soil-type is ranked next in importance; most of the windthrow being associated with gley soils. Finally, age of plantation is significantly related to incidence of windthrow, with damage peaking in 20-39 years age-group.

Altitude, aspect, and soil-type are, in that order, the variables most functionally related to windthrow at the scale of Northern Ireland. Analysis of smaller areas reveal that these three variables are consistently among the most significant variables, but the order of importance is likely to change. These variables are strongly interactive such that the damage associated with a site possessing deleterious levels of all three variables (e.g. peaty gley at an altitude of 175 m on a northeast slope) is much greater than the sum of damages associated with these site attributes individually.

Acknowledgment: The author is indebted to Mr. R. F. MacKenzie, Planning Officer, Forestry Division, Department of

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

T. C. BOOTH[2]

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.

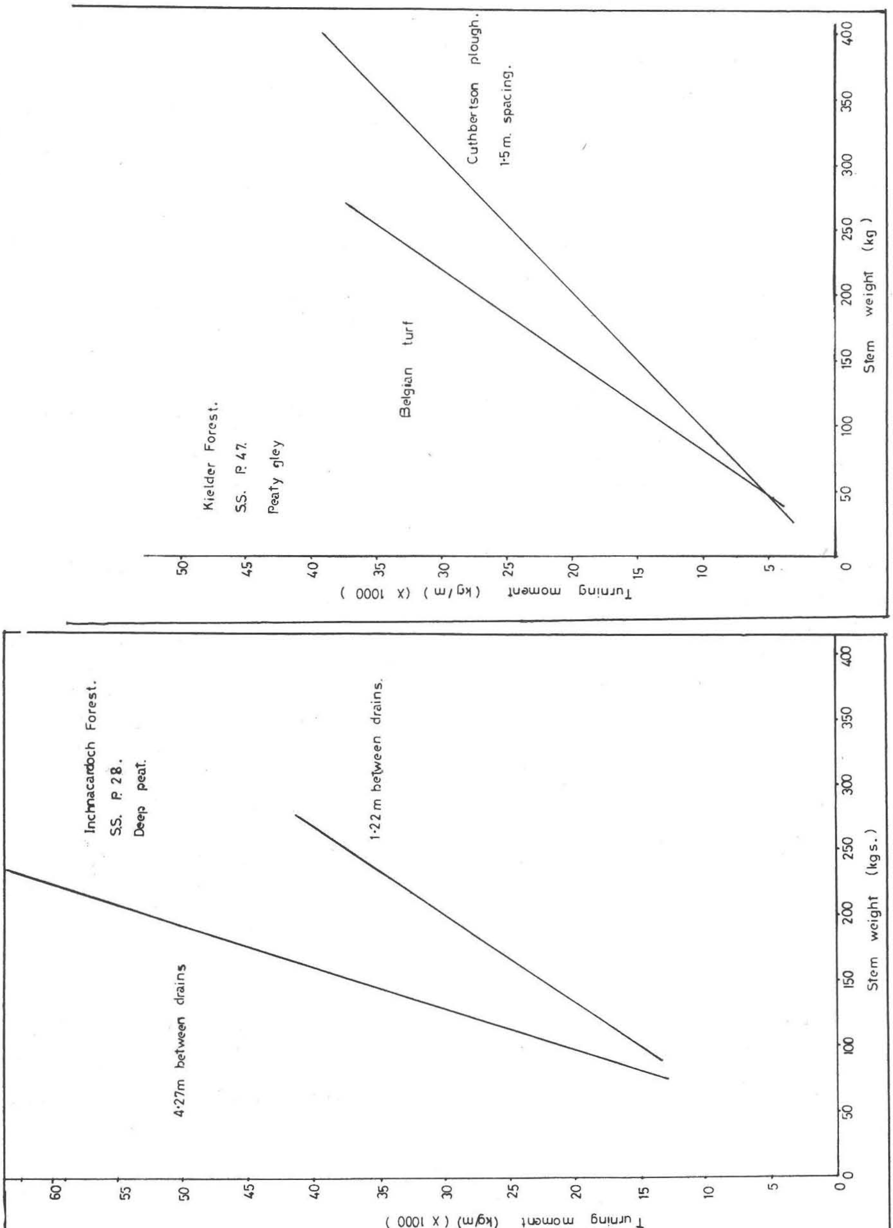

Figure 1: Relationship between turning moment and stem weight in tree-pulling tests in two experiments.

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

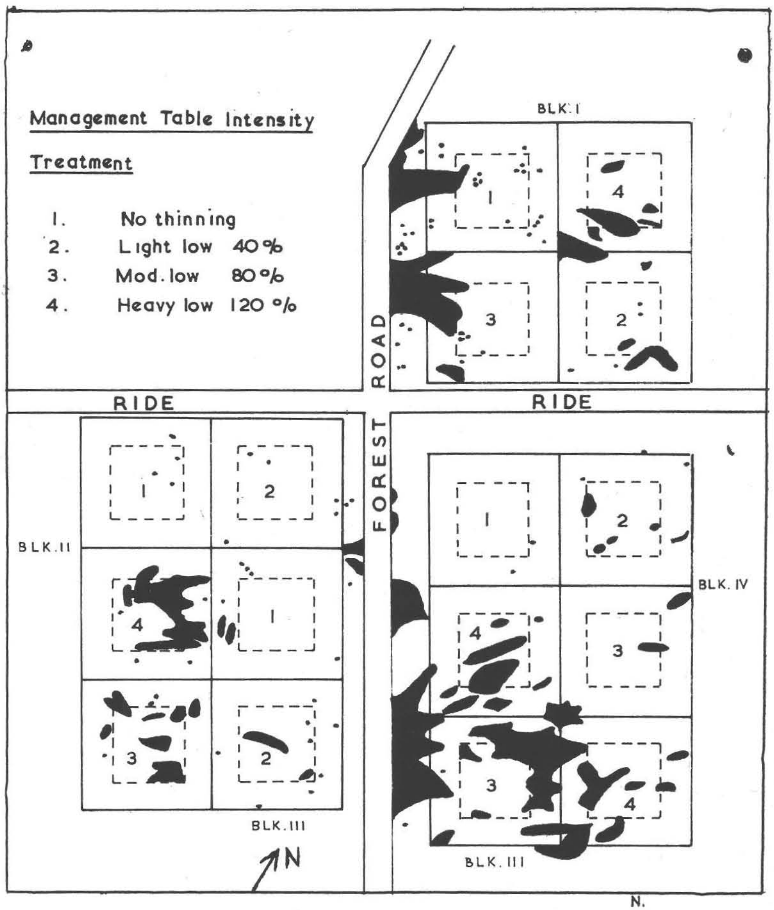

Figure 3: Kielder Expt 84/66. Pattern of Windblow at July 1973. (Plot size 1 acre = ·405 ha.)

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 ($1\frac{1}{2}$-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.

Windthrown in State Forests in the Republic of Ireland[1]

G. J. GALLAGHER[2]

Background

"A north west wind, along with the west wind to its south prevails here, and is more frequent and violent than any other. It bends (in the opposite direction) almost all trees in the west that are placed in an elevated position, or uproots them." This is not the acquisition report on a new planting site, but the comment of a visitor to Ireland, the Welsh monk Geraldis Cambrensis, who toured Wicklow in 1183 (O'Meara 1951).

That Ireland should have an endemic windthrow problem is hardly surprising, situated as the country is on the edge of Europe in the paths of the Atlantic depressions. Indeed in a review of storms throughout Irish history (Dixon 1959), wind and its effects can be traced back, in the annals of Clonmacnoise, to 1029 B.C. Storms and tempests have been mentioned regularly since A.D. 563, according to the Annals of Ulster. Here, the first mention of windthrow refers to A.D. 856 when "very great winds blew down woods and laid waste the islands in the lakes". Destructive storms have been recorded since then, numbering up to 15 in a century—and averaging about 7 per century. It is also interesting to note that exceptionally severe storms have occurred around the beginning of each century since 1608, when "a great tempest causing shipwreck occurred in Dublin". The greatest of the British "big winds" occurred in 1703, while "appalling disasters" occurred on the 19th of November 1807. This was followed by severe storms in 1815 and the "night of the big wind" in 1837, which caused damage to the extent of £64,000 in Dublin. The second greatest storm in recent historical times was in 1903 when 3,000 trees were uprooted in Phoenix Park. In fact damage to woods and plantations was widespread (Anon 1903). Windthrow was noted at Dromconrath, Ballybrack, Waterford, Kilkenny (thousands of trees), Killaloe, Nenagh (hundreds of thousands of trees) and Rockingham. The frequency of these storms seems to fit a pattern of exceptionally severe winds every century, being severe every 35 years or so—with bad storms also occurring at intervals of 11 to 15 years (Dixon 1959, 1974).

Storm damage in State forests

Though storm damage has occurred extensively in private wood-

1. Paper delivered at Wind Risk Symposium, Pomeroy, Co. Tyrone, 1st–3rd May 1974.
2. Research Branch, Forest and Wildlife Service, Dublin.

lands throughout the years, this paper will deal primarily with State forests because more detailed information is available. State forestry commenced in Ireland in 1903. The incidence of storm damage has been recorded in Departmental annual reports and files since 1915. Significant damage is reported for years ending March 1916, '36, '38, '40, '43 and '44. (Table 1.) While the magnitude of the damage must be related to the area under trees, it is probable that the storms of 1935–'36 caused relatively severe damage considering that the area of productive State woodlands was only 4,000 ha.

TABLE 1
Records of Early Windthrows

Year ending March	Extract from Report
1916	Some timber blown by severe storm.
1930	Windfalls in Douglas fir.
1931	Windfalls in Douglas fir
1936	Whole plantation of Larch and Douglas fir suffered. Thousands of trees were blown. Winds and snow occurred on 9th–10th January 1936.
1938	Serious storm damage in recently thinned conifers at Dundrum.
1939	Some losses in October.
1940	Many trees uprooted on centre and north midlands.
1943	Kenmare and Killarney suffered. Large trees in Kilrush were felled in December.
1944	Windfalls in Northern District whose plantation had been recently thinned.

Table 2 gives more detailed information on storms occurring since 1944. Here we see the pattern of damage to plantations beginning to emerge—with severe storms in 1945/6, 1954/5, 1951/2, 1957/8 and 1961/2—culminating with the windthrows of January this year.

Estimations of numbers of stems blown, irrespective of size, and the volume they comprised, are given in Table 2.

They show windthrow occurrences over 30 years—during which

TABLE 2

Storms causing damage in State forests between 1944–1974

Year ending March	Month	Forests reporting damage	Trees blown (1000's)
1945	January	33	8.0
1946	September	31	5.0
1948	April	6	3.0
1949	—	—	1.0
1950	—	22	5.9
1951	September	35	3.4
1952	December	81	113.0
1953	—	2	—
1954	—	—	—
1955*	May–December	2	126.5
1956	—	4	4.7
1957*	January–February	144	281.5
1958	January	21	3.5
1959	November	19	1.5
1960	—	26	40.5
1961	December–January	34	25.1
1962*	September	140	213.0
1963	November–January	32	65.5
1964	February–March	11	58.0
1965	December–January	11	32.7
1966	October–February	13	37.7
1967	December–February	6	19.6
1968	December–February	2	2.7
1969	October–January	—	4.3
1970	October–January	—	2.3
1971	August	68	2.6
1972	February	39	3.0
1973	December	65	21.0
1974*	January	150	not est.

*Storms causing greatest damage to forests.

time the size of productive State forest area has increased from 55,000 ha to almost 250,000 ha.

Weather

Table 3 gives a very condensed outline of weather conditions over the last 17 years. (Meteorological Service 1954–'72.) It can be seen that during the two most severe storms, 1st January 1957 and 16th September 1961, maximum speeds during highest gusts were over

90 knots in parts of the country, while gusting was over 70 knots over all stations, with mean speeds during gusts averaging 50 knots. The table also shows that individual gusts of over 60 knots occur throughout the country each year. Most gales come from west and south-west.

TABLE 3

Maximum Gust and Windspeed during Gust for all Meteorological Stations (knots)

	Highest			Mean for all stations	
Year ending December	Date	Speed of highest gust	Mean windspeed during highest gust	Speed of highest gust	Mean windspeed during highest gust
1950	16/9	72	47	61	39
1951	27/12	82	51	66	42
1952	28/10	68	40	58	37
1953	19/4	69	35	56	34
1954*	15/1	83	40	65	40
1955	28/12	69	44	61	37
1956	29/2	81	40	65	40
1957*	1/1	94	66	77	50
1958	8/1	86	52	63	39
1959	13/11	85	53	73	44
1960	26/12	76	29	66	40
1961*	16/9	98	66	85	52
1962	15/12	80	54	71	41
1963	20/1	75	53	63	38
1964	7/12	75	51	64	40
1965	13/1	88	60	73	44
1966	25/2	87	58	72	44
1967	27/1	78	58	66	36
1968	14/1	91	60	72	43
1969	21/10	71	46	60	34
1970	3/11	71	44	62	38
1971	9/1	76	45	59	32
1972	3/3	81	56	65	41

*Storms causing greatest damage to forests.

The picture then is one of frequent and often extremely severe gales of an intensity likely, according to recent studies, to cause some damage each year.

The 1974 Storms

The details of the storms of January 1974 should be familiar by now. Gale gusts occurred on at least 20 days during the month, while severe storms occurred on the 10th–12th, 15th–16th, 27th–28th. These had gusts over 70 knots. The highest gusts were recorded at Cork on the 12th (94 knots) and at Claremorris on the 27th (97 knots). Rainfall was above normal, 220% above normal in parts of the southern half of the country (Meteorological Service 1974).

TABLE 4
Windblow volume expressed—as ratio m^3 blown per ha of State forests 21 years and over

Forest Year	Volume blown m^3 (1000)	Area 21 years and over (1000)	Ratio
1947/48	1.24	9.4	.13
1948/49	0.30	10.8	.03
1949/50	1.80	12.2	.15
1950/51	1.06	13.4	.08
1951/52	4.23	14.9	.28
1952/53	0.31	16.4	.02
1953/54	—	17.8	—
1954/55	40.87	19.5	2.09
1955/56	0.17	21.7	.01
1956/57	108.00	24.5	4.40
1957/58	1.10	27.5	.04
1958/59	0.47	30.5	.02
1959/60	12.68	32.6	.39
1960/61	7.87	33.3	.24
1961/62	84.86	34.8	2.44
1962/63	6.10	35.3	.17
1963/64	5.34	45.6	.15
1964/65	6.97	36.4	.19
1965/66	4.26	37.0	.12
1966/67	4.33	37.9	.12
1967/68	0.53	39.0	.04
1968/69	0.56	40.8	.01
1969/70	2.23	49.4	.45
1970/71	0.69	58.6	.01
1971/72	1.42	68.1	.02
1972/73	3.04	77.3	.04
1973/74	277.00	85.3	3.25
Total 27	574.58	920.0	14.76
Mean	21.28	34.1	.62

The preliminary data can be compared with a very different type of storm, the Debbie windthrow of September 1961 in which gusts

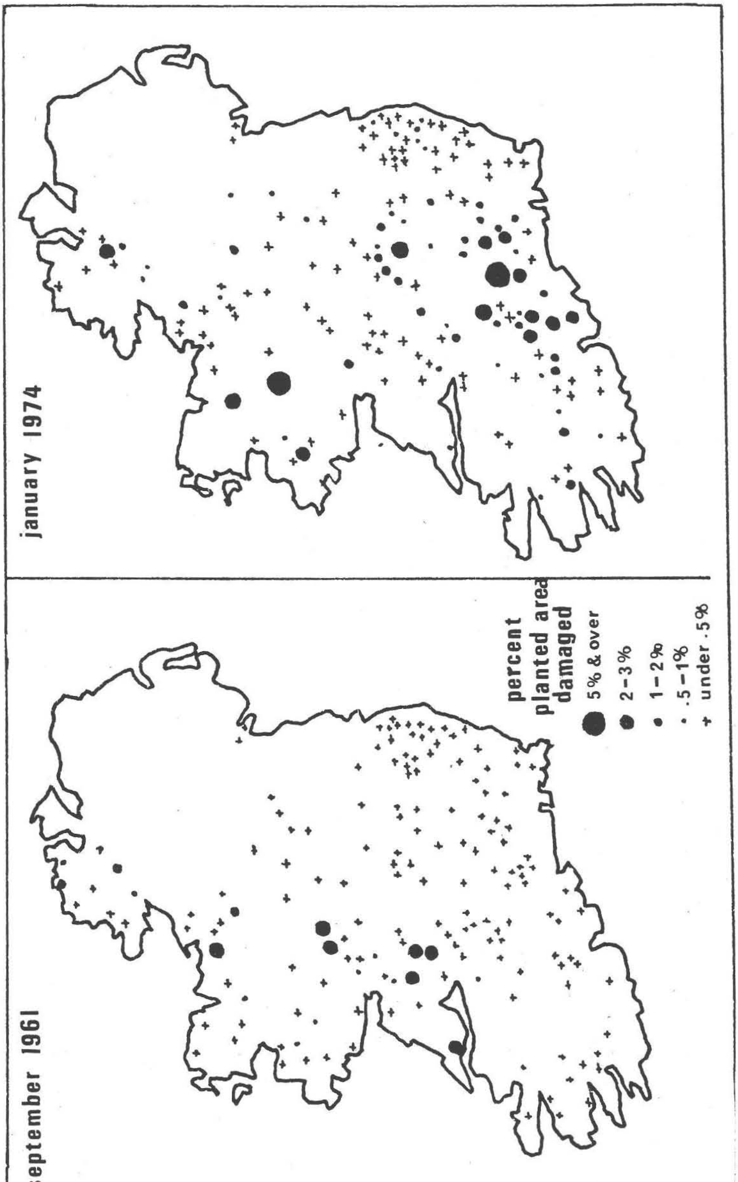

Figure 1: A comparison of area damaged in State forests in the Republic of Ireland in the storms of 1961 and 1974.

exceeded 90 knots over a wide area in western Ireland and over 70 knots over most of the island (Cruikshank, Stephens and Seymore 1962). Figure 1 shows the percentage, by area, of State plantations thrown. Forests damaged to the extent of 2–5% numbered 6 in 1961 and 10 in 1974. Those damaged to the extent of 1–2% were 3 in 1961 and 20 in 1974. Volume thrown in relation to total area—and to productive area was greater in 1974 (see Table 4). Damage was reported from some 140 forests in Forest year ending March 1962 and from over 150 in 1974. However as Table 5 shows, the ratio of volume thrown to area of forests over 21 years is not dramatically greater in the 1974 storms.

TABLE 5
Experimental and Permanent sample plots damaged
Thinning/Damage Category

	No Thin			Lt. to Mod.			Heavy			Mech.			Crown		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Contorta pine	2	3	3	5	6	9	–	4	14	1	5	12	–	–	–
Sitka spruce	25	–	–	25	–	1	6	3	8	40	9	6	6	–	1
TOTAL	27	3	3	30	6	10	6	7	22	41	14	18	6	–	1

0 = Little or no damage
1 = Moderately heavily damaged
2 = Severely damaged

Expectedly, Sitka spruce (*Picea sitchensis*) and contorta pine (*Pinus contorta*) which now comprise 80% of the planting programme in the Republic, constituted the major species thrown in both storms.

As Figure 1 shows, damage was most severe in the south and south midlands as a result of the early January storms. Some individual forests suffered badly in the west and north-west from the storm on the 27th–28th January.

Breakage occurred in a number of centres, mainly in the older crops on dry soils. This was approximated at 15% of total numbers of trees.

Causal Factors

Research into causal factors has been carried out in Britain and Germany. Such aspects as mean wind speed during gusts and associated climatic factors (Gloyne 1968), topography factors such as oblique and middle windward slopes (Hütte 1968), susceptibility of species (Fraser and Gardiner 1967) and thinning (Neustein 1971) have been investigated.

Factors contributing to windthrow in the Republic

(1) *Climatic*

The historical detail given earlier demonstrates that our climatic conditions will result in extensive periodic windthrow—with severe gales at 10–15 year intervals, sometimes more frequently. The occurrence of annual gales at various locations suggests that some windthrow will occur each year.

(2) *Site*

The elevation, topography and soils, on which forests in the Republic are situated, mean that some of these must be pre-disposed to windthrow.

21% of the soils of the Republic are classified as mountain and hill, of which 5% are peaty gley and 3% peat. The 29% classified as wet lowland, include 8% Drumlin gleys and 10% of other gley soils, 7% climatic peats, and 3% basin peats (Gardiner and Ryan 1969). The forest area on peat is estimated at 101,000 ha (Carey 1973), 20,000 ha on high level peats, 20,000 ha on basin peats and the rest on climatic peat. An estimate of forest areas on peaty gleys and gleys shows approximately 10,700 ha on peaty gley, 7,000 ha on Drumlins, and 5,000 ha on other gleys. This amounts to a total of 123,700 ha on wet soils. As peat plantations are yet rather an unknown quantity as far as windthrow is concerned (Fraser 1965), forests, therefore, on soils definitely susceptible, amount to a little under 10% of the total productive area in State forests.

Other site factors to be considered are topography and elevation. 18% of the country lies between 244m and 360m, 21% of which is classified as mountain or hill. The many plantations at this elevation would lie on a variety of soils—podsols, peaty podsols, peaty gleys and peats. Again the most susceptible category here would be peaty gleys—about 10,700 ha or 5% of the national forest area. Valleys and rounded slopes are part of the environment of all our mountainous forests.

(3) *Silviculture*

Stress has been laid on thinning practices as factors contributing to windthrow. Thinning is, of course, general practice in State forests. Economic considerations, leading to the increased use of machinery, has meant the introduction of row thinning into many forests. "No thinning" regimes are the exception rather than the rule, and are usually related to very low productivity. The pressure for pulp and chipboard materials, and the need for fast growth has meant an increase in thinning intensity, and the "marginal" intensity proposed in forest management tables (Hamilton and Christie 1971) is now generally applied.

Virtually all plantations established since the early 1950s, over 200,000 ha, are on ploughed ground, another factor likely to contribute to instability.

Evidence of Contributing Factors

(1) *Climate*

Tables 2 and 3 indicate very generally that greatest damage in State forests was associated with individual gusts over 80 knots and mean of gusts in all stations over 65 knots showing average speed during gusts of over 50 knots. High gusting up to 60 knots for all stations occurs virtually every year.

(2) *Site*

By far the greatest damage is done during catastrophic storms and windthrow is greatest in the locality of the storm irrespective of site. For example, in the January 1974 storm windthrow occurred on old red sandstone soils in the south, and on peaty podsols and shallow brown earths in the midlands. Damage occurred throughout a variety of topographical conditions.

(3) *Silviculture*

(a) *Species*
Sitka spruce and contorta pine constitute the major species to be thrown, followed by Douglas fir and other conifers. These proportions are probably related to proportion of the species in plantation.

(b) *Ploughing*
There are many instances of young plantations planted on ploughed ground being thrown—but the contribution of ploughing to windthrow cannot be specifically isolated.

(c) *Drainage*
Drainage in thicket plantations is not practised in the Republic so again no conclusions can be drawn as to its effects.

(d) *Spacing and Thinning*

Most plantations in the Republic were established at 1.6m–1.8m spacing.

Windthrows have been reported over the years from row thinned, selectively thinned and in a few cases unthinned plantations. Sample plots and thinning experiments have been damaged in the recent throw, and Table 5 gives a summa'y of damage done in various thinning treatments in two species. Here, it certainly seems as if unthinned plots get off lightly and heavily thinned contorta suffers. Also, however, a surprising number of row thinned plots in Sitka spruce have escaped serious damage.

Management Problems

The problems posed by extensive windthrow in management and marketing in State forests in the Republic can be outlined again, by reference to the January 1974 windthrow. In this context, the lessons learned from the 1961 and Scottish have been useful (Holtam 1971).

A committee was formed shortly after reports on the extent of damage caused on the 12th and 27th January. Its aims were to co-ordinate efforts in dealing with mensuration and extraction, and to review progress with clearing, without interfering in the normal chain of management command. Divisional officers were instructed to return estimates of thrown material as rapidly as possible. Initial returns indicated that the volume was between 200,000–300,000m^3. It became apparent that though extensive, the volume of thrown material would not greatly exceed the normal annual cut. Mature crops, however, constituted a large portion of the volume—this volume could be included within a two year normal clear fell.

The problem was mainly one of measurement and disposal. A questionnaire was issued to yield information on volume of sawlog and pulpwood material and extent of species, area and breakage. Information for sales purposes was also compiled—whether lots had been measured for sale, or sold. Extraction problems were also dealt with. An advisory group was set up to advise on measurement, and to provide help in the field if required.[1]

A study on factors contributing to the windthrow was initiated. The preliminary findings of the Committee put the damage into perspective. These were:

(1) In area, approximately 1,200 ha were thrown.

1. Forest and Wildlife Service. Unpublished information.

(2) Volume was estimated at at least 150,000m³ sawlog and 130,000m³ pulpwood.
(3) Breakage affected 15% of stems reducing useable wood content in these stems by 20%.
(4) The storms did not cause severe extraction problems.
(5) Though big by Irish standards the windthrow was not as fxtensive as those in Scotland or Germany in recent years. These have been estimated as 15,000,000m³ and 250,000,000m³ respectively (Holtam 1971, Hütte 1968).

Forecasting Windthrow

It has been shown that in the short-term windthrow has been, and will be a fairly unpredictable event. Management and silvicultural techniques will be unlikely to ensure against damage by catastrophic storms.

Over a long term it can be seen (in Table 4) that windthrow expressed as a ratio of volume per unit area of productive forest 22 years and over (O'Murgheasa 1964, O'Flanagan 1973) fluctuates as a result of severe storms. The ratio averages 0.62. Using this ratio an estimate could be made, as in Table 6, to cover 10 year periods or longer. While predictions within any given year would be unreliable they would serve as a guide for forecasting purposes and for early felling after a period free from storms.

TABLE 6

An Estimate of Windthrow for 1974–'84 in State Forests

Year ending March	Estimated area 21 and over (1000 ha.)	Volume blown (1000m³)
1975	93.0	57.6
1976	101.0	62.6
1977	109.0	67.6
1978	117.0	72.5
1979	125.0	77.5
1980	133.0	82.5
1981	141.0	87.4
1982	149.0	92.4
1983	157.0	97.3
1984	165.0	103.2
TOTAL		800.6

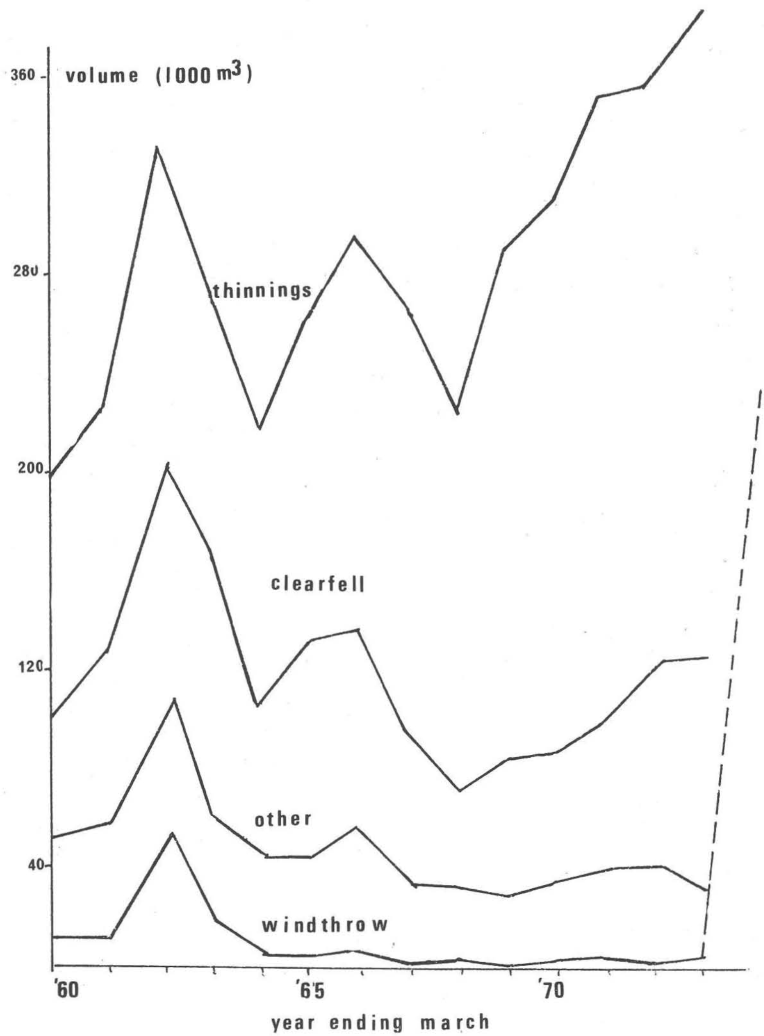

Figure 2: Volume (m³) of blown material cleared each year in relation to total production (including cleanfell, thinnings and other fellings) iince 1960.

The release of thrown material over a number of years in relation to total production can also be seen on figure 2. In past years this has been a minor part of total production but the 1974 windthrow shows a rather different situation. Here thrown material will constitute the major proportion of total production forecasted at .34 million m³ (O'Flanagan 1973) for 1974/'75.

Inferences and Conclusion

Our climate ensures that foresters must live with windthrow—and that it will be periodically extensive. In the short term this will be unpredictable. Investigations of storm periodicity may, however, help the forest manager to regulate felling, especially towards the end of periods of relative quiet. Soil and site conditions will predispose some 10% of our plantations to damage—perhaps much more if large areas of wet mineral soils are afforested. Though there is little room to extend species selection, consideration must be given as to how our conifer forests will be managed silviculturally—for example—the necessity of ploughing, spacing at establishment, thinning or no thinning and what rotation length to adopt. Records of new and continuing damage in these areas will be important. There also seems a need for soil/site mapping in individual forests. There is an obvious need to study the stability of peat plantations and to assess the relative stability of Sitka spruce and contorta pine.

It seems unlikely that damage from catastrophic storms can be greatly reduced by silvicultural techniques, though again some damage may be ameliorated by judicious management. However management must be considered with reference to demand and price for material as well as in the context of risks involved.

Up to now, the measurement and disposal of thrown material has not posed very serious problems, certainly not of the magnitude as in some other western European countries. In view of the extremely stormy conditions in January 1974 this is somewhat encouraging. Good communications between forest managers, marketers and merchants, and rapid feed-back of information from the forest greatly facilitate disposal.

The extent to which technology can deal with windthrow, by means of new and rapid methods of harvesting and processing, should not be underestimated.

Various institutions are involved in the study of wind and its influence. There is ample room for the exchange of ideas and facilities, to increase information on patterns of recurrence and biological and physical effects, without much replication. New techniques in computing will allow better analyses of the many interacting variables and provide management alternatives taking risk and economic factors into account. These studies require data which can be supplied through maintenance of adequate records and research.

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Research Note

The Hybridisation of Red Deer and Sika Deer in Northern Ireland

RORY HARRINGTON[1]

THE existence of extensive hybridisation between the exotic species, sika deer (*Cervus nippon* (Tamminck)) and the native species, red deer (*Cervus elaphus* (L)) is now an established phenonomen (Harrington, 1973).

Although red × sika hybrid deer were observed in 1896 at Colebrooke, Co. Fermanagh (Brooke, 1898), there has been until now no further information on the occurrance of hybrid deer there. On 6th February 1974 I observed a number of deer at Colebrooke (Grid Ref. H40 44) and concluded that two of them (one hind and her calf) were hybrids. This conclusion has recently been confirmed by the shooting of one red × sika hind at Colebrooke (Mr. C. S. Kilpatrick ahd Mr. J. A. W. Whiteside, pers. comm.). Observations of other hybrid deer have also been made recently at Killeter forest (Grid Ref. H08 82) Co. Tyrone (Mr. J. A. W. Whiteside, pers. comm.).

Conditions for hybridisation between sika deer and red deer are ideal in Northern Ireland: The present range of the red deer originating from the Co. Donegal population is now extensive as it stretches from the northern part of that county to southern Co. Fermanagh. At both Killeter and Colebrooke red deer and sika deer have been living together in recent years. It is also very likely that the sika deer of Northern Ireland are of a stock which was contaminated by red deer genes before their introduction to the area.

Just as the Co. Wicklow region has lost its red deer through incipient hybridisation with sika deer it would now seem that the red deer of North-western Ireland are likely to be lost in a similar way!

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Trees, Woods and Literature—11

And when the blood spouts and the brain matter splashes over him, he grinds his teeth and laughs. Like a hunted animal he flies to the woods while his henchmen wash the floor and prudently make away with the corpse and clothing.

He wanders in the forests that surround Tiffauges, dark, dense, deep forests such as Brittany still boasts at Carnoet.

He sobs as he goes, drives off in desperation the spectres that assail him, looks about him and of a sudden sees the obscenity of the ancient trees.

It seems Nature is turning evil before his eyes, and that it is his *presence causes her depravity; for the first time he comprehends the unchangeable salacity of the woods, spies out the images of lubricity in the great trees.*

Here the tree appears to him a living being, standing upside down, its head buried in the tangled tresses of the roots, lifting its legs in the air and spreading them apart, then dividing again into other thighs that stand open in their turn, getting slenderer and slenderer the further they extend from the trunk; there, between those limbs another branch is embedded in a motionless fornication, repeated of a smaller and smaller size from bough to bough to the top; there again, the stock seems a phallus that rises and disappears in a petticoat of leaves or else in the opposite sense issues from a fleece of green and dives into the velvety belly of the soil.

Visions terrify him. He sees again the tender skins of young boys, skins with the white sheen of parchment, in the pale smooth bark of the tall beeches; he finds again the leathery hides of his mendicants in the blackened, rugged envelope of the old oaks; then, where the branches fork, holes gape, orifices where the bark cushions on bowelled entrails, puckered apertures that mimic foul emunctories or yawning organs of animals. Then again, at the elbows of branches, are other visions, hollows underneath arms, pits fringed with grey lichen, there are in the very trunk wounds that open in great lips under tufts of russet velvet and bunches of moss!

Everywhere the obscene shapes spring from the earth and mount to corrupt the heavens; the clouds swell in bosoms, part in the cleavage of buttocks, reveal the rotundity of pregnant bellies, disperse in long-drawn trails of milt; they repeat the sombre luxuriance of the high woods, where nought is to be seen now but visions of thighs, gigantic or dwarfed, festering wounds and dank discharges! And this landscape of abomination undergoes a change. Now Gilles beholds on the tree-trunks terrifying excrescences and dreadful wens. He notes tumours and ulcers, excoriated sores, cancerous tubercles and hideous blotches *of rottenness; it is a pest-house of the earth, a venereal clinic of the trees, wherein rises at the turn of a forest-ride a blood-red beech.*

And in these empurpled leaves that fall about him he seems to see a rain of blood drenching him; he falls into a hallucination, dreaming that beneath the bark dwells a woodland nymph and he would fain tear the flesh of the goddess, slaughter the Dryad and violate her at a place never attempted by the lubricity of madmen!

He envies the woodcutter who, can hack and massacre the tree; he bellows in a frenzy, and listens in haggard suspense to the forest that answers his cries of longing with the strident howlings of the winds; he sinks exhausted, weeps and resumes his march till, worn out with fatigue, he reaches the castle and drops on his bed an inert mass.

From *Down There* (*La-Bas*) by J.-K. Huysmans. An anonymous translation published in an undated limited edition by The Fortune Press, London. It has not been possible to trace the copyright holders.

Joris-Karl Huysmans was born in Paris in 1848 of French/Dutch parents. In 1866 he entered the French Ministry of the Interior where he remained for thirty-two years, making liberal use of official time and stationery in the writing of novels. He then spent two years as a lay monk in a Benedictine abbey and finally died of cancer in 1907.

In the early part of his career he was regarded as a promising novelist in the line of Zola and Flaubert, but his novels are now mainly of value in charting the history of spiritual movements in France. His best-known novel *A Rebours* (*Against Nature*) (1884) has been described as "the breviary of the Decadence". *La-Bas* (1891) intertwines an account of a group of Parisians interested in satanism with the story of Gilles de Rais. The latter was born in 1404 and, a wealthy young marshal of France, joined with the army of Joan of Arc before the relief of Orleans. After her capture he dissipated his wealth and person in alchemy, necromancy, torture and ritual murder. He may have killed up to 200 children. After a brawl during Mass he was investigated by the bishop, arrested for heresy and hanged for murder in 1440.

The passage from *La-Bas* is freely recommended to those who may wish to launch a counter-attack against the "anti-conifer" lobby.

Notes and News

A NEW RECRUIT

WE have succeeded in recruiting a new contributor, **Wood Kerne,** to edit these Notes.

In making the appointment we tried to impress on him the need to have all his copy with the printer in good time and his reply was incoherent. We pointed out the difficulties of the Business Editor in keeping up the level of advertising and his comment was unprintable. When we went on to detail the concern of our advertisers with regular and prompt publication schedules he launched forth on a tirade concerning the obligation of those who profit from forestry to support loyally the only forestry journal in the country, but before he had finished so great was the anger developed that the liquid in his glass went on fire.

CONTRASTS

"I want to emphasise that if you want to change forestry from a 2% to 3% business you must be prepared to make the investment. There must be a sense of urgency to our business. We cannot afford idle acres or stands growing at less than their potential. Again, time is money. We must manage the forest—not allow the forest to manage us."

(H. E. Morgan. Senior Vice-President, Weyerhaeuser-Company, U.S.A. in a lecture entitled *High yield forestry—the philosophy and the technology,* given at a congress held in connection with the International Exposition of Technology of Forestry and Forest Industries, Munich, 1970.)

* * *

"All you want to set up in business as a forester is a spade." (*Planting for Profit,* issued by Trees for Ireland Committee, 3rd edition, 1974.)

EVELYN'S SYLVA (see over)

Through the courtesy of its owner, the President of the Society, we have been able to reproduce the title-page of a first edition of the famous *Sylva* of John Evelyn, and to copy some passages from it.

This book, one of the first English text-books of forestry and the

SYLVA,

Or A DISCOURSE OF

FOREST-TREES,

AND THE

Propagation of Timber

In His MAJESTIES Dominions.

By *J. E.* Esq;

As it was Deliver'd in the *ROYAL SOCIETY* the xv^th of *October*, CIↃIↃCLXII. upon Occasion of certain *Quæries* Propounded to that *Illustrious Assembly*, by the *Honorable* the Principal *Officers*, and *Commissioners* of the *Navy*.

To which is annexed

POMONA· Or, An *Appendix* concerning *Fruit-Trees* in relation to *CIDER*; The *Making* and several ways of *Ordering* it.

Published by express Order *of the* ROYAL SOCIETY.

ALSO

KALENDARIUM HORTENSE; Or, *Gard'ners Almanac*; Directing *what* he is to do *Monethly* throughout the *Year*.

——Tibi res antiquæ laudis & artis
Ingredior, tantos ausus recludere fonteis. Virg.

Thomas Wentworth
Coll: Divi Joh: Cant. 1710
Ex dono Patris.

LONDON, Printed by *Jo. Martyn*, and *Ja. Allestry*, Printers to the *Royal Society*, and are to be sold at their Shop at the *Bell* in *S. Paul's* Church-yard, MDCLXIV.

most influential for about two centuries, was initiated by queries in 1662 from the commissioners of the navy who had become alarmed by the depletion of standing timber. A lecture to the Royal Society was the result, and that was expanded into the book which was first published in 1664 and had run into ten editions by 1825.

John Evelyn (1620-1706) is best known as a diarist.

The present volume is 30 cm × 19 cm, and bears indications of much of its own history. It started life as a present, judging by the inscription (the quill seems to have been of poor quality) on the fly-leaf: "Joseph Liversage this is his booke given him by his Lady. My Lady Arabella (Macartie?). At Farnham greene March 26th 1667." Joseph apparently had it bound, for the spine bears the date 1669.

It was later owned by Thomas Wentworth, a gift from his father while at Cambridge in 1710. He had his initials and date "T W 1711" stamped on the front cover. The bookplate (opposite) is printed directly onto the title-page from an engraved plate.

Another bookplate, stuck on the inside front cover, without a date, is that of William Charles De Meuron, Earl Fitzwilliam. Wentworth was a family name of the Earls Fitzwilliam.

* * *

In his introduction Evelyn writes:

"For it has not been the late increase of shipping alone, the multiplication of glass-works, Iron-Furnaces, and the like, from whence this im-politick diminution of our Timber has proceeded; but from the disproportionate spreading of Tillage, caused through that prodigious havock made by such as lately professing themselves against Root and Branch (either to be re-imboursed of their holy purchases, or for from some other sordid respect) were tempted, not only to fell and cut down, but utterly to grub up, demolish, and raze, as it were, all those many goodly Woods, and Forests, which our more prudent Ancestors left standing, for the Ornament, and Service of their Country."

In these extracts some of the flavour of the original is lost through the absence of the long s's and of the constant italicisation of nouns, which would distract a modern reader.

* * *

Chap. XXI

Of the Fir, Pine, Pinaster, Pitch-tree, &c.

2. There are of the fir two principal species; the Male which is the bigger Tree, and of a harder wood; the Female, which is much the softer, and whiter. They may be sown in beds, or cases, at any time

during March; and when they peep, carefully defended with Furzes,[1] or the like fence from the rapacious Birds, which are very apt to pull them up, by taking hold of that little infecund part of the seed which they commonly bear upon their tops: The beds wherein you sow them had need be shelter'd from the Southern aspects with some skreen of reed, or thick hedge: Sow them in shallow rills, not above half-inch-deep, and cover them with fine light mould: Being risen a finger in height, establish their weak stalks, by siefting some more earth about them; especially the Pines, which being more top-heavy are more apt to swag. When they are of two, or three years growth, may may transplant them where you please; and when they have gotten good root they will make prodigious shoots; but not for the three or four first years comparatively.

3. The Pine is likewise of both Sexes, whereof the Male growing lower, hath its wood more knotty and rude than the Female. They would be gathered in June before they gape, and cultivated like the Fir in most respects; only, you may bury the Hulls a little deeper. By a friend of mine they were rolled in a fine compost made of Sheeps-dung, and scattered in February, and this way never failed; Fir and Pine; they came to be above Inch high by May: this were an expeditious process for great Plantations: unless you would rather set the Pine as they do Pease; but at wider distances, that when there is occasion of removal, they might be taken up with earth and all; because they are (of all other Trees) the most obnoxious to miscarry without this caution; and therefore it were much better (where the Nuts might be commodiously set, and defended) never to remove them at all, it gives this tree so considerable a check.

7. The domestic Pine grows very well with us; but the Pinaster or wilder best for Walks, because it grows tall, and proud, maintaining their branches at the sides, which the Pine does less frequently.

8. The Fir grows tallest being planted reasonable close together; but suffers nothing to thrive under them. The Pine not so Inhospitable; for (by Plinies good leave) it may be sown with any Tree, all things growing well under its shade, and excellent in Woods, hence Claudian,

Et comitem quercum Pinus amica trahit.[2]

9. They both affect the cold, high and rockie grounds; yet will grow in better; but not in over rich, and pinguid. The worst land in Wales bears (I am told) large Pines; and the Fir according to his aspiring nature, loves also the Mountain more than the Valley;

1. It is interesting to observe the use of the name *furze*, still in common use in Ireland, but replaced in England and elsewhere by Gorse.—*Editor*.
2. And the friendly pine draws up its companion oak.

though they will also descend, and succeed very well in either; being desirous of plentiful waterings till they arrive to some competent stature; and therefore they do not prosper so well in an over sandy, and hungry soil or gravel, as in the very entrails of the Rocks, which afford more drink to the Roots, that penetrate into their meanders, and winding recesses. But though they require this refreshing at first; yet do they perfectly abhor all stercoration; nor will they much endure to have the earth open'd about their roots for Ablaqueation, or to be disturb'd. This is also to be understood of Cypress. A Fir for the first half dozen years seems to stand, or at least make no considerable advance; but it is when throughly rooted, that it comes away miraculously. That Honourable Knight Sir Norton Knatchbull (whose delicious Plantation of Pines, and Firs I beheld with great satisfaction) having assur'd me that a Fir-tree of his raising, did shoot no less than 60 foot in height in little more than twenty years, is a pregnant instance, as of the speedy growing of that material; so of all the encouragement I have already given for the more frequent cultivating this ornamental, useful and profitable Tree.

10. The Picea is another sort of Pine, and to be cultivated like it

——Piceae tantum, taxique nocentes
Interdum, aut ederae pandunt Vestigia nigrae.[3]
Georg. 2.

to show in what unprofitable soils they grow; And therefore I am not satisfied why it might not prosper in some tolerable degree in England, as well as in Germany, Russia, the colder Tracts, and abundantly in France: It grows on the Alpes among the Pine; but neither so tall nor so upright.

11. There is also the Piceaster, out of which the greatest store of Pitch is boyl'd. The Teda likewise, which is a sort more unctuous, and more patient of the warmer scituations.

12. The Bodies of these being cut, or burnt down to the ground, will emit frequent suckers from the Roots; but so will neither the Pine nor Fir.

13. That all these, especially the Fir, and Pine, will prosper well with us is more than probable, because it is a kind of Demonstration that they did heretofore grow plentifully in Cumberland, Cheshire, Stafford, and Lancashire, where multitudes of them are to this day found intire, buried under the Earth, though supposed to have been o'rethrown and cover'd so ever since the universal Deluge: For we will not here trouble our Planter with M. Cambden's Quaerie,

3. Only pitch trees, and sometimes noxious yews, or black ivy announce traces of it.

Whether there be not subterraneous Trees growing under the ground? though something to be touched anon might seem to excuse the presumption of it; besides that divers Earths, as well as Waters, have evidently a quality of petrifying wood buried therein.

* * *

CHAP. XXVI

Of the Infirmities of Trees

THe Diseases of Trees are various, affecting the several parts: These invade the Roots; Weeds, Suckers, Fern, Wet, Mice, and Moles.

1. Weeds are to be diligently pull'd up by hand after Rain, whiles your seedlings are very young, and till they come to be able to kill them with shade and over-dripping: And then are you for the obstinate to use the Haw, Fork, and Spade, to extirpate Dog-grass, Bear-bind, &c.

2. Suckers shall be duly eradicated, and with a sharp spade dexterously seperated from the Mother-roots and Transplanted in convenient places for propagation, as the Season requires.

3. Fern is best destroy'd by striking off the tops, as Tarquin did the heads of the Poppies: This done with a good wand or cudgel, at the decrease in the Spring, and now and then in Summer, kills it in a year or two beyond mowing, or burning, which rather encreases than diminishes it.

4. Over-much wet is to be drained by Trenches, where it infests the Roots of such kind as required drier ground: But if a drip do fret into the body of a Tree by the head, (which will certainly decay it) cutting first the place smooth, stop and cover it with loam and hay till a new bark succeed.

These infest the Bark; Bark-bound, Teredo, or Worm, Conys, Moss, Ivy, &c.

5. The Bark-bound are to be released by drawing your knife rind-deep from the Root, as far as you can conveniently; and if the gaping be much, filling the rift with a little Cow-dung; do this on each side, and at Spring, February or March; also cutting off some branches is profitable; especially such as are blasted or lightning-struck.

6. The Teredo, Cossi, and other worms, lying between the Body and the Bark, poyson that passage to the great prejudice of some Trees; but the holes being once found, they are to be taken out with a light Incision.

7. Conies and Hares, by barking the Trees in hard Winters spoil very many tender Plantations: Next to the utter destroying them

there is nothing better than to annoint that part which is within their reach with *stercus humanum*,[4] tempered with a little Water or Urine, and lightly brushed on; this renewed after every great Rain.

8. Moss is to be rubb'd and scrap'd off with some fit instrument of Wood, which may not excorticate the Tree, or with a piece of Hair-cloth after a sobbing Rain: But the most infallible Art of Emuscation is taking away the cause, which is superfluous moisture in clayey and spewing grounds.

9. Ivy is destroy'd by digging up the Roots, and loosning its hold: Missleto, and other excrescences to be cut and broken off.

10. The bodies of Trees are visited with Canker, Hollowness, Hornets, Earwigs, Snails, &c.

11. Cankers (caused by some stroak or galling) are to be cut out to the quick, the scars emplaistered with Tar mingled with Oil, and over that a thin spreading of loam; or else with clay and Hors-dung; or by laying Wood-ashes, Nettles, or Fern to the roots &c.

12. Hollowness is contracted when by reason of the ignorant or careless lopping of a Tree the wet is suffer'd to fall perpendicularly upon a part, especially the Head: In this case if there be sufficient sound wood cut it to the quick and close to the body, and cap the hollow part with a Tarpaulin, or fill it with good stiff loam and fine hay mingled. This is one of the worst Evils, and to which the Elm is most obnoxious.

13. Hornets and Wasps, &c. by breeding in the hollowness of Trees infest them, and are therefore to be destroy'd by stopping up their entrances with Tar and Goos-dung, or by conveying the fumes of brimstone into their Cells.

14. Earwigs and Snails do seldome infest Forest-trees, but those which are Fruit-bearers, and are destroy'd by enticing them into sweet waters, and by picking the Snails off betimes in the Morning, and rainy Evenings. Lastly,

Branches, Buds, and Leaves extreamly suffer from the Blasts, Jaundies, and Caterpillars, Rooks, &c.

15. The blasted parts of Trees are to be cut away to the quick; and to prevent it, smoak them in suspicious weather, by burning moist straw with the wind, or rather the dry and superfluous cuttings of Arromatick plants, such as Rosemary, Lavender, Juniper, Bays, &c.

Mice, Moles, and Pismires cause the Jaundies in Trees, known by the discolour of the Leaves and Buds.

The Moles may be taken in Traps, and kill'd as every Woodman

4. Excrement.

knows: It is certain that they are driven from their haunts by Garlick for a time, and other heady smells buried in their passages.

17. Mice with Traps, or by sinking some Vessel almost level with the surface of the ground, the Vessel half full of water, upon which let there be strew'd some huls or chaff of Oates; also with Bane.

18. Destroy Pismires with scalding water, and disturbing their hills.

19. Caterpillars, by cutting off their webs from the twigs before the end of February, and burning them; the sooner the better: If they be alredy hatched wash them off, or choak and dry them with smoak.

20. Rooks do in time by pinching off the Buds and tops of Trees for their Nests, cause many Trees and Groves to decay.

These (amongst many others) are the Infirmities to which Forest Trees are subject whilst they are standing; and when they are felled, to the Worm; especially if cut before the Sap be perfectly at rest.

DEFINITION

What is science but the absence of prejudice backed by the presence of money?

(Henry James: *The Golden Bowl,* 1905).

. . . AND IT STICKS

The following passage appeared in a review of a book on O'Sullivan Beare which was printed in the June 1974 issue of the English magazine *Books and Bookmen:*

"The author had been interested in the Georgian 'great houses' all along the way and at the end of his journey he came to the last of them, the once-gracious planned expanses of Rockingham, the home of the King-Harmons. Osbert Sitwell had considered it the best example of a Nash country house he had ever seen. It survives no longer. After an accidental fire in 1957 the owners handed it over to the Irish Forestry Department, who have gone to great lengths to finish what the fire began. The mansion, which was still nearly perfect after the fire, has been demolished, even its name has gone, and the wooden buildings of the forester's caravan park make an inadequate substitute for Nash's masterpiece. Remembering what happened to Coole Park, Lady Gregory's home, in the hands of the same department, one can share the author's disgust."

DEBATE

Mr. Gorey (*Deputy for Carlow-Kilkenny*): You would have to emigrate nearly all the people if you want to plant forests. . . . There are only a few timbers of any marketab'e value in this country. All the soft timbers are of value. I could give any Deputy 2,000 tons of hard timber at 10s. a ton. We cannot get a price for it at all. Nobody wants it, or enquires about it. I want to know which of the softwoods is the more suitable? We all know what softwood is.

Mr. Carney: The Deputy knows nothing about it.

Mr. Gorey: Can we grow white deal for roofing and flooring?

Mr. O'Reilly: Certainly.

Mr. Kilroy: Is larch not better?

Mr. Gorey: Nobody but an imbecile would suggest larch for flooring.

Mr. Kilroy: I believe I am safe in saying that there are upwards of 1,000,000 acres of mountain land not fit for tillage, that could be serviceably used by planting it with timber, particularly softwoods.

Mr. Gorey: I would like to know which of the timbers is most suitable for wood pulp?

Mr. T. Sheehy (*Deputy for Cork West*): I rise most heartily to support the forestry vote of the Minister for Agriculture. I commiserate with you, Minister for Agriculture! My advice to you is to be of good heart. You are building up the nation and its agriculture, and afforestation is a part of agriculture. It is one of the planks in that movement.

Mr. O'Reilly: I wonder does Deputy Gorey know the class of timber that is required for the construction of boats, for the ribs, knees and keels of boats.

Mr. Gorey: Or the handles of steel pens.

* * *

The foregoing is not an extract from a Myles na Gopaleen column, nor from the script of a Frank Hall show, but comes from a debate which took place in Dail Eireann on a supplementary forestry vote in 1929. (Reported in John Mackay's *Forestry in Ireland*, Cork, 1934.)

A FORESTRY (NOT TO SAY IRISH) JOKE

Paddy and Shamus were passing the offices of the Forestry Commission.

"What does that notice say?" asked Paddy.

"Tree fellers wanted."

"Ah. Well we'll come back again tomorrow, and we'll bring Mick."

Reviews

A SURVEY OF CUTOVER PEATS AND UNDERLYING MINERAL SOILS. Bord na Mona. Cnoc Dioluin Group.

Soil Survey Bulletin No. 30. T. A. Barry, M. L. Carey and R. F. Hammond. A Joint Publication of Bord na Mona and Foras Taluntais, Dublin, 1973, pp. 144.

As the general public becomes more conscious of its physical environment the old question of "what to do with it when we are finished with it" is being asked in ever widening and higher circles. The question has particular relevance to the areas of bog now being exploited by Bord na Mona (the Irish Peat Development Authority). Moss peat and fuel are at present being produced mechanically on about 52,000 ha. When one considers that this area is bigger than the present total forest area in Northern Ireland the importance of its future utilisation can be better appreciated. It is expected that the present area will be completely cutover within the next 30 years. Research and survey work have been in progress since 1963 to investigate the land use potential of such cutover areas.

The present Report describes the mineral soils and residual peat left after cutting operations of the Cnoc Dioluin Sod Peat Group. This group, which comprises four separate bogs with a total area of 1,579 ha, lies in the Shannon valley on the Roscommon-Longford border. Most of the peat is used to fire the power generating station at Lanesborough.

Preliminary drainage of the bogs began in the early 1940s and cutting began some 6-9 years later. By 1967, some 620 ha (39%) had been cutover.

As with much of the central plain of Ireland the parent rock materials belong to the Carboniferous period. They are predominantly limestone but with some areas of sandstone. Much of the area is overlain by glacial boulder till which is derived primarily from Carboniferous limestone. Chemical and physical characteristics of this drift material are recorded in an appendix to the Report.

Mineral soil development in the area is dependent partly on parent material and partly on the length of time over which the soil forming processes have been acting on it. In all, seven soil types are defined and described in some detail in the Report. The types range from the well-developed grey-brown podsolic soil occurring on the higher ground within the area (and which apparently have never been peat covered) to the shell marls and calcareous muds which were developed under lacustrine conditions and which, even after cutting operations, have between 1 and 2 m of fen peat overlying them. Apart from the upper horizons of the more developed soils the pH of the soils is generally high but the content of major plant nutrient is low.

The section dealing with the description of the peat remaining after cutting operations begins with a description (taken mainly from T. A. Barry's paper which appeared in Vol. 26 (2) of this journal in 1969) of the main peat types found in the raised bogs of the Central Plain. The typical effects of sod-peat removal on peat profiles in different topographical situations is then illustrated. What must be realised—and is well emphasised in the Report—is that only one peat type (the "older Sphagnum-Eriophorum peat") is normally used for the production of sod-peat. The "younger Sphagnum peat" originally on the bog surface is scraped off and deposited on top of the older, deeper layers which form the surface of the area of peat cutover during the previous operation. The future potential of the cutover peat will therefore be influenced by the depth and physical and chemical properties of (a) the upper stripped material (the redistributed peat), (b) the remaining undisturbed peat, and (c) the sub-peatian mineral soil. Together these factors are used to designate the so-called "natural regions" of the bogs. As pointed out in the glossary in the Report the term "semi-natural region" would be more appropriate. Five such "regions" are recognised in the Report and these will be the units on which future utilisation of the cutover is based.

One aspect in which the bogs of the Cnoc Dioluin Group differ from those previously surveyed is that approximately 70% of the area is underlain by reed-swamp peat with a high pH and high total N and Ca contents. Previous surveys of two bogs in Co. Offaly and Co. Kildare showed proportions of only 20% and 12% respectively.

Section 4 of the Report deals with the terminology and classification of the often confusing term "sapropel". Although organic in origin this material is quite different from the peat overlying it. Sapropel is an organic sediment of algal or planktonic origin which was desposited under water. In the glossary of the Report it is defined as "a sub-peatian, non-calcareous, organic mud relatively rich in sulphur and a number of metals". It also has a very high ash content (38.1%). This characteristic could usefully have been included in the definition and the term "sediment" or "deposit" might have been preferable to 'mud' since the latter is more widely used in the mineral soil context.

In two of the four bogs in the Group there is a good correlation between the "natural regions" of the cutover peat and the underlying mineral soils but in the other two bogs there is no such consistent relationship. This is explained by differences in the geological histories of the bogs; the simpler the history the better the correlation. This point is well illustrated by maps of mineral soil distribution and accompanying transparent overlaps delineating the "natural regions" of the cutover peats. Since the "natural region" is defined, in part, by reference to the underlying mineral soil this inconsistency in the relationship between peat type and mineral soil makes inter-bog comparison of natural regions somewhat difficult.

In the context of future land use the underlying mineral soils are relevant in the near future only in natural regions in which the undisturbed peat was shallow and little remains after cutting operations. At Cnoc Dioluin the only region like this occupies the higher ground in the bogs and is underlain by a soil "with affinities with the grey-brown podsolic soil . . . a common cultivable soil of farmland". In the other four natural regions it is estimated that it will be between 50 and 125 years after cutting stops before the underlying mineral soils will come within 30 cm of the surface of the peat. During this period the characteristics of the remaining peat rather than the mineral soil will affect utilisation.

One aspect of the greatest importance and future utilisation of the cutover peat is its permeability to water. Fortunately, the least permeable peat—"the older Sphagnum-Eriophorum"—is the one most often removed furing cutting operations. The permeability of the various types of fen peat, particularly those with a considerable quantity of wood remains, is relatively good. However, not much is known about the permeability of the redistributed "younger Sphagnum peat" which will form the initial working surface for future use. Even if the redistributed peat is mechanically mixed with the lower peats it will still have an important influence on the characteristics of the upper layers.

The last 44 pages of the Report present details of the chemical (including trace element) and physical analyses of the peats and mineral materials discussed in the text. There are 13 plates illustrating the soils and peats and some of the machinery used in sod-peat production. These latter are extremely helpful to any reader not familiar with this process. Much of the details of the survey is included in the 3 appendices, 4 tables and 24 figures in the Report.

Of necessity, a report of this type includes a mass of detailed information which is of interest only to the specialist. However, the authors have wisely included in the text only information necessary for its full understanding and the Report is recommended to all foresters—and others—who have a present or future interest in the utilisation of these cutover Midland peats.

As long ago as 1962 N. O'Carroll stated in a paper in this journal: "In time large areas of cutover bog will become available for use either for forestry or agriculture. Should the decision be in favour of afforestation, the problems presented will be totally different from those presented by the afforestation of blanket bog," The present Report indicates just how big the differences will be but it favours neither the farmer nor the forester, although the reader gets the impression that present thinking is more towards agricultural use. The final decision on future use will anyway probably be a political one but the merit of a Report such as this is that it provides the factual data on which the final decision can be based.

D. A. DICKSON

GUAGAN BARRA FOREST PARK—Pairc Foraoise Guagan Barra. Forest and Wildlife Service. John Augustine Ltd. 25p.

FOREST Park booklets have created a new standard with this issue on Guagan Barra Forest Park. Eminently readable, it has an introduction in Irish, which is, thankfully, not a direct translation of the English version which follows, while conveying the same type of information. On the other hand the descriptive requirement of the stops on the nature trail dictate that both the Irish and English versions should be similar if not direct translations.

The booklet gives an outline of the geology of the area in and around Guagan, traces the development of its plant ecology after the ice age and follows with a brief description of the wildlife one may expect to see in the Forest Park. The principal tree species are adequately documented and serve as a reminder to us that forest production rather than recreation was the dominant theme in the years following 1938 when the property was acquired. The dominant feature of the presentation, however, which permeates throughout the booklet, is the authoritative description of the local scene and the original Irish forms of the placenames are used extensively in support of this endeavour. For the foreigner (Irish or other nationality) a short chapter listing a number of these placenames, together with their meaning in English, is provided. A route map of the walks available completes the presentation and it is here that the newcomer without an elementary knowledge of Irish may have some difficulty in deciding which walk to select. A reference to pages 14 and 15 would have been helpful at this point.

The assistance of the Geological Survey, the Placenames Commission and Mr. Lucey of Guagan Barra is acknowledged and it is obvious that the ground has been well studied and researched. The Forest and Wildlife Service are to be complimented on this multidisciplinary approach while the authors deserve a bouquet for their sensitive use of the poetry and prose of writers like Merriman, Callanan and Gibbings to emphasise the beauty of Guagan and explain the harvesting of forest produce.

The booklet is printed on matt art white paper interleaved with moss green and fawn-grey cartridge paper. It is tastefully designed by Bernardini, Birket and Gardner Ltd. in the three colours, black, brown and green. The front page carries a half-tone drawing in brown of the entrance to the Forest Park, while numerous line illustrations, in black and brown, of animals, plants and scenic views illuminate the entire booklet. At 25p it is excellent value for the visitor to Guagan Barra.

P. M. JOYCE

OTHER PUBLICATIONS RECEIVED

A Handbook of Forestry and Woodland Terms. L'Exploitation Forestiere. Guide Pratique des Termes, by J. W. A. Newhouse, in collaboration with Cyril Hart and Elizabeth Stjernsward. Hazelholt Farm, Bishops Waltham, Hampshire SO3 1GA, England, £1.35. (English-French and French-English. 600 entries covering: survey and purchase of a woodland estate; trees and forestry systems; technical and economic management of woodlands; timber utilisation; shooting, fishing, camping and special interest holiday activities in forest areas; bibliography.)

Forestry Commission Publications

Bulletin No. 47. *Work Study in Forestry*, Papers produced for a course organised for the joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers, July 1971. Edited by W. O. Wittering. £1.00. (It is hoped to have this reviewed in our next issue.)

Report on Forest Research for the year ended March 1973, £1.75.

Fifty-Third Annual Report and Accounts of the Forestry Commission for the year ended 31*st March* 1973 *together with the Comptroller and Auditor General's Report on the Accounts,* 90p.

Forest Record No. 87. *Hydraulic Grapple Cranes for Forest Use,* by F. B. W. Platt.

Research and Development Papers (Unpriced)

No. 103. *Survey of Losses of First-Year Conifer Seeds and Seedlings in Forestry Commission Nurseries* 1972, by L. A. Lee and S. J. Petty.

No. 105. *Summary Report on the IUFRO* 1938 *Provenance Experiments with Norway Spruce,* by R. Lines.

No. 106. *Nothofagus Yield Tables,* by J. M. Christie, A. C. Miller and L. E. Brumm.

No. 107. *Organisation of Outdoor Recreation Research and Planning in the Netherlands,* by R. M. Sidaway.

Society Activities

ANNUAL STUDY TOUR 1974

The 1974 Annual Study Tour took place on 21st–23rd May with headquarters in Westport, Co. Mayo. The tour leader was Mr. Tom de Gruineil, District Inspector, Castlebar. Over fifty members took part.

Tuesday, 21st May

Following a drive through Newport and along the north shore of Clew Bay, the first stop was at Mulranny. The centre of interest here was a patch of Mediterranean heath (*Erica mediterranea* L.). This species, a native of Spain and S.W. France, absent from Britain, occurs locally in western Mayo and Galway.

Further north, at Ballycroy, Mr. Joe Fahy, Acquisition Officer, Castlebar, gave an account of the special problems of land acquisition in the west of Ireland. A discussion developed on the general question of land use in that region. A question was raised as to the propriety of converting considerable areas of blanket bogs into forests of moderate productivity, thereby detracting from the visual quality of these unique tracts of landscape, while large areas of land of the highest forest potential, for instance in the drumlin belt, continue to be devoted to sub-marginal agriculture.

The first forest stop was at Glenamoy Research Forest (Forester in Charge Mr. P. J. Lyons; Assistant Mr. Seamus O'Connor). At Glenturk property Messrs. Maurice Swan and Ray Keogh described an investigation, part of the International Biological Programme, into the primary productivity of forest on peat, and aspects of its hydrology. In general, runoff is about one half of precipitation and there is very little difference between runoff from plots with deep and shallow drains.

A little further on Mr. Art Lance of the Agricultural Institute described his research on grouse. This work, which is funded by the Forest and Wildlife Service, has two aims: To understand the processes limiting population size, and to explore ways of increasing grouse numbers. The main limiting factor seems to be the quantity and quality of heather for food, a fact not conducive to great enthusiasm from foresters. A general account of the research carried out at Glenamoy by the Agricultural Institute was given by Mr. Louis Grubb, Station Manager.

The highlight of the day came at Belderg, about 10 miles west of Ballycastle, where Mr. Seamas Caulfield, of University College, Dublin, showed us his excavations which revealed a farmstead occupied in the Neolithic Period sometime before 2500 B.C., abandoned, and re-occupied in the Bronze Age around 1500 B.C. The whole area was subsequently covered by a deep layer of blanket bog peat. It was the removal of some of this peat for fuel which first revealed the traces of stone walls which led to the present excavations. On the site we could see the remains of a round house, tillage plots with ridges intact, stone walls of both periods of occupation, and an area of pottery manufacture. Evidence of burning was visible in a distinct layer of ash in the remaining peat.

N. O'CARROLL

Wednesday, 22nd May

The party were taken north from Westport by the scenic route to the east of Nephin More to enter Nephin Beg forest by the northern entrance. They were welcomed by the forester-in-charge Mr. M. Costelloe. The first area visited was a crop of badly frosted Sitka spruce in the pre-thicket stage planted 1964. The bad weather conditions prevailing at the time cut short discussion but the concensus of opinion was that with the powers of recovery of the species a crop should result.

The next stop was at a manurial experiment. Dr. N. O'Carroll, Research Branch, Forest and Wildlife Service, explained an investigation in progress in a 10-year-old fertilizer experiment in a crop of Contorta pine 23 years old. The present investigation is aimed at finding out how the major nutrients are distributed in the ecosystem (trees, litter, ground vegetation and peat) and if possible the source of these nutrients. He also demonstrated a typical excavated root system showing extensive root development to a depth of about 60 cm. After some discussion lunch was provided at a comfortable site in the forest.

In the afternoon a Salmon Research Station was visited at Furness. Here Dr. David Piggins gave a talk and demonstration on the artificial rearing of salmon stocks to smolt stage to increase the numbers of adult salmon over natural spawning, and so conserve stocks for rod fishing in the area. Natural spawning beds he said were badly affected in recent years by flash floods which he attributed to forestry drainage.

The day's itinerary was completed by visiting a deciduous woodland area at Oldhead, Doolough forest, Co. Mayo. The party were met by Mr. Michael Neff, Conservation Section, Forest and Wildlife Service and forester-in-charge, Mr. Maurice Lynch. The objects of management were outlined by Mr. Neff. The elimination of alien species and conservation of native ones he said was the main aim. A discussion followed, during which considerable interest was shown in the ground vegetation.

Mr. O. V. Mooney, President of the society thanked the leaders at the different stops for the considerable trouble to which they had gone to facilitate the society

THOMAS J. PURCELL

Thursday, 23rd May

Despite a certain amount of tour attrition, and a rather feeble sun, the drive through the stone walled countryside, south of Westport to Cong forest, was pleasant. At Cong, Mr. Tom Guilfoyle, assistant District Inspector, welcomed the party and Mr. P. Campbell, forester-in-charge, gave us the vital statistics of the very fine stand of 42-year-old Sitka spruce. This stand had suffered in the January wind blow and the party was shown blown specimens with volumes up to 4 cubic metres.

The second stop brought the varied life of the modern forester home to us as Mr. Brian Stronach discoursed with some erudition on the sexual life of the woodcock. Cong was the best woodcock shoot in Europe and we were told that in 1908 five guns shot 280 birds in two drives in one day. The present day death toll is somewhat less—the shoot producing about 50 birds.

Mr. M. Maye, forester-in-charge, Cong sawmill, discussed the background to the present mill which dates from the fifties, and told us that the annual production is about 50,000 cubic feet of sawn timber, mostly roofing material. The mill operates at a working profit and also produces huts and amenity signs to meet inservice demands. This brought us to lunchtime and the hotel hampers were unpacked with the enthusiasm of hungry men (and women).

A short stop, after lunch, was made at Broad Avenue, Ashford Castle, where we saw the oldest *Pinus Contorta* in the country, unfortunately laid to rest by the January storm. Mr. Cambell and Mr. Mulloy supported by Mr. Galvin discussed the shooting, while Mr. Tony Mannion gave us some facts regarding the ornamental woodland, leased by the Forest and Wildlife Service to the hotel.

As the little man with the hammer, in the engine of one of our omnibuses, became more adament we were forced to abandon the vehicle, so the party doubled up in the remaining bus and with the help of car transport, provided by the local staff, the tour proceeded to Moore Hall.

Moore Hall, with its snotgreen lake (though I doubt if Joyce was ever a house guest there), is always evocative of recent history. The ruins of the mansion still dwarf the sea of Norway spruce on its front lawns, while a curious juxtaposition of revolutionary thinking allows a memorial plaque on its walls.

Mr. Stronach talked on the ecology of mallard in the pleasantly situated amenity area and discussed the findings from his research work here over the past six years. The party was shown a Norway spruce/oak mixture, where Mr. J. Tighe, forester-in-charge, and Mr. P. Murray, deputy forester, were introduced. Mr. Murray gave us the statistics of the stand and the possible treatment was discussed at some length, the future of the oak being the main point at issue. The concensus was for the retention of the oak.

The last stop of the tour was at Moore Hall itself, where Dr. N. O'Carroll, speaking from the steps in a light drizzle, discoursed on the history of the Moore family in some detail, dwelling mostly on George, the best known member of the family and, obviously, the speaker's favourite. Dr. O'Carroll, with relevant quotation and amusing anecdote (helped by Mr. R. O'Cinneide on the classical side) conjured the ghosts of the gamblers, paterfamilias and litterateurs that once were lords of those walls.

Rejoining the bus the tour headed for Westport and the society's annual dinner, stopping briefly at Ballintubber, where some members visited the abbey and others an adjoining premises.

L. P. O'Flanagan

Participants

Mr. O. V. Mooney (President), Mr. T. de Gruineil (tour leader), Mr. F. Mulloy and Miss L. Furlong (meetings committee), Mr. S. Carney, Professor T. Clear, Messrs. M. Costello, C. C. Crowley, J. J. Crowley, G. Cunningham, J. M. Doyle, F. Drea, D. Egan, F. Fahy, J. Fahy, G. Karragher, J. Fennessy, A. M. Finnerty, P. Finnerty, M. Forde, A. Gallinagh, S. Galvin, G. V. Harney, C. J. Jeffers, F. Jennings, J. E. Johnston, J. Kelly, E. J. Lynch, D. Mangan, A. Mannion, D. Murphy, T. McCarthy, N. J. McCormack, M. O'Brien, Dr. N. O'Carroll, Messrs. M. F. O'Donovan, L. P. O'Flanagan, T. J. O'Mahony, P. O'Malley, M. O Neachtain, D. O'Sullivan, G. H. Pickles, T. Purcell, J. Quinn, Miss J. Tierney, Messrs. C. Tottenham, R. Tottenham, J. Twomey, D. Walsh, A. van der Wel, D. P. Willis, J. Whyte.

ENVIRONMENTAL POLICY

At a meeting in Shell-BP House, Dublin, on 16th August 1974 Dr. Frank Convery, Assistant Professor of Natural Resource Economics, School of Forestry, Duke University, North Carolina, U.S.A., delivered a paper entitled *Concepts for Environmental Policy.*

In the first part of his paper Professor Convery discussed the necessity for change from a cowboy economy to a spaceship economy, from an economy of dynamic economic growth to a no-growth economy, or nearly, and gave examples on a world scale of damage to the environment resulting from our present system, and the likely future consequences of current development, for instance in the field of nuclear power generation.

He went on to consider two possible methods for the control and abatement of environmental pollution: residuals charges and subsidy/enforcement. The first of these envisages the levying of a charge on the pollutor related to the amount of degrade caused to the environment by the residuals released thereto, while the second would involve subsidies and tax reliefs for pollution abatement equipment together with legal enforcement of specified discharge standards. Professor Convery favoured the first method mainly on the grounds that the cost of the pollution resulting from any process would be directly reflected in the price of the product, thereby reducing the demand for that product in relation to the degree of pollution caused. He concluded with some examples of this system in operation.

OUTDOOR MEETINGS

Forest Walks

In accordance with what has now become an accepted tradition the Society's guided forest walks for members of the general public took place on the second weekend in September. While attendance on Saturday 7th was limited by rain and wind, it is estimated that 4,500 to 5,000 people attended on Sunday 8th. The walk locations and leaders were as follows:

Forest		*Leader*
Churchhill, Meenirroy, Co. Donegal	...	James Melia
Killygordon, Co. Donegal	...	C. Jeffers
Tardree, Co. Antrim	...	W. J. Crawford
Baronscourt, Co. Tyrone	...	C. S. Kilpatrick
Ballyfarnon, Co. Roscommon	...	M. Donnelly
Castleshane, Co. Monaghan	...	M. Dooley
Headford, Virginia, Co. Cavan	...	J. Crowley
Ballymahon, Co. Longford	...	J. Quinlivan
Mount Bellew, Co. Galway	...	J. Cronin
Breaffy, Castlebar, Co. Mayo	...	J. A. Mannion & T. de Gruineil
Union Wood, Collooney, Co. Sligo	...	J. E. Johnston & B. Moloney
Dromore, Ennis, Co. Clare	...	P. J. White
Coole Park, Gort, Co. Galway	...	T. Guilfoyle
Portumna, Co. Galway	...	P. Keane
Donadea, Co. Kildare	...	P. Crowe
Monasterevan, Co. Kildare	...	F. Fahy
Killakee, Co. Dublin	...	M. O'Brien & D. T. McAree
Glencree, Co. Wicklow	...	D. McGuire
Glenealy, Co. Wicklow	...	H. M. FitzPatrick
Stradbally, Co. Laois	...	B. J. Collins
Durrow, Co. Laois	...	L. Condon
Gorey, Co. Wexford	...	G. Murphy
Graiguenamanagh, Co. Kilkenny	...	J. Dooley
Carrickbyrne, Co. Wexford	...	J. Vaughan
Dundrum, Co. Tipperary	...	J. Hanley
Currachase, Adare, Co. Limerick	...	M. O'Donovan
Newcastle West, Co. Limerick	...	J. Costello
Muckross, Killarney, Co. Kerry	...	P. J. Bruton
Macroom, Co. Cork	...	M. F. Darcy

Currabinny, Co. Cork	...	J. Ryan
Kilworth, Co. Cork	...	P. Verling
Glengarra, Co. Tipperary	...	M. Mac Giolla Coda
Mount Hillary, Co. Cork	...	M. J. Doyle

Lettercran and Kesh Forests

A meeting organised by the Northern Region was held in Lettercran forest, Co. Donegal and Kesh forest, Co. Fermanagh on Wednesday, 2nd October 1974. The leaders were Mr. Paul Hand, District Inspector, Donegal, and Mr. Peter Savill, Research Officer, Belfast. The Forestry Division, Belfast, and the Forest and Wildlife Service, Dublin, facilitated members who wished to attend, resulting in an attendance of over sixty, an encouraging sign of the potential of mid-week meetings in contrast with the steadily declining attendance at Sunday meetings.

In Lettercran the subjects discussed included provenance and rooting habits of contorta pine, and nutrition of Sitka spruce on peat, and in Kesh an experiment on soil preparation for the establishment of Sitka spruce on gley soils was demonstrated and discussed.

Cratloe Forest

A meeting in Cratloe forest, Co. Clare, led by Mr. Michael O'Donovan, District Inspector, Limerick, was held on 13th October 1974. The topic for the meeting was the management of high quality conifer plantations having a wide variety of species in varying stages of development.

Clonsast Bog—Trench 14

The first plantations on Bord na Mona machine-cutaway were established in 1955 in Trench 14, Clonsast Bog, Co. Offaly. These plantations have been extended as more cutaway ground has become available, and a number of experiments are in progress. Some of the original Japanese and hybrid larch plots were thinned in the spring of 1974. The meeting, led by Mr. Michael Carey (Research Officer, Forest and Wildlife Service) saw and discussed the development of these plantations and experiments. Some of the highlights were a twenty-year-old crop of *Abies grandis* of yield class 22 (metric) with roots descending about two metres into calcareous glacial till, and a similarly aged crop of *Pinus radiata* on a deep layer of peat with a yield class of 20.

ANNUAL GENERAL MEETING 1974

COUNCIL REPORT FOR 1973

Meetings

Attendances at indoor and outdoor meetings held during the year were encouraging. One venture in particular met with great response. This was a weekend tour held on the 28th and 29th September, which combined the Annual Dinner held at the Bush Hotel, Carrick-on-Shannon, with visits to Lough Key Forest Park and Drumkeeran Forest. The Guided Forest Walks, which were also held in September, were highly successful. This was due to the extensive advertising campaign launched by the Meetings Committee in the weeks preceding the Walks. The Society was honoured by the presence of both the President of Ireland and the Minister for Lands at the Forest Walks held at Glenealy and Monaghan. The Forest Walks were organised in co-operation with the Forest and Wildlife Service, Dublin and the Forestry Division, Belfast and held in fifteen counties so that they were easily accessible to the public.

Council Meetings

During 1973 seven Council Meetings were held and the attendance was as follows:

Miss E. Furlong and C. B. Tottenham	7 meetings
Drs. Jack and O'Carroll, Messrs. Sharkey, F. Mulloy, J. Prior, E. Joyce and Prof. T. Clear	5 meetings
Mr. E. Larkin	4 meetings
Mr. P. Clinch	3 meetings
Dr. D. Dickson and Messrs. J. Mackin and T. O'Brien	2 meetings
Messrs. W. Dallas and G. Hipwell	0 meetings

Due to Mr. P. Clinch's posting abroad Mr. E. Larkin was co-opted as Secretary on 29th September.

Annual Study Tour

The Annual Study Tour was held in Belgium. A summary of the events of the tour are to be found in Vol. 30, No. 2 of the Journal. Our thanks are due to Professor Van Migroet and his staff who organised the itinerary and for their generous hospitality.

Annual General Meeting

The Annual General Meeting of the Society was held at the Shelbourne Hotel, Dublin, on 10th March 1973, the Minutes of which are written up in Vol. 30, No. 2 of the Journal. Dr. D. A. Dickson read a very interesting paper on "Aspects of Tree Nutrition" an abstract of which appeared in *Irish Forestry* 30(2) and which has since been printed in full in "Forestry".

Library

The Council decided that since the book *The Forests of Ireland* by H. M. Fitzpatrick was in short supply, the Treasurer should place the remaining copies in the bank for safekeeping. A revision of the book is under consideration.

Society Publications

In 1973 two issues of the Journal were again published. The Council decided that the price of each issue would be increased to £0.75 from 1974. A postage and haldling charge of £0.15 would also be charged, making the total subscription rate to non-members of £1.80 per year.

The Society also published a pamphlet entitled *Why Forests?* which was circularised to all members in conjunction with the Guided Forest Walks.

New Members

The Council was pleased to record that during the year sixty new members were elected to the Society.

Examinations

The Society held its examinations for both the Woodman's and Forester's Certificates. From the four applications originally received only one candidate presented himself for the former and was successful in obtaining his certificate. The applicant who sat for the Forester's Certificate was unsuccessful.

Elections

Elections were held for the positions of Councillor Technical (three posts for the period 1974/'76 and one post for the period 1974/'75) and Councillor Associate (one post).

MINUTES OF 32nd ANNUAL GENERAL MEETING, 23rd MARCH 1974 IN THE SHELBOURNE HOTEL, DUBLIN

The President, Dr. W. H. Jack, in the chair, present were Miss E. Furlong, Professor T. Clear, Messrs. C. Tottenham, F. Mulloy, E. Larkin, D. McGlynn, O. V. Mooney, S. Galvin, T. McEvoy, N. O'Carroll, D. Dickson, P. Savill, J. Prior, J. Twomey, M. Swan, P. Clinch, M. Ward, E. O'Connor, N. Kavanagh.

Secretary's Business

The minutes of the 31st Annual General Meeting having been published in *Irish Forestry*, Vol. 30, No. 2, were taken as read and were duly signed.

The Secretary read the Council Report for 1973, and its approval was proposed by Mr. T. McEvoy and seconded by Professor T. Clear.

Matters arising from Council Report

When questioned about the future development of the Society the President said that there had been a good reaction to the pamphlets published by the Society during the year in conjunction with the guided Forest Walks and that he hoped that this would continue. Mr. McEvoy commented on this and excellence of the pamphlets.

Mr. McGlynn asked if the Society could do anything to counteract the adverse publicity that forestry has been getting. It was the feeling of the meeting that the incoming Council should concentrate their efforts on getting more public opinion in favour of forestry and if possible to make more use of the media. It was also felt that television would be useful especially if publicity was included in farming programmes.

On the item of examinations the President said that the mechanics in setting up examinations took a great deal of work and it was very disappointing to note that very few candidates presented themselves for examinations. On the proposal of Mr. T. McEvoy and seconded by Mr. S. Galvin, it was agreed that a note should appear in the Journal urging applications to be taken seriously.

With regard to the book, *The Forests of Ireland,* the question arose as to whether the Society should update the already detailed book or produce a smaller, less detailed, soft-backed version that could be produced by a local printer. It was the feeling of the meeting that the smaller, less detailed work would be more favourable.

Treasurer's Report

The Treasurer presented the abstract of Accounts and commented on the happy state of the Society's finances. A motion of appreciation to Messrs. Mulloy and McGlynn having been proposed by Mr. T. McEvoy and seconded by Dr. Jack was passed.

On the proposal of Dr. N. O'Carroll, seconded by Mr. T. McEvoy, the Society decided to place on record its appreciation of Mr. Duncan Craig who for many years acted as Hon. Auditor and did so much to keep the Society's Accounts in order.

Elections

The 1974 Council elections were confirmed as follows:

President	...	Mr. O. V. Mooney
Vice-President	...	Mr. D. McGlynn
Secretary	...	Mr. E. Larkin
Treasurer	...	Mr. F. Mulloy

Editor	...	Dr. N. O'Carroll
Business Editor	...	Mr. M. Sharkey
Hon. Auditor	...	Dr. W. H. Jack

Councillors

Technical: Mr. M. F. O'Donovan, Mr. P. S. Savill, Mr. J. J. Prior and Mr. A. Duffy.

Associate: Miss E. Furlong.

Meetings

Miss E. Furlong, Meetings Convenor, outlined the meetings programme and stated that plans for the Annual Study Tour, to be held in Mayo from 20th–24th May, with headquarters at Westport, were complete.

On the subject of meetings, Mr. Mulloy asked if the members wished the Society to continue with its Guided Forest Walks. In the discussion which followed it was generally agreed that the Guided Forest Walks should be an annual affair but that the walks themselves should be reduced in number and that more effort should be concentrated on the remainder. It was also agreed to consider the idea of holding some walks in areas which are conveniently reached by public transport.

Other Business

To mark the recent death of Mr. Bill Bell a minute's silence was observed. The President extended the condolences of the Society to his wife and family.

In bringing the meeting to a close the President paid tribute to the work done by the Council members during the past year.

SOCIETY OF IRISH FORESTERS

STATEMENT OF ACCOUNTS FOR THE YEAR ENDING 31st DECEMBER 1973

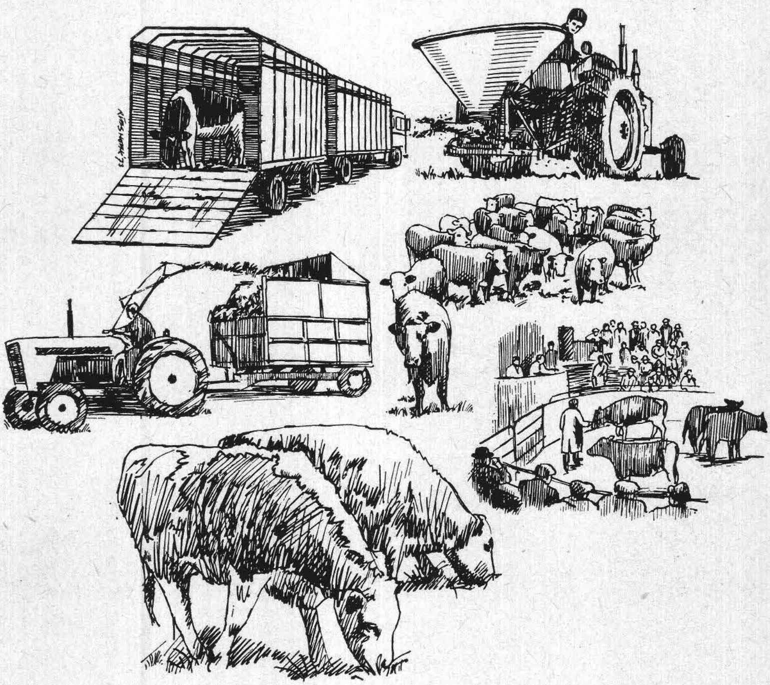
1972 £	Receipts		£	£
107.91	To Balance from last Account			650.18
	,, Subscriptions Received		£	
	352 Technical	1973	854.73	
	15 Technical	1972	32.00	
	113 Associate	1973	202.20	
	6 Associate	1972	7.00	
	10 Student	1973	11.00	
	— Other Arrears		5.50	
	— Advance payments		22.50	
1,154.61	Over Subscriptions		22.50	1,157.43
	,, Interest on Investments			
	Interest on 5% Stock		6.50	
14.18	,, Interest on Savings A/c.		80.42	86.92
	Journal			
	Sales		118.41	
774.30	Advertisements		674.80	793.21
—	Examination Fees			4.00
21.41	Book Sales			20.82
5.25	Donations			10.00
2,077.66				2,722.56

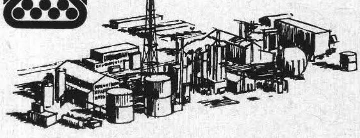
1972 £		Payments	£	£
260.63	By	Stationery and Printing		23.49
874.14	,,	Printing of Journal and Reprints		258.41
191.84	,,	Postages		202.36
22.61	,,	Expenses re Meetings		26.32
13.26	,,	Bank Charges		21.20
—	,,	Secretarial Expenses		182.55
15.00	,,	Examination Expenses		3.00
—	,,	Value Added Tax		32.78
—	,,	Refunds		22.50
		Honoraria:		
		Secretary	12.50	
		Treasurer	12.50	
		Editor	12.50	
50.00		Business Editor	12.50	50.00
	,,	Balance		
		In Bank on Current A/c.	11.85	
650.18		In Bank on Savings A/c.	1888.10	1,899.95
2,077.66				2,722.56

I have examined the above account, have compared it with vouchers and certify same to be correct, the balance to credit being £1,899.95, which is on Current and Savings Accounts at the Ulster Bank Ltd. There is also a holding of Dublin Corporation 9¾% Stock. The above statement does not take account of a bill outstanding of £433.47 for the printing of Journal Vol. 30, No. 2.

Signed: D. McGLYNN,
Hon. Auditor

4th February 1974





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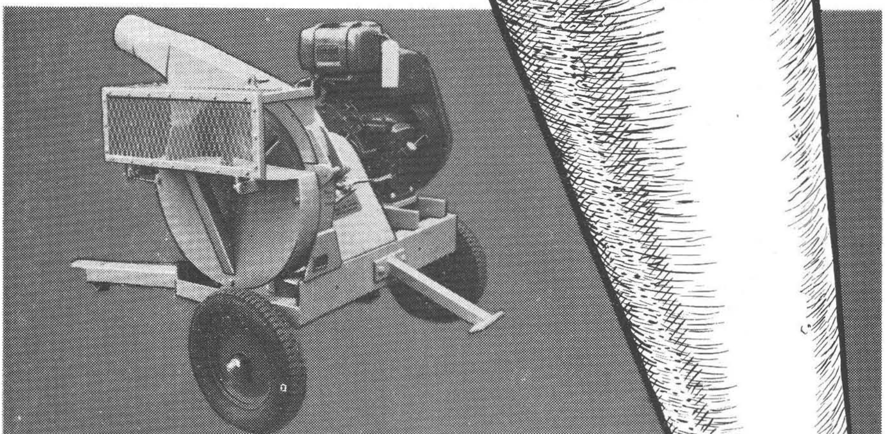

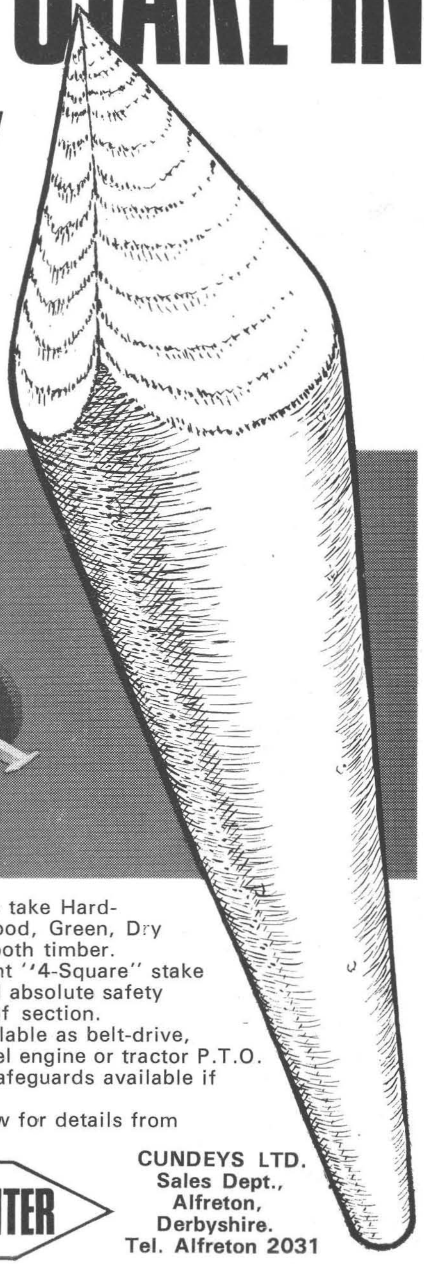


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