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THE SCOTTISH GALE DAMAGE

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THE gale which struck N.E. Scotland on 31st January, 1953, caused unprecedented havoc among our woods. It seems likely that the final volume assessment of blown timber will be over 40 million cubic feet. Of this it is estimated that 85% is of coniferous and 15% of broad-leaved species. Some idea of the magnitude of the damage is gained by reflecting that only 7 million cubic ft. of conifers were authorised by the 1951-52 felling quota for the whole of Great Britain. The latter, however, does not include Forestry Commission fellings or timber cut in thinnings, which would bring the figure up to about 16 million cubic feet. Nevertheless it is clear that Scotland has never before had such a disastrous gale.

METEOROLOGY

There are many difficulties in trying to assess the relative values of particular gales. This is partly because one must consider four variables: wind speed, duration of high speeds, geographical extent and direction. It is also difficult to make comparison with earlier gales due to the smaller number of records as one goes deeper into the past. In particular is this difficult for gales before 1900, in many cases only average wind speeds rather than speed of the maximum gusts being recorded.

The " gustiness factor " is higher for inland than for coastal stations, i.e., for a given mean speed of 30 m.p.h. the gust-level might be 37 m.p.h. for a coastal station and as much as 45 m.p.h. for an inland station. This is important as it is the gusts which blow down trees. Gusts do not change in speed with height above the ground in the same way as mean winds. " During any one gust over open country it is not expected that the speed will change in any regular manner with height. On the average, however, the maximum gust does increase with height although more slowly than in the case of mean speed." [2]

It is important to realise that in the higher ranges, as the wind speed increases so does the chance of gust occurrence become less. Gusts of 70 m.p.h. are not uncommon but gusts exceeding 90 m.p.h. are most rare.

At midnight on 30th January the storm centre was located between the Orkney and Faroe Islands and during the next twenty-four hours it took a straight course towards southern Denmark. By noon on January 31st it was situated about 150 miles off the N.E. coast of Scotland.

The hourly anemometer readings for the stations at Kinloss, Morayshire, at Dyce, Aberdeen and at Leuchars, Fife, give the best picture of what happened. The pattern is similar for all three. The early hours of Saturday 31st were increasingly windy, with the wind coming from W.S.W. at Kinloss and at Dyce and from W.N.W. at Leuchars. By 6 a.m. the wind had moved round almost to N.W. and was steadily increasing in violence. By eight a.m. it had reached Strong Gale strength and it was about then that major wind-blow commenced. It continued to rise until by eleven a.m. it was blowing a Whole Gale and veering to N.N.W. It is noteworthy that it continued for so long at this high strength. At Dyce it was blowing a Whole Gale from 10.30 a.m. till 3 p.m., by which time most of the damage had taken place. By five p.m. it had abated slightly but was still at Strong Gale strength. It had also veered almost to due N. and it remained blowing strongly from this direction until after 10 p.m.

These are, of course, mean wind-speeds, and it is the gusts which interest us most. At Leuchars there were gusts exceeding 32 knots (37 m.p.h.) in twenty hours of the twenty-four, and seven hours with gusts exceeding 47 knots (54 m.p.h.). The highest gust was 62 knots (71 m.p.h.) at 12.20 p.m. from N.N.W. At Dyce the number of hours with gusts exceeding 32 knots was twenty-two and nineteen with gusts exceeding 47 knots The peak gust was 88 knots (101 m.p.h.) at 11.30 a.m. from N.N.W. At Kinloss there is no anemograph, but frequent gusts of 85 knots (98 m.p.h.) were recorded between 9 a.m. and 11 a.m. The peak gust of 93 knots (107 m.p.h.) was recorded at Milltown near Lossiemouth.

January had been an exceptionally dry month in Scotland with only two inches of rain over most of the affected area. It must be remembered, however, that the water table is at its highest at this time of year, and that this depends upon many factors, of which rainfall is only one. The gale was accompanied by varying amounts of snow or sleet. Along the Moray Firth there was but little snow, higher up and inland from Aberdeen the gale carried with it a fair fall of snow. There is no report of this snow clinging to the branches as occasionally happens with wet snow.

Reference to figures of previous gales shows that though this part of Scotland does have periodic high winds, it is in fact more sheltered than most of Scotland north of the Tay. In his table of " Gales and Extreme Winds at Anemometer Stations " Bilham [2] shows that in this respect N.E. Scotland has a similar number of hours of gale per year as Croydon or Felixtowe, with maximum gusts for the period 1907-1947 of 83 m.p.h. at Aberdeen and 84 m.p.h. at Balmakewan, Kincardine. However, bad gales do occur frequently, so that weakly rooted trees are eliminated. Gold [3] records that for the period 1909-1935 winds exceeding 58 m.p.h. occurred every year except 1921 and 1922 at Aberdeen.

From the forestry point of view past gale records are sparse. According to Fisher [4] there were severe storms in 1801, 1833, 1868, 1876, 1893 and 1894. There has been one destructive storm about every four years. In this century there have been gales of unusual severity in 1901, 1903, 1911, 1912, 1924, 1927, 1935, 1936, 1941, 1945, 1949 and 1952 [5] The worst were probably those in 1876, 1893, 1911, 1927, 1935 and 1952. That of November 17th, 1893, blew down 1,850,000 trees in Perth and Forfarshire and many people remember the widespread havoc of the 1927 gale, when a gust of 70 m.p.h. was recorded at Aberdeen. The 1893 gale was noted as being westerly, that of 1927 was S.W. During the period 1922-1947 only ten places recorded wind speeds in excess of 100 m.p.h. The 1927 gale accounts for three of these records, which testifies to its widespread violence.

It would appear that severe gales occur once every four or five years and phenomenal gales every 30 years or so. With regard to direction, most severe gales are south westerly and north westerly gales of exceptional violence are rare.

THE EXTENT OF THE DAMAGE

Geographical. The ill effects of the storm were very widespread, including the calamitous flooding in East England and Holland, the foundering of the Princess Victoria in the North Channel, and the damage to woodlands in Scotland. Damage to trees was reported from as far west as Mull and from Caithness in the north to Wykeham, Yorkshire, in the south ; but with isolated exceptions there was no heavy damage west of a line between Inverness and Arbroath, Angus. It is also probably true to say that the severity of the damage increases as one goes eastwards, though the tendency is hidden by the higher proportion of agricultural land there. The isolated estates of Fyvie and Haddo have both suffered severely relative to their total area of woodland. The area which has suffered the greatest loss in volume is Middle and Lower Deeside. About 90% of the blown timber is on private estates and 10% on Forestry Commission land.

By Species. N.E. Scotland has always been a predominantly coniferous area, as the maps in the Census of Woodlands [6] show. Approximately 85% of the blown volume is of coniferous and the rest of broad-leaved species. Of the conifers Scots pine is by far the most common species and has undoubtedly suffered the worst damage. Larch and Norway spruce are also common species ; Norway spruce has suffered more than the Larch, but perhaps chiefly because it is selected for planting on wet sites. Although there is a large acreage of Sitka spruce it is mostly much younger than the Norway spruce and for this reason does not figure high in the damage lists.

Of the broad-leaved species, there was far more beech in the area than anything else, and it is this species which has chiefly suffered. A high proportion of the volume of fallen beech is made up of mature or overmature stands, though middle-aged beech also has blown. One has to look for stands of oak—other than scrub—and when found it is surprising to find that in many places it has not proved wind-firm.

Blown Scots Pine, 70 years old, on Haddo Estate, Aberdeen.

In general there is no species which has not been blown at one place or another, while on the other hand species notorious for their poor root-hold have sometimes stood firm in exposed positions.

By Age Classes. By far the highest proportion of the damage has been in the middle-aged and mature woods. There was very little over-mature timber left after the wartime fellings but where this has been in the line of the wind it has also suffered badly. This has surprised some people, who point out that the trees have stood in the mature state for fifty years and were therefore thought to be wind-firm. It merely serves to accentuate the extreme violence of the gale.

FACTORS AFFECTING THE DAMAGE

We now come to a more detailed consideration of the factors combining to cause the damage. There is no doubt that the chief cause was the wind velocity, which has already been dealt with ; added to this was the unusual direction. The prevailing winds are south-west, so that it is to gales from this direction that the trees are most wind-firm. Inside the plantations there is no unilateral pattern of the root systems directed in a N.E. to S.W. direction and this is generally also true for the edge trees, but one of the noticeable and recurrent features of the gale has been the "hedges" left on the S.W. edge of the smaller woods. In several woods the whole compartment is flattened except for a line of trees perhaps 40 feet wide on the S.W. edge. In these " hedges " only a few trees are blown. This effect is most noticeable in woods surrounded by fields on all sides, which have always had a high degree of exposure.

The snow probably had little effect, although it may have increased the relative damage to Scots pine in pine/larch mixtures. Its presence, however, would increase the " punch " given by the wind.

Physiography. The important factor is exposure, but this is compounded of elevation, aspect, slope and surrounding shelter. Elevation does not seem to have had a considerable effect and in some cases there are badly blown woods on the lower slopes of a hill and little damage higher up. Woods at 50 feet elevation near the coast are as badly blown as those at 1,300 feet, many miles inland. Aspect is of far greater importance. It has been remarked that it is as if a giant searchlight had been turned on to the countryside knocking down all it illuminated. During a six week's inspection tour I found less than half a dozen woods with a southern aspect which were seriously damaged. The vast majority were on northerly slopes or else on flat ground. Slope again appears to have had little effect, although it is very hard to say whether a difference in angle of slope would have made any difference. On very steep slopes the damage seems to be less. This is explained partly by the wind being " buffered off " and its direction changed to a vertical one, and partly by the greater force needed to blow down a tree whose main roots are downhill. Shelter from surrounding hill features or mature crops has sometimes saved a crop, but more often the shelter-wood has itself been blown. There has been little change in the wind's direction along valleys ; a feature which had been noted before. The effect of the high hills of Upper Deeside has been more to lift the general level of the wind so that valley bottom woods have been "jumped." Several interesting cases have been observed where the wind has alternately flattened and "jumped" woods along a line in this region. There is much truth in the saying: "The wind bloweth where it listeth."

Edge Effects. It is clear that the state of the windward edge of the wood is very important. To illustrate this point, I have found uniform stands in which the windthrow of one edge tree has been responsible for the start of a "wedge" carrying down dozens of trees. These "wedges" were most commonly cut into the older pole woods of say 40-50 years and in almost every case one could trace their origin back to some small gap in the edge, trees with diseased root systems, or a local wet patch. It is a common practice to plant an edging row of some other species along the edge of the Scots pine plantations. Often beech is used and in other cases Abies nobilis or Douglas fir. Generally these have stood very well, but where they have blown there is usually damage to leeward. This does not apply to woods where wholesale destruction has been caused and which look as though a giant bulldozer had smashed its way across them. As for gaps, so it is for holes. It is common to find that a small clearing, used perhaps for stacking pitwood, has been the cause of a "wedge" starting. It would seem that an eddy is set up in such places causing a greatly increased local pressure. Another not uncommon feature is a "sucking-out" effect. Wind passing over a tall stand creates a strong vacuum in its lee and this is often enough to "suck" trees out.

Funnel effects have been noted in many places and are undoubtedly responsible for certain wind-blows. Funnels are caused by the edges of a wood running out at an angle which will funnel the wind down into it. Funnelling can be due to the topography or the layout of the surrounding woods. Examples of both are frequently found. This point is of some importance as it is one of the few ways that the forester can help to prevent wind-blow. Even wide angle funnels are to be avoided if possible and any angle less than 100 degrees may be dangerous. Very noticeable funnel effects are sometimes seen along forest rides or roads. If they are running in the same direction as the wind, it becomes canalised along them, and then impinges with its full force on the trees at the end of the road, when the road stops or turns a sharp corner. It is a commonly held belief that if a wind stream is forced up at the edge of a wood it will hit the horizontal stream above and rebound down into the wood some distance from the edge. According to wind experts this is not so, at least not to any appreciable extent.

The Root System. Under this head soil, drainage, root patterns and disease are included.

There are three chief parent rocks in the area: Old Red Sandstone, Granite, and Mica schists and Gneiss; but these have been so often overlain with glacier drift that a classification of the soils on their geology is liable to be misleading. On the whole, a mild podsol is the common

One of the youngest woods blown—Scots Pine, 30 years old, 37 ft. total height

condition, the worst soils having a thin highly acid peat layer sharply differentiated from the mineral soil. Below this is a leached layer and at varying depths a very vague horizon of deposition of humus and sesquioxides. A sharply defined iron pan is the exception rather than the rule. The best soils are very fertile. The main feature of the soils of this region is the very compact layer of soil (the indurated layer) which occurs particularly on the granitic soils. The soil experts are still in the early stages of research on this factor but to the foresters its presence is well-known and it is sometimes referred to as the "pan." It should not be confused with the pan of a heath podsol. The compacting effect may be slight, or it may be so hard as to resemble concrete and it occurs at varying depth, but usually at 1 to 3 feet. It is found only on freely drained or slightly impeded soils. On some sites it appears to form a solid impenetrable layer causing the trees to be shallow rooting, elsewhere it has fissures of less compact material in a sort of hexagonal pattern and it is down these fissures that the roots penetrate, forming vertical plates, almost like a honeycomb. There is usually a very dense plate of roots directly above the indurated layer. Above this, in the leached layer, roots are sparse, and there is another active zone of rooting in the thin peat layer near the surface. From the point of view of wind it will be seen that the arrangement is not ideal, the surface roots easily pull out of the peat and the roots in the fissures also have less holding power than if they were more evenly distributed. It it almost invariably the case that the roots "peel off" at the indurated layer as this forms a plane of cleavage. It would, however, be entirely wrong to put all the damage down to poor root systems, as the case described is the worst and in many cases trees with deep, spreading, root systems have blown. The vast majority of roots have been torn up rather than broken, breakage most frequently taking place in hardwoods and in surface roots.

Poor drainage results in a high water table with the consequence that only shallow rooting is possible. There is no doubt whatever that this has been a very potent factor in aggravating windblow. The areas of poor drainage in this part of Scotland are, however, not large and it is doubtful if 10% of the damage could be attributed to this cause.

Root disease played only a small part in the damage, in fact it was not unusual to find trees rotten and snapped off at the base, but whose roots remained firmly embedded. On the physiologically shallower soils the lowest roots were often dead, but rot did not appear to spread into the rest of the root system. In this investigation only Abies nobilis was observed to have suffered windblow as a direct result of pathogenic fungal attack.

Wind-blow and Wind-break. Reduced to its simplest form if the wind is exerting sufficient pressure a tree will be wind-thrown, but whether it is blown down or broken depends chiefly on its roothold. The main exceptions to this are trees with some mechanical fault in the stem, such as a previous injury or a forked leader. Roothold has already been discussed above.

Metzger considered the tree as a beam of uniform resistance, but he was concerned more with static breaking forces whereas we must picture a tree lashing about in a hurricane. The crown will be bent almost parallel to the ground with the stem forming a scimitar-like curve. Here the rigidity of the stem is important. Tall, whippy stems may easily take up this movement, whereas less pliant older stems will probably break. The proportion of heartwood to sapwood and the taper will govern the flexibility of any particular species. There are eye-witness accounts that the trees in some cases broke on the rebound after a gust and not as they were bent down. How far this is the general state of affairs is hard to say.

Over very large areas a sort of unselective thinning has taken place. It would not be true to say that the wind has selected trees in any one class. Some dominants have gone, presumably because their crowns offered a greater resistance to the wind, but sub-dominants and suppressed trees have also blown.

Once a blow has started there will be a tendency for it to continue, as the trees fall on each other and add their weight and wind resistance to that of the tree on which they fall. With large heavy timber this may be especially important. There have been very few eye-witness accounts of the blowing down of a large wood, but according to one, a swathe was first cut through the wood on a narrow front and this was then

S.P./E.L. blown at Allticailleach Forest, Upper Deeside.

increased on either side, as the wind veered about, until most of the wood was down.

Crop Height. No other factor has proved so striking as crop height. There appears to be a fairly narrow limit between stands in the undamaged and heavily damaged categories. At the time of writing this opinion is based on about 80 stands examined in detail. The lowest crop-height at which serious wind damage occured was 35 feet, in Scots pine, and there are a few others less than 40 feet tall. As a general rule however, it can be firmly stated that there was no widespread windblow in crops below 40 feet tall. Crops 40-50 feet tall were approaching the danger height and crops over 50 feet tall were seriously damaged. The majority of damage has occurred in woods 60 feet and over, but this is what one would expect, since there are more woods in this class than in the 50 - 60 feet class. It is the main reason why Forestry Commission woods have suffered so little damage. This point is being further examined in detail. There seems to be some basis for believing that Scots pine is at least as liable to windblow at 45 feet as either larch or the spruces, assuming the drainage to be good, and possibly may be more liable.

The critical height below which damage does not occur seems to vary with the district and is presumably a demonstration of the different wind speeds which existed at the same height above the ground in different regions. Thus in the easterly parts such as Haddo House and on the

Dunecht estate there has been more damage in the 40 - 50 feet stands than in those of Upper Deeside.

It is difficult to explain this sharp dividing line and I suggest the explanation is based on the decreasing flexibility of the lower part of the stem which begins to be apparent about this stage. It may be possible to test this by experiment. Added to this, of course, is the fact that it will need very little extra force to cause the wind-throw of an already highly stressed tree.

Thinning and Spacing. Up to now the factors which have been dealt with are largely beyond the control of the forester, but when one approaches thinning it is immediately apparent that there are strongly divergent views. The majority of the woods have been very much underthinned. On at least one estate it is the policy to do no thinnings until the crop is 60 years old. The reasons are chiefly financial, though the non-thinning tradition takes a long time to die. It is therefore natural that the vast majority of the blow has taken place in underthinned woods. It is only when one gets side by side, comparative plots thinned to different intensities that one can make a comparison. In half a dozen places where this is possible one cannot help observing that it is the more heavily thinned plots which have suffered most and the more lightly thinned plots which have suffered least. In some cases there had been previous windblow in the heavily thinned plots, but this reinforces rather than weakens the argument. One factor which might explain this difference is that after thinning the crop is always more liable to windblow until the root systems have enlarged and the trees closed canopy again. The trees give each other less mutual protection in the more heavily thinned plot, so that if a gale does follow close on a heavy thinning, it is not unnatural to get windblow.

Having said this, it should be pointed out that examples of closely spaced stands being blown while wider-spaced stands of similar height have stood alongside also exist.

To some extent the effects of thinning cancel each other out. The root system is able to expand and forms a more secure roothold, but at the same time the crown enlarges in girth and depth so that its wind resistance increases. It may, however, be desirable to have a deep crown with a low centre of gravity. Spruce is a case in point; on well drained soils both Sitka and Norway spruce have a strong tendency to break at 6 - 16 feet up. This can often spoil a high proportion of the timber due to cracks and shakes. With a deeper crown and a lower centre of gravity the tree may not blow down at all, but if it does, then it will be windthrown rather than broken and the timber consequently saved.

There is a school of thought which favours the forest being as irregular as possible, and from many points of view there is much to commend it . When windblow is considered, however, my experience points to the opposite view. Irregular natural Scots pine woods have suffered just as badly as plantations where the wind has struck them, and in all the crops which have an uneven canopy, due to the failure of one species in a mixture, indifferent soil conditions, grazing etc., then damage has always occurred. In fact some of the smallest trees blown (down to 15 feet tall) have been in such crops.

DAMAGE BY SPECIES.

Scots Pine. As already stated, Scots Pine has suffered more than any other species due to its widespread occurrence. It has a reputation for being a wind-firm, deeply rooted tree. Over large areas of N.E. Scotland, however, this is not the case; root systems deeper than three feet are the exception rather than the rule, and where a compact "indurated layer" exists, two feet is more common. After examining hundreds of root systems I conclude that tap-roots are extremely rare, - if they exist at all, - though on deep friable soils a good "root-ball" develops. A surprising feature of the gale was the large number of isolated trees and trees in hedges which have been blown down, after standing fully exposed to gales from all directions for 150 years.

Larch. One has perforce to deal chiefly with European larch, as there is very little Japanese larch tall enough to suffer. The few stands which I saw indicated that both species behave similarly from the point of view of wind-blow. Larch timber is stronger than that of Scots pine so that it is rare to find a broken tree. Where they are found it is usually a break at the base due to butt rot. Added to this the leafless crown offers less wind resistance, so that it is not surprising to find more larch standing than Scots pine in a mixed wood. The root systems are not greatly different; that of larch tends to be more spreading whereas that of Scots pine is deeper and less extensive. Most of the older crops were rather open so that the trees gave each other little mutual protection. Heavy losses are usually the result. On the other hand some of the tallest stands which have not blown were closely spaced larch whose whippy stems probably saved them.

Spruces. Norway spruce has a poor reputation for wind-firmness and as a whole this has proved correct. Past policy has always been to plant it in the wetter parts where the water table is frequently only a few inches down. In these circumstances it is hardly surprising that it should blow down. What is more interesting is the fact that on a deep, freely-draining soil it can adapt its root system to the conditions and make a great "ball" four feet six inches deep. In some cases, due to error, Scots pine has been planted on these wet patches and, whereas the spruce can adapt itself to deeper rooting, the pine is not able to form the extensive plate root which is so characteristic of the spruce. A notable feature of the blows in spruce plantations has been the wind-throw of drainside trees. In one case seven trees blew down along a drainside, their roots all interlocked, and forming a neat carpet of the thin surface peat, where it peeled off the underlying clay. It is difficult to suggest measures to deal with this problem, other than to fell all drainside trees during thinnings,but where drains are frequent this is out of the question. Another feature of wind-blow in spruce has been the high percentage of trees which have snapped. The main reason is doubtless the weaker wood, though it does suggest that a plate type of root can provide just as firm a hold as a deeper, less extensive root system. Sitka spruce behaves in a similar manner to Norway spruce. One point which should be noticed is that these trees, because of their faster rate of growth, have often produced a millable log by the time they are blown, whereas Scots pine planted alongside is still of pitwood size.

Douglas Fir. This species is in many respects anomalous. It has acquired a reputation for being less wind-firm than Scots pine, but this is partly due to its very fast rate of growth, which brings it into the danger category long before Scots pine planted alongside. On the other hand it is not unusual to find very large Douglas fir standing up with occasional other trees, above a sea of devastated policy woods including hardwoods, Scots pine and Norway spruce. Douglas fir 60 - 70 feet high is certainly liable to wind-blow. It has an adaptive root system which can sink deeply into a freely drained soil or make an impressive "plate" on shallow soils.

Other conifers. There are few stands of unusual conifers in this region, though plenty of individual exotic trees exist. One stand of Thuja plicata was seen, which had been damaged in a peculiar manner. 75% of the damage consisted of trees snapped just below the junction of a forked leader. The Abies species have proved very liable to windblow in policy woods and elsewhere where the ground is fertile. On the drier, less fertile parts they have stood remarkably well, as edge trees to plantations, or in small pure woods. The timber is rather brittle and it is usual to find tops broken off; but little windblow has occurred except in really big trees, or where root rot was present.

Broad leaved species—Oak. Of the comparatively small number of oak stands one is surprised to find so many which have been blown. The only reason seems to be the strength of the wind, as roothold was good and they have usually been well tended. The only lesson one can draw is that one must not rely upon oak as being completely wind-firm, though there are many instances of it standing better than beech.

Beech. Probably 90% of the hardwood timber blown is beech, which has certainly not proved wind-firm as an old tree, indeed I found several cases of windblow amongst the younger stands I visited. There is a great dearth of young and middle-aged beech so that this impression may be due to chance.

Other broad-leaved species. Sycamore has stood the gale well and would probably repay more widespread planting. It is not unusual to find a mixed wood with many beech blown and nearly all sycamore standing. It has also stood well as a roadside tree. Alder, again, has proved remarkably wind-firm, considering the boggy ground on which it is found. Birch has suffered rather badly and has been blown about equally when in a loose mixture with Scots pine. Ash has stood fairly well, so long as it has a freely draining soil; on wet soils it has blown rather badly.

Minor Damage. The effects of the storm will continue to be felt for several years to come. Insect attack, particularly of Pine Shoot Beetle *(Myelophilus piniperda)* will almost certainly be heavy in 1954. They will be aided by the exceptionally early spring this year. Pine Weevils *(Hylobius abietis)* will also be a menace to any new planting.

The trees which remain in the devastated woodlands will be subject to full exposure to gales from all directions. Many trees were injured by surrounding trees falling on them, leaders were broken and branches pulled out. In Douglas fir woods the ground was completely carpeted with foliage torn off by the wind and the lashing of branches against each other. Even trees which did not blow have probably had their root systems injured by wrenching and rubbing between stones, with the consequent risk of fungal infection.

Indirect effects such as rabbit fences broken down, letting rabbits into young plantations, roads blocked for extraction, and the neglect of other forest work until the timber is cleared should all be remembered.

Some Conclusions. The importance of drain maintenance cannot be overstressed. The edges of plantations and their outlines, - planted so as to be free from funnels, - are matters which must be attended to from the start. Once gaps exist in pole woods, either made consciously for stacking, cross cutting, etc. or occurring naturally, they are difficult to fill.

The choice of species is very important. There is little doubt that Scots pine is the correct tree for the area, and it would be wrong to switch to another species just because of this gale. At the same time it should be noted that other species will give a greater volume of timber. If one's planting programme is to be governed by phenomenal gales, then it may, on some sites, be better to produce a large volume of Douglas fir by the time it is blown, rather than hope that a smaller volume of wood of Scots pine will survive the next gale.

As the author's knowledge of Irish conditions is slight, it has been the intention to concentrate on the facts and leave readers to draw their own conclusions.

Acklowledgments. In conclusion I would like to take this opportunity to thank the very many owners, factors and foresters, who at all times gave me generous assistance. Thanks are also due to the staff of the Meteorological Office who gave both factual information and useful advice. The work would not have been possible without the helpful co-operation and advice of members of the Forestry Commission staff.

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