Topography and Wind Risk[1]

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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 $\frac{1}{4}$" 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%.

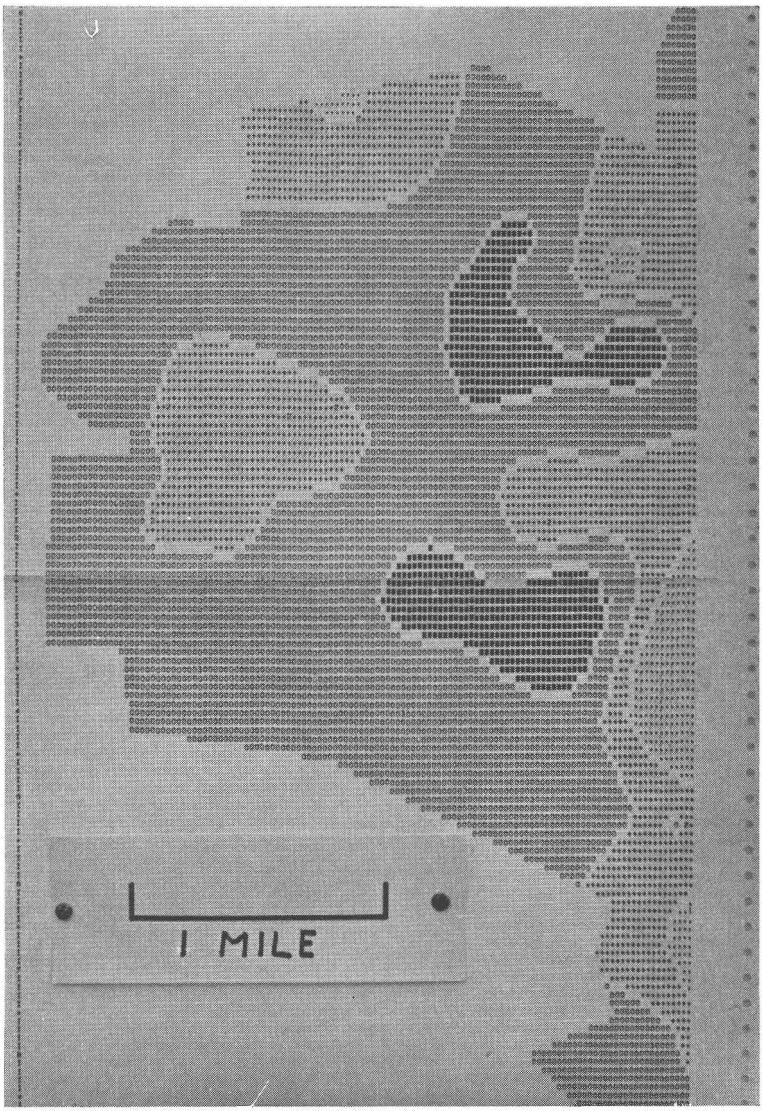

Figure 1: Section of a computer-drawn map of part of Kintyre forest (Argyll). Four zones of relative windspeed, the darker the printing the higher the windspeed. (Photo: A. J. Low.)

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%