TREES ON FARMS ON THE SOUTH COAST OF WESTERN AUSTRALIA

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THE REGION

Esperance as an agricultural district covers about two million hectares. About 1.5 million hectares of this is alienated agricultural land and about half the area is sandplain (approximately 770 000 ha).

The coastal sandplain runs parallel to the coast, and stretches, with some interruptions, about 600 kilometres West to East, and up to 40 kilometres inland.

Soils of the sandplain range from deep fine sand to shallow duplex soils with gravelly sand A horizons. Sand formed from the Eocene sediments of the area are finer than in most of the wheatbelt areas. Details of the landforms and soils are in 'The Esperance Land Resource Survey' (in publication 1).

DEVELOPMENT AND LAND DEGRADATION

Much of the area has been developed since the 1950s, when the technology of superphosphate, trace element use, and new land clearing became available, together with a suitable economic and political climate.

Clearing tended to be excessive in the early years. Conditions for clearing changed with later land releases in the area, but rational use of natural vegetation and introduced vegetation was sporadic.

Cleared land is estimated at 92% of the total agricultural land in the Esperance Shire (which contains most of the sandplain). This estimate is based on Bureau of Statistics and Clearing Notification figures (2,3). While these figures are not considered to be accurate, they do give a good indication of the level of clearing. Clearing of the remaining alienated land has increased over the last few years, possibly due to fears of clearing bans.

Land degradation following removal of the natural scrub has been rapid, and varied.

Wind erosion of the sands occurred fairly commonly with cultivation for cropping, clover harvesting and heavy grazing of annual pastures.

Non-wetting sands appear to affect the majority of sandplain soils, and the problem is increasing. A report in 1985 (4) estimated lost production of at least $10 million to $15 million per year due to non-wetting sands.

Rising water-tables and associated salinization has become of particular concern following the wet years of 1986 and 1989. These problems have been the subject of another NSCP project base in Esperance, started in 1988 (5).

TREES - HOW MANY TO FILL THE NEED?

A minimum of five per cent of the agricultural landscape could be planted to trees for reasons explained later. In the Esperance region, this means 75 000 hectares. If trees were planted at 500 per hectare, this would give 37.5 million trees.

With a projected tree life of 30 years, the target could be reached with thirty years' planting of 1.25 million trees per year.

Unfortunately, the highest rate of planting so far, in 1990, has been less than one million. Over the last four years, seedlings *planted* have increased from about 200 000 to about 750 000.

The annual target planting rate needs to be much higher for the following reasons;

- Survival of seedlings planted averages less than 50 per cent.
- Waiting thirty years to reach five per cent revegetated is too slow; land degradation needs treatment in the next decade.

This means that the annual planting target may need to be 7.5 million trees for the Esperance region.

If more than five per cent of the area needs replanting to trees, the planting rate has to be even higher. The Esperance Land Conservation District Committee is recommending that 12.5 per cent of farms be left vegetated. Managed trees for windbreaks and increased water use can be justified on about ten per cent of the landscape.

WHY TREES?

Proven track record

Trees for windbreaks and shelterbelts have been used and reported on for many decades. Most of the literature is from Europe, the United Kingdom, and the United States of America (6,7,8).

Farmer experience with windbreaks for livestock shelter, erosion control and horticultural protection is very extensive.

Trees for revegetating saline areas and lowering water-tables have been used in the past. Recent interest in Western Australia, and Australia generally, has been well documented (9, 10, 11).

Low running costs

After establishment, most tree systems do not require separate fetilizer, watering or protective spraying. In some cases, management of the trees for saleable products will increase the 'running' costs.

Low maintenance

Trees should be selected for their suitability to the conditions they are planted in. Selection based on soil, moisture and other conditions will give a hardy tree.

Multi-purpose

Trees can give shelter, use more water, reduce windspeed, and produce saleable products *at the same time*. There is usually a primary consideration for planting trees, but the secondary benefits should also be accounted for.

Long life

Most of the trees recommended for on-farm planting will have a useful life of greater than 20 years. For some uses, lives of greater than 40 years are possible. These life times equate to those expected of soil conservation earthworks, fencing, and in many cases, the farmer's working life on a given property.

Work independently of land management or season

Because of their long life, trees will continue to do their job, independent of annual changes. For instance, windbreaks give their *best* result during drought years, conditions of strong wind, over-grazing, etc. Management that depends on annual decisions may go wrong through no fault of the operator.

Reduction of erosion by stubble retention, reduced grazing pressure, and direct seeding of crops works in most seasons. However, late breaks to the season, dry and strong winds, and very poor livestock prices can lead to accidental erosion. Trees in place safeguard against these circumstances.

WOOD FROM WINDBREAKS AND OTHER TREES ON FARMS

As an indication of the tree numbers being considered, refer to page 2.

At a minimum, there should be 37.5 million trees planted over 30 years. That is, 1.25 million trees per year, or 75 000 hectares at 500 trees per hectare. (As an indication of the tree numbers being considered, refer to page 2.)

Pine windbreaks would be suitable on at least ten per cent of the area - 3.75 million trees, or 125 000 trees a year for 30 years.

Hardwoods on about 20 per cent of the area would be suitable for post and pole harvesting. If one strainer or four posts per tree could be harvested, this would produce 250 000 strainers or one million posts per year.

Another 20 per cent of the area may be suitable for fuelwood harvesting. At 0.5 tonnes per tree, this would give 3.75 million tonnes, or 125 000 tonnes per year.

Woodchip production from *Eucalyptus globulus* windbreaks, timberbelts and block plantings is currently being investigated by the Department of Conservation and Land Management.

The economics of timber/wood production from land conservation plantings needs re-assessing. The primary reasons for, and economic gains from, these plantings are in the control of land degradation and increased agricultural productivity.

Many land owners will be attracted to harvesting if the returns cover the cost of harvesting, site cleaning and re-establishing the windbreak (or other planting).

EXPECTED BENEFITS OF TREE SHELTER IN AGRICULTURE

- *Reduction in mechanical damage to pasture and crop plants.* This damage has not been extensively quantified, but is thought to be common on exposed pastures and some crops. 'Bruising', splitting of stem and leaf material, and removal of the waxy cuticle have been documented.

- *Reduced evaporative demand on soil.* Slowing windspeed reduces evaporation and leaves more soil moisture available for photosynthetic activity. Under some conditions this will lead to increased water usage, reflected in greater production.

- *Livestock shelter.* The effect of cold winds, with or without rain, has been extensively monitored and researched in Australia. The most obvious instances of gains from shelter are for off-shears sheep, and recently born lambs.
  Other expected gains, more difficult to quantify in the field, are from modifying microclimatic effects on energy demands of livestock. Most of this work relates to the effect of cold.
  Changes in social and grazing behaviour of sheep in relation to shelter has been observed and researched.

- *Control of wind erosion.* This is an obvious, but apparently poorly understood benefit from reducing windspeed with trees.
  The design principles have been widely researched; but the field design is less well understood.
  The benefits come from preventing sand blasting, and preventing the loss of topsoil containing valuable nutrients.

- *Improved management conditions.* Lower windspeeds will usually allow more days suitable for spraying, and improved operator conditions to work in. Stopping dust and grit entering the house is usually a high priority!

- *Increased water use.* Windbreaks and other tree plantings will use more water than the pastures they replace. This is particularly so near swamps and sumps, saline areas, drainage lines, and seeps.
  On clearly defined 'intake' areas, trees are very suited to prevent recharge.

- *Tree and shrub products.* Secondary products can increase the value of windbreaks. The type of product will be determined by the environment and the management demands on the farmer.
  Examples of secondary products are:
  - sawlogs
  - poles and posts
  - fuel wood
  - fodder
  - honey, oil, and flowers.

At the end of this article, there are a number of references that can be used to follow up the details of reported gains and losses from windbreaks in agriculture.

The figures below are taken from the literature, and some comment is given as to its applicability in Western Australia.

LIVESTOCK RESPONSES TO WINDBREAKS

Post shearing losses. On average about one per cent of post shorn sheep are lost to cold per year. This figure is conservative, and hides the fact that losses in some areas are consistently higher (12).

A Western Australian example is reported for the losses during a summer storm in 1982 (13, 14). Although this was an extreme example, it points out that the degree of shelter has to be taken into account.

Losses from autumn shearing through to early spring are commonly observed (15), and have been the focus of animal welfare activity in Victoria.

Lamb losses. On average, 15 per cent, or more, of all lambs born, die of exposure (16). Very high losses have been recorded under conditions of high windspeed and relatively light rainfall (17).

An indication of the regularity of such losses is found in the Esperance Shire statistics. Over the twenty years of data collected, there were four years of severe lamb loss. Individual farmers have admitted that lamb marking in 1981 was often around 10 to 20 per cent (D Bicknell, personal communication). The Shire average was reported to be 48 per cent for that year, and is higher than 70 per cent in a 'normal' year (Fig 1. 18)

It is reasonable to expect that 50 per cent of lamb losses can be prevented with adequate shelter (19). Under severe conditions, lambing havens give a much higher degree of protection. This form of shelter costs very little, and gives high economic benefits (20, 21, 22, 23).

ENERGY REQUIREMENTS FOR MAINTENANCE AND WOOL GROWTH.

Most of the work published relates to pen studies. If this information can be extrapolated to the field quite small reductions in windspeed can reduce energy needs (24).

For example, a reduction in windspeed from three m/sec to two m/sec can result in a ten per cent saving in maintenance energy requirements (12, 24).

Wool growth studies have shown marked increases in wool growth (31% over a five year period) and body weight using windbreaks at high stocking rates (25). The windbreaks were of corrugated iron, and the gains were largely due to pasture gains. Many other references are available, mostly relating to the effect of cold stress (12, 26, 27)

There are few trials reported using field studies with tree windbreaks. Many have used artificial shelter or grass barriers. The results from these studies are hard to extrapolate to a tree system.

Trees, as long lived perennials, develop complex interactions with their environment. The most commonly reported interaction is root competition with pastures and crops for moisture and nutrients.

A trial was established in Esperance in 1988/89 to investigate the effect of a young *Pinus radiata* windbreak on pasture and sheep production (28). The trial has shown marked differences in pasture growth at different distances from the trees (Fig 2); but no significant difference in sheep bodyweight (Fig 3). The small differences in fleece weight were not related to pasture growth.

A complication of the site demonstrates the confounding factors found in farm systems. The pines were planted into deep sand (a species requirement) and the sand became shallower further away. This soil type change is associated with a pasture species change and the occurrence of non-wetting sand near to the pines (Fig 4).

It is thought that non-wetting has been accelerated by the presence of the windbreak. Sheep have been observed to graze more often in the shelter of the windbreak, leading to conditions favouring clovers and development of water repellancy. The pasture near the windbreak is now poorer than before, not better, and has hidden any effect the shelter is having.

PLANT RESPONSES TO TREE WINDBREAKS

This is the area that has been most widely reported in the overseas literature. There have been many reviews and rediscoveries of the costs and benefits of windbreaks (29, 30, 31).

Unfortunately this is the topic that is rarely taken to be relevant except where the work was done. This is often because not enough of the background data has been recorded, for instance lack of rainfall or soil description.

A table of "Past studies concerning shelterbelt effects on crop yields" is given by J Kort (32). Most of the reported material relates to snow trapping windbreaks. However, there are instances of Mediterranean and Marine climatic areas with crop yield increases of up to 35% (33).

Yield increases of 20 to 30 per cent of pastures and crops, to a distance of about 15 tree heights in the lee of shelterbelts, are often quoted (12, 24). However, the size and direction of a change in yield varies with the crop, season, soil type, tree species, windbreak orientation, etc.

It is important to use data from well constructed windbreaks with the correct management to show the potential gains from tree windbreaks.

Western Australian information on the value of tree windbreaks for crop production

There is very little accurately quantified data available in Western Australia on this topic.

Most of the material available is farmer observation, sometimes with coarse estimates of production changes.

A measuring program was started in 1988 at Esperance to find the effects of young *Pinus radiata* windbreaks on lupin and oat yields (34). This work was done near Gibson, in a 450 mm rainfall zone. The soil was fine podsolized sand, between 2.5 and 4.5 meters deep.

Pine windbreaks were established by the farmer, Garry English, in 1984 as part of a program to prevent soil erosion and allow cropping. The windbreaks are parallel, about 200 m apart, and run approximately North-South.

The lands were cropped on a wheat-lupin rotation until 1988, then oats were introduced for an oat-lupin rotation. Lupin and oat yields were measured in 1988. Nine treatments with four replicates were harvested for each crop, cutting 20 meter long plots with a Department of Agriculture trial harvester.

Lupins in 1988 showed a distinct response to the windbreaks on the Western and Eastern sides (Fig 5). This was interpreted as a response to protection from the cold North-Westerlies in early winter, and protection from the dry Easterlies in spring.

Lupins are more susceptible to cold growing conditions than are the cereals. Also, lupin flowers are particularly susceptible to stress.

If the center lupin value is taken to be an 'open paddock yield', then the nett yield increase between the windbreaks is about 27 per cent. Allowing for the area under the windbreaks, the nett yield increase is 19 per cent. It is possible that the actual yield increase is greater than this, because the center value is at 20 tree heights from the windbreaks, and there is likely to be some windbreak effect at this distance.

The return on costs of establishment in 1984, till the single benefit of 1988, was estimated at 28 per cent per annum. This is obviously an underestimate, because there has been a reduction in soil loss, and yield increases in other years.

Oats in 1988 did not give a clear response to the windbreaks (Fig 6).

In 1989, plots were harvested every ten meters between the windbreaks, with four replicates.

Variation in yield across the paddock is more evident with more measuring points (see explanation below). However, the yield increase due to windbreaks has been estimated at 30 per cent between the windbreaks. About 17.5 per cent was from the Western windbreak, and 12.5 per cent from the Eastern windbreak.

This gives a nett yield increase of 22 per cent (allowing for the land taken up by the windbreaks).

Oats in 1989 appeared to respond to the Western windbreak and not the Eastern windbreak (Fig 8). This has not been estimated yet. It appears to be about ten per cent gain between the windbreaks; giving about two per cent gain nett.

There are several problems interpreting this information. There is a complex interaction between the elements of the system; it should not be compared to a set of imposed treatments such as in a crop variety trial.

The cropped area between windbreaks is 200 m by 2000 m. The planting, fertilizing and harvesting machines are not exactly the same width, and therefore there are lines of higher and lower yields along the long axis of the paddock. This effect in one crop year then affects the following crop in the rotation.

Weather that affects crop growth differs between years, and therefore gives widely differing responses to the windbreak.

Les Webster, farming East of Esperance, recorded a 47 per cent yield increase in the lee of a three year old windbreak. Three rows of *Pinus pinaster* were planted on the North-West side of a sand paddock. The wheat crop was sandblasted several times at the beginning of the season.

From the one year's results, it was estimated that investment in a windbreak gave an annual interest return of 40.6 per cent. The windbreak is now taller, and continuing to work *especially* in the worst seasons.

WIND AND WINDBREAKS

Tree windbreaks are highly variable between sites, species and design. To interpret the value of a windbreak, it is necessary to understand its design and management in the field.

A common recommendation is to have a 'porosity' of about 50 per cent. This is thought to allow a longer lee effect and reduce turbulence. However, there are more likely to be holes in high porosity windbreaks established in agricultural areas. Denser windbreaks give more protection close up, and may be able to avoid turbulence problems.

Examples are given in figures 9 and 10. Figure 9 shows the windspeed recordings for a single line, mature *Pinus pinaster* windbreak, about 20 meters tall. The porosity along the line was not even. Points to note are the relatively high windspeed close to the trees (all measurements taken at 1.5 m), and the level of turbulence. Turbulence is indicated by the high gusting windspeed and its variability.

The windbreak in figure 10 is a three line, mature *Pinus pinaster* planting about twenty meters tall. Porosity is lower and more even along the line. Note that there is low windspeed next to the trees, and that the gusting and steady windspeed rise steadily with increasing distance from the windbreak.

Windbreaks in the Garry English example above are three row *Pinus radiata* with low porosity in the bottom half of the trees, and increasing porosity toward the top. Windspeed recordings reflect this (Fig 11).

Note that the relative, or percentage reduction in windspeed, <u>may</u> be independant of windspeed, but the control of erosion is a more important measure.

There are thresholds of windspeed for erosion to occur (five to eight meters per second at a given height), above which the erosiveness increases as the cube of windspeed. Small reductions in windspeed therefore have a large affect on erosiveness.

Windbreak design and layout can be planned, knowing the 'wind-roses' and the erosion risks for a given site.

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Figure 1

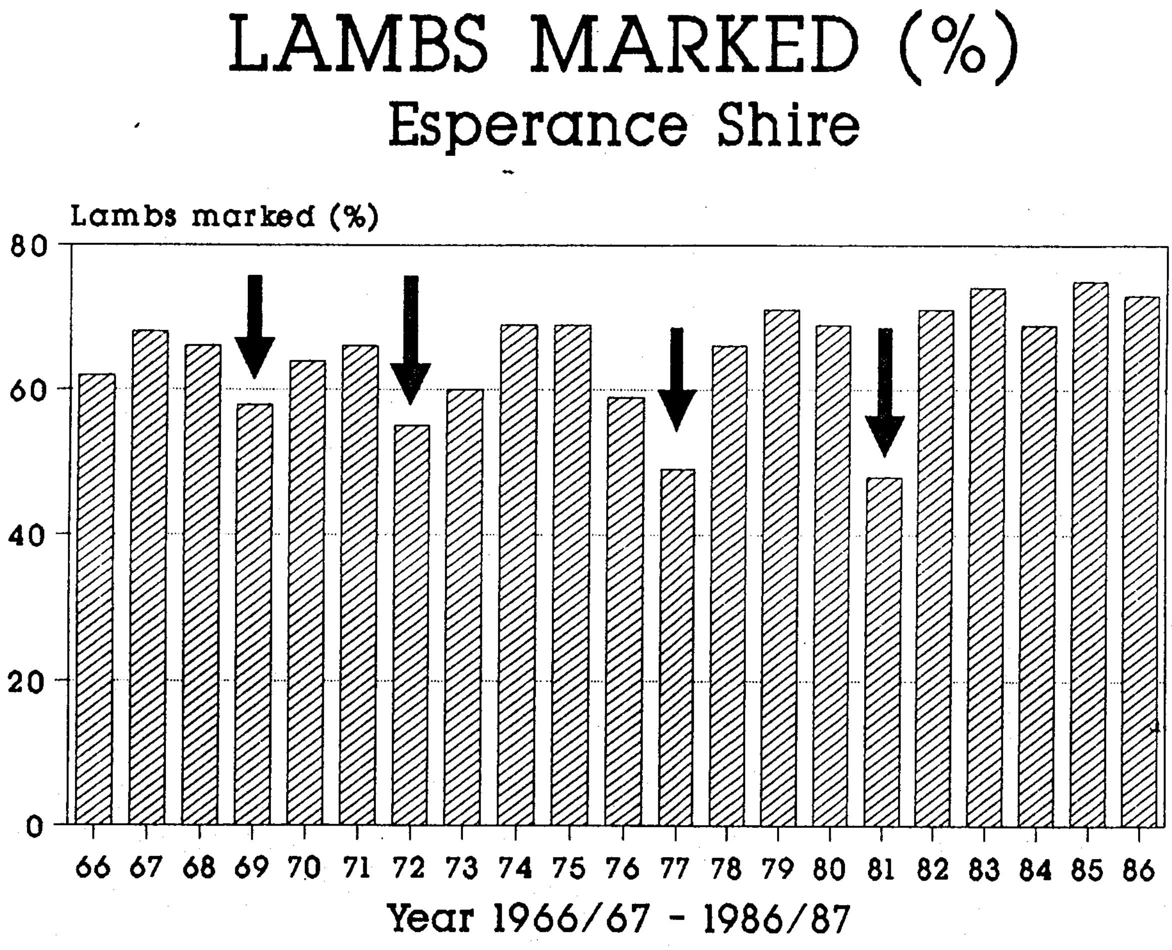

LAMBS MARKED (%)
Esperance Shire
Lambs marked (%)
80
60
40
20
0
66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
Year 1966/67 - 1986/87

Figure 2

WINDBREAK-SHEEP TRIAL
Pasture Production

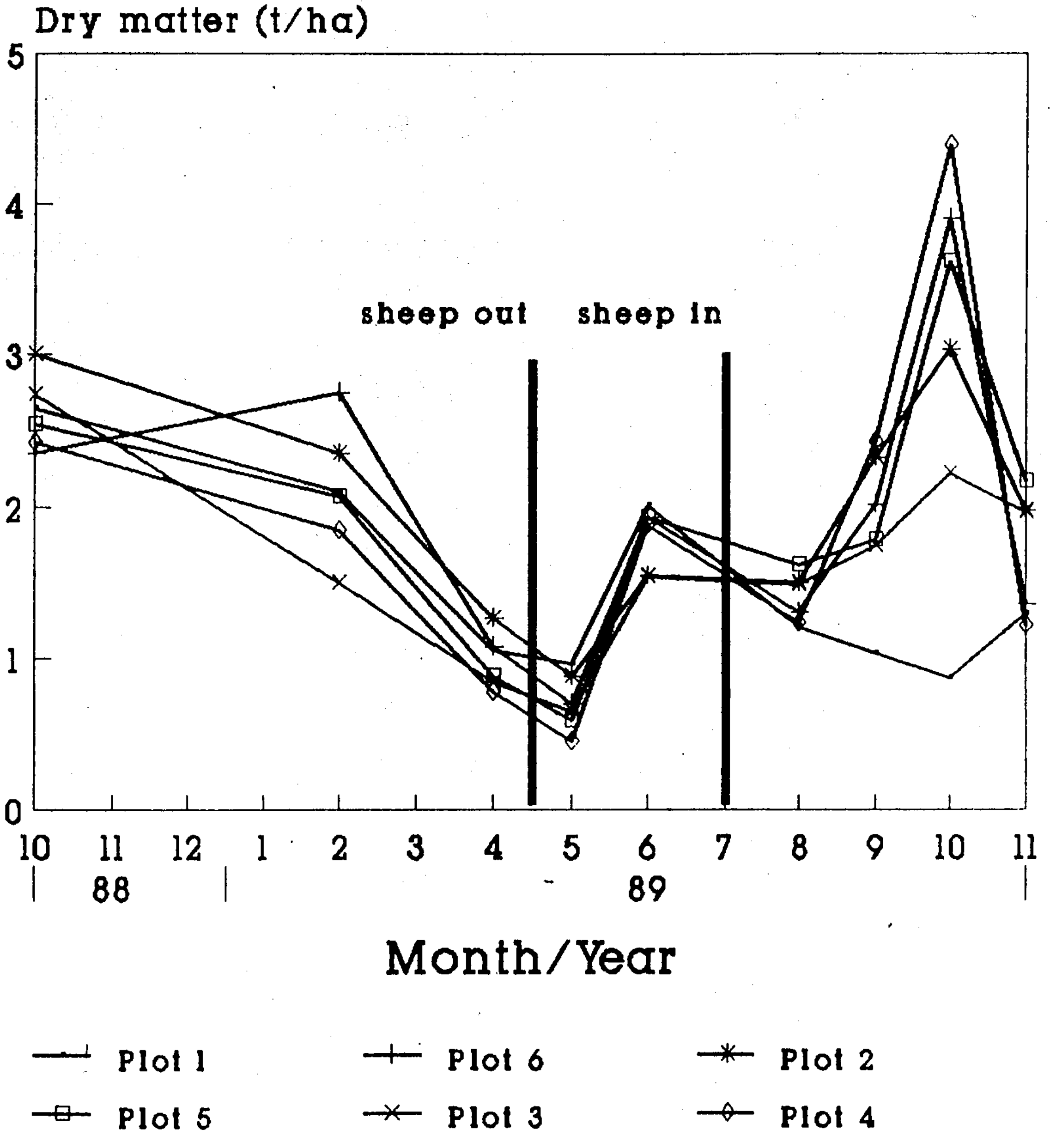
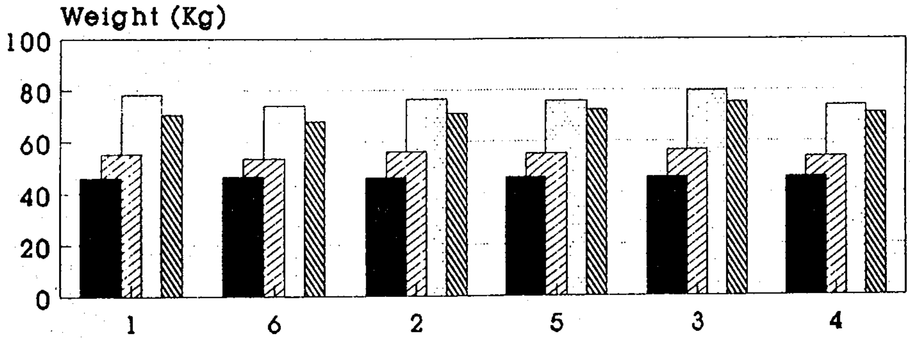


Figure 3

WINDBREAK ON SHEEP PRODUCTIVITY
'Jangarri' - Gibson



	1	6	2	5	3	4
27/5/89	46.2	46.4	46.1	46.3	46.3	46.3
28/6/89	55.4	53.7	56.3	55.4	56.4	53.9
06/10/89	78.5	74.1	76.8	75.9	79.6	73.9
15/2/90	70.6	67.8	71	72.4	75.3	71

Plot Number

27/5/89 28/6/89 06/10/89 15/2/90

Figure 4

WINDBREAK ON SHEEP PRODUCTIVITY
'Jangarri' - Gibson

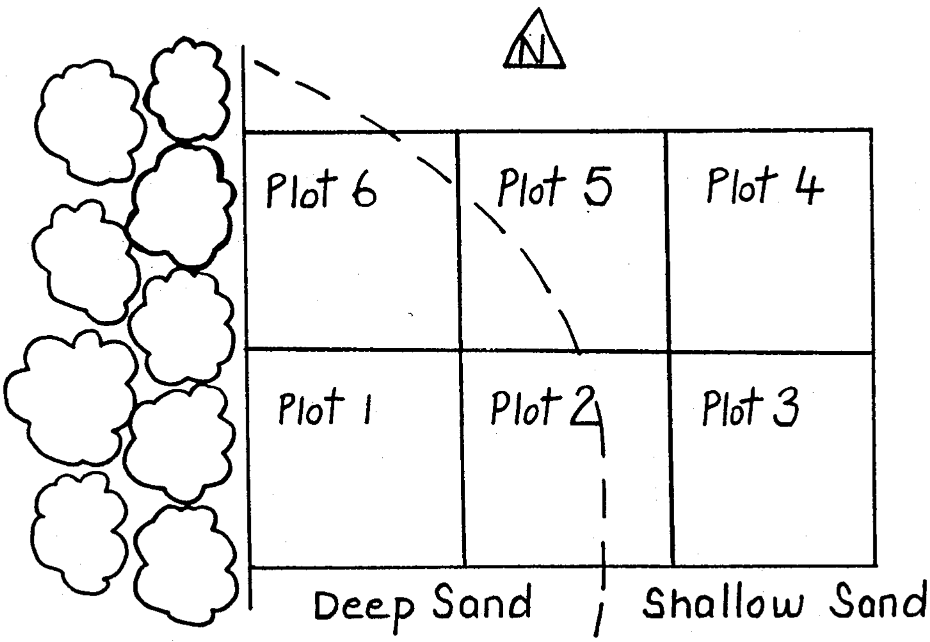


Figure 5

WINDBREAK EFFECT ON CROP YIELD
Lupin yield between parallel windbreaks

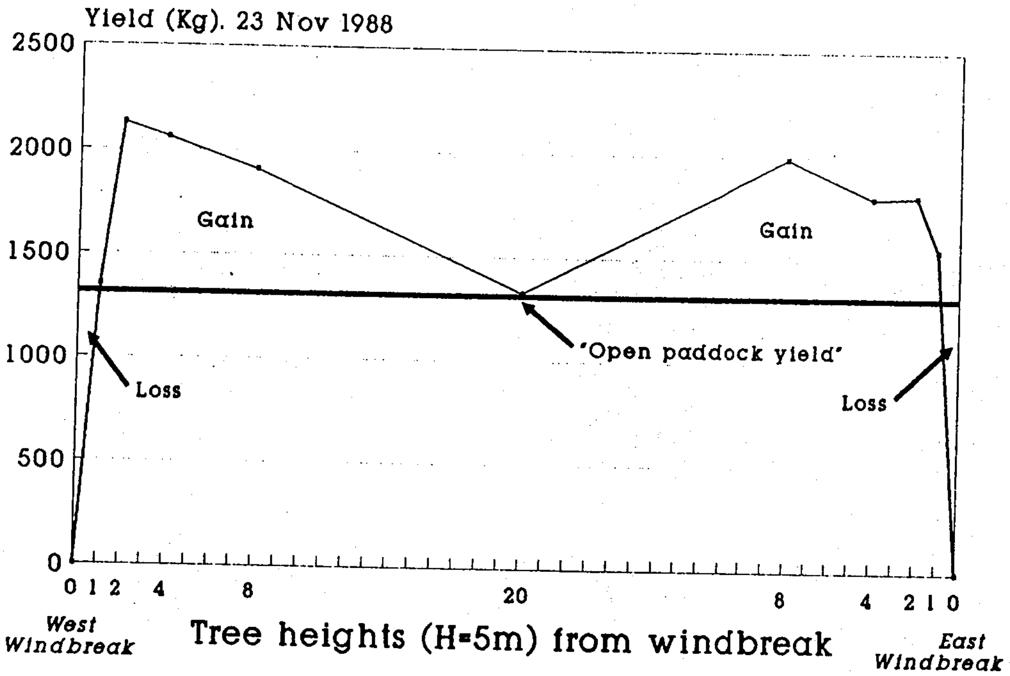


Figure 6

WINDBREAK EFFECT ON CROP YIELD
Oat yield between parallel windbreaks

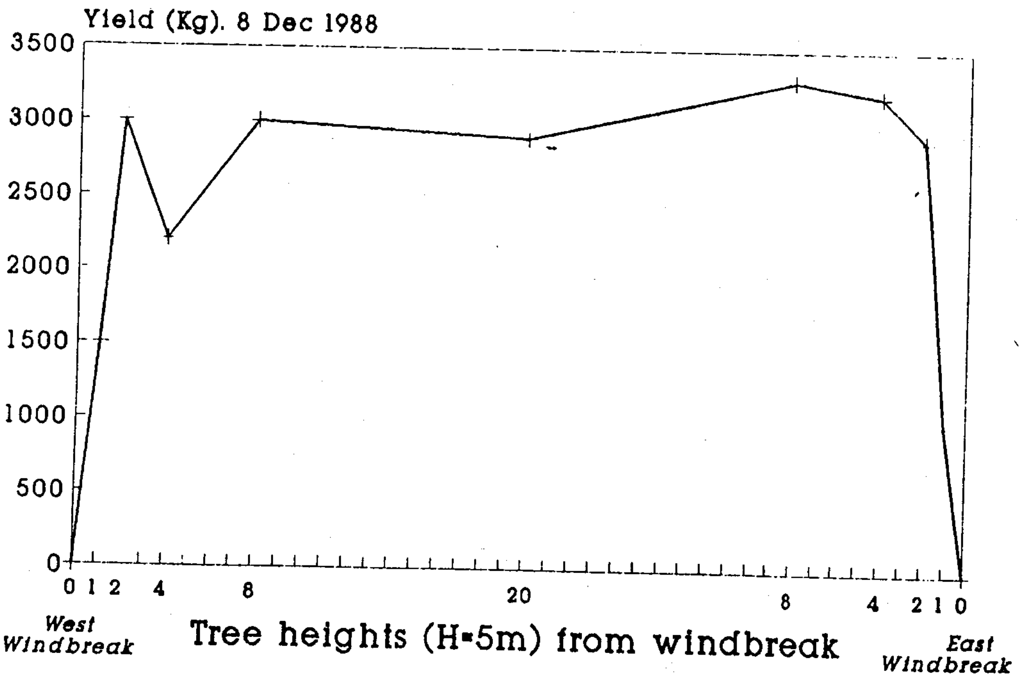


Figure 7

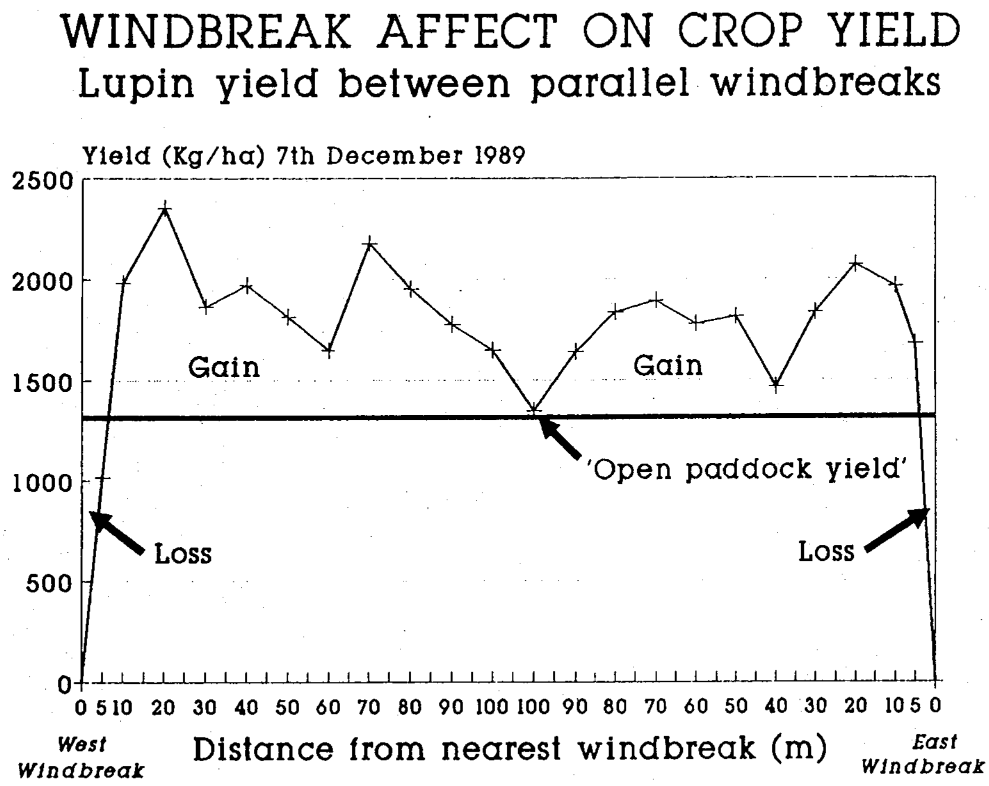


Figure 8

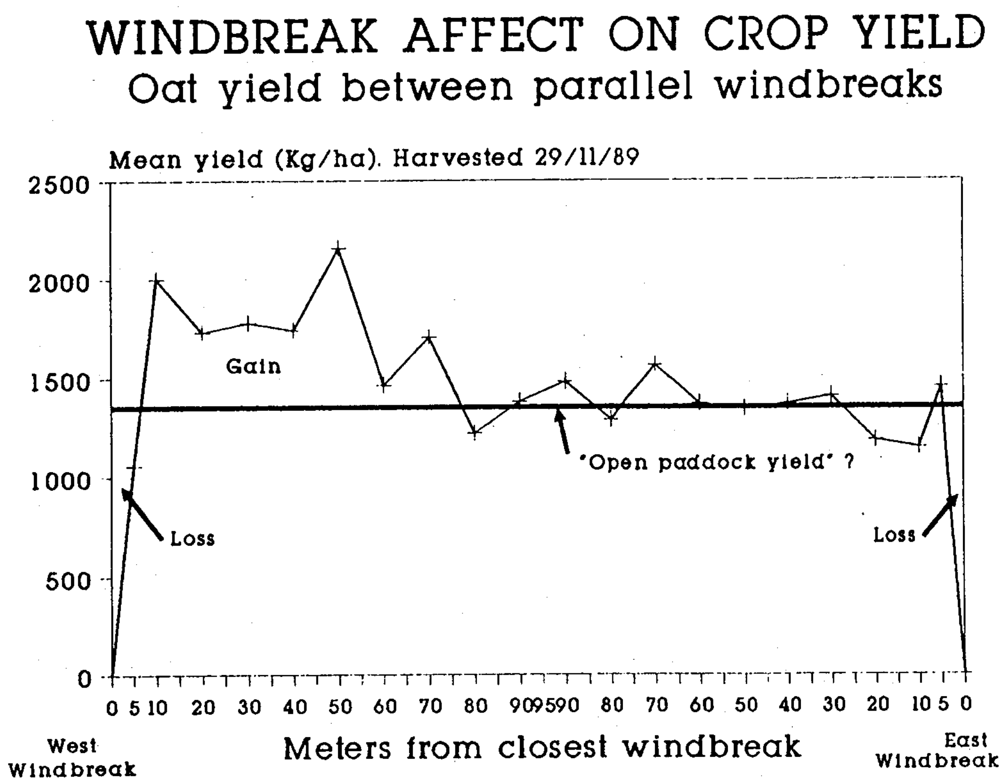


Figure 9

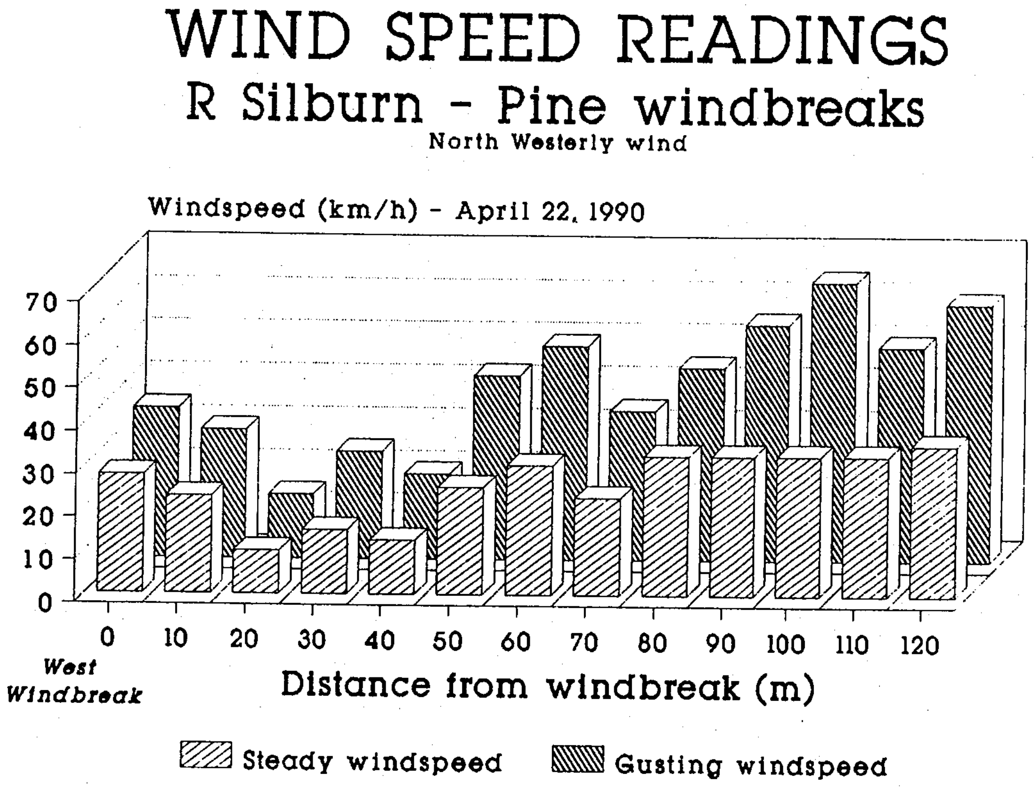


Figure 10

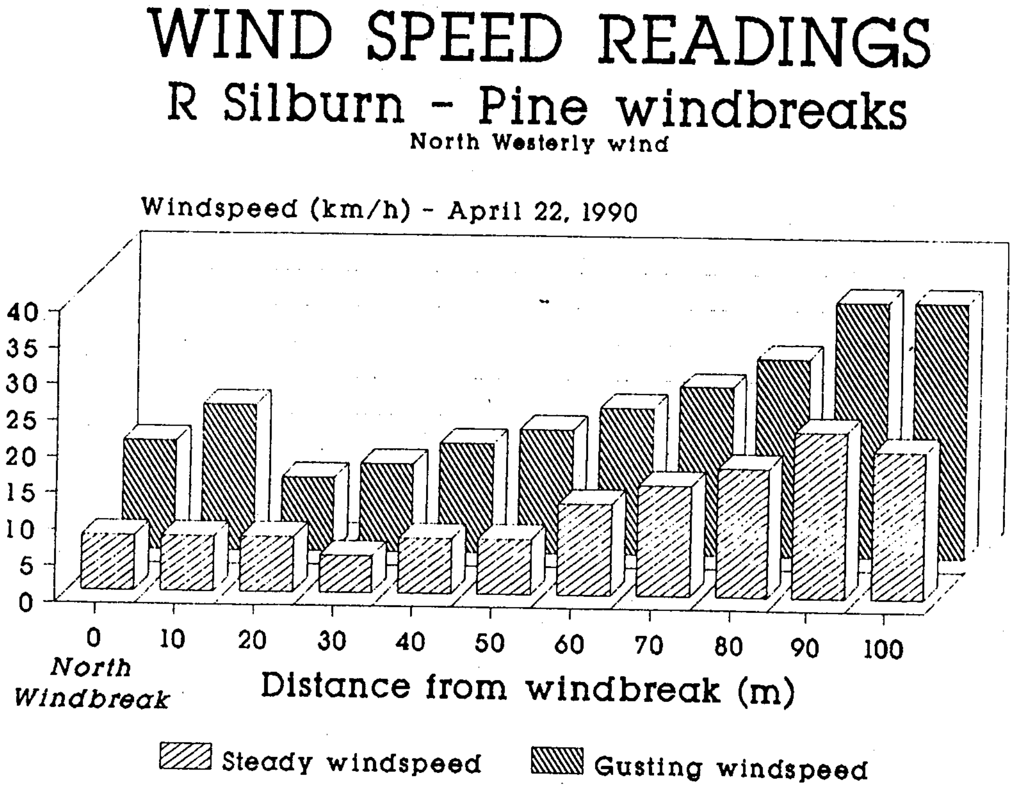
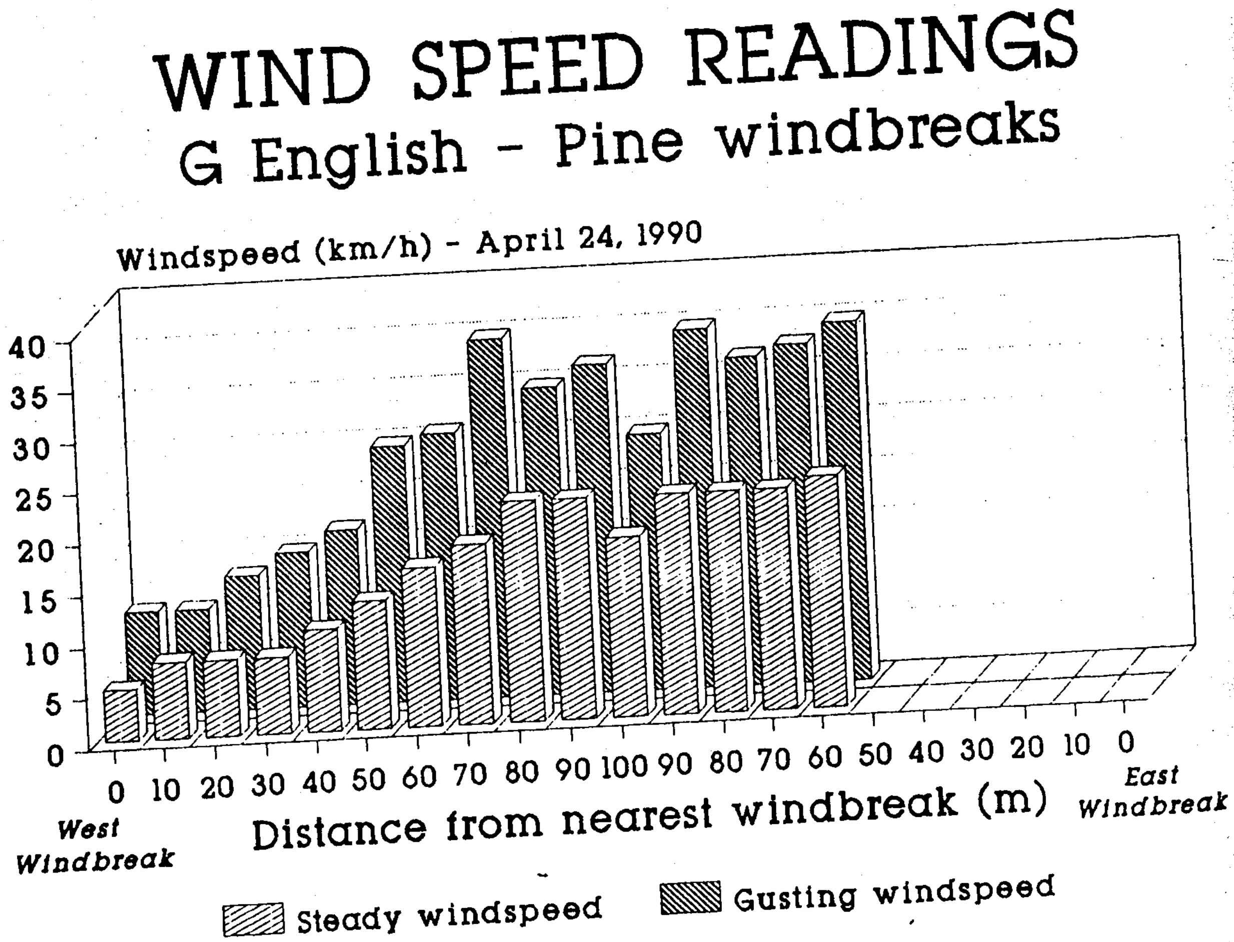


Figure 11



WIND SPEED READINGS
G English - Pine windbreaks
Windspeed (km/h) - April 24, 1990
40
35
30
25
20
15
10
5
0
0 10 20 30 40 50 60 70 80 90 100 90 80 70 60 50 40 30 20 10 0
West Windbreak
Distance from nearest windbreak (m)
East Windbreak
Steady windspeed
Gusting windspeed