Forestry Commission

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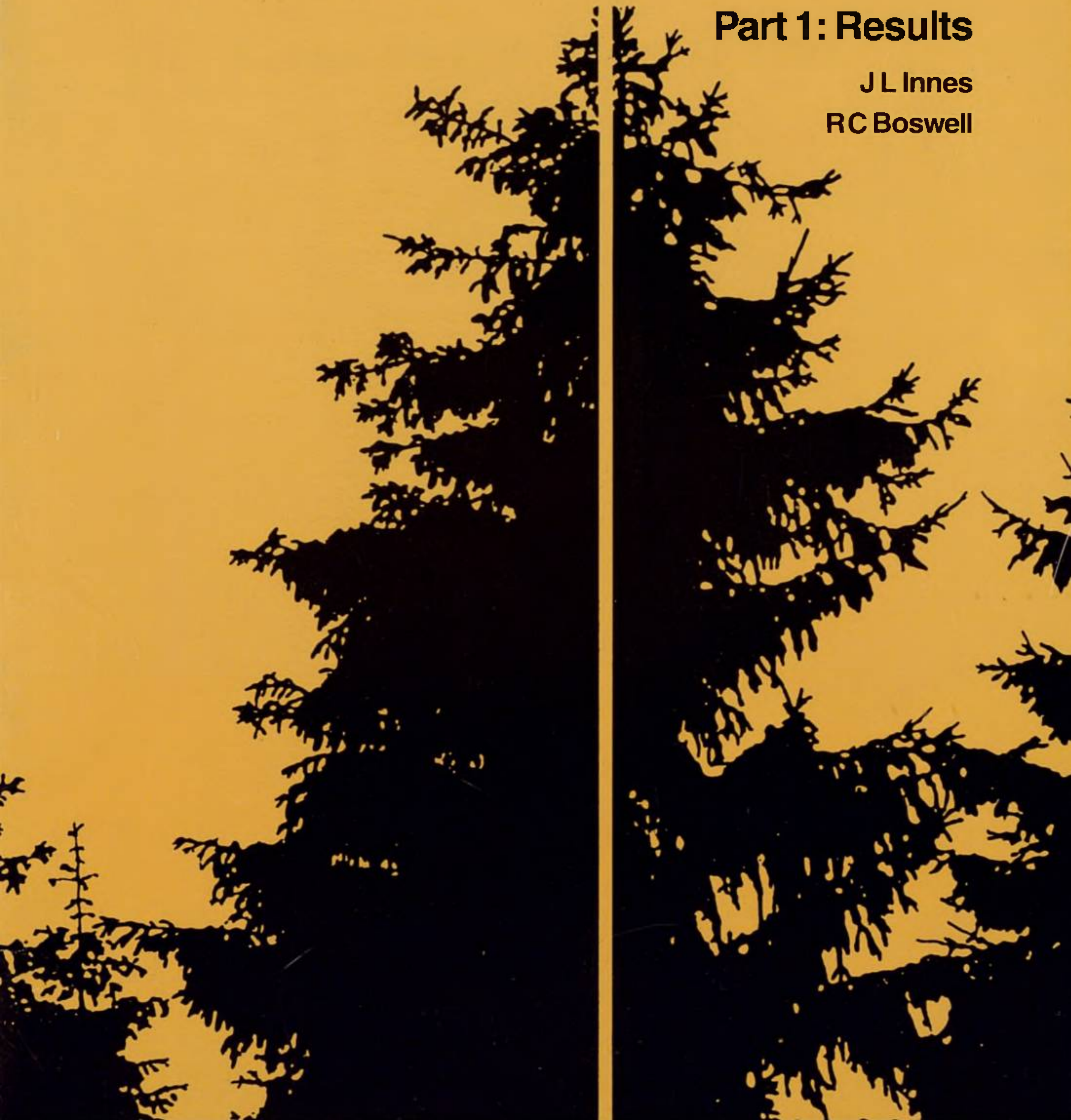
Forest Health Surveys 1987

Part 1: Results

J L Innes

R C Boswell



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Part 1: Results

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FRONT COVER: Composite silhouette of two Norway spruce (*Picea abies*) of different crown habits, showing the difference in light transmission. Left half, brush type; right half, comb type. Both trees are fully needled.

Contents

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Part 1: Results

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Introduction

An annual forest health survey has been conducted in Great Britain since 1984 (Binns *et al.*, 1985, 1986; Innes *et al.*, 1986). From the outset, the survey has been designed to determine both the extent of any deterioration in crown condition and, if possible, its causes. Over the years a number of changes have been made in the survey as more information has become available on the extent and nature of forest decline in central Europe and on possible causal factors. This year sees the most substantial changes yet. They are: 1) the inclusion of broadleaf species: beech (*Fagus sylvatica* L.) and oak (*Quercus petraea* (Mattuschka) Lieblein, *Q. robur* L. and hybrids between the two), 2) the inclusion of older Scots pine (*Pinus sylvestris* L.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) (up to 100 years old) and 3) the establishment of a better survey coverage across the country. The last was necessary if any correlations with spatial variables (e.g. climate and pollution) are to be measured effectively.

In addition, to comply with EEC regulations, an inventory based on a 16 by 16 km grid survey has been set up. The inventory extends across all member states of the EEC and will, for the first time, provide comparable data for all countries within the Community.

In view of the level of interest in such surveys, the national results are being published as early as possible. A second part of the report will be published during 1988 in which an attempt will be made to analyse the results obtained in the main (FC) survey. It is intended that this analysis will make use of meteorological data for the 1987 growing season as well as the much more comprehensive data on pollution levels that will become available in the near future.

Plot Selection
Main (FC) survey

The country was divided into 12 regions based on consideration of their climate and pollution characteristics. For conifers – Norway spruce (*Picea abies* (L.) Karst.), Sitka spruce and Scots pine – a minimum of five plots of each species were sought in each region. At least two of these plots were to consist of trees in the 30–50 year age class and at least two in the 50–100 year age class. Where necessary, new plots were added to supplement those established in previous years. For broadleaves, three plots each of beech and oak were sought in each region. Both beech and oak were divided into three age classes and one plot per age class per region was sought. For beech, the age classes were 60–80, 81–100 and 101–120 years, and for oak they were 80–110, 111–140 and 141–180 years. There were 24 trees in each plot.

No restrictions on growth performance were imposed on the new plots, but several criteria of the 1984 survey were maintained. These required that the stand should not consist of forest edge trees, nor should it have had an edge exposed during the last 5 years or have had edge trees removed for road widening at any time. Also no windthrow should have occurred in the stand.

The restrictions on the nature of the sites and the distribution of species within Great Britain, together with the requirement that each of the 24 trees' crowns be visible from the ground, meant that the sampling design was not completed. For example, Sitka spruce is relatively rare in the east of Britain as it is not normally planted in areas with less than 1000 mm annual rainfall. Similarly, problems were encountered in locating suitable beech and oak stands in some parts of Scotland, where stands of the appropriate age are relatively rare.

Two plots used in previous surveys were abandoned, one because it had been clear felled and the other because of severe windthrow. With the addition of new sites, the survey now involves 264 plots. Of these, 57 are Sitka spruce, 80 are Norway spruce, 66 are Scots pine, 32 are oak and 29 are beech. The locations of all plots used in the survey are shown in Figures 1 and 2.

EEC (grid) survey

The chosen sampling design was based on a 16 km by 16 km grid. Sample points were established wherever grid

Figure 1. Approximate locations of Norway spruce and Sitka spruce plots used in the 1987 survey.

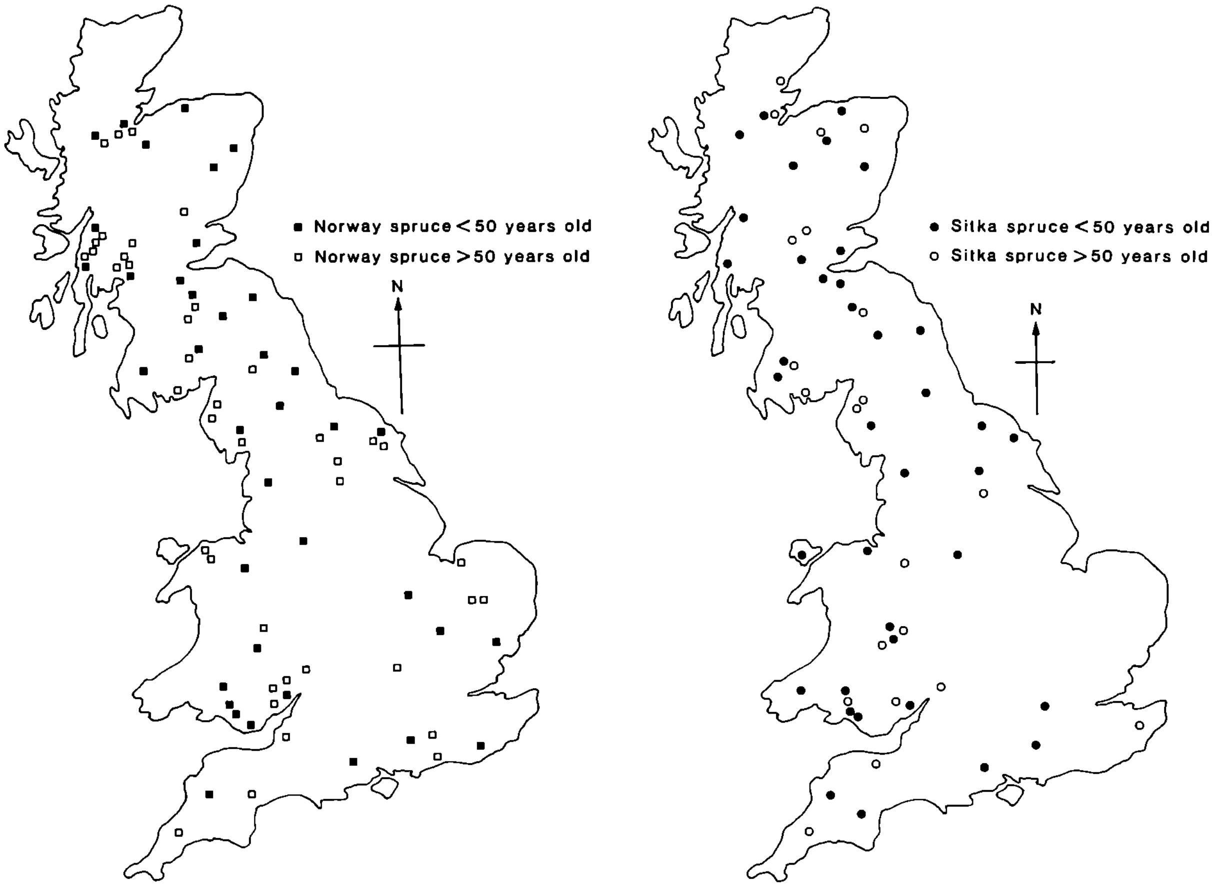
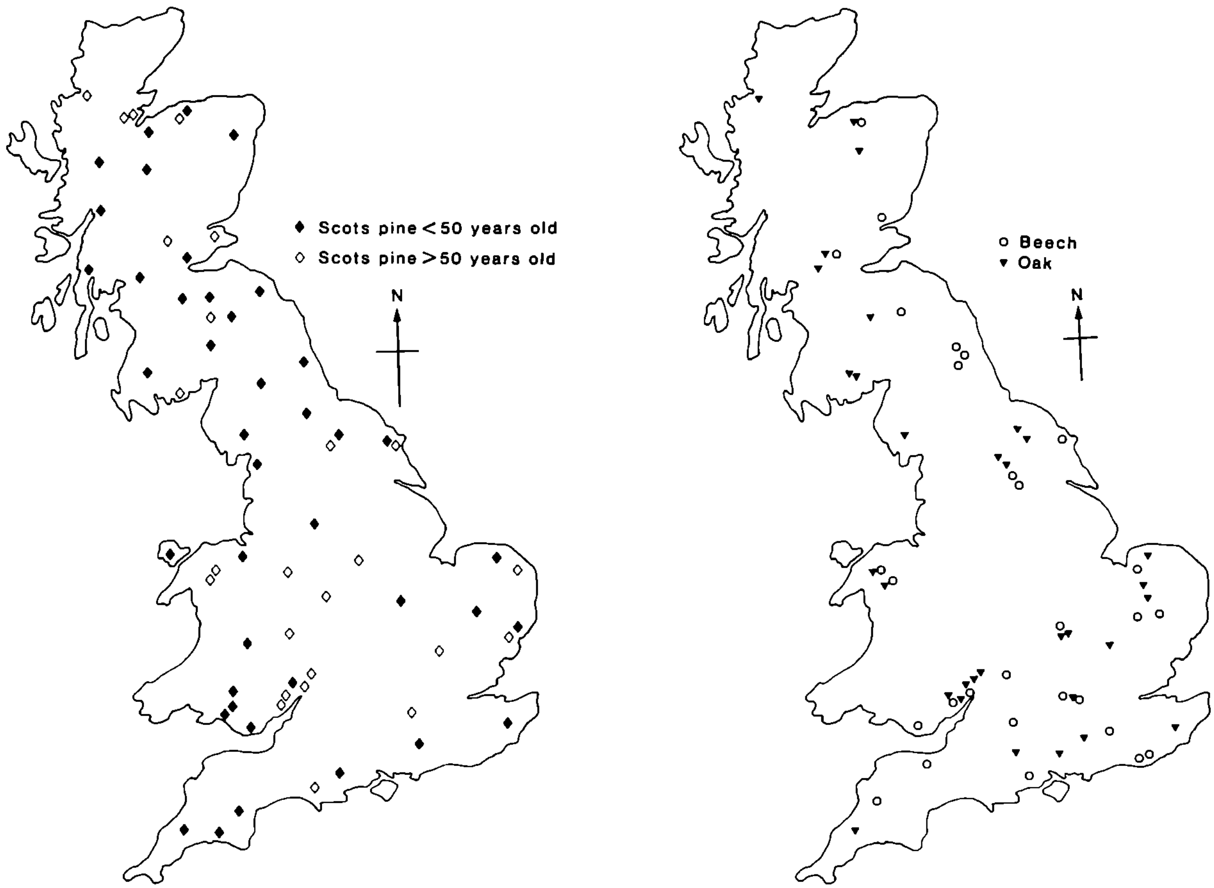


Figure 2. Approximate locations of Scots pine, oak and beech plots used in the 1987 survey.



intersections coincided with woodland of 0.5 ha or more, regardless of species, age or ownership. In Great Britain, 71 plots have been surveyed (Figure 3), and a further four plots in Northern Ireland have been assessed by the Forest Service of the Department of Agriculture for Northern Ireland.

Survey Procedures – Main Survey

For conifers, the methods used in 1987 were very similar to those in 1986 (Innes *et al.*, 1986). The only changes made were to accommodate the recommendations of the Economic Commission for Europe working group on forest assessments (Anon., 1987).

1. Needle discoloration was assessed on a 4-point scale with 0–10, 11–25, 26–60 and >60 per cent classes. The distinction between the 0 and the 1–10 per cent classes was dropped. However, yellowing and browning were still distinguished. The intensity and the extent of the discoloration were combined to obtain the score.
2. Overall discoloration of the tree was scored (in addition to the scores for current and older foliage). The scale described above was used in order to provide a better comparison with continental data.
3. Top-dying was dropped as an index of health as it has been so rare in the plots. If it occurred, it would be identified under defoliation type. (Top-dying as a defoliation type is not necessarily related to the pathological syndrome bearing the same name and described by Diamandis, 1978.)
4. Shoot death in the live crown was scored as absent, rare (1–10 shoots) or common (>10 shoots), rather than simply present or absent.
5. The degree of flowering on Scots pine was recorded, using a 4-point scale: absent, light, medium and heavy.

The techniques for assessing broadleaves are much less developed than those for conifers, although the studies of Lonsdale (1986a, 1986b) and Roloff (1985a, 1985b) have indicated possible indices for use in surveys. The inclusion of broadleaves in the survey meant that a new form had to be designed. The data form (together with that for conifers) is shown in Figure 4. Crown density was scored in 10 per cent classes, as with conifers. The same discoloration classes were used for the browning and yellowing of leaves as were used for conifers. The assessment of epicormic shoots relates principally to oak. Only epicormics on the branches were included. The purpose of determining their frequency was to assess their impact on the overall crown density. Crown dieback was included as many broadleaves show this phenomenon.

Figure 3. Approximate locations of plots used in the 1987 grid survey.

For beech, premature leaf loss was recorded in view of reports of this phenomenon in beech plots on the continent (Schütt and Summerer, 1983). Assessment was restricted to the frequency of green leaves on the ground. Unfortunately, a misunderstanding about how this should be recorded meant that data on the phenomenon are unreliable and these have therefore been omitted. The rolling of green leaves has also been attributed by some to air pollution although the evidence for this is limited. The extent and the degree of rolling were recorded separately. The long-term growth pattern of beech is likely to be important in any assessment. A system for the assessment of long-term growth patterns in beech has been developed by Roloff (1985a, 1985b). This was tried in our survey but

Figure 4a. Data-recording form used for conifers in the 1987 survey.

FOREST HEALTH SURVEY FORM C – CONIFERS

ASSESSOR | | | | | | | | | | | | | | DATE | | | | | | |

PLOT | | | | |

BRANCH HABIT [1]					DEFOLIATION TYPE [2]	% NEEDLE LOSS [3]	NEEDLE DISCOLOURATION [4]					NEEDLE RETENTION		[4]	[5]
EDGE ASSESSED	TREE NO.						BROWNING		YELLOWING						
		DBH	HT (m)				CURRENT NEEDLES	OLD NEEDLES	CURRENT NEEDLES	OLD NEEDLES	TOTAL DISCOLOURATION [4]	BINOCULAR COUNT	BRANCH COUNT	FLOWERING	SHOOT DEATH LIVE CROWN
N															
E															
S															
W															

(1) Spruce: 1 = Comb　2 = Brush/Plate　Pine = 0

(2) Spruce: 1 = Larch　2 = Sub-top dying　3 = Top dying　4 = Peripheral
Pine: 5 = Regular　6 = Top dying

(3) Over whole crown　0 = 0 - 10%　1 = 11 - 20%　up to 9 = 91 - 100%

(4) Score: 0 = 0 - 10%　1 = 11 - 25%　2 = 26 - 60%　3 = 61 - 100%

(5) Needles absent but shoots not suppressed, no physical injury (abrasion, Snow break).

NB. 0 = absence and 1 = presence of a feature. IF NOT ASSESSED, LEAVE BLANK

FS 2

Figure 4b. Data-recording form used for broadleaves in the 1987 survey.

FOREST HEALTH SURVEY FORM B – BROADLEAVES

ASSESSOR [ ]

DATE [ ]

PLOT [ ]

EDGE ASSESSED	TREE NO.	DBH	HT (m)	LEAF DISCOLOURATION (2): LEAF LOSS % (1)	LEAF DISCOLOURATION (2): BROWNING	LEAF DISCOLOURATION (2): YELLOWING	NO EPICORMIC BRANCHES (3)	CROWN DIE-BACK (4)	PREMATURE LEAF LOSS (3)	ROLLED LEAVES: FREQUENCY (3)	ROLLED LEAVES: DEGREE (5)	GROUND COVER (6)	ROLOFF SCORE (7): CROWN	ROLOFF SCORE (7): TWIG	SIGNIFICANT CROWN EFFECTS (8): FUNGI	SIGNIFICANT CROWN EFFECTS (8): INSECTS
N																
E																
S																
W																

(1) Over whole crown 0 = 0 - 10%, 1 = 11 - 20%, up to 9 = 91 - 100%

(2) Score 0 = 0 - 10%, 1 = 11 - 25%, 2 = 26 - 60%, 3 = 61 - 100%

(3) 0 = none, 1 = rare, 2 = common

(4) 0 = none, 1 = 1 - 10%, 2 - 11 - 30%, 3 = > 30%

(5) 0 = none, 1 = light, 2 = moderate, 3 = severe

(6) 1 : Calluna / Vaccinium heath type; 2 : Bracken predominant; 3 : dry grass herb; 4 : moist grass herb; 5 : other

(7) Score 0 to 3 depending on intensity

(8) 0 = none, 1 = present

NOT ASSESSED : LEAVE BLANK

FS 3

the assessments made by the observers were unreliable and the results have not been included here. Assessments will be made during the coming winter when twig form is much more readily visible.

Survey Procedures – EEC Survey

The methods of assessment were the same as those used in the main survey, although the data collected were much less detailed. Each tree was scored for defoliation and discoloration according to the German system of classification and any easily identifiable causes of damage were noted. A number of sources were used to provide reference photographs (e.g. Bosshard, 1986; EEC, 1985), and tests undertaken during training indicated that new species were being reliably assessed.

Reliability of Observations

In 1986, there were considerable differences in the ways in which the four different teams of observers assessed the same trees, despite the introduction of a limited training programme. This caused some of the apparent regional variation in the results. Variation between observers is not restricted to Great Britain: it occurs both within and between many of the countries undertaking surveys. In order to try and reduce the impact of observer variation, a week-long training course was mounted. This successfully reduced the variation between teams, despite an increase in the number of survey teams from four to ten. The training techniques used during the course were similar to those used in West Germany (Schöpfer, 1985). In order to maintain consistency, the first author visited all teams in the field. In each survey team's area, a number of plots were examined concurrently with the survey team. In total, 16 per cent of the trees assessed in the survey were checked (a much higher figure than on the continent where similar checks are normally made on only 5–10 per cent of the trees).

The results of this work indicate that the majority (95 per cent) of estimates of crown density fell within ± 15 per cent of those made by the control observer, depending on species. There were differences between species in the consistency of the observations and the species estimates can be ranked in order of decreasing consistency: oak, Norway spruce, Sitka spruce, beech and Scots pine. The finding that the estimates of crown density for Scots pine are the least reliable is not surprising: pines are widely acknowledged as being one of the most difficult genera to assess.

Results

These are presented by species and by age. As in last year's report, data from trees less than and more than 50 years old are presented separately. Fifty years is an arbitrary choice but is considered to be more appropriate in Britain than the limit of 60 years which has been adopted on the continent, where rotations are generally much longer.

Terminology

Over the past few years, several terms have become commonplace in surveys of forest health. Because confusion exists over their meaning, they are defined below.

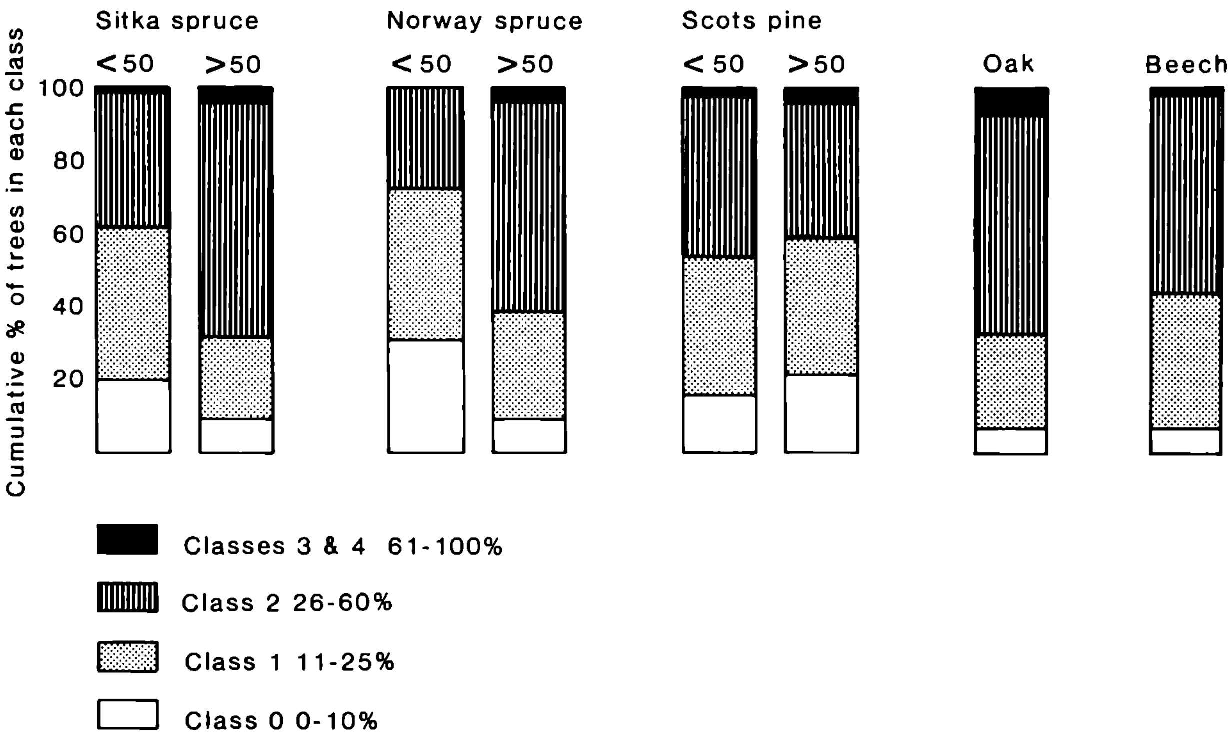
Crown density (previously referred to as needle loss). In the British survey, crown density is estimated by comparing the density of the crown of the tree in question, in 10 per cent classes, with that of a perfect tree. A crown density class of 1 is equivalent to a tree having a density of 10–19 per cent less than that of a perfect tree, that is a needle or leaf 'loss' of 10–19 per cent. Class 2 is equivalent to 20–29 per cent and so on. Thus, a high crown density score indicates a thin crown, whereas a low score indicates a relatively dense crown. Crown density is influenced by a wide range of factors, and a high score is not necessarily indicative of damage.

Damage. In the literature, this is frequently identified with any crown density or discoloration score of 1 or more. This is based on the German classification system which has only four categories and in which 10–25 per cent needle loss (their category 1) is defined as 'slight damage', 26–60 per cent as 'moderate damage' and 61–100 per cent as 'severe damage'. (There are actually five categories, 0, 1, 2, 3 and 4 but the last two, severely damaged and dead trees, are normally combined). In the German report for 1986 (Anon., 1986a), the 'slight damage' category has been reclassified as a 'warning' category in recognition of the widely accepted principle that density losses of up to 25 per cent or more may occur quite naturally without the tree having been damaged. Even this figure is conservative and there is an increasing amount of evidence which suggests that reductions of up to 50–60 per cent can occur without any loss in stem diameter increment. In order to avoid ambiguity, the term damage is not used in this report.

Crown density (Tables I–3)

Crown density is the most important of the indices of forest condition used in the international surveys. The results for all plots surveyed in 1987 are presented in Table 1. As many countries now present their results in a 4–category classifi-

Figure 5. Distribution of crown thinning by German classes for the five species surveyed in 1987. A class of 0 is equivalent to a reduction of density of 0–10%. All data gathered in each year of the survey are presented.



cation, our data are also presented in this fashion (Table 2a). The results are portrayed graphically in Figure 5 using the 4-category convention.

For consistency with other countries, our figures for conifers have also been recalculated using a limit of 60 years (Table 2b). As pointed out below, the data from the grid survey presented in Table 11 are much more suitable for international comparisons.

Discoloration (Tables 3 and 4)

The second index of crown condition is the extent of needle or leaf discoloration. In the British survey, this is examined in rather more detail than is the case elsewhere. As a result of the training, we can now reliably separate browning and yellowing. (They were combined in 1986 because of confusion between the two.) To maintain consistency with continental surveys, the overall discoloration of the tree is also recorded. The extent of browning, yellowing and total discoloration is shown for conifers in Table 3 and for broadleaves in Table 4.

Needle retention

The needle retention of a tree is the number of years that it retains needles. In the past, this has been thought to be an exact measure and has consequently been recommended as a useful index of crown condition (Dong, 1986). However, it is frequently impossible to see needles more than 6–7 years old in the crown. Consequently, the calculated figure for mean needle retention (as has been used in our past reports) may seriously underestimate the true value. This does not apply to Scots pine which rarely retains its needles for more than 5 years in Great Britain. In Figure 6, the proportions of trees in each needle-age category up to 7 years and the proportion in the category of more than 7 years are given.

Defoliation type (Table 5)

Four types of defoliation are currently recognised in spruce (Pollanschütz *et al.*, 1985) although recent work has suggested that up to ten may exist (Westman and Lesinski,

Table 1. Percentage distribution of trees by 10 per cent crown density classes, 1987; all plots

	n	Crown density class 0	1	2	3	4	5	6	7	8	9
Sitka spruce (less than 50 years old)	923	20	27	28	15	7	2	1	0	0	0
Sitka spruce (more than 50 years old)	432	8	15	19	25	18	10	4	1	0	0
Sitka spruce (all trees)	1355	16	23	25	18	11	5	2	0	0	0
Norway spruce (less than 50 years old)	984	31	29	24	11	4	1	0	0	0	0
Norway spruce (more than 50 years old)	864	8	18	24	22	15	8	4	1	0	0
Norway spruce (all trees)	1848	20	24	24	16	9	4	2	1	0	0
Scots pine (less than 50 years old)	907	17	23	27	19	9	3	1	1	0	0
Scots pine (more than 50 years old)	648	21	26	22	17	6	3	1	1	2	1
Scots pine (all trees)	1555	19	24	25	18	8	3	1	1	1	0
Oak (80–180 years old)	767	8	15	23	29	14	5	4	2	0	0
Beech (60–120 years old)	672	8	22	26	28	12	3	1	0	0	0

Table 2a. Percentages of trees in each crown density category according to the West German 4-category classification. Figures in parentheses refer to % reduction in density in each category

	n	Crown density category 0 (0–10)	1 (11–25)	2 (26–60)	3+4 (>60)
Sitka spruce (<50)	923	20	41	38	1
Sitka spruce (>50)	432	8	24	63	5
Sitka spruce (all)	1355	16	36	46	2
Norway spruce (<50)	984	31	41	28	0
Norway spruce (>50)	864	8	30	57	5
Norway spruce (all)	1848	20	36	41	3
Scots pine (<50)	907	17	37	44	2
Scots pine (>50)	648	21	37	37	5
Scots pine (all)	1555	19	37	41	3
Oak	767	8	26	60	6
Beech	672	8	35	56	1

Table 2b. Percentage of trees in the 4-category German classification system with the age threshold adjusted to 60 years

	n	Crown density category 0 (0–10)	1 (11–25)	2 (26–60)	3+4 (>60)
Sitka spruce (<60)	1235	18	38	42	2
Sitka spruce (>60)	120	0	11	85	4
Norway spruce (<60)	1320	27	41	31	1
Norway spruce (>60)	528	4	25	62	9
Scots pine (<60)	1387	18	36	42	3
Scots pine (>60)	168	29	32	38	1

Table 3a. Percentages of trees in each needle-browning class, 1987. In this and subsequent tables, class 0 includes trees with 0–10% needles affected, class 1, 11–25%, class 2, 26–60% and class 3, >60%. Sample sizes are the same as in Table 2

	Current				Old			
	0	1	2	3	0	1	2	3
Sitka spruce (<50)	95	4	1	0	89	10	1	0
Sitka spruce (>50)	92	8	0	0	95	4	1	0
Sitka spruce (all)	94	6	0	0	91	8	1	0
Norway spruce (<50)	96	4	0	0	93	6	1	0
Norway spruce (>50)	94	5	1	0	95	4	1	0
Norway spruce (all)	95	4	1	0	94	5	1	0
Scots pine (<50)	94	5	1	0	94	6	0	0
Scots pine (>50)	95	4	1	0	90	8	2	0
Scots pine (all)	94	5	1	0	92	7	1	0

Table 3b. Percentages of trees in each needle-yellowing class, 1987

	Current				Old			
	0	1	2	3	0	1	2	3
Sitka spruce (<50)	96	3	1	0	91	8	1	0
Sitka spruce (>50)	99	1	0	0	85	11	4	0
Sitka spruce (all)	97	2	1	0	89	9	2	0
Norway spruce (<50)	100	0	0	0	98	2	0	0
Norway spruce (>50)	96	4	0	0	98	1	1	0
Norway spruce (all)	98	2	0	0	98	2	0	0
Scots pine (<50)	99	1	0	0	96	4	0	0
Scots pine (>50)	97	3	0	0	97	3	0	0
Scots pine (all)	98	2	0	0	96	4	0	0

Table 3c. Percentages of trees in each total needle discoloration class, 1987

	0	1	2	3
Sitka spruce (<50)	88	10	2	0
Sitka spruce (>50)	87	9	4	0
Sitka spruce (all)	88	10	2	0
Norway spruce (<50)	97	3	0	0
Norway spruce (>50)	93	6	1	0
Norway spruce (all)	95	4	1	0
Scots pine (<50)	92	7	1	0
Scots pine (>50)	91	7	2	0
Scots pine (all)	91	7	2	0

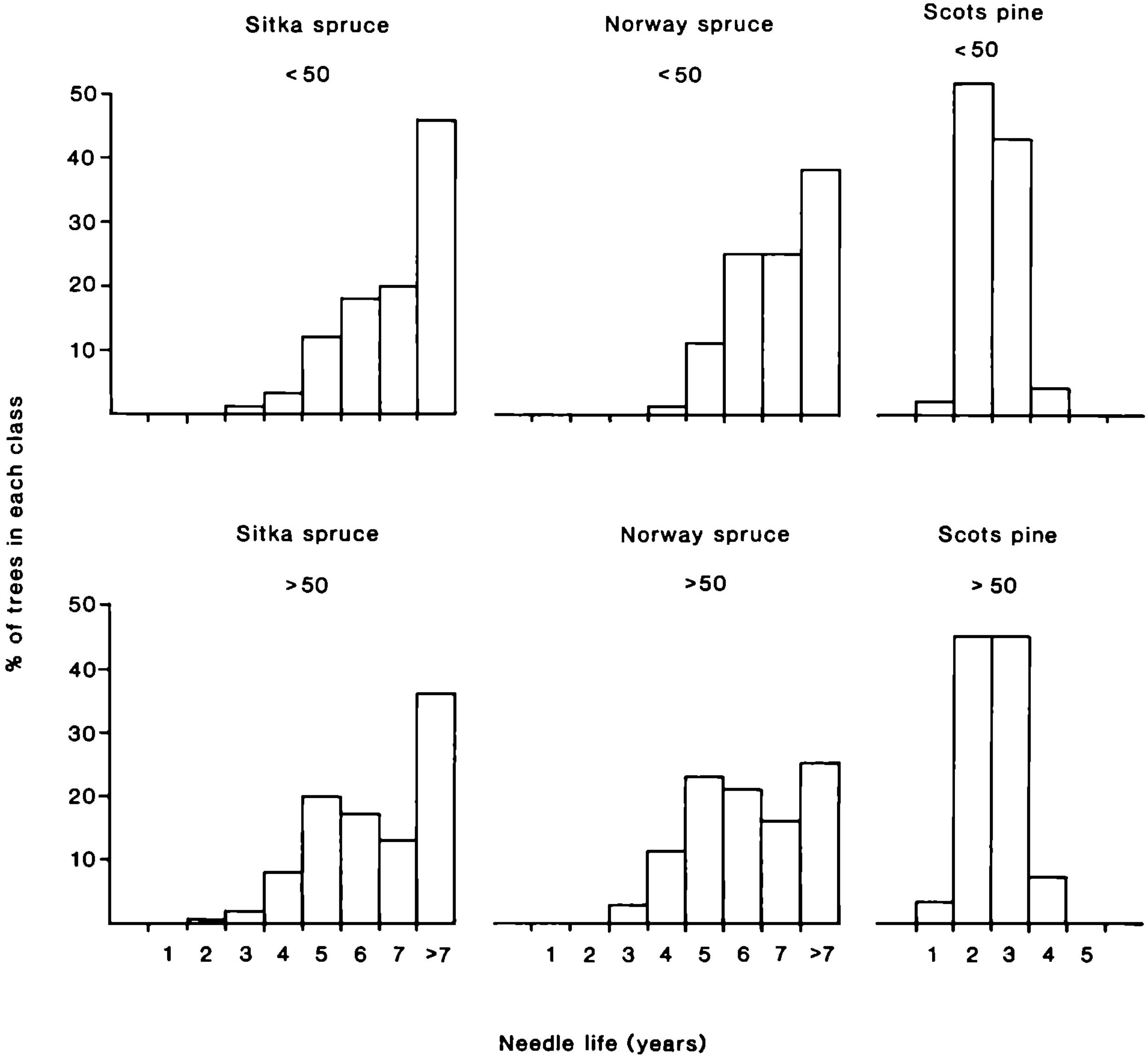
Table 4. Percentages of oak and beech showing leaf discoloration in different classes, 1987

	n	Brown leaves				Yellow leaves			
		0	1	2	3	0	1	2	3
Oak	767	98	2	0	0	97	3	0	0
Beech	672	74	22	4	0	86	13	1	0

Table 5. Percentages of spruces in each defoliation type: defoliated trees only

	n	Larch	Sub-top dying	Top-dying	Peripheral
Sitka spruce (<50)	696	95	4	1	0
Sitka spruce (>50)	408	93	5	2	0
Norway spruce (<50)	723	97	3	0	0
Norway spruce (>50)	806	90	8	2	0

Figure 6. Distribution of needle life (needle retention) in each of the three coniferous species in 1987.



1986). The four types (illustrated in Binns *et al.*, 1986) grade into each other; indeed, two types of defoliation may be present on the same tree (a combination of larch-type and sub-top dying-type is particularly common). In Great Britain, larch-type defoliation is by far the most frequent form.

Flowering in Scots pine (Table 6)

The extent of flowering in Scots pine has not been previously recorded in our surveys. It was included this year as flowering may significantly affect the estimate of crown density by creating a gap in the needles (see Figure 7). In Germany, estimates of crown density take into account the amount of flowering: if flowering has occurred, the crown density score is reduced by an appropriate amount. At an international level, there is considerable disagreement over this procedure and in Britain we have decided to keep the estimates of flowering and crown density separate.

Crown dieback in broadleaves (Table 7)

Many of our broadleaves show a certain amount of dieback. This is particularly noticeable in hedgerow trees (where it is the subject of a separate study at Aberdeen University sponsored by the Department of Environment (Air and Noise Division) and the Forestry Commission). The results in Table 7 provide some indication of its presence in plantations.

Figure 7. Flowering in Scots pine. The shoot on the left has no flowers present and has two years of needles (with the remnants of a third year also shown), whereas the shoot on the right exhibits the effect of flowering in the most recent needle-year.

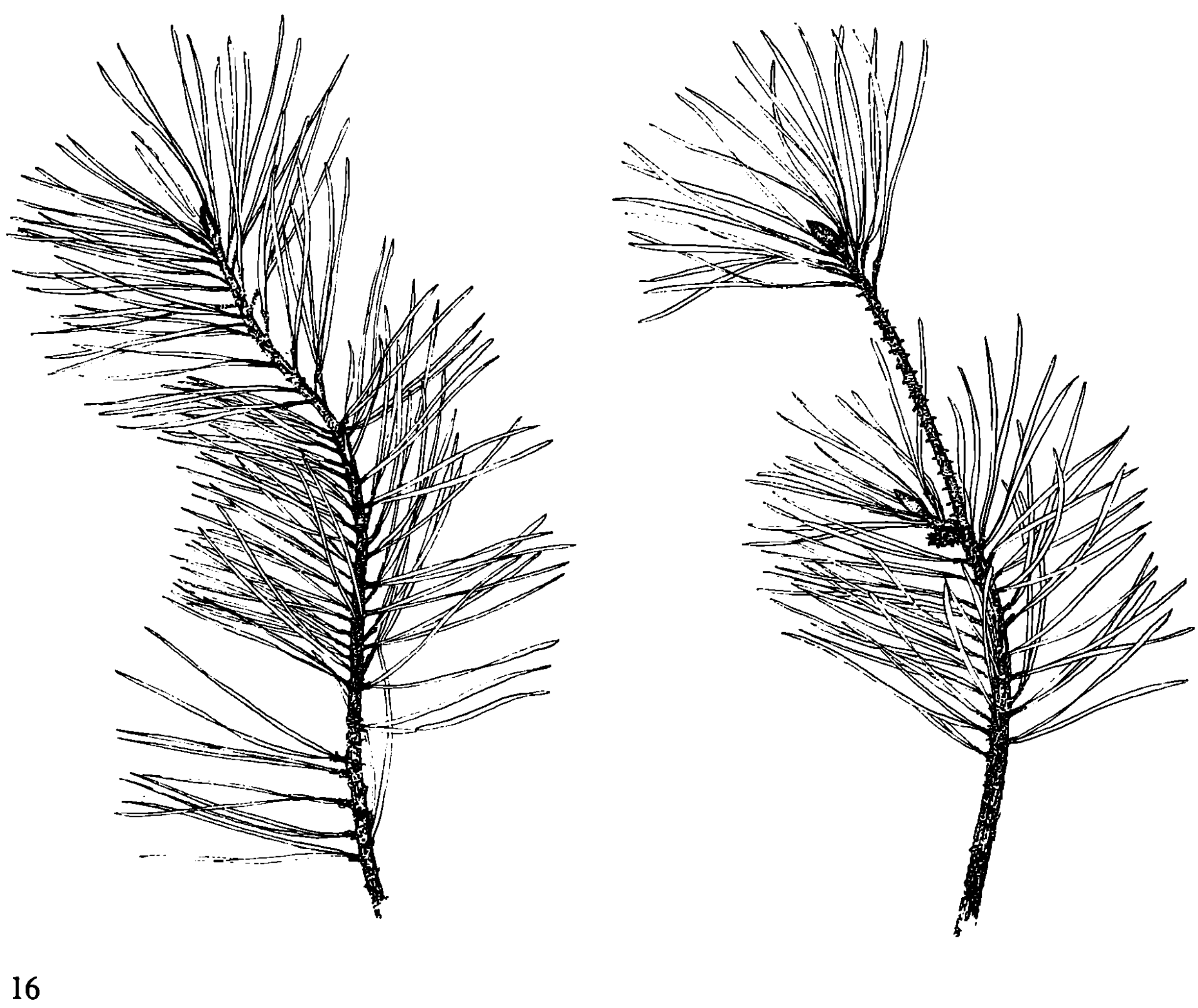


Table 6. Percentage of pine in each flowering class, 1987

	n	0–10% None	11–25% Light	26–60% Medium	>60% Heavy
Scots pine (<50)	907	63	28	8	1
Scots pine (>50)	648	46	34	18	2

Table 7. Percentages of beech and oak in each crown dieback class

	n	Extent of crown dieback None	1–10%	11–30%	>30%
Oak	767	63	25	9	3
Beech	672	70	21	8	1

Table 8. Percentages of conifers in each shoot death class, 1987.

	n	None	<10	>10
Sitka spruce (<50)	923	79	18	3
Sitka spruce (>50)	432	56	38	6
Sitka spruce (all)	1355	72	24	4
Norway spruce (<50)	984	82	16	2
Norway spruce (>50)	864	50	42	8
Norway spruce (all)	1848	67	28	5
Scots pine (<50)	907	64	32	4
Scots pine (>50)	648	63	31	6
Scots pine (all)	1555	63	32	5

Table 9. Percentages of beech with leaf-rolling in crown (n=672).

		Nil	Light	Degree Moderate	Severe
	Absent	80	0	0	0
Extent	Rare	0	12	3	0
	Common	0	3	4	0

Shoot death in conifers (Table 8)

Whilst crown dieback in conifers is relatively rare, there may be significant numbers of dead shoots within the crown. It is important to record these as they contribute to the overall crown density and they might be attributable to a specific cause. Shoot death as a result of abrasion is not included in these estimates.

Leaf-rolling in beech (Table 9)

Both the extent and the degree of leaf-rolling were recorded. Severe rolling could reduce apparent crown density as more light penetrates through the crown.

Presence of insects and fungi in broadleaves

If the crown density or the extent of discoloration was considered to be significantly affected by either insects or fungi, this was recorded on the data form. In oak, damage by fungi was recognised in 2 per cent of the trees and insect damage in 59 per cent of the trees. In beech, fungal damage was identified in 1 per cent of the trees and insect damage in 54 per cent of the trees.

Comparison of Results with Previous Years

In Figure 8, the overall data from all four years are presented. In this Figure, the difference between years is attributable to a number of factors, including changes in sampling design and size, changes in assessment technique as well as genuine changes in the condition of the forest. Innes *et al.* (1986) described ways in which the results of 1984 and 1985 were not comparable with those of 1986. However, it is of interest to compare the changes in the data recorded in those plots which have been assessed each year and these are shown for the percentage of trees (all ages) with crown density reductions of 25 per cent or more (Figure 9). It is clear that the deterioration in appearance that occurred between 1985 and 1986 was even greater between 1986 and 1987.

Figure 10 presents data for crown density obtained in 1986 and 1987 for those plots assessed in both years. The changes for the individual species have been assessed using a two-tailed two-sample Kolmogorov-Smirnov test. With all species and age classes, there has been a significant ($p < 0.01$) reduction in crown density between the two years. With both Norway spruce and Scots pine,

Figure 8. Distribution of crown thinning for the four survey years. All data gathered in each year of the survey are presented.

this was greater for younger trees than for trees more than 50 years old.

Browning and yellowing were not distinguished in 1986, and this means that the 1987 data for these two types of discoloration can be compared with the 1986 data only if they are similarly combined. With Norway spruce and Sitka spruce there was no significant difference in the extent of discoloration between 1986 and 1987. With Scots pine, there was no significant difference in the discoloration of first year needles, whereas discoloration of older needles was significantly less.

Figure 9. Percentage of trees with more than 25% reduction in crown density over the four years of the survey. As stated in the text, differences in survey techniques mean that the data for 1984 and 1985 are not directly comparable with those for 1986 and 1987. The data refer only to those plots examined in all four years.

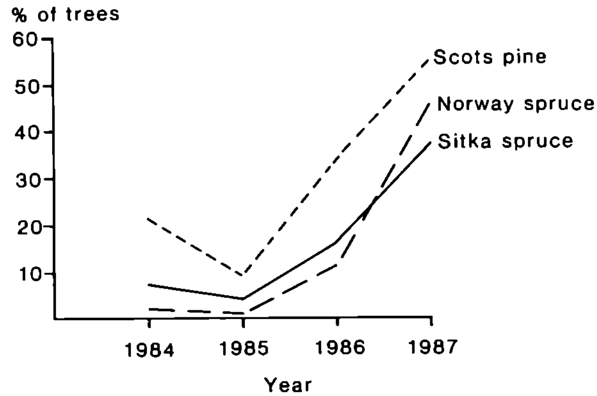


Figure 10. Comparison of distribution of crown thinning in 1986 and 1987. Only the plots examined in both 1986 and 1987 have been included.

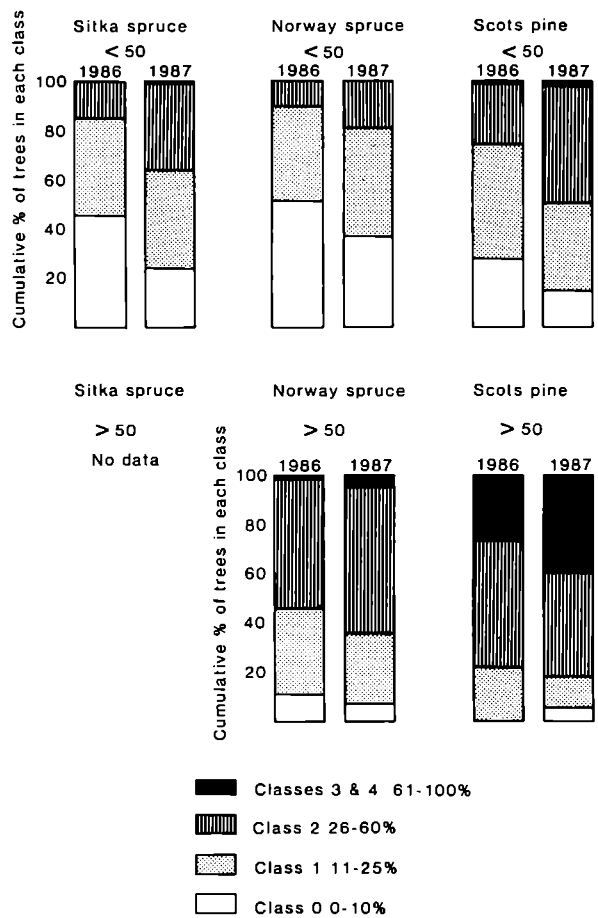
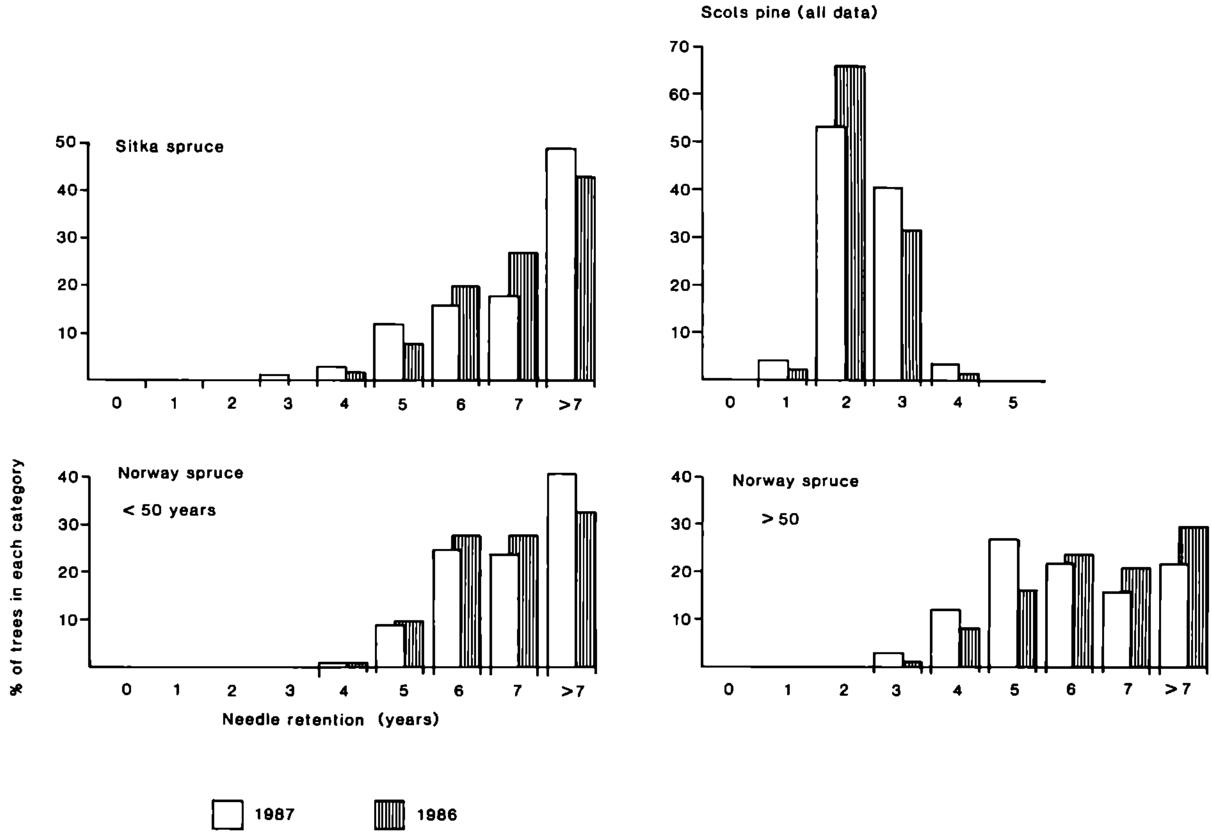


Figure 11. Comparison of needle life between 1986 and 1987.



It is also possible to compare needle retention data for the two years. The distribution of needle years, as shown in Figure 6, was compared with similar distributions prepared from the 1986 results, again using the Kolmogorov-Smirnov test. In all cases, the distributions of needle years were significantly different. When portrayed graphically (Figure 11), it appears that needle retention in Scots pine has increased, although the mean needle retention only changed marginally: from 2.3 years in 1986 to 2.4 years in 1987. Needle retention in younger Norway spruce has also increased but in older Norway spruce it has decreased. Although the distributions are significantly different, the direction of change is not readily apparent in Sitka spruce. These results are in contrast to the evidence from the crown density assessments and the reasons for this are currently being investigated.

Results of the EEC Grid Survey

The results obtained from the grid survey are considered to be representative of the forest condition throughout the community (Anon., 1986b). While this holds true for some countries, Innes (1987) has argued that it does not apply for some species in Britain. This is because of the sampling difficulties created by the presence of large numbers of poorly-represented species. However, for the main species, the 16 x 16 km sampling grid has produced a remarkably similar species distribution to that of the Forestry Commission census data (Table 10) and the information from the grid survey can therefore be taken as being broadly indicative of the crown condition of British woodland.

The results of the survey are shown in Table 11 and Figure 12. The format is that required by the EEC: they have been presented in this fashion to enable direct comparison with other countries when their data become

Table 10. Woodland extent derived from the grid survey compared to that derived from the Forestry Commission 1979–82 census (Locke, 1987). All figures in percentages of total woodland cover.

	Grid survey	Census
English oak	7	9
Ash (*Fraxinus excelsior* L.)	4	4
Sycamore (*Acer pseudoplatanus* L.)	3	3
Beech	4	4
Birch (*Betula* spp.)	6	5
Other broadleaves	12	5
Sitka spruce	29	28
Scots pine	13	13
Lodgepole pine (*Pinus contorta* Dougl.)	7	7
Japanese larch (*Larix kaempferi* (Lamb.) Carr.)	5	6
Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco)	4	2
Other conifers	6	14

available. In line with EEC conventions, only the data for the five commonest broadleaves and the five commonest conifers have been presented. To comply with EEC requirements, English oak (*Quercus robur*) was separated from sessile oak (*Q. petraea*). This was done by allocating trees to either species according to a number of taxonomic characteristics. It is likely that many of the oaks examined were hybrids and their allocation to one or other of the species is therefore arbitrary. The majority of oaks assessed in the survey were classified as *Q. robur* and the *Q. petraea* individuals have been included in the 'other broadleaves' category.

Comparison of Main Survey Results with the EEC Survey

It is possible to compare the data obtained from the grid survey, which is representative of the general condition of woodlands in the United Kingdom, with the data from the main survey reported above. To make the results more comparable, the data set used in this comparison excludes the data from Northern Ireland. The comparison has been

Table 11. Defoliation and discoloration in British woodlands as determined from the grid survey of forest health. All figures refer to the percentage of trees in each category within each species

	n	Crown density category 0 (0–10)	Crown density category 1 (11–25)	Crown density category 2 (26–60)	Crown density category 3+4 (>60)	Discoloration category 0 (0–10)	Discoloration category 1 (11–25)	Discoloration category 2 (26–60)	Discoloration category 3 (>60)
English oak	127	21	37	38	4	92	6	2	0
Ash	74	69	22	8	1	99	1	0	0
Sycamore	68	65	31	4	0	69	28	3	0
Beech	66	32	50	17	1	72	23	4	0
Downy birch	61	52	28	20	0	89	7	4	0
Other broadleaves	239	46	37	17	0	90	9	1	0
Sitka spruce	538	49	31	16	4	78	16	4	2
Scots pine	227	31	34	29	6	85	14	1	0
Lodgepole pine	120	16	33	37	14	26	43	31	0
Japanese larch	103	37	55	7	1	90	8	1	1
Douglas fir	70	69	23	5	4	99	1	0	0
Other conifers	107	57	36	7	0	69	19	12	0
All broadleaves	635	45	35	19	1	87	11	2	0
All conifers	1165	43	34	18	5	76	17	6	1
All trees	1800	44	34	18	4	80	15	5	0

made graphically (Figure 13) and it is readily apparent that the crown densities of the trees examined in the grid survey are significantly better than those of the trees in the main survey. Conversely, discoloration is much greater in the trees examined in the EEC survey. These findings will be discussed further in the second part of the report. As the grid survey is undertaken on a comparable basis to the surveys in other countries of the EEC it is these data which should be used when comparing the condition of trees in Britain with those in other European countries.

Conclusions

This report, together with those from previous years (particularly that of 1986) indicates that both crown thinning and the yellowing of needles (the two symptoms most frequently associated with forest decline on the continent) are present in Britain. The extent of crown thinning and discoloration in Britain is similar to that in West Germany. However, as neither of these symptoms is specific to any given cause, no easy interpretation of this similarity is possible.

We are also concerned with identifying whether any long-term trend in the health of our trees is present. In 1987, there has been a significant reduction in the recorded crown densities of Sitka spruce, Norway spruce and Scots pine; no such statement can be made about beech and oak as this is the first year that data have been collected. A similar decrease in the condition of conifers occurred between 1985 and 1986, after a slight improvement between 1984 and 1985. It is clear from data such as those presented in Figure 5 that low-density crowns are widespread in Great Britain. What is unclear is whether they have reached this condition as a result of a recent deterioration in condition or whether we are now better at recognising reduced crown density (Innes *et al.*, 1986).

The next stage is the examination of the above data for regional differences in the crown condition and the potential correlation of any regional patterns with variables such as those relating to climate, altitude and pollution. This will form the basis of the second part of the report.

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Figure 12. Distributions of crown thinning in the trees examined during the grid survey. In line with the EEC/ECE convention, the five most important broadleaves and the five most important conifers are shown, together with the totals.

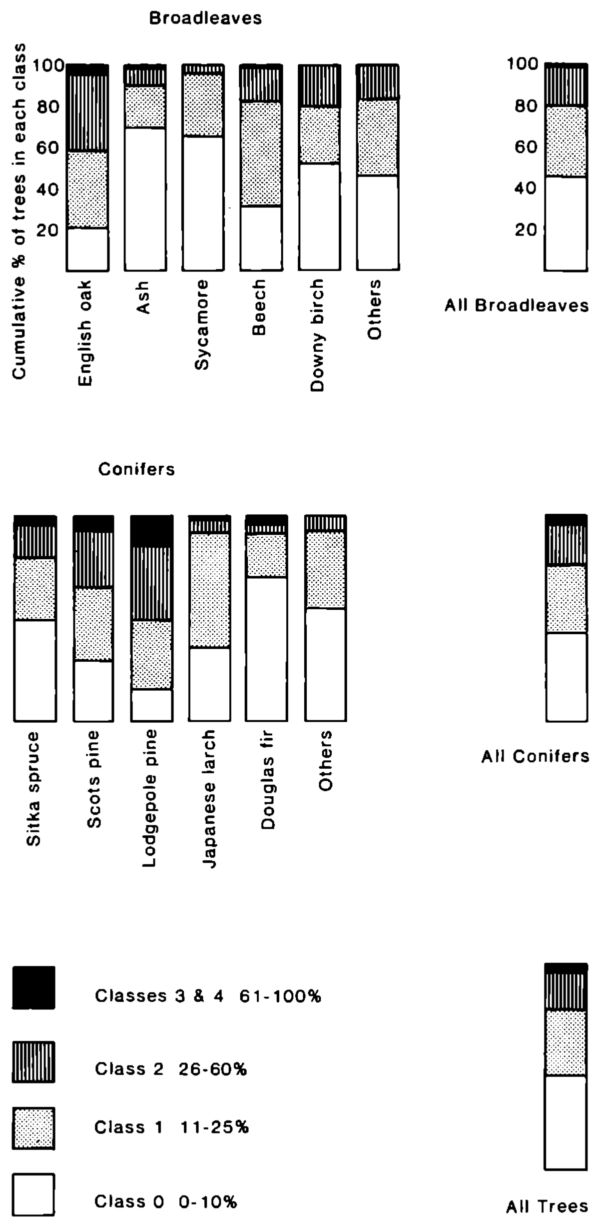
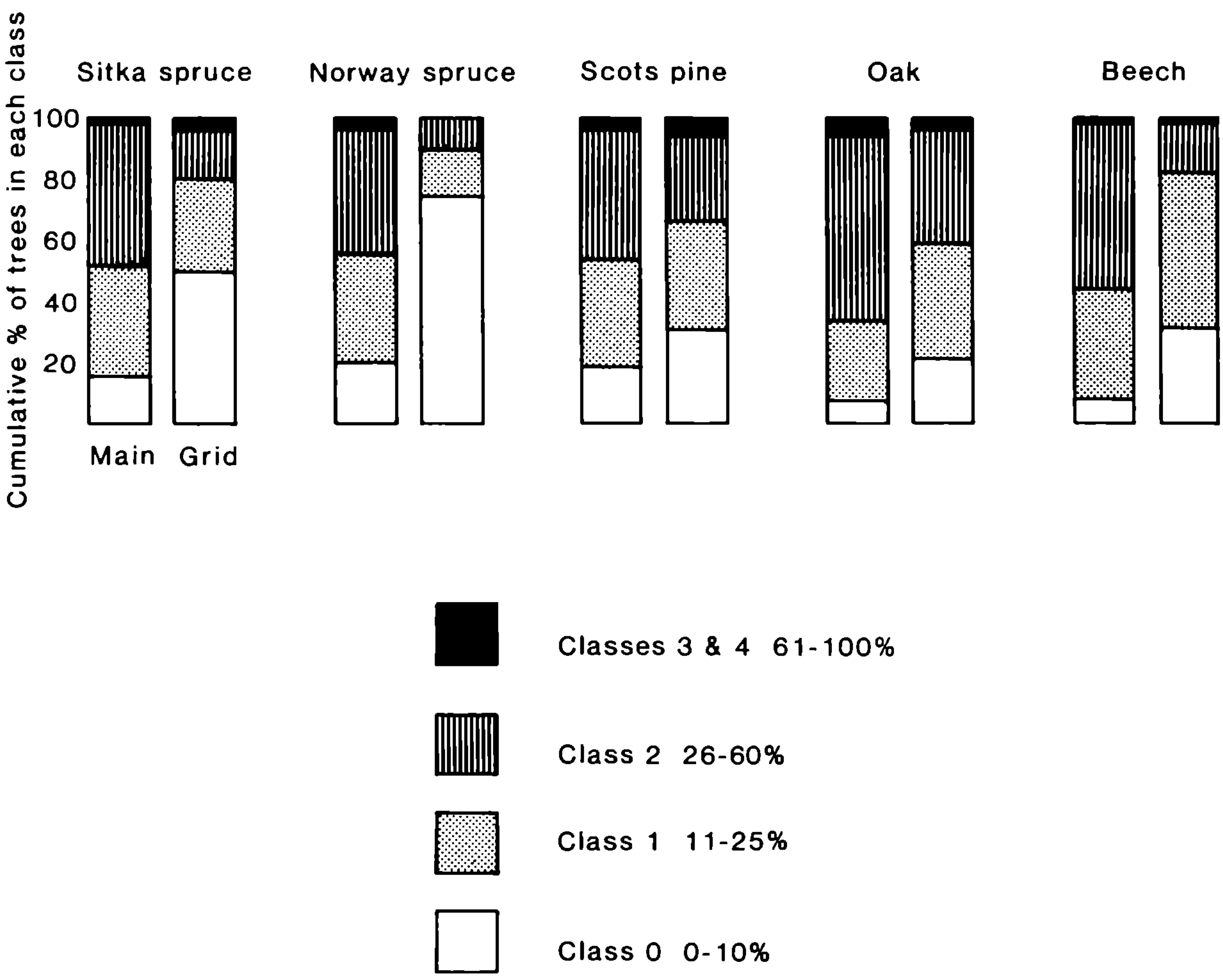


Figure 13. Comparison of distributions of crown thinning revealed by the main (FC) survey and the grid (EEC) survey.



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