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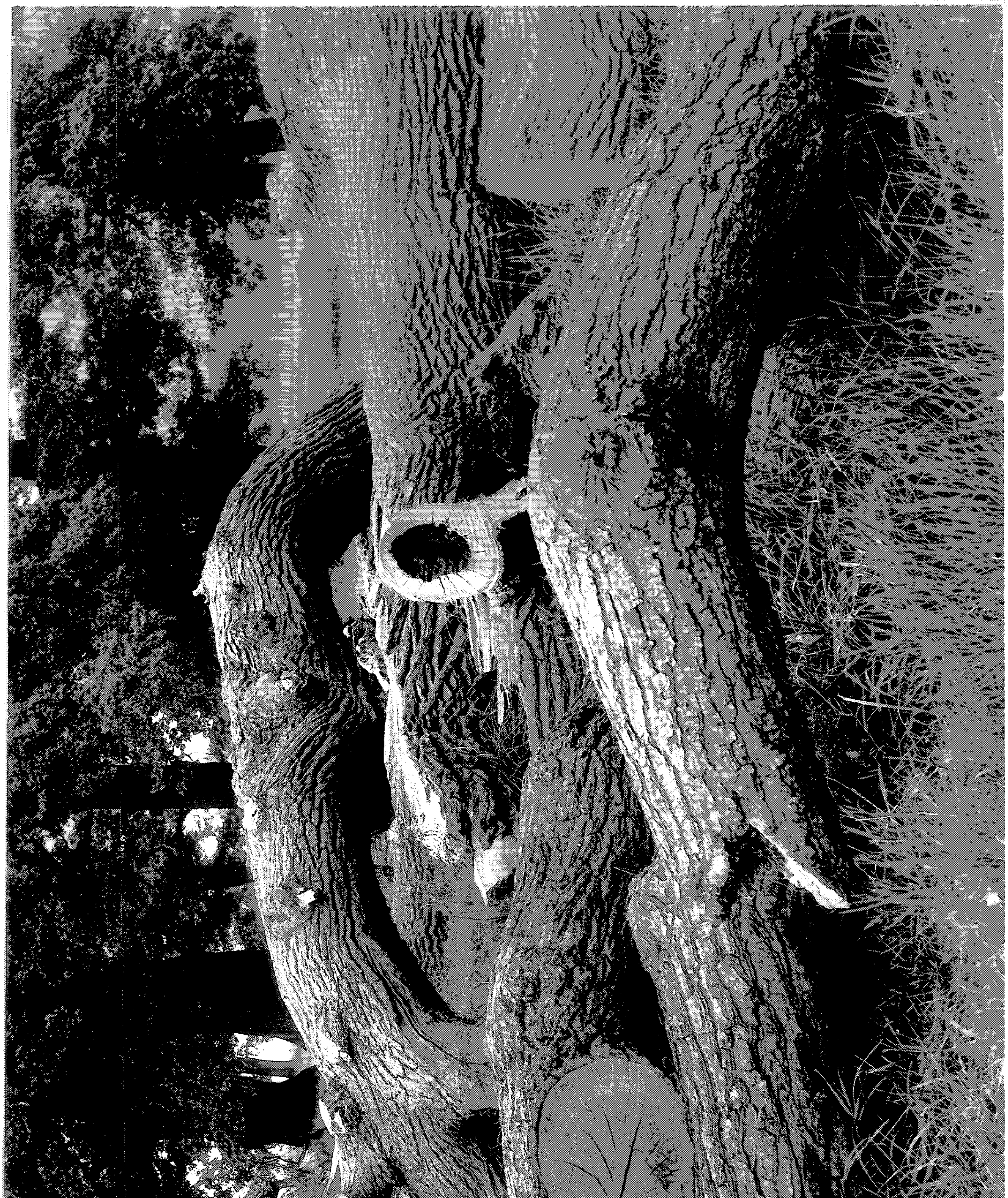

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Ecological responses to the 1987 Great Storm in the woods of south-east England

Edited by K J Kirby & G P Buckley

Proceedings of a British Ecological Society
Meeting held at Wye College, University of London,
Kent on 10, 11 September 1993

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PREFACE

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The 1987 storm stamped its mark on the woods of south-eastern England and on ecologist, foresters, planners, owners and managers of woods who had to deal with the consequences. Six years on, what have we learnt about its effects? The papers in this volume describe a range of studies on the woods and their flora and fauna presented at a conference in Wye in September 1993. In addition we have included shorter, less detailed accounts from the poster presentations. What we hope is that they will stimulate others to follow up the studies carried out in 1987 and 1988.

We deliberately did not cover in the conference the initial clear up operations, the effects on forest production or on the landscape. These are well described elsewhere (e.g. Countryside Commission 1988, 1993; Forest Windblow Action Committee 1988; Grayson 1989; Spencer & Feest 1994). Rather we wanted to know what had happened to the *cablish*.

> *Cablish*. English form of the Latin *cableicium* and the French *chablis*, both words meaning wind fallen trees; used in the Middle Ages for uprooted trees.

Structure of the report

The initial papers provide the context for the rest by describing the nature of the storm (Hopkins), the scale of damage that occurred and what has happened since in Kent (Davies & Pritchard) and the types of baseline studies that were set up immediately after the storm (Whitbread). The evolution in people's attitudes to the storm is illustrated by newspaper extracts from 1987, 1988 and 1992 (Kirby & Wakeley). There are then various contributions summarising the general changes that have taken place in specific areas of storm-damaged woodland (Blair-Brown, Flynn, King, Parker, Ryland, Whitbread & Montgomery). Ferris-Kaan's paper reminds us that conifer plantations as well as broadleaved woods were affected and provides one of the few attempts to establish controlled experiments in storm-damaged areas.

Thomas *et al.* concentrate particularly on the survival (or not) of individual damaged trees, while Buckley *et al.* provide what may be the first detailed description of "pit and mound" vegetation in England. An unexpected bonus of the storm was the reappearance of *Carex depauperata* described by Tim Rich.

Animals as well as plants were affected. Fuller *et al.* describe changes in breeding bird populations generally, while Smith looks specifically at the effects on woodpecker populations. Less is known about changes in invertebrate populations but Badmin's work on leafhoppers and Alexander's on dead wood species provide pointers to the broader effects.

Monitoring of storm effects is also placed in the context of other work looking at long-term changes in woods (Kirby).

Acknowledgements

As well as those listed in the individual contributions we would like to acknowledge the following: the British Ecological Society under whose aegis the meeting was held and who provided financial support; the postgraduate students at Wye College who helped to organise the programme (Morwenna Bolas, Francis Burch and Andrew Pennington); and various staff in English Nature who helped produce this volume and in particular Stefa Kaznowska for help with the editing.

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SUMMARY

In October 1987 a severe storm (estimated return time 200 years) over south-east England caused widespread damage to woods. Numerous studies were carried out immediately afterwards, many of which were intended to form the basis for long-term monitoring studies. Six years on, this conference explored what could be determined about the early response of the woods to the storm.

The papers and posters presented at the conference covered a wide range of sites and topics, but a number of general themes came through which are summarised below.

1. The storm was an unusual event in the south-east by human timescales (average return period of about 200 years), but this is within the lifespan of many of our major forest trees. We should not be surprised that the woodland system was able to respond well to it.

2. There was considerable patchiness in the original effects of the storm to which has been added variability in the extent to which areas were cleared and replanted (and when this took place). At present it is still reasonably easy to distinguish what was storm-damaged and its subsequent treatment but this will not necessarily be true in 20 or 30 years time. In most cases future ecologists will only be able to speculate as to whether the patterns they observe are a direct result of the storm or not.

3. Natural regeneration has been good in most woods for which we have information, even where no clearance of the fallen trees took place. This has undoubtedly been helped by the low deer numbers in the south-east. Had the storm been concentrated in East Anglia or the East Midlands there might not have been such rapid recovery.

4. Regeneration is not always of the same species as formed the previous crop. Birch for example is growing abundantly in what were formerly oak and beech stands. This is consistent with the response of temperate woodland elsewhere to disturbance. If for landscape or production reasons there is a need to establish a high proportion of other tree species to achieve a particular composition in the canopy, then planting may be necessary.

5. Far fewer trees died completely than was at first feared. Those that lost their tops have often sprouted below the break forming natural pollards. Others lying almost flat but still with some roots intact have lines of young stems growing up vertically along the trunks. How stable will such stems be in 10 years time; will the lines be taken as evidence of planting in future?

6. Although media attention after the storm was on the areas of very large scale blow-down, these were the minority. In most woods the gaps were quite small; on the whole they have not been enlarged by subsequent tree loss, but have filled up by regrowth of damaged trees and expansion of adjacent canopies. The opportunities for gap-dependent regeneration and gap-phase species were more transient than was at first thought.

7. The ground flora response in storm damaged woods depends on the size of the gaps created and level of ground disturbance, the latter either caused directly by the storm or the subsequent clearance. Bramble has become dominant in many areas left undisturbed after the storm, forming impenetrable thickets over the fallen trees. There is however usually regeneration coming through the bramble. Bramble tends to be less abundant in cleared areas.

8. Abundant pits and mounds, associated with overturned tree bases, are a new element in modern broadleaved woods in England. Distinct vegetation patterns have developed with some species found mainly on the plate, others in the pit. It will be interesting to see whether long-term differences develop such as have been found in North American studies.

9. The changes in woodland structure have had consequent effects on bird populations. The increase in low cover (bramble growth, root plates, regeneration and regrowth from fallen trees) has benefitted warblers and other young stage species. However in some woods there have also been benefits for mature stage species such as woodpeckers because of an increase in available dead wood and potential nest sites.

10. Less is known about changes to invertebrate populations, but some increases in saproxylic species will have occurred because of the increased availability of fallen timber. Gap phase species and those on shrubs have also shown localised increases.

11. The research set up after the storm has provided numerous insights into how woods respond to natural disturbances which will help us to assess the impact of human intervention. However there is an imbalance in the type of studies carried out, with few experiments or fully controlled surveys. Studies have been pursued in isolation rather than drawing together data across sites or across groups on any one site.

12. Notwithstanding the previous point, the number of potentially long-term studies that were established after the storm was as unprecedented as the event itself in recent times. Unfortunately it is not clear that all are being or will be maintained. The conference highlighted the value of such work but also its vulnerability to changes in funding, personnel etc. We hope sufficient will survive to repeat the conference in 10 years time.

CONTENTS

THE STORM

Brian Hopkins, New England College, Arundel, West Sussex BN18 ODA

Summary

The ecological effects of a storm depend on the ecosystems in its path and the life stages of the organisms present. They also depend on the nature of the storm itself. What happened during the night of 15-16 October 1987 is described in physical terms. Particular attention is paid to the wind and gust speeds for, ecologically, these are the main factors. The storm is compared with other major storms, and their cause and likely frequency are considered briefly.

Introduction

Wind is the movement of air from areas of high pressure to areas of low pressure, and wind speed depends on the pressure gradient - the difference in pressure relative to the distance. A gale is Beaufort Force 8, a mean wind speed of at least 34 knots[1] at ten metres above ground level maintained for ten minutes. Winds stronger than gale are uncommon over land areas of Britain: storm 10 (48-55 kn) is 'seldom experienced' and violent storm 11 is 'very rarely experienced' (Meteorological Office 1982).

Tiree has the highest annual mean wind speed (15 kn) in the UK; for comparison, Gatwick has 9 kn. The record wind speeds over 1 h for the UK are 78 kn at the summit of Mt. Cairngorm (1245 m) and, for the English uplands, 53 kn on Great Dunn Fell (847 m). In the lowlands the values are 44 kn at Teesmouth and, for southern counties prior to 1987, 41 kn at Portland Bill.

Wind has constant gusts and lulls, and gusts are generally up to two Beaufort units above the mean wind speed. Where there is a recording anemometer the highest gust can be read off. Otherwise, wind speed is recorded as the mean of two 15-second readings taken within the ten minutes preceding each hour - a method which underestimates the maximum gust.

What causes storms?

The excess inflow of solar energy to equatorial regions and outflow from polar regions drives the earth's atmospheric circulation and causes the mid-latitude storms. Depressions arise when two air masses, the south-westerly tropical maritime air mass and the north-easterly polar maritime air mass, in the case of north-western Europe, meet at a front. An area of low pressure, with its associated warm and cold fronts, forms and deepens as it moves north-eastwards across the Atlantic Ocean. As it approaches north-western Europe, the fronts generally occlude and the depression fills. Around the low pressure area the winds are anti-clockwise with the highest wind speeds generally about 300 km to the south-east of its centre.

Depressions are a normal part of British weather and produce most of the gales that the coasts of southern England experience on five to ten days a year; at Dungeness, for example, gales blow for 0.3% of the time. In inland lowland areas gales occur on less than two days a year. This may be compared with 49 days at Lerwick and the 3.3% of the time they occur at Tiree.

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1 Whilst not an SI unit, knots, like millibars (mb), are approved by the World Meteorological Organisation. Use the multiplier x 1.15 to convert to miles h^{-1}, x 1.85 for km h^{-1} and x 0.515 for m s^{-1}.

Effects of storms

The ecological effects of high winds depend on the history and maturity of the ecosystems in a storm's path, the season of the year, and the age and life stages of the organisms present. Severe storms are infrequent in southern England and the ecosystems and species are, consequently, ill-adapted to them. The 1987 storm occurred before the autumn leaf-fall when the trees still possessed most of their leaves. The summer had been the wettest for 30 years in parts of the south-east and the soil had been saturated since late August - three months earlier than normal. October itself was the fourth wettest in England and Wales since records commenced in 1727 (Northcott 1988). Consequently the trees were rooted in very wet soil.

Storm track

In the account which follows all times are UTC (GMT) and, unless otherwise stated, those after 1600 refer to Wednesday 15 and those before 1300 to Thursday 16 October 1987. This account is restricted to the British Isles and is based mainly on Burt and Mansfield (1988) supplemented by Advisory Services Branch (1988) and Woodroffe (1988). Adjustments have been made to correct inaccuracies in the early meteorological data. After about 0400, the storm disrupted electricity supplies and prevented the timing of many anemometer records.

Rain fell throughout the 'storm area' during the 2100-0900 period of the storm. The Thames Valley and north Hampshire received 12-18 mm, whilst the West Country, Wales, and parts of northern England had considerably more. These amounts were not particularly unusual.

The track and central pressures of the storm centre are shown in Figure 1. The westerly track of the depression commenced to turn northwards on the morning of 15 October as it headed towards Spain and, by 1800, the storm had developed a vigorous centre in the Bay of Biscay. By midnight it had deepened further and developed two centres between Cornwall and Brittany. Its lowest pressure, estimated as 951 mb, occurred about 0100, shortly before the centre made landfall south of Plymouth. It then travelled north-eastwards across England, increasing in pressure as it went, and crossed the coast to the north of Hull with a pressure of 959 mb about 0600.

Wind speeds

The wind speeds were quite exceptional and it was the gusts that caused the main damage and disruption. So, this paper will concentrate on the wind. South of a line from Southampton to Ipswich the mean wind speed was over 70 kn for a period of three to four hours. This is hurricane force 12 (>64 kn). (Hurricanes themselves are tropical storms and are structurally different from mid-latitude depressions. Also, their energy comes from the latent heat of condensation of the enormous amounts of water evaporated from tropical oceans.)

The pattern of wind speeds around the centre changed little as it moved across England. A computer model, prepared after-the-event, showed the winds around the storm centre were a huge vortex with the highest wind speeds in the region of 300 km to its south-east (Lorenc *et al.* 1988). The evidence however from the direction of fallen trees and of trees whose tops were twisted off shows that the storm was more complex than this and that local topography caused many small, but equally violent, eddies.

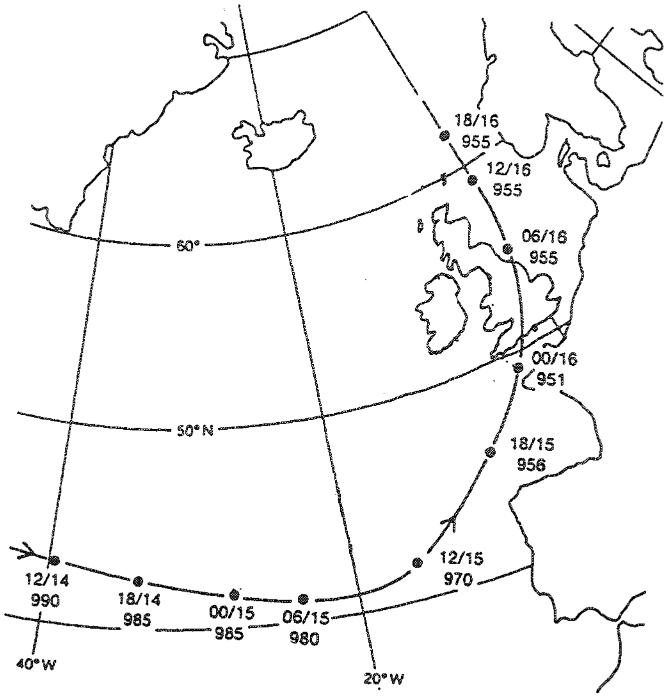

Figure 1 The track and central pressures (mb) of the storm centre from 14 to 16 October 1987. The numerals are in the form '12/14 990' depicting the position of the storm centre at 1200 on 14 October when the central pressure was 990 mb. Simplified from Swinnerton-Dyer & Pearce (1988).

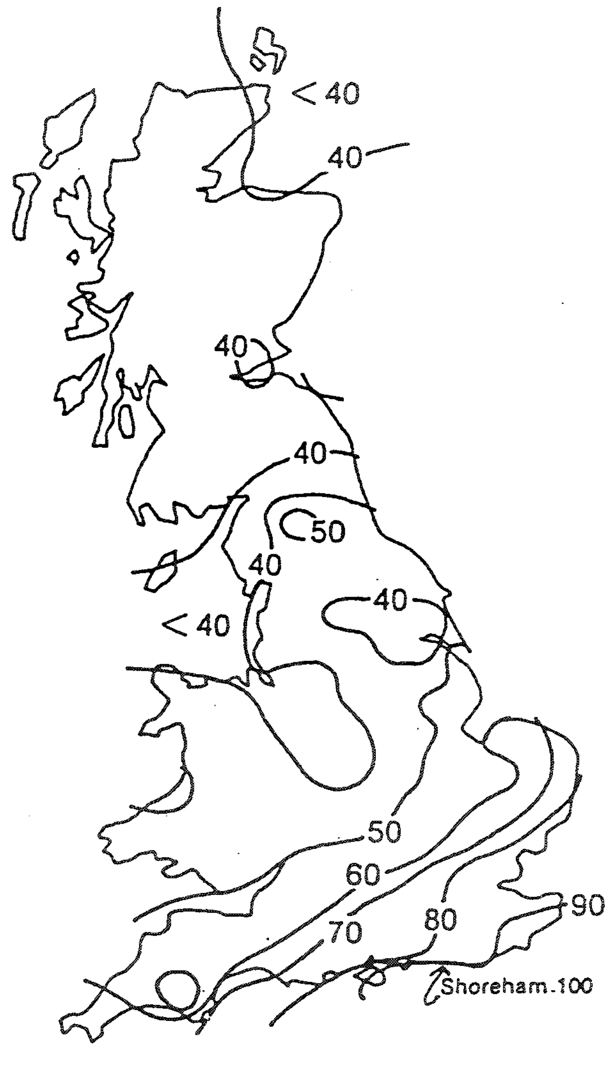

Figure 2 Magnitude of the highest reported gusts (kn) on 16 October 1987. Simplified from McCallum (1990).

Gales started along the Channel coast at 2200 and, by midnight, there were storm force winds in the Channel and gusts of 70 kn along some coasts. The first inland gales were at 0100 and, one hour later, came the first storm force winds, a pressure of 957 mb at Exeter (the lowest over England and Wales for 150 years) and gusts of 63 kn in central London. By 0300, the wind was more than 30 kn over all south-western, central-southern and eastern England and the London Weather Centre reported a record gust of 82 kn.

The storm was at its strongest and over the widest area from 0400 to 0500 when the wind was at least storm force 10 (48 kn) over a wide area of southern and south-eastern England. This was the time of some of the strongest gusts: 100 kn at Shoreham and 94 kn at both Langdon Bay (Dover) and at a height of 195 m on the British Telecom Tower in London. It was also the time of widening gaps in the records because of telecommunication problems. At 0500 there was an exceptional pressure gradient all around the southern side of the centre which caused mean winds of about force 11 at St Catherine's Point (Isle of Wight) and Herstmonceux and gusts over 80 kn there and at Gatwick.

By 0600 the wind had abated slightly over the south-east but there were still many force 11 gusts. With the storm's centre over the North Sea the winds dropped and, by 0800, the only gale force winds were near the East and Channel coasts. By noon there were no gale force winds on land and, so far as the UK was concerned, 'The Great Storm was over'.

The highest reported gusts (Figure 2) were over 100 kn in the English Channel and at Shoreham (the storm's highest in Britain). The region of greatest damage was south-east of a line from Southampton to Ipswich where the mean wind speeds reached at least 70 kn and gusts over 80 kn occurred.

Additional aspects

In addition to these extremely high wind speeds, the storm was unprecedented in its very rapid increases in pressure and temperature. There were substantial falls in pressure on the afternoons of 14 and 15 October, so that pressure was already low before the rapid fall during the early morning of 16 October (Figure 3). None of these rates of fall were exceptional. However, the ensuing rise of over 9 mb in an hour over a wide band from Dorset and the Isle of Wight to the Wash, and about 20 mb in three hours in some places, broke previous records; the 12 mb rise in an hour at Hurn Airport (Bournemouth) and the 25 mb rise in 3 hours at Portland also set new records.

The warm front associated with the depression was well ahead of it and was responsible for an unprecedented rise in temperature of 7-9 ^{O}C in an hour, but mostly within 20-30 minutes, in a broad band from Dorset to Norfolk. At Heathrow it set a new record of 8 ^{O}C in an hour. The passage of the front was associated with a change in wind direction from north-easterly to south-westerly and an increase in wind speed (Figure 4). At 2100, Gatwick had a 15 kn SSW wind and a temperature of 17 ^{O}C whereas at Heathrow, only 35 km to the north-west, there was a 5 kn NE wind and a temperature of 9 ^{O}C.

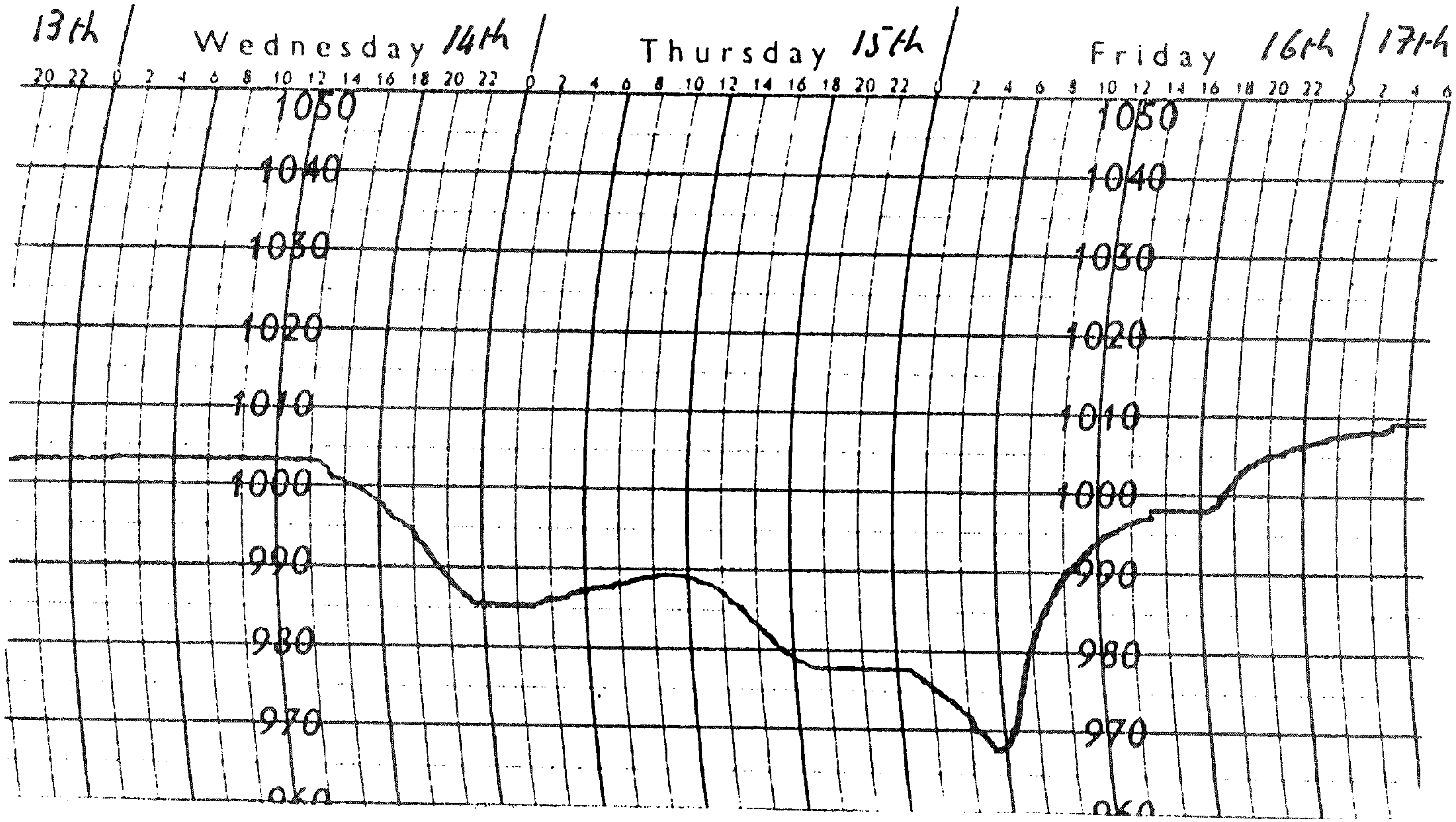

Figure 3 Barograph trace (mb) for Arundel from noon on 13 October to noon on 17 October 1987. New England College, Arundel.

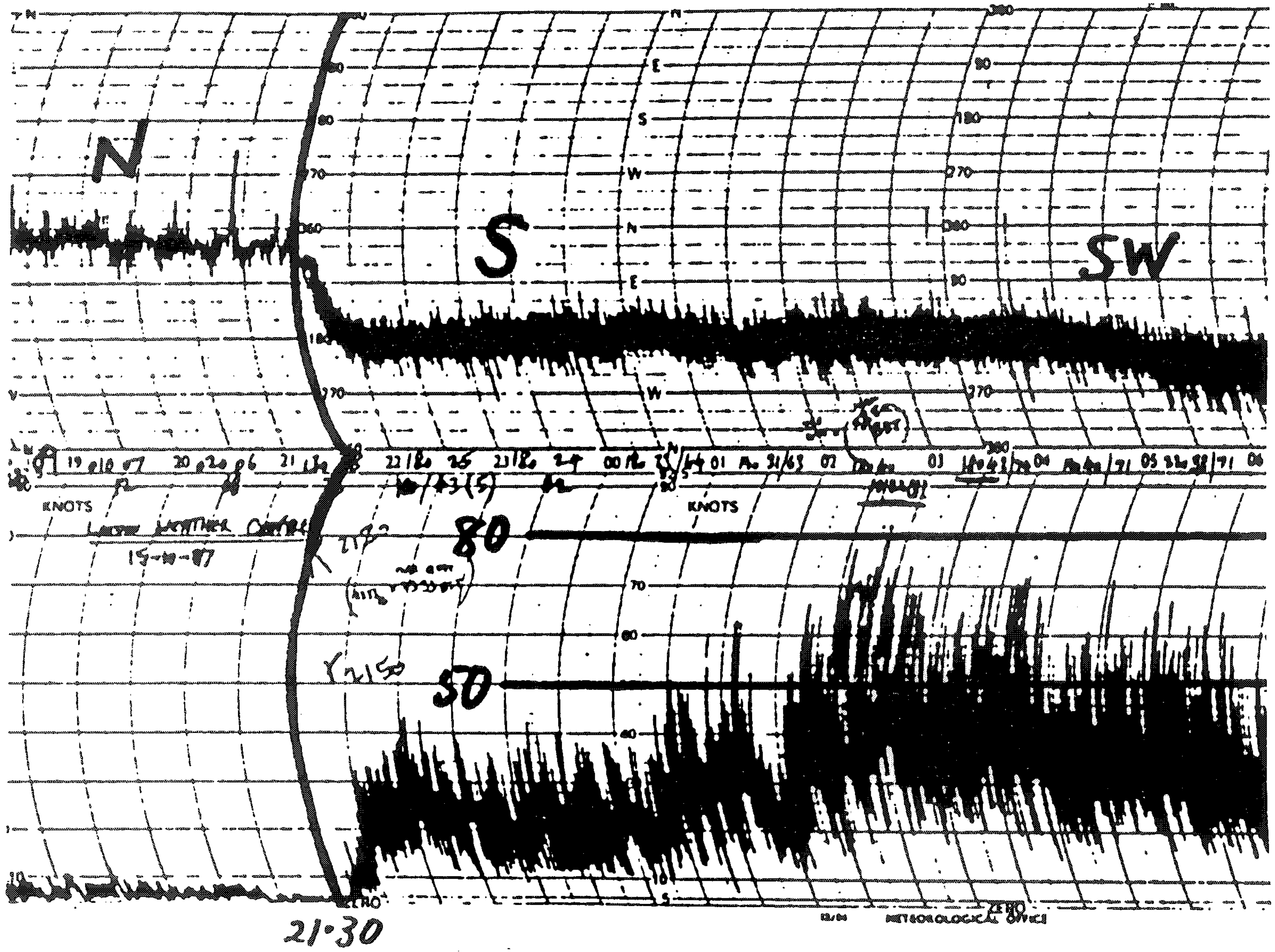

Figure 4 Anemometer traces (kn, and degrees and compass points) for the London Weather Centre from 1900 on 15 to 0600 on 16 October 1987. Simplified from Burt & Mansfield (1988).

Consequences of the storm

The storm caused much of south-eastern England to be at a standstill for a day; it was the largest disruption since World War II. The Port of Dover, the Tower of London and the Bank of England closed and the Stock Exchange suspended trading; there were virtually no trains south of Rugby and 90% of the roads in Kent were blocked; three cross-Channel ferries were in difficulties and 13 lifeboats were launched; 5 million people were without electricity; over half the churches in Sussex were damaged; 15 million trees were blown over; one in six of the householders in south-eastern England submitted an insurance claim and the total insurance loss (including continental Europe) was £3500 million (ten times the previous maximum for a weather loss); and the uninsured cost is unknown - it would have been enormous for fence repairs and tree removal alone. Surprisingly, there were only 19 deaths, but the storm did occur during the night. The destruction would have been worse had there not been the rapid rise in pressure and a neap tide which undoubtedly saved much flooding from the overnight high tide on the South Coast (Ramsay 1988).

Comparison with other storms

What made this storm so severe? It was a vigorous mid-latitude depression which intensified abruptly by explosive cyclogenesis due to its large temperature contrast and the earth's rotation increasing its vorticity (Hoskins & Berrisford 1988). Autumn is the warmest time of year in Biscay and, in October 1987, there was very warm moist air over France and a large temperature contrast in north-western Europe. It is likely that a powerful jet streak triggered this large energy store into the great storm. All such intense cyclonic storms have a 'back-bent' warm front surrounding a warm core (Figure 5) and a curved zone of very strong winds (Monk 1992).

Comparisons with other storms are not easy. Anemometer sites are often changed and socio-economic disruption depends largely on the level of development of the affected region. There are however some historic records of major storms (Lamb 1991) and good data on aspects such as mortality and damage to churches.

There have been about ten major storms since October 1987; most were in January and February 1990. Although some were intense cyclonic storms with back-bent warm fronts, a comparison of the meteorological data and the damage caused shows that only the one on 25 January 1990 (McCallum 1990) was of the same order of magnitude as the 1987 storm. It had an estimated over-land minimum pressure of 949 mb near Edinburgh (compared with 957 mb in 1987) and wind speeds of 90 kn over a wide area of southern England and western Wales. Its maximum recorded gust of 93 kn (100 kn in 1987), at Aberporth, was one of the several new records including one for Heathrow. There were 47 deaths; two-and-a-half times the number in 1987, but the 1990 storm covered a wider area and occurred during the daytime. Over three million trees were destroyed, only one-fifth of the number in 1987 when they were in leaf; also, the 1987 losses ensured that fewer susceptible trees were available for wind-throw in 1990. The insurance loss was however £3200 million - 90% of that in 1987.

The most recent historical storm over southern Britain which was of similar magnitude to 1987 was on 26-27 November (7-8 December New Style) 1703 (Lamb 1988, 1991). Daniel Defoe (1704) gave a careful account of this based on his own observations - he gave up counting wind-thrown trees when his total reached 17,000 - and on letters from respondents (Clow 1988). South of a line from mid-Wales to Lincolnshire, there was widespread structural damage to buildings, including the destruction of over 400 windmills and the then new Eddystone lighthouse. Twelve naval ships were lost with two-thirds of their crews and an estimated total of about 8000 deaths.

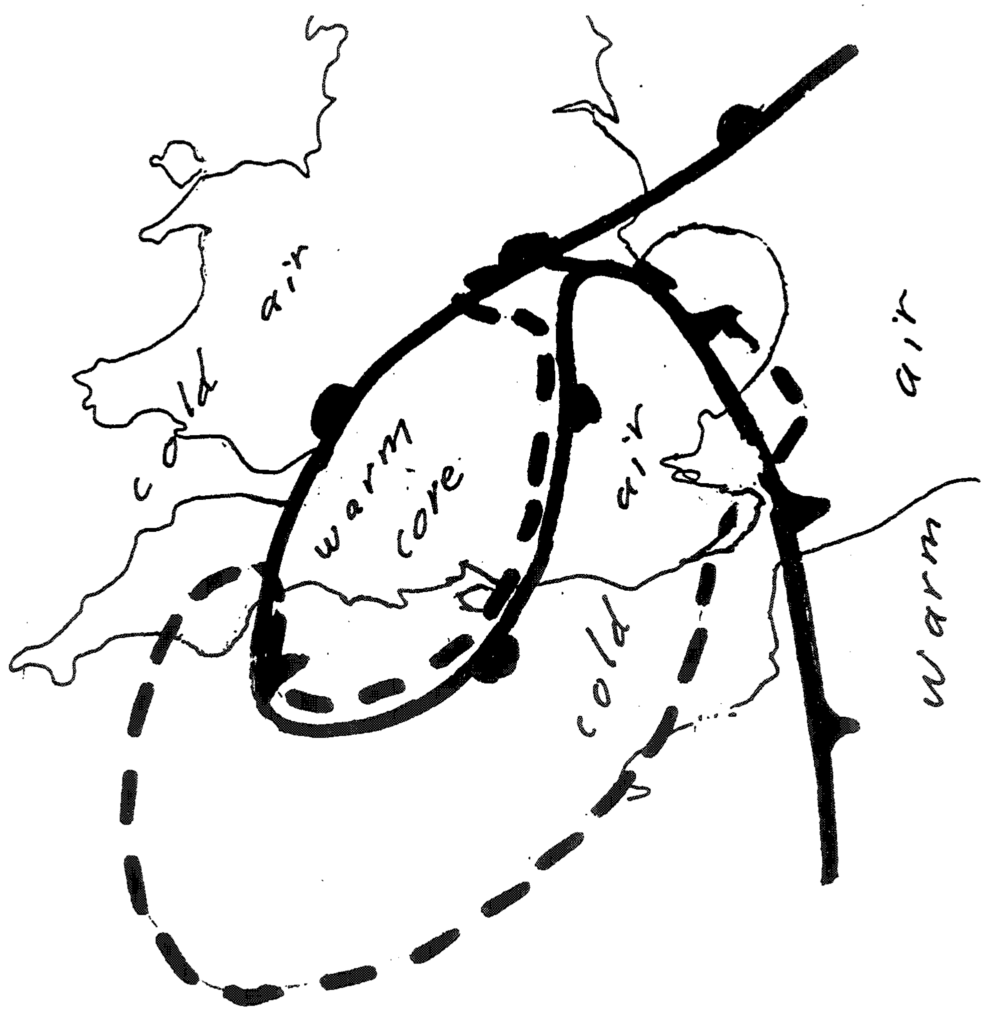

Figure 5 Surface analysis for 0300 on 16 October 1987 showing the positions of the fronts and (interrupted line) the area of strongest winds. Modified from Monk (1992).

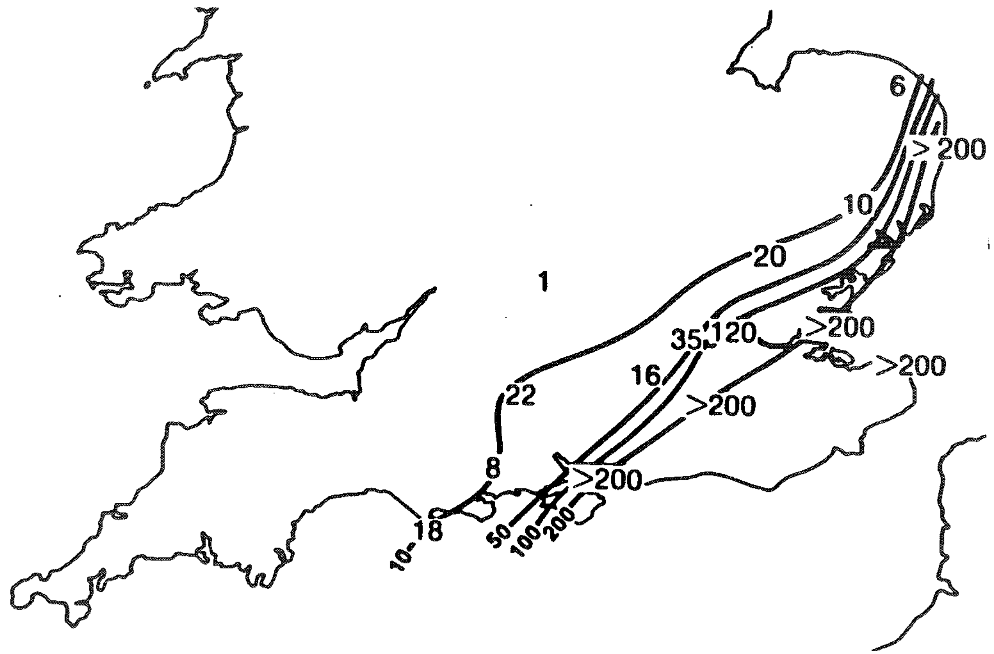

Figure 6 Estimated return periods (years) for the highest gusts on 16 October 1987. Simplified from Advisory Services Branch (1988).

Comparison with 1987 is difficult. In 1703, there were many more ships and trees (but these would have been leafless), and buildings were less substantial. However, from the available meteorological data (including three barometer records), Lamb (1988, 1991) prepared the earliest synoptic map for a severe storm and, whilst there are no reliable wind speeds, concluded that the two were among the eight most severe storms in the whole of north-western Europe since 1509, and that the 1703 one was probably the greater of the two.

There is another measure of severity. This is to calculate the return periods of extreme records for stations with at least 30 years' data. Maps of the return periods for the highest mean wind speed and highest gust speed of the 1987 storm were prepared by Advisory Services Branch (1988). Both were very similar and the somewhat less smooth map for the highest gust speed is reproduced as Figure 6. To the south-east of a line from Southampton Water to the east Norfolk coast the return period is greater than 200 years. It falls off rapidly to the north-west of this line, and from Portland to Norwich it is about 10 years. This method has advantages in that it is based entirely on physical data and is independent of location. Thus, southern England is directly comparable with Scotland, where mean wind speeds over 55 kn and gusts of 90 kn occur more often than once in 50 years (Burt & Mansfield 1988).

Conclusion

The storm was unprecedented in three ways: the rapid rises in pressure and in temperature, and the extremely high wind speeds that were its main ecological factor. Storms of this magnitude are to be expected less than once in 200 years in southern England. However while the previous one was 284 years earlier, the next occurred only 39 months later.

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SATELLITE PHOTOGRAPHS AND METEOROLOGICAL CHARTS (poster)

Brian Hopkins, New England College, Arundel, West Sussex, BN18 ODA

A major feature of all intense cyclonic storms is a 'bent-back' warm front surrounding a warm core - although this was not generally known until after the 1987 storm. Five infra-red photographs from a polar orbiting satellite illustrated the development of the storm. These showed two banks of cloud over the Bay of Biscay (during Wednesday 15 October) which corresponded with two fronts. Such a phenomenon is the precursor of a 'bent-back' warm front which, in this case, occurred about midnight. It is a valuable forecasting aid and was used successfully to predict the intense nature of the storm on 25 January 1990 (Monk 1992).

The Meteorological Office's Daily Weather Summaries for Wednesday 15 and Thursday 16 October were also demonstrated. Unlike later analyses, these had not been corrected for errors and did not show the 'bent-back' warm front. Nevertheless, they illustrated several features of the storm including the wind speeds, and areas of heavy rain and thunderstorms.

MONK, G.A. 1992. Synoptic and mesoscale analysis of intense mid-latitude cyclones. *Meteorological Magazine* **121**, 269-283.

AN ASSESSMENT OF POST-STORM WOODLAND ACTION CENTRED ON TWO AREAS SURROUNDING SEVENOAKS AND CANTERBURY, IN JULY 1990

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Summary

An assessment of post-storm woodland action was undertaken as part of a much larger survey of land use change in Kent (1961-1990). Nearly one third of Kent was studied and this focused upon two areas, Sevenoaks and Canterbury. Photointerpretation of colour aerial photography taken after the Great Storm was compared to later aerial photography to appraise the type of action taken and to identify areas where nothing had been done. Initial results show that by July 1990, over two-thirds of windblown sites had received some form of post-storm woodland action leaving less than a third of sites apparently as "wilderness" areas. Broadleaved woodlands were the most affected in the sample sets with small woods most prone to storm damage.

Introduction

The storm in the early hours of 16 October 1987 was the most destructive since Daniel Defoe's record of the great gale of 1703 (Hopkins 1994). Gusts of wind in excess of 100 mph were recorded causing an estimated damage of 15 million windblown trees in the south-east of England (Forest Windblow Action Committee 1988). In Kent alone it has been estimated that 2 million trees were windblown, destroying 18% by volume of broadleaved timber and over a third of the coniferous timber.

Storms of this magnitude are very unusual in Britain and as such provide a unique opportunity to study their immediate and long-term effects, identify landscape impacts and monitor woodland management initiatives. The study presented here was initiated in 1991 as part of a broader landscape and land use change project carried out by Kent County Council Planning Department, with support from Task Force Trees. The findings reported here provide strategic information to inform and support the development of the Kent Landscape and Woodland Rehabilitation and Countryside Strategies.

Aims and objectives

The aim of this study was to assess the scale and type of post-storm woodland action by determining the extent of storm impact in Kent in 1987 from available aerial photographic coverage and the fate of selected areas from 1990 aerial photographs. Aerial surveys after the storm were confined to two areas of East and West Kent and these provided the baseline for this study.

Although not as accurate or as informative as ground survey, aerial photographic interpretation offers a rapid method of assessing changes in woodland with the result that more land can be surveyed at any given time. Other studies on storm damage assessment have relied on sampling as a form of research. This provides detail but lacks broad coverage. In this study the aerial photograph interpretation was adopted since a broad picture of the impact of these storms and the action taken subsequently was sought.

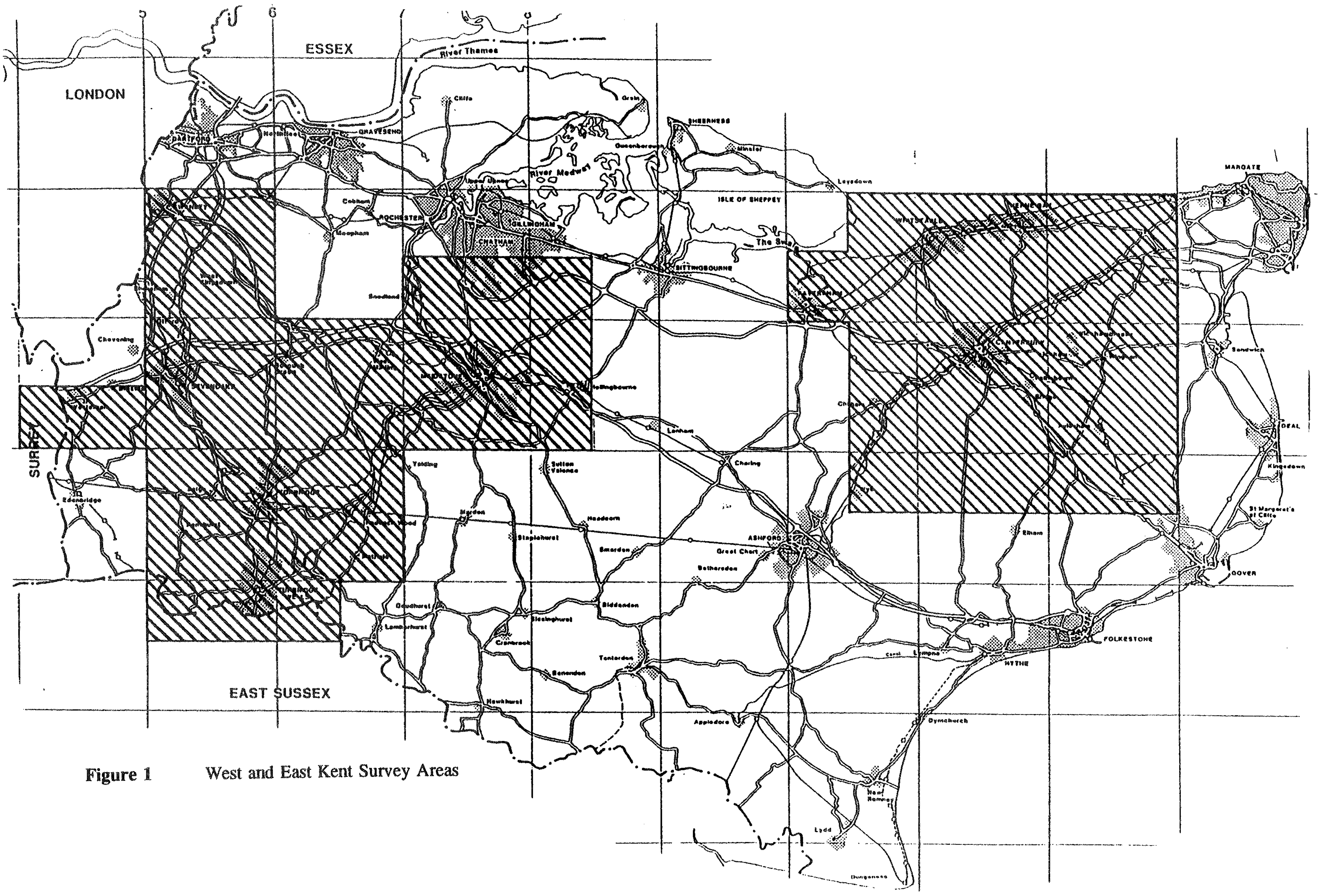

Figure 1 West and East Kent Survey Areas

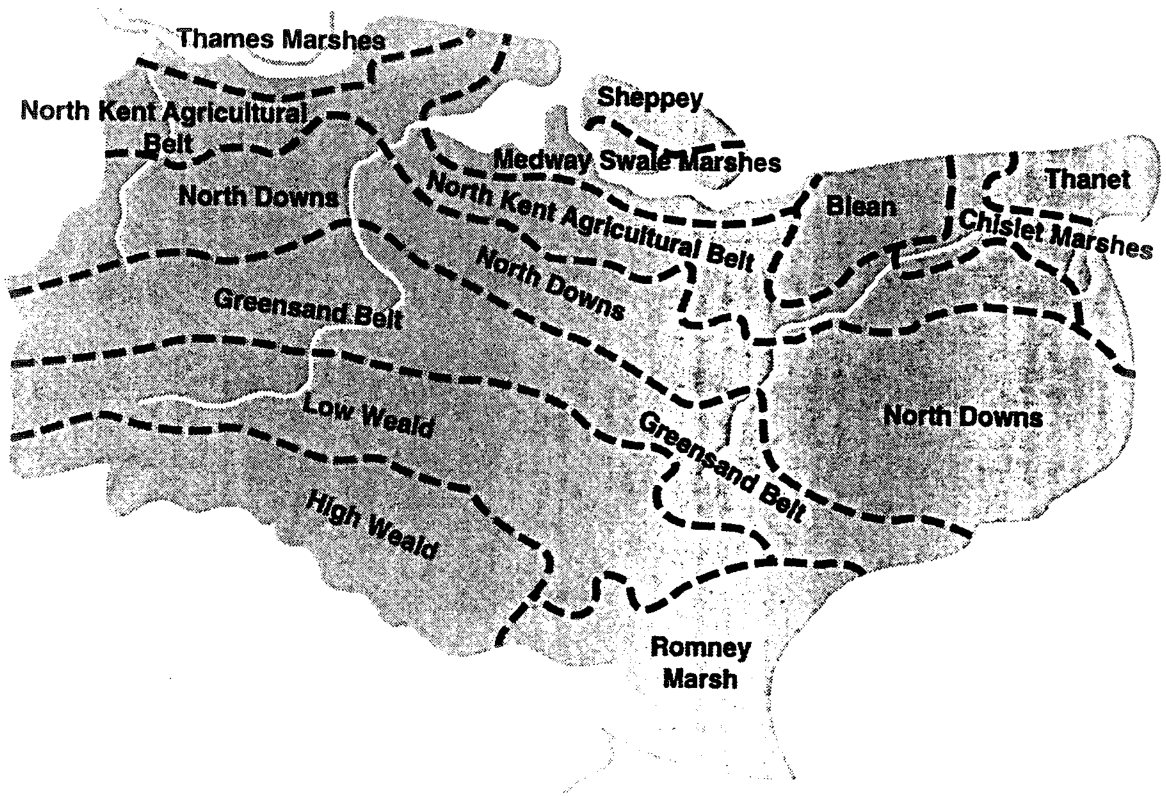

Figure 2 Landscape Character Areas

The study areas

Two areas were investigated, one in east, one in west Kent). There are only relatively minor differences in landform, climate and vegetation. The following summary description of the two areas is based on the Landscape Character Areas approach used in the Kent Landscape and Nature Conservation Guidelines (Figure 2) (Kent County Council Planning Department 1993).

In West Kent, from north to south, there was partial vertical aerial coverage of the following Landscape Character areas.

1. North Downs. A chalk scarp rising to over 200 m, incised with numerous dry valleys trending to the north. Scarp woodlands serve to emphasise the prominence of the landform as well as being a feature in its own right. On the dip slope there is less woodland.

2. Greensand Belt. Below the North Downs is the Vale of Holmesdale, a distinct linear belt of a generally more open landscape of mixed farming with occasional woodland. To the south is the distinct Western Woodland Belt heavily wooded with occasional heaths and commons.

3. Low Weald. This broad clay vale rises to 50 m in height. It is a highly managed landscape containing both large and small woodland.

4. High Weald. Rising to a height of 125 m the Western High Weald is an area of small woods surrounded by fields of pasture.

In East Kent, from north to south, there was partial vertical aerial coverage of the following Landscape Character areas:

1. Blean. A soil derived from London Clay which is acidic and difficult to work. Large woodlands create the unique landscape character of the Blean and they are of great nature conservation value.

2. Chislet Marsh. To the east of Blean is a traditional arable landscape, very open and bland. There are a few copses of willow, blackthorn and hawthorn.

3. The Northern Agricultural Belt. South of Blean and the Chislet Marshes is found the North Kent Fruit Belt, a landscape composed of orchards, shelterbelts, small woodlands and arable fields and the East Kent Horticultural Belt, a gently rolling landform varying in height from 15 m to 25 m with occasional copses.

4. North Downs. South of the Horticultural Belt is the well-wooded, and extremely undulating, dry valleys of the Eastern Northern Downs. To the west of this, the landform is more gently rolling with woodland blocks found to the south declining towards the Horticultural Belt and the eastern coast.

Methods

After the storm of 16 October 1987 two large areas of Kent were flown and vertical aerial photographs taken of East Kent in November 1987 at a scale of 1:10,000, in colour and West Kent in May 1988 at a scale of 1:5,000 and 1:10,000, in black and white. In all, these two areas amount to 1500 km^2, approximately one third of Kent. We are not aware of any other comprehensive aerial photographic coverage of Kent after the 1987 storm, although some isolated and small oblique coverage exists.

They were not however used in this study. A very small amount of field survey was carried out to supplement the photographic interpretation.

Storm damaged areas were identified from the aerial photographs using stereoscopes (or handheld lens where aerial photographs were not in stereo pairs). The criterion used to define storm damage was the presence of windblown trees covering an area equal to or greater than 0.25 hectares (discussed in more detail below). All trees in this minimum area had to be windblown. The area of storm damage was then transcribed on to OS 1:10,000 scale maps and given one of five prefixes indicating the woodland management believed to have occurred:

WM	No action
WR	Replanting only
WC	Cleared only
WCR	Cleared and replanted
WCG	Cleared and grubbed up

Initially each individual storm-damaged woodland boundary was recorded and assigned to one of the five woodland action prefixes from the 1987/88 aerial photographs. Transcribed on to this boundary was then the subsequent 1990 woodland action prefix which identified, if any, the type of post-storm woodland action that had taken place. To be assigned a woodland action prefix the woodland parcel had to be identified clearly on both sets of aerial photography (1987/88 and 1990). This criterion was met for 401 sites in the Kent study.

Because the minimum area of woodland storm damage transcribed was 0.25 hectares, smaller stands of windblown trees were not recorded. This lower limit was applied because it was the smallest area that could be used to record storm damage by eye using a Romer grid and 0.25 ha is also the lower limit defined by the Forestry Authority for grant making purposes. The fate and general location of damaged areas, rather than very precise area measurements, were the most important aspects of this survey. Digitisation of this data using GIS would have provided greater accuracy, but the scale and objectives of the project did not justify this effort. Other sources of information held by Kent County Council were drawn upon to identify woodland type in these storm damaged areas, including Kent Phase 1 Habitat data, Kent Land Cover Change use data, revisions to Kent's Ancient Woodland Inventory (Pritchard *et al.* 1994), historical aerial photographic coverage and some field visits.

Overview of Storm Damage and subsequent action in West and East Kent

The total extent of windblown woodland in West and East Kent was recorded and broken down into broadleaf, mixed and coniferous woodlands types.

The extent of woodland treated in different ways was compared by looking at the total areas assigned to each prefix classes for 1987/88 and 1990 and for West and East Kent separately. Comparisons were made between the immediate (1987/88) and subsequent post-storm action up to 1990.

Relationship between 1990 Post-Storm Woodland Action and Woodland parcel Size

Storm-damaged areas were divided into four parcel size classes (0.25-2.00 ha, 2.25-5.00 ha, 5.25-10.00 ha, >10.00 ha). The relationship between parcel size and post-storm woodland action was then examined bearing in mind that in the larger windblown parcel sizes more than one post-storm woodland action type could have occurred.

Location of No action (WN) "Wilderness" Areas

Parcels were identified that were still No action (WN) "wilderness" areas in 1990, because of a need to consider a strategy for their future. Is it desirable that they continue as minimum intervention areas or would a shift to active woodland management benefit the landscape more? Is there a case for a shift to an alternative land use such as heathland? The location of all No action (WN) sites was listed and transcribed on to a map containing the Landscape Character areas.

Table 1 The woodland resource and windblown area in the Kent survey

(a) **Both study areas**

	Broadleaved Woodland	**Coniferous Woodland**	**Mixed Woodland**	**Total Woodland**
Woodland resource (ha)	11,554	921	822	13,297
Percentage of total woodland in survey	87.0%	6.8%	6.2%	100.0%
Windblown damage (ha)	891	173	161	1,225
Percentage of total woodland in this type	6.7%	1.3%	1.2%	9.2%
Percentage of woodland type windblown	7.7%	18.8%	19.6%	9.2%

(b) West Kent only

Woodland resource (ha)	5,638	657	526	6,821
Percentage of total woodland in survey	82.7%	9.6%	7.7%	100%
Windblown damage (ha)	753	135	154	1042
Percentage of total woodland in this type	11.0%	2.0%	2.3%	15.3%
Percentage of woodland type windblown	13.4%	20.5%	29.3%	18.5

(c) **East Kent only**

Woodland resource (ha)	5,916	264	296	6476
Percentage of total woodland in survey	91.4%	4.0%	4.6%	100%
Windblown damage (ha)	138	38	7	183
Percentage of total woodland in this type	2.1%	0.6%	0.1%	2.8%
Percentage of woodland type windblown	2.3%	14.4%	2.4%	2.8%

Results

Overview of Storm Damage in West and East Kent

The total amount of woodland in Kent, including all blocks of woodland with an area greater than 0.25 ha in size, is approximately 42,664 ha (Forestry Commission Census, 1980). The woodland surveyed in this study is approximately 13,297 ha, slightly over a third of Kent's total woodland. The area of windblown damage is approximately 1,225 ha, representing 9.2% of the surveyed woodland. A previous estimate of the total volume blown down in Kent is 22.0% (Forest Windblow Action Committee 1988), but this figure is subject to some uncertainty. Kent's other woodland may have had proportionately higher damage but this is unlikely since the areas used in this study were targeted after the storm to reflect the perception that they suffered the greatest damage. Thus if the estimates of damage in this study are close to that for the rest of Kent then the total damage for the county would have been 3957 ha.

The extent of woodland type and windblown damage, respectively, in different woodland types are summarised in Table 1a. Broadleaved woodland predominates (87.0% of the total). However, as a proportion, mixed woodland has the greatest windblow damage (19.6%), followed closely by coniferous woodland (18.8%), whereas broadleaved showed only 7.7% damage. The County estimates are only available for volume but they also show that coniferous stands suffered more with values for Broadleaved and Coniferous woodland of 18.0% and 36.0% respectively (Forest Windblow Action Committee 1988).

In Tables 1b, 1c the results are shown for East and West Kent study areas separately. Although the total amounts of woodland in each are similar storm damage in absolute and relative terms was very much less in East Kent. The difference is least marked for coniferous woods.

Because the observed windblown damage in East Kent was small in comparison to that in West Kent, the results must be treated with caution since in East Kent they refer to just a few individual parcels of damage.

Post-Storm Woodland Action

Immediately after the storm in 1987/88 1,110 ha were identified as having received No Action (WN) amounting to 90.6% of the total windblown area. Only 115 ha (9.4%) had received any treatment and this was Cleared Only (WC) (Table 2a). However by July 1990, approximately two-thirds of the windblown areas had received some form of post-storm woodland action. Cleared Only (WC) with 616 ha (50.3%) was still the primary post-storm woodland action, whereas 203 ha (16.6%) had also been replanted and only 7 ha (0.6%) grubbed out. No Action (WN) or "wilderness" areas amounted to 32.2% of the total in 1990.

The comparison between of post-storm action between East and West Kent study areas is shown in Tables 2b and 2c. Given that West Kent suffered more damage it is not surprising that all the immediate post-storm action was in West Kent and Cleared Only (WC) remained dominant post-storm activity in 1990. The 7.0 ha of Cleared and Grubbed (WCG) were also all in West Kent.

Post-storm woodland action in East Kent appears from this study to have been slower. In 1987/88, no areas had been cleared. By 1990 clearance was still lagging behind with 43.7% of No Action compared to 30.5% in West Kent. However a greater proportion of that cleared had also been replanted.

Table 2 Total damage and post-storm woodland action

WN = no action
WC = cleared only
WCG = cleared and grubbed
WR = replanting only
WCR = cleared and replanted

(a) Both study areas

Woodland Action	1987/88 Total Hectares	1990 Total Hectares	% of 1987/88 Storm Damage Area	% of 1990 Storm Damage Area
WN	1,110	399	90.6%	32.5%
WC	115	616	9.4%	50.3%
WCR	0	203	0%	16.6%
WCG	0	7	0%	0.6%
TOTAL	1,225	1,225	100%	100%

(b) West Kent only

WN	927	318	89.0%	30.5%
WC	115	544	11.0%	52.2%
WCR	0	173	0%	16.6%
WCG	0	7	0%	0.7%
TOTAL	1,042	183	100%	100%

(c) East Kent only

WN	183	80	100%	43.7%
WC	0	63	0%	34.4%
WCR	0	40	0%	21.9%
WCG	0	0	0%	0%
TOTAL	183	183	100%	100%

Changes in the state of particular storm-damaged parcels of land

Table 3 shows the number of storm-damaged parcels that were in each category in 1987/88 and how they had changed by 1990. In 1987/88 the majority of parcels of damage (344 out of 391) were No action (WN) parcels with 47 instances of Cleared Only (WC).

In 1990 over one-third (35.3%) of the parcels showed no change from 1987/88. The largest change, not surprisingly, was from No Action (WN) to Cleared Only (WC), and a high proportion of those cleared in 1987/88 had been replanted by 1990.

Of the 391 parcels 271 (69%) had received some post-storm woodland action by 1990, ie similar to the proportion treated by area. Only 75 of these had been replanted.

Table 3 **A comparison between 1987/88 and 1990 woodland action**

WN	=	no action	WR	=	replanting only
WC	=	cleared only	WCR	=	cleared and replanted
WCG	=	cleared and grubbed			

The numbers in each cell are the number of parcels in a particular category. Underlined figures represent no change.

Woodland Action		In 1990				
		WN	WC	WCR	WCG	Total
In 1987/88	WN	<u>120</u>	174	46	4	344
	WC		<u>18</u>	29		47
	WCG					
	WCR					
	Total	120	192	75	4	391

<u>Post-Storm Woodland Action and Windblown Parcel Size</u>

From the 1990 photographs nearly two-thirds (60.6%) of windblown sites were between 0.25 and 2.00 ha (Table 4) whereas the largest parcel size category (>10.00 ha) had only 15 recorded instances (3.7%). There was a slight tendency for more of the windblown parcels (particularly in the 5.25-10 ha category) to have been cleared than the smallest ones.

Table 4 **Recorded instances of 1990 post-storm action and in relation to woodland parcel size**

WN	=	no action	WR	=	replanting only
WC	=	cleared only	WCR	=	cleared and replanted
WCG	=	cleared and grubbed			

Woodland Action	0.25-2.00	2.25-5.00	5.25-10.00	>10.00	Total	%
WN	75	36	5	4	120	29.9%
WC	123	49	20	8	200	49.9%
WCR	43	27	4	3	77	19.2%
WCG	2	2			4	1.0%
Total	243	114	29	15	401	
%	60.6%	28.4%	7.3%	3.7%		100%

Identification of No Action (WN) "Wilderness" Areas

From the 1990 survey 120 instances of No Action (WN) damaged areas were identified and transcribed onto the Landscape Character areas map (Tables 5a and 5b).

In West Kent most No Action (WN) areas were associated with the heavily wooded Western Woodland Belt in the Greensand Belt zone and the small woodlands of the High Weald. In East Kent far fewer instances of No Action (WN) were recorded with the majority being in the well-wooded Eastern Northern Downs.

The most severely affected Landscape Character areas were those dominated by forestry as a land use; the more plantations, the greater chance of storm damage. Also prone to windblow damage were areas characterised by small woodlands and woodland on high ground which tended to be more exposed and therefore more susceptible to windblow damage.

Table 5 Location of No Action (WN) instances in different Landscape Character Areas

(a) **West Kent**

Landscape Character Area	No Action (WN) instances	% No Action (WN)
1. North Downs	18	19.2%
2. Greensand Belt	38	40.4%
3. Low Weald	13	13.8%
4. High Weald	25	26.6%
TOTAL	94	100.0%

(b) East Kent

1. Blean	4	15.4%
2. Chislet Marsh	2	7.7%
3. Northern Agricultural Belt	4	15.4%
4. North Downs	16	61.5%
TOTAL	26	100.0%

Conclusions

Broadleaved woodland was the most storm-damaged woodland type in absolute terms. However, as a proportion of the total area of each type mixed woodland was the most affected.

By May 1988, only 9.4% of all storm damaged woodlands recorded in this survey had been cleared but this situation had changed with approximately two-thirds of all storm damaged woodland having received some sort of post-storm woodland action by July 1990. In less than a fifth of those however had any replanting taken place.

Areas of "wilderness" where no post-storm action had taken place by 1990 may be used as a guide for targeting future action. There is a need to develop further ideas as to what such action should be.

Storm damage was greatest in the smallest parcel size of between 0.25-2.00 ha and much post-storm action has similarly been most common in these woods. A recommendation for future woodland management initiatives might be to plant woods larger than two hectares, because if future storms do occur there is at least a chance that some of the wood will still survive as a landscape feature.

From the Landscape Character area map, woodland susceptibility to storm damage appears to be affected by density of woodland as a land use (heavily wooded areas suffer most) and exposure (woodlands on high ground or on exposed ridges suffer most).

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SURVEYS OF STORM-DAMAGED WOODS SET UP IN 1987-88

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Summary

The resurgence of interest in natural disturbance stimulated by the 1987 storm provided a useful stimulus for the establishment of long-term monitoring studies in order to investigate such natural processes.

Though the storm was widespread, its effects were very patchy in distribution and variable in nature. Therefore it was necessary to establish a range of study sites, in varying situations, throughout the affected area. Such study sites included not only National Nature Reserves but also reserves owned by the Wildlife Trusts, the National Trust and others. Thus over 20 sites were established in the south-east, from Suffolk to the Isle of Wight, in woodlands of varying types and in varying situations.

Introduction

During the small hours of 16 October 1987 the south-east of Britain was hit by a windstorm of exceptional magnitude (Hopkins 1994). At the height of the storm windspeeds of over 100 mph were recorded. An area extending from Hampshire through to the southern parts of Norfolk was affected, some of the worst effects being felt in Sussex, Surrey, Kent and Essex. In all, around 14 counties were affected. About 15 million trees blew over, half conifers and half broadleaves, although many of these did not die until someone cleared them up.

Such events are unusual, particularly in the south-east, but nevertheless wind disturbance is a natural initiator of vegetation change in woodland. Britain seems to experience a series of exceptionally windy winters about every 100 years - usually around the turn of each century (for no apparent reason). Given the life span of our dominant forest trees (say 500 years) such windstorms could be considered as comparatively frequent events.

Patterns of damage in woodland

At the landscape scale south-facing slopes, waterlogged areas, districts with thin soils, etc. all appeared to have received high levels of damage. This was complicated by effects of topography - funnelling along valleys, lee slope turbulence, etc. and there was a great deal of apparent randomness in which woods suffered and which did not.

These landscape scale patterns were followed to some extent at a site scale - the effects being greatest on some slopes or unstable soils; occasionally whole sites in such situations blew down. The apparent randomness of the effects is perhaps even more remarkable at this scale. Occasionally a reason for why a particular area was blown-down can be found, but elsewhere localised patches of damage may be simply where several gusts focused to form short-lived, extreme local turbulence.

At the stand scale the trees most heavily affected seem to have been the fully grown, yet still quite young trees. This is probably why so many well-maintained broadleaved and conifer woods were damaged. Stands of overstood coppice were also vulnerable, but in worked coppice woods the coppice was often stable while the standards were affected. Really ancient trees were often little affected; frequently they have little foliage relative to their size, they are often short relative to their diameter (being old pollards) and presumably they have had to survive several previous storms (so those in vulnerable locations have already blown over).

Looking at particular sites, it is possible to distinguish about three levels of damage. Extensive blowdowns where whole sites were flattened were often shown by the media, but were relatively uncommon. Canopy gaps in woodland were much more common. Areas of up to about a hectare of woodland were windblown but surrounded by intact woodland. Such areas were often surprisingly discrete. Within a gap the amount of damage varied and not all trees were removed. Some trees were almost undamaged, others were severely pruned whilst more were laying down or crushed. Thirdly scattered disturbance occurred in many sites where crown damage and occasional windthrow and windsnap in effect "ruffled" the wood without leaving obvious canopy gaps.

These categories are, of course, not discrete but three parts on a continuum of damage which could be extended to undamaged woodland. In spite of the 1987 storm being an extreme event, most woodland was not significantly damaged. In Surrey, one of the most affected counties, less than 4% of the trees had been damaged (Surrey Wildlife Trust 1989).

An opportunity to study natural woodland dynamics

These effects were the result of a natural event on a semi-natural habitat. The storm therefore provided us with an opportunity to study vegetation dynamics following disturbance and study sites were sought in which monitoring could be established.

The ideal candidates should have been National Nature Reserves (NNRs), where it should be easy to set up and maintain long term studies. However, there were too few appropriate NNRs in the area affected by the storm (and in some the damage was light) so nature reserves controlled by the Wildlife Trusts, the National Trust, some Local Authorities and private individuals were also used. The aim was to study a range of woodland types that occurred in a variety of geographical and topographical situations and which were affected in different ways by the storm. Much of the impetus for this work came from Dr George Peterken, then woodland ecologist with the Nature Conservancy Council.

Sites fulfilling the following criteria were selected:

* The woodland structure should be as close as possible to a natural forest; high forest rather than coppice or plantation for example.

* The species composition should be as near natural as possible, and in particular be free from exotics.

* The site should be as large as possible.

* Ideally there should be data on the wood from before the storm.

In addition, several basic needs have to be met in order for results to be of continuing value (Peterken & Backmeroff 1988):

* The location of the study sites must be recorded and the location of sample stands within them carefully marked and relocatable.

* Data collected should be clearly and logically recorded, should be archived, its existence should be known of and it should be relocatable.

* The above two should be correlated so that the correct data can be found for a particular site.

* The method should be reproducible at the same plot at any time in the future.

If these principles are adhered to, the details of the methodology become less important. Often this may consist of simple observations that could be valuable in the future. Indeed apart from the establishment of long-term monitoring studies, the importance of anecdotal accounts and information gathered through subjective observation should not be underestimated. A great deal of information was gathered by people who made notes just after the storm and in the following years. These as well as more detailed surveys have been summarised in Whitbread (1991) and add greatly to an understanding of the details of how species respond to opportunities provided by natural disturbance. Over 28 sites were identified in which some form of post-storm monitoring was established.

Examples of post-storm studies

Many of the surveys were based on detailed examination of sample stands. An accurate chart was produced for each sample plot showing the location of trees, shrubs and saplings, with further notes on ground flora, canopy spread and ground features. Within this basic approach, three variants may be noted but in each case the exact location of each tree and shrub was detailed with notes of the tree species, its girth at breast height, its height category, its condition, the direction of fall of trees and major branches, the size of any root plates and the presence of other ground features.

Canopy gap monitoring (Figure 1)

This involved plotting the location of canopy gaps within a site and then mapping the gap in detail, together with some of the surrounding stand. This was often accomplished by laying a transect line through the gap and then taking coordinates from this line to each tree. The location of the transect line had to be accurately recorded. This method was used in several locations in The Mens, West Sussex.

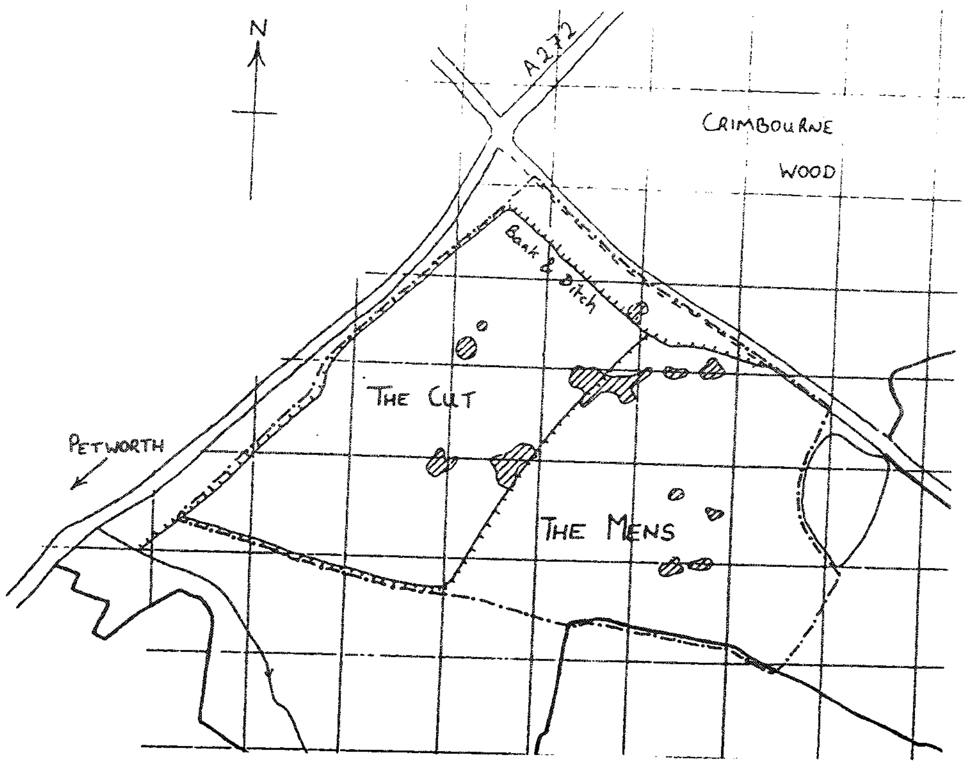
Quadrat recording (Figure 2)

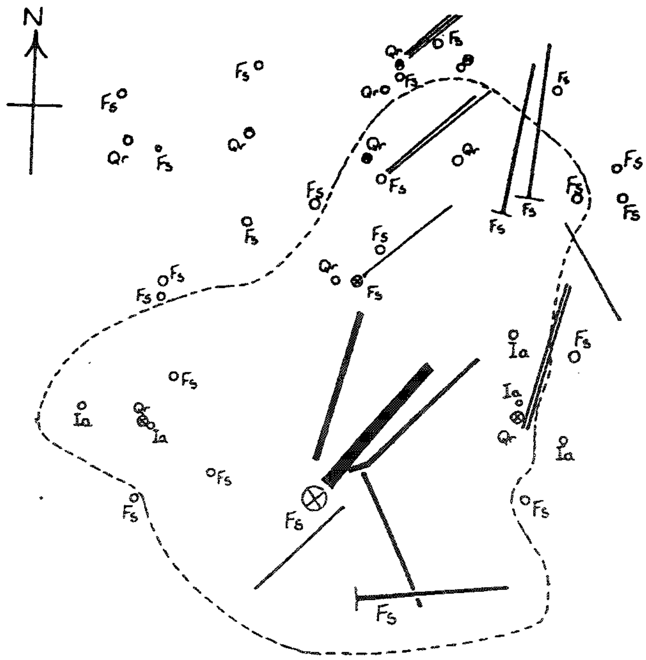
Where storm damage was irregularly scattered, rather than in discrete gaps, then quadrat recording was the preferred method. Such quadrats needed to be relocatable and a convenient way of doing this was to base their location on the intersections of a grid system.

Work done on Ebernoe Common, West Sussex, provides an example of this approach. The site had previously been marked out on a grid system with quadrats located at the intersections of the grid. Quadrats were set up immediately to the north-east of each intersection. It was also used at The Mens, where the intersections of the grid system marked the centre of circular quadrat samples (Cooke 1994; Parker & Whitbread 1993; Whitbread & Montgomery 1994).

Belt transects (Figure 3)

Belt-shaped transects, 10-20 m wide, have been established at National Nature Reserves to monitor structural change (Peterken & Backmeroff 1988; Peterken & Jones 1987). This method was also useful in storm damage monitoring and many of the post-storm monitoring projects used this approach (Parker & Whitbread 1993). The length of the transect varied according to the nature of the site. Generally the transect was laid out so that both damaged and undamaged woodland were sampled either by running the transect across a canopy gap, such that it started and finished in undamaged woodland, or by starting it in undamaged woodland on the edge of a swathe of damage and running it into the swathe. Where whole woods were blown down, as at Toys Hill, Kent, it was often not possible to sample a control area of undamaged woodland.

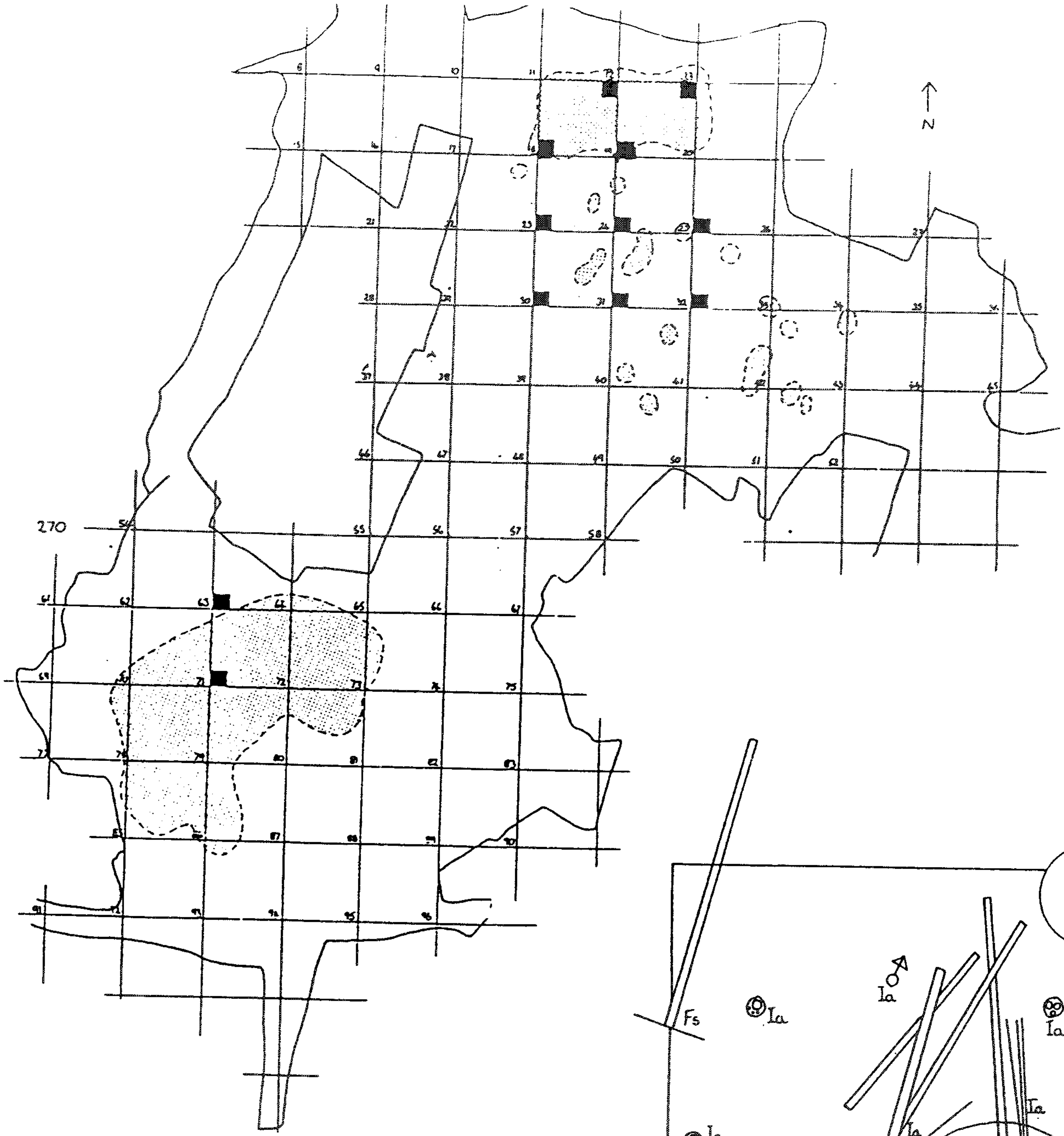


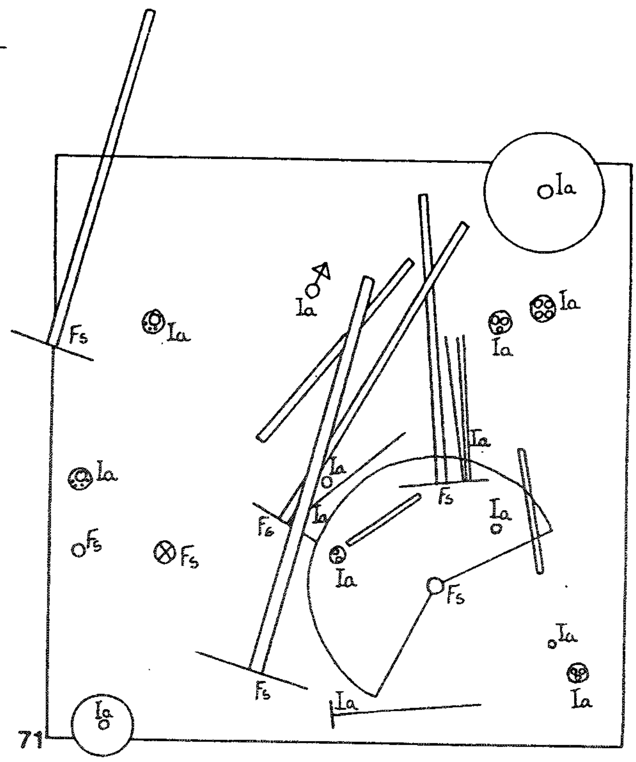


Key
Fs = *Fagus sylvatica*
Qr = *Quercus robur*
Ia = *Ilex aquifolium*
Other symbols relate to the location of the tree and its condition (see Whitbread 1991 for details).

Canopy gap map

Figure 1 The Mens and The Cut (West Sussex) - locations of canopy gaps and an example of a canopy gap map. Grid lines are 100 m apart. A key to the symbols is given in Appendix 1 to this paper.





Grid lines are 100 m apart

Key ■ Location of sample quadrats

Areas of storm damage

Figure 2 Ebernoe Common (West Sussex) - map showing canopy gaps and sample quadrat

A key to the symbols used is given in Appendix 1 to this paper.

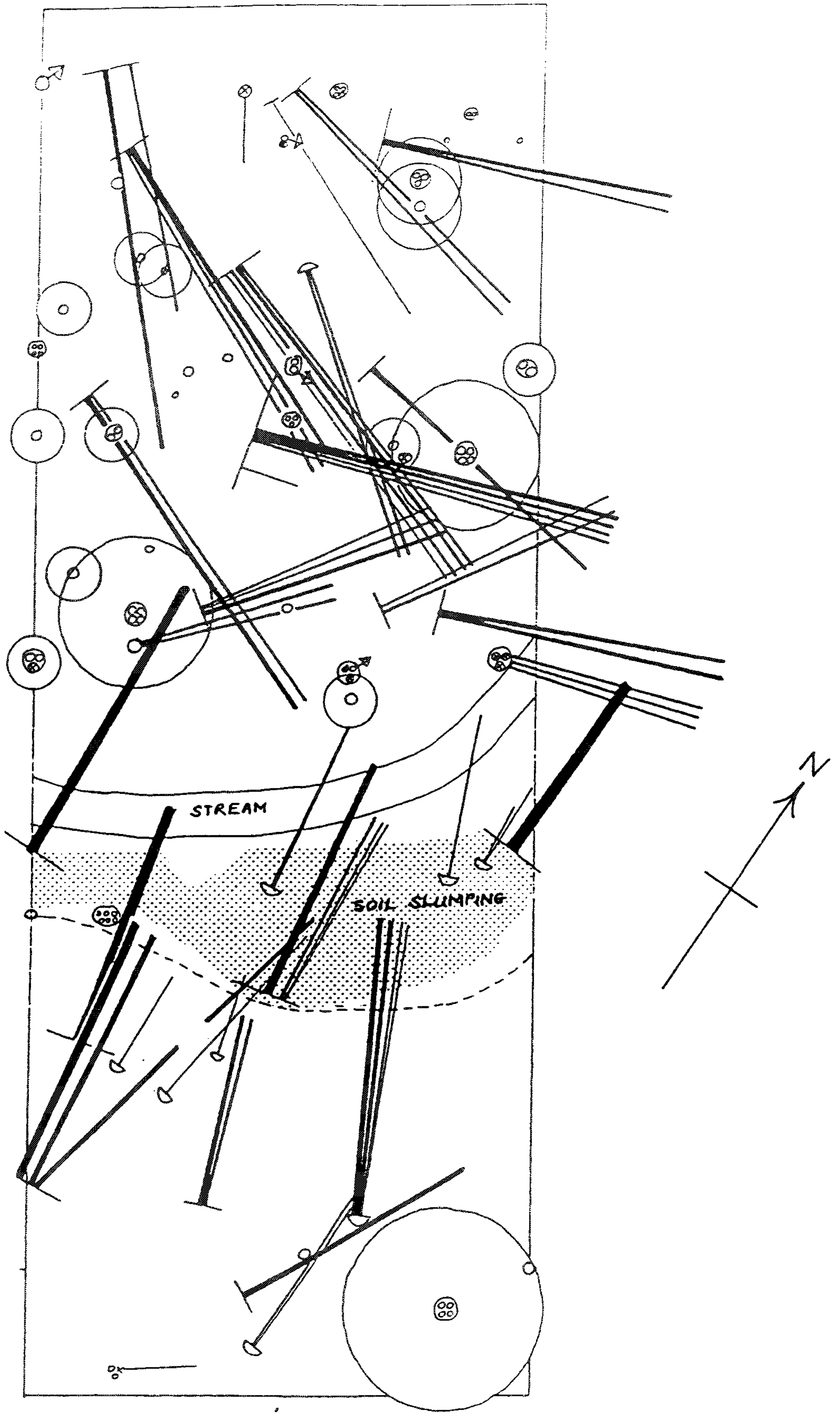


Figure 3 Marline Wood (East Sussex) - diagram of a belt transect 20 m wide and 60 m long across the gill.

The location of fallen stems, surviving stems and the tree canopies are indicated (see Appendix 1 to this paper for the key).

Conclusion

Before 1987 there was only limited interest in long-term studies of the response of woodland vegetation to follow natural disturbance. The storm provided the impetus to start these. The main objective of these studies was to obtain a snapshot in time; presenting a picture of the stand as it was immediately after the storm. Exactly the same stand could be examined now and in the future. In this way the details of the vegetation dynamics can be followed. Ideally the monitoring of structural change should be linked to other studies, carried out in the same stand or in the same vicinity as vegetation monitoring. Groups of studies can then be correlated and a great deal more learned about for example the succession of fungi, lichens or insects during canopy growth and closure following disturbance. Unfortunately less of this has occurred than was hoped.

The storm happened over six years ago and already it is fading in our memory. Long-term monitoring however has a continuing function. The studies referred to were designed to follow woodland dynamics after the storm but in the future as results become available we cannot know how we will wish to use them, only that they should be of interest. The plots of various sorts are established but could easily become forgotten. The work that has been put into them must be seen as part of our broader attempts to understand woodland processes rather than just the response to a particular event.

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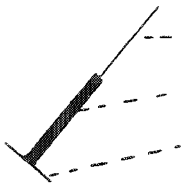
Appendix 1 Generalised key for quadrat and transect diagrams

Uprooted tree

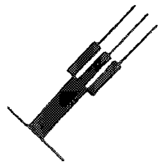


crown

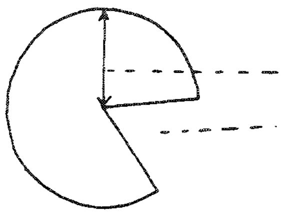
main section of trunk

root plate

Uprooted pollard



Standing tree



crown radius

crown loss, shown as a proportion and showing the side on which loss occurred

Major fallen branch

 standing tree, narrow crown

 wind-snapped tree

 leaning tree, showing direction of lean

 multi-stemmed tree

 intact canopy

 tree seedlings

 tree stump

 disturbed ground around root plate

Species codes

Ac	*Acer campestre*	Fe	*Fraxinus excelsior*
BG	Bare ground	Hm	*Holcus mollis*
Bpu	*Betula pubescens*	Ia	*Ilex aquifolium*
Bp	*Betula pendula*	Je	*Juncus effusus*
Cb	*Carpinus betulus*	Pa	*Pteridium aquilinum*
Ca	*Corylus avellana*	Qr	*Quercus robur*
Cm	*Crataegus monogyna*	Rf	*Rubus fruticosus*
Cs	*Castanea sativa*	Sac	*Sorbus aucuparia*
Fs	*Fagus sylvatica*	Sx	*Salix caprea*

REACTIONS TO THE 1987 STORM (poster)

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Not surprisingly the 1987 storm was treated by the press as a major disaster, which it was for the people whose property, views and timber crop were damaged or spoilt. From the outset however, there were some indications that the effects in nature conservation terms not only were not catastrophic, but might even be beneficial. Five years on the positive aspects of the storm were more readily appreciated. A selection of headlines and extracts illustrate these points.

LOVE'S LABOURS LOST IN A NIGHT

Foresters at Cowdray Park are picking up the pieces from last week's environmental and emotional catastrophe. (Daily Telegraph, October 24, 1987.)

STORM DESTROYED 15M TREES IN THE SOUTH

It is now clear that damage to the country's forests and woodlands is more than double that of any previous gale in living memory. (Times, November 17, 1987.)

TIME RUNNING OUT FOR RAVAGED WOODLANDS

Last autumn, the devastion created by the October storm was too great and too recent for landowners to do anything but reel from the shock. The work of centuries had in many instances been undone in a few short hours.... Today 75% of the affected land remains to be cleared and time is fast running out if the remaining area is to be made ready before rot and the growth of surface vegetation smother the prospects of new generations of trees. (Sunday Telegraph, October 10, 1988.)

NOW LET THE BLUEBELL BLOOM

Next spring.... light entering the reduced woodland tree canopies will encourage a massive increase in woodland flowers such as primrose, bluebells, wood anemones and wood sorrel. (Observer, October 22, 1987.)

WOODS REAP RICH HARVEST OF HURRICANE

.... a vast number of wild species from bluebells to butterflies, deer to dormice, primroses to pipits, all flourished in the wake of the storm ... (Observer, October 22, 1992.)

PERMANENT TRANSECT RECORDS OF SELECTED STORM DAMAGED WOODLAND IN KENT (poster)

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Summary

Following the storm of October 1987, KTNC was contracted by the Nature Conservancy Council to set up and record permanently marked relocatable transects through selected areas of storm damaged woodland within areas designated as non-intervention zones. The main purpose was to provide base line recording for future studies on the stand scale at the selected sites.

The following sites were monitored:

1. Scords Wood, Toys Hill, Sevenoaks. (National Trust owned.)
2. Westfield Wood, Maidstone. (KTNC leasehold.)
3. Parsonage Wood, Cranbrook. (KTNC owned.)

The recording was based on 20 m wide transects.

This survey was a follow-up to that carried out after the storm. Selected lengths of the transects have been resurveyed using the same method, the objective being to monitor changes in the woodland structure.

Recording method

The recording method used was the same as that used by Hutton (1989).

In some areas it was not possible to record the girths of saplings even if they reached the required height of 1.3 m, because of the considerable amount of regrowth. In such cases an attempt has been made to estimate the density of saplings per unit area.

In areas of extremely vigorous regrowth no attempt was made to force an access. This would have caused damage to the regrowth and also have been hazardous for the surveyor. Instead an attempt was made to describe these areas from a nearby vantage point.

Changes to woodland structure in the 1992 survey were noted on the original (1987) survey maps. The original schedules have been modified noting any obvious changes to individual trees.

Summaries of the changes to each area are presented here.

Scord Wood

The areas resurveyed were as follows:

Transect 180-270 m - An area of major storm damage

Transect 410-440 m - An area of major storm damage

Transect 180-270 m

Most fallen trees (*Fagus sylvatica*) have now died and are in an advanced state of decay. The range of fungi noted included *Neobulgia pura, Stereum hirsutum* and *Coriolus versicolor*. Vigorous growth of *Betula pendula* occurs throughout the area (reaching a density of $15/m^2$ in the more open areas). Patches of *Ilex aquifolium* have increased in area and height. The ground flora is dominated by *Chamerion angustifolium* and *Digitalis purpurea*, with *Blechnum spicant* growth apparent around the base of root pits. Some root plates showed signs of recent disturbance; this may have been due to recent heavy rain washing the soil off the roots. There has been some disturbance in the area when the footpath was reinstated.

Transect 410-440 m

All fallen trees are still living and showing epicormic growth. Girths of trees, lengths of fallen timber and the size the canopy gap show no change. Vigorous growth of *Vaccinium myrtillus* of up to 0.75 m now forms a field layer with few of no other species present. There has been a spread of *Ilex aquifolium*, in some areas forming a dense scrub.

Westfield Wood (Transect A)

Transect A 0.10 m - An area of slight storm damage

Transect A 10-20 m - An area of moderate storm damage

Transect A 40-60 m - An area of major storm damage

Transect A 60-70 m - An area of no storm damage

Transect A 60-70 m

This area has undergone very minor or no change since the original storm survey.

Transect A 0-10 m

This area has only undergone minor changes. Growth of *Acer psuedoplatanus* saplings has occurred in the area. These are at a low density and less than <.4 m in height. *Clematis vitalba* and *Rubus fruticosus* occur at a low density in the area.

Transect A 10-20 m

This area has undergone major changes with vigorous growth of *Rubus fruticosus* and *Clematis vitalba*, climbing over fallen trees. There has been some growth of *Fraxinus excelsior* and *Sambucus nigra* up to 2 m in places.

Transect A 40-60 m

This is an area of major storm damage where the vigorous re-growth only permitted limited access.

The exposed woodland floor has vigorous and abundant regeneration of *Fraxinus excelsior* up to 2 m in places, and some *Acer pseudoplatanus*. There is a field layer of *Rubus fruticosus* and *Clematis vitalba*. Most fallen trees are still living, with *Taxus baccata* showing epicormic growth. The increased occurrence of herbaceous plant species, noted in the original report, has now decreased and they have been replaced by the species noted above.

Westfield Wood (Transect B)

The areas resurveyed were as follows:

Transect B 110-120 m - An area of slight storm damage.

Transect B 100-110 m - An area of slight storm damage.

Transect B 70-90 m - An area of major storm damage.

Transect 110-120 m

This area has only undergone minor changes. Some 20 *Taxus baccata* seedlings and one *Fagus sylvatica* have germinated in the area. Most fallen (or leaning) trees are still living, with *Taxus baccata* showing epicormic growth. *Rubus fruticosus* occurs at a low density in semi-open area.

Transect B 100-110 m

This area has undergone a major change since the last survey in that a fall of trees has occurred. No change was detected however in the ground flora.

Transect B 70-90 m

An area of major change; the exposed woodland floor has vigorous and abundant regeneration of *Fraxinus excelsior* up to 2.5 m in places. This growth has a field layer of *Rubus fruticosus* and *Clematis vitalba*.

General notes on Westfield Wood

Girths of trees, lengths of fallen timber and the size of the canopy gap show no change. Root pits show little or no sign of change.

Parsonage

The area resurveyed were as follows:

Transect 0-20 m - An area of no storm damage.

Transect 20-30 m - An area of minor storm damage.

Transect 30-60 m - An area of major storm damage.

Transect 0-20 m

This area has undergone very minor or no change since the storm.

Transect 20-30 m

This area shows only minor changes with growth of *Rubus fruticosus* in more open areas.

Transect 30-60 m

This is an area of major storm damage, with vigorous re-growth that only permitted limited access. The exposed woodland floor has vigorous and abundant regeneration of *Acer pseudoplatanus, Betula pendula*, and *Castanea sativa*. This growth has an under layer of *Rubus fruticosus*.

General observations of Parsonage Wood

Girths of trees, lengths of fallen timber and the size of the canopy gap show no change since the original survey. Most fallen trees are still living, many showing epicormic growth. Root pits show little sign of change. The fern species noted in original survey, have 'disappeared' under the carpet of *Rubus*.

Acknowledgements

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