Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
www.forestry.gov.uk

Forest Condition 2002

INFORMATION NOTE

BY S. J. HENDRY, R. C. BOSWELL & J. C. PROUDFOOT OF FOREST RESEARCH SEPTEMBER 2003

SUMMARY

Crown density and various other features were assessed on a total of 8460 trees of five species - Sitka spruce, Norway spruce, Scots pine, oak and beech – distributed over 353 plots throughout Britain. Although growing conditions during 2002 were generally good, the crown condition of most species changed little or declined when compared to 2001. A sharp decrease in the crown density of Sitka spruce was due to widespread attack by the green spruce aphid (*Elatobium abietinum*). Following a major improvement last year, a slight decline in the condition of beech this year was associated with heavy mast production and is not necessarily an indication of ill health. A small reduction in the crown density of Scots pine was largely due to needle cast caused by the fungus *Lophodermium seditiosum* and to the production of a heavy male flower crop. The condition of oak deteriorated markedly but the change was attributable to a minor reduction in the crown density of many trees rather than a notable increase in the incidence of attack by pests or pathogens.

INTRODUCTION

1. Since 1987 the Forestry Commission has monitored annual changes in the condition of Britain's forest trees by assessing the status of five forest species *via* a network of monitoring plots distributed throughout the country. In 2002 a total of 8460 trees was assessed distributed over the following numbers of plots: 63 Sitka spruce (*Picea sitchensis* (Bong.) Carr.), 56 Norway spruce (*P. abies* (L.) Karst.), 81 Scots pine (*Pinus sylvestris* L.), 86 oak (*Quercus* spp.) and 64 beech (*Fagus sylvatica* L.). There were also three plots in mixed stands of Sitka spruce and Scots pine. The assessments were carried out between 14th June and 27th September 2002.

2. Plots consist of twenty-four trees, located in four sub-plots of six trees. Depending upon the species assessed, between 29 and 33 features indicative of condition are scored for each of the surveyed trees. Evaluations of the incidence of flowering and fruiting, or the incidence of damage by insects or fungi are therefore made, but the feature of greatest interest is an assessment of crown density. This is an estimate of the degree of transparency of the crown, which is used as an index of tree condition. Until 1993, the basis for comparison used in the surveys conducted in the United Kingdom was an 'ideal' tree carrying the maximum possible amount of foliage. However, in similar surveys conducted in most other European countries comparisons are most commonly made with reference to a tree with full foliage under local conditions (the 'local tree' method). Usually this method involves selecting the tree with the greatest amount of foliage in the general vicinity of a survey plot to serve as a standard against which the plot trees are assessed. The same local tree is generally retained from year to year but it may be replaced by another tree in the event that its condition deteriorates. In order to harmonise with results obtained in other countries, crown density estimates in the United Kingdom have been made using the local tree method since 1993. However, in order to maintain the existing time series of crown density figures, all plot trees have also been assessed using the previous idealised standard.

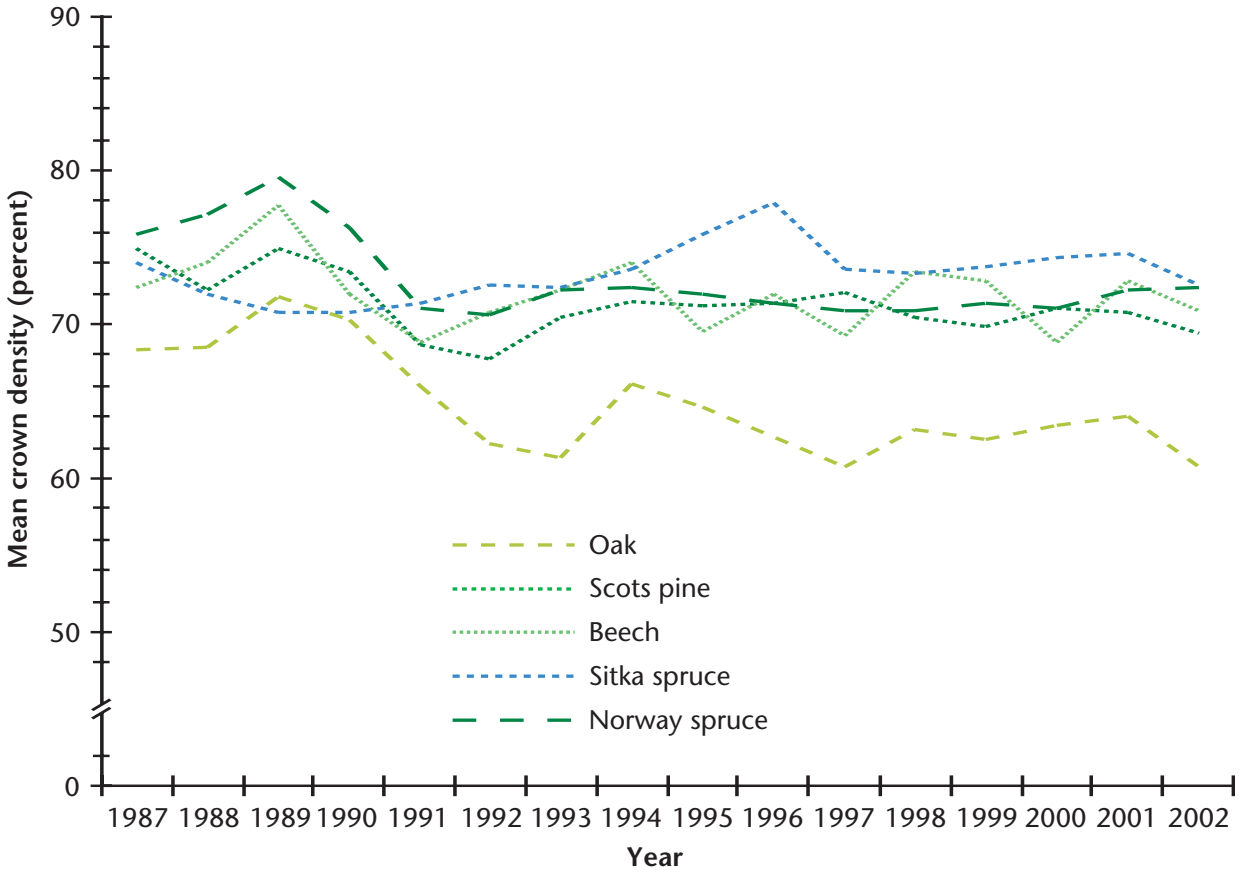
3. Reductions in crown density are estimated in 5% classes by reference either to a standard set of photographs of 'ideal' trees (Innes, 1990) or to 'instant' photographs of individual local reference trees. Data are collected on hand-held computers and are checked for consistency and for departures from expected values both in the field and before analysis.

4. In order to check the consistency of the crown density scores made by the 16 teams of assessors involved in the survey, 95 plots were re-assessed by one experienced supervisor. The proportion of trees for which the scores of the survey team and standard assessor fell within one 5% class ranged from 89.7% in Norway spruce to 92.2% in Sitka spruce. The

Table 1 **Percentages of trees in each crown density class for five species in 2002.** Each 10% class represents the density of the tree's crown compared either to an 'ideal tree' (I), i.e. a tree with the maximum possible amount of foliage, or to a 'local tree' (L), i.e. a tree with full foliage under local conditions.

% crown density [% reduction in crown density]	Sitka spruce		Norway spruce		Scots pine		Oak		Beech	
	I	L	I	L	I	L	I	L	I	L
90–100 [0–10]	11.4	24.9	11.5	30.7	4.8	32.2	0.9	15.3	2.7	37.5
80–89 [11–20]	25.9	36.6	25.8	33.0	24.8	30.7	8.2	29.4	26.6	37.8
70–79 [21–30]	32.5	22.4	32.2	22.5	32.4	22.5	22.7	29.4	37.4	16.7
60–69 [31–40]	18.5	9.0	20.6	9.4	24.3	8.9	35.2	15.3	23.6	5.5
50–59 [41–50]	6.7	3.1	5.6	2.2	8.8	3.0	19.6	6.2	6.6	1.5
40–49 [51–60]	1.8	2.0	2.2	0.8	2.4	1.2	7.7	2.2	2.0	0.3
30–39 [61–70]	1.5	1.0	0.7	0.2	0.8	0.5	3.0	0.7	0.3	0.3
20–29 [71–80]	0.7	0.4	0.3	0.2	0.7	0.2	1.3	0.5	0.4	0.1
10–19 [81–90]	0.5	0.3	0.1	0.0	0.2	0.1	0.3	0.3	0.1	0.0
0–9 [91–100]	0.5	0.3	1.0	1.0	0.8	0.7	1.1	0.7	0.3	0.3

Figure 1 Changes in crown density since 1987 for five species surveyed annually. The crown density compared to an 'ideal' tree with a completely opaque crown is shown for each species.



corresponding figures for two class limits (10%) were 97.1% for Scots pine and 98.3% for oak. Since the teams operate on a regional basis any bias would be a cause for concern but there was evidence neither of consistent bias (i.e. bias affecting several species) nor of a bias in scoring individual species. The mean difference between the scores of the survey team and the standard observer did not exceeded 5% for any of the 49 team/species combinations tested.

THE 2002 RESULTS

5. As noted above, crown condition is assessed by estimating the *reduction* in density of a tree's crown when compared either with an 'ideal' tree or with the best 'local' tree in the vicinity of a plot. Since 1987, the crown condition data from the Forest Condition Survey have similarly been presented in terms of reductions in density. However, rather than considering the percentage of the crown which is *absent*, it may be easier to visualise the condition of trees on the basis of the percentage of the crown which is *present* when compared with a known standard. Therefore, although the methods used for assessing crown condition in 2002 remained unchanged from those employed in previous years, the results of the survey are presented here in terms of crown densities rather than crown density reductions. It should be noted that percentage scores for crown density and crown density reduction are *complementary* i.e. the sum of the two measures for an individual tree is always 100%. To compare the numerical results presented here with those from previous surveys, percentage crown density can be converted to percentage crown density reduction by applying the following formula:
% crown density reduction = 100 – % crown density

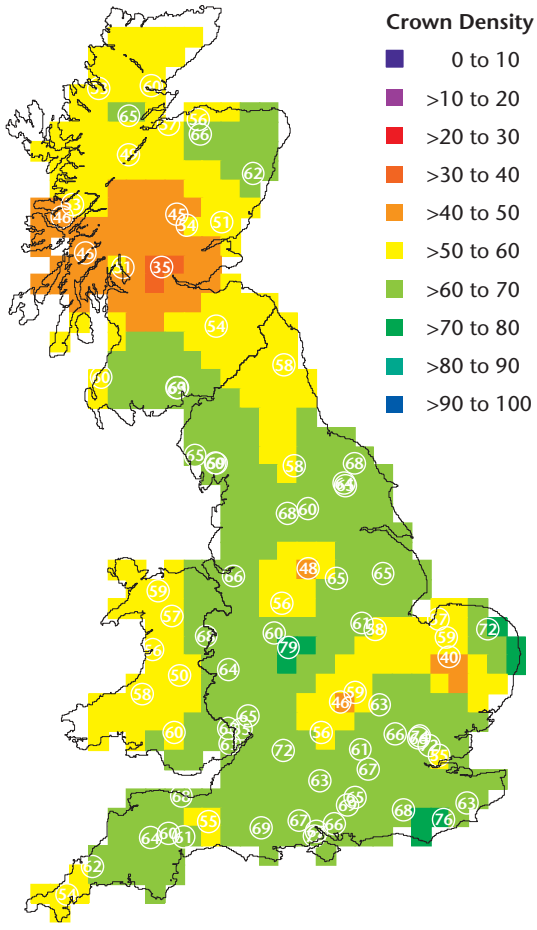
6. The crown density results obtained using both the ideal and local tree methods are presented in 10% classes in Table 1. The marked effect of using a local reference tree rather than an ideal tree as the basis for comparison can be seen for all species. Much of the difference can be accounted for by variations in growth habit between the reference photographs of ideal trees (Innes, 1990) and the trees in and around the plots to be assessed, from among which a local reference tree is chosen. For example, young trees of all species, but particularly Scots pine, tend to have a more open appearance (i.e. a lower crown density) than the older trees illustrated in Innes (1990). Some older oaks and spruces also have a naturally open structure. The crown densities of trees like these are much lower when compared to an ideal tree than when judged against local trees of the same age and form.

7. Figure 1 shows the changes in crown condition that have taken place since 1987. A **downward** gradient in this figure indicates a **deterioration** in crown condition. Changes in condition compared to last year were minor in Norway spruce, Scots pine and beech, but marked reductions in crown density occurred in Sitka spruce and oak. In spite of this, none of the changes in crown density which occurred between 2001 and 2002 were statistically significant: analysis of the time series for each species shows that relatively large fluctuations in crown density (more than 3% to 4%) between years are required for the statistical

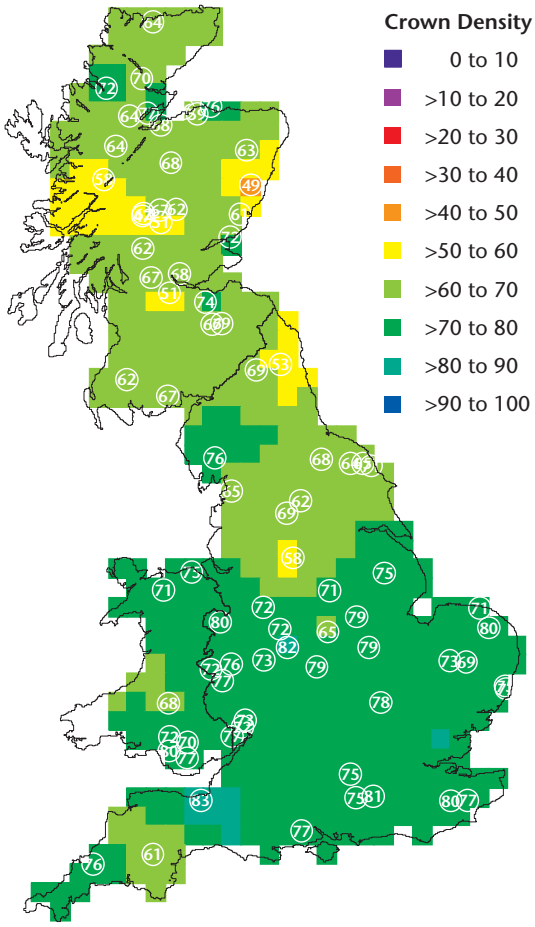
Figure 2

Geographical variation in crown density for five species in 2002. White circles show the locations of plots, and figures within the circles are mean crown densities (percent). Some plots are too close to be distinguished individually. The value assigned to each 20 km square was calculated from weighted averages (weight $\propto 1/d^2$, where d = distance) for all plots within 70 km of the 20 km square centre.

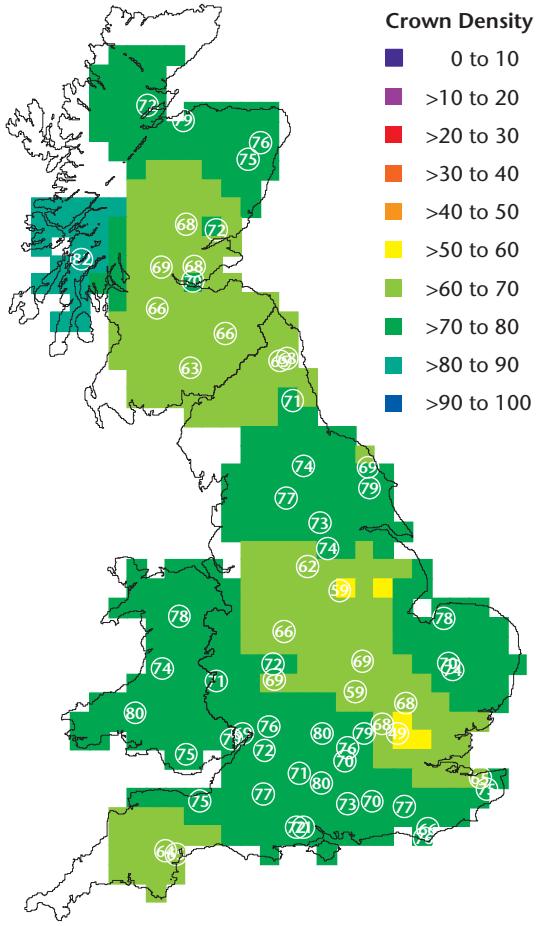
Oak 2002



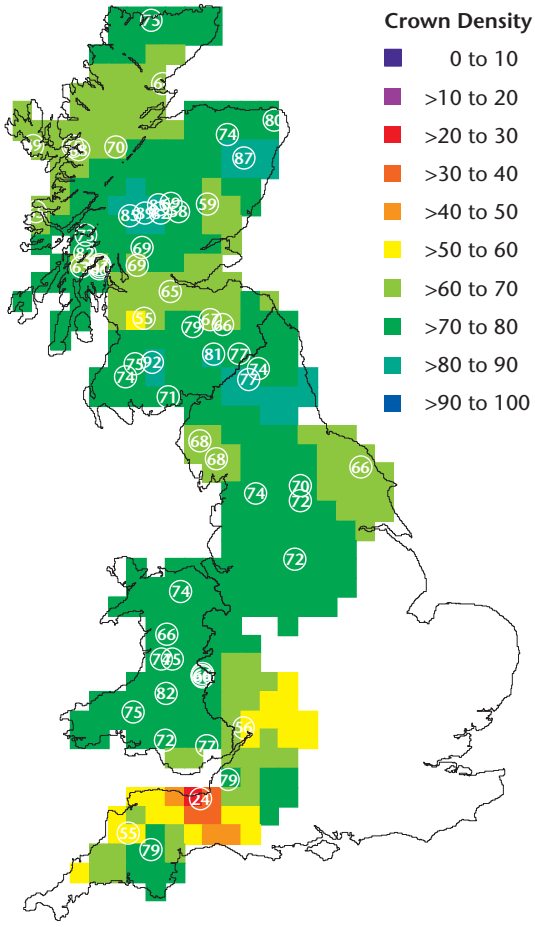
Scots pine 2002



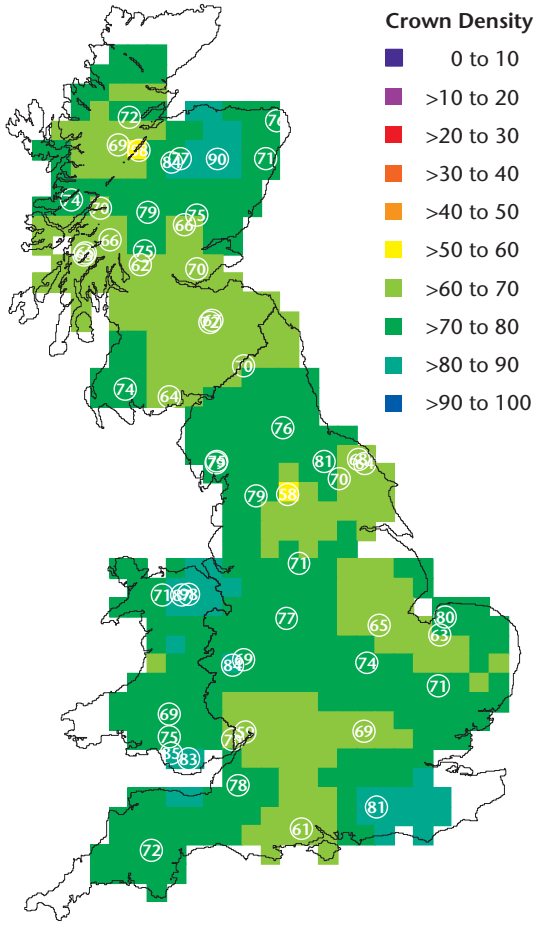
Beech 2002



Sitka spruce 2002



Norway spruce 2002



significance of such changes to be established. Short-term fluctuations of such magnitude are relatively infrequent in all of the surveyed species except beech, the condition of which has been characterised by large inter-annual changes in crown density over the 16 year survey period. However, there is no evidence of a long-term trend for deterioration or improvement in the crown density of beech; similarly, no trend in the crown density of either Sitka spruce or Norway spruce is apparent. In the case of Norway spruce, this observation indicates a reversal in the trend for deterioration which has previously been reported (Hendry, Boswell & Proudfoot 2001, 2002). However, since Forest Condition Survey plots are subject to normal silvicultural operations, clearfelling of old crops in poor condition has had an effect on the overall score for the species by removal of those plots displaying the lowest crown densities. As a result, the improvement in the condition of Norway spruce indicated by the survey does not simply reflect a long-term change in the health of the species *per se* but is at least partly attributable to a change in the nature of the population which is being sampled.

8. Analysis of the 1987–2001 data indicates that a statistically significant deterioration in the crown condition of both Scots pine and oak has occurred over the duration of the survey. However, the time series is of short duration and the indicated rates of change are small, with an apparent reduction in crown density of 0.24% per annum in Scots pine and 0.53% per annum in oak. For oak, the trend is heavily influenced by the high crown density values recorded in the period 1987 to 1990 when the number of survey plots of this species was relatively low and caution should therefore be excercised in the interpretation of this result. The magnitudes of past increases in crown density in both oak and Scots pine suggest that a single year of major improvement in condition could nullify the current trends for either species.

9. Since 1991 the condition scores of Scots pine and Norway spruce have changed less than those of any of the other species. Although Scots pine deteriorated slightly in 2002 and the condition of Norway spruce showed a minor improvement, neither of these changes was significant. Following a sharp decline in 1997, the condition of Sitka spruce improved between 1999 and 2001 but this recovery was completely reversed in 2002. The crown density of oak also decreased this year, its condition now being as poor as in 1997. The major improvement in beech which occurred in 2001 was partially offset by a minor reduction in its crown density in 2002.

10. Figure 2 shows the geographical variation in crown density for the five species assessed. Variation was greatest in oak, which continues to display a pattern substantially unchanged since 1997 when data were first presented in this way (Redfern *et al.,* 1998; 1999; 2000). The condition of oak was poorest in northern and central Scotland, north-east England, Wales and East Anglia, and best in southern England. Scots pine also displayed a pattern which was similar to that of previous years, with crown density tending to be highest south of the Humber-Mersey line. Beech and Norway spruce showed no clear pattern. Sitka spruce was poorest in southern and western England, but this impression is created by relatively few plots and the species shows considerable local variation.

FACTORS AFFECTING CROWN CONDITION IN 2002

11. The autumn of 2001 was generally warm and wet, with frequent heavy rainfalls and a record high average October temperature. Mild, wet conditions also predominated over the winter months with February being abnormally warm. Although April and May were largely dry and clear, minimum temperatures rarely approached damaging levels and there were few instances of spring frost damage to trees. Towards the end of April, severe squalls in certain parts of the country led to localised branch breakage and windblow. Rainfall was higher than average over the summer months, with July being particularly wet, and as a result no drought damage to forest trees was reported. Continuing warm weather over the remainder of the growing season provided conditions which were generally good for tree growth.

12. The decrease in the crown density of Sitka spruce recorded in 2002 was of sufficient magnitude to reverse the improvement in condition which the species had displayed between 1999 and 2001 (Figure 1). This deterioration was almost entirely due to widespread defoliation by the green spruce aphid *Elatobium abietinum*, with attacks being reported from 43 of the 63 survey plots. However, damage was often confined to the lower areas of the crowns of the surveyed trees and was therefore not as severe as might have been anticipated from inspection of

individual trees and shelter belts located near to plots, which were often completely defoliated.

13. In common with previous cases of decline in 1995 and 2000 (Hendry, Boswell & Proudfoot, 2001), the deterioration in the condition of beech recorded in 2002 was largely associated with heavy masting. Mast production was noted on 78% of the surveyed trees and was recorded as heavy (common or abundant) in 58% of the population. Levels of insect damage to beech in 2002 were broadly similar to those recorded in 2001, although the incidence of severe damage was slightly elevated due to heavy attack by the leaf mining insect *Rhynchaenus fagi* in 17 plots.

14. Changes in the crown densities of Norway spruce and Scots pine this year were minor, thus continuing a pattern of little variation in condition which has held since 1993. In 2002, Norway spruce was defoliated by *Elatobium abietinum* but it is less susceptible to attack than Sitka spruce and damage was slight. Distortion of the branching pattern of trees caused by the bud blight fungus *Cucurbitaria piceae* was observed in plots in northern England and southern Scotland but this had little influence on the crown density of affected individuals. The slight deterioration in Scots pine noted this year was attributable both to elevated levels of infection by the needle pathogen *Lophodermium seditiosum* and to abundant production of male flowers on the 2002 shoots. The loss of foliage infected by *L. seditiosum* was reflected by a reduction in the percentage of trees retaining needles for 3 or more years from 62% in 2001 to 47% in 2002.

15. The deterioration of oak which occurred in 2002 completely reversed the improvement in condition which had occurred over the previous two years, and the crown density of the species is now as low as at any time during the 16 year survey period. However, this decline cannot be related to serious climatic injury, or to a major outbreak of a particular pest or disease in 2002, since the incidence of abiotic and biotic damage to trees was broadly similar to that recorded in 2001. Analysis of the changes in crown density which occurred between 2001 and 2002 in the 1955 trees common to both surveys indicates that 1009 trees deteriorated in condition. Of these, 68% displayed a reduction in crown density of only 5–10% whilst 86% displayed a reduction of 5–15%. The overall change in the condition of oak since last year is therefore attributable to a minor reduction in the crown density of many trees rather than a major change in the condition of a few trees. Since the classes which are used to record abiotic and biotic damage in the Forest Condition Survey are broader than those used for the recording of crown density, a minor change in the crown density of a tree would not necessarily be reflected by a change in the damage class to which it was allotted. Thus, a small but general increase in the level of insect and fungal damage to oak in 2002 may account for the recorded change in condition.

16. Insect damage was present in 81 of the 86 oak plots assessed in 2002 but was severe in only 9 plots where defoliation by the winter moths *Operophthera brumata* and *Erranis defoliaria* had occurred. Central Scotland was particularly affected and it is noticeable that the highest concentration of plots in poor condition was located here (Figure 2). Branch break resulting from the severe winds in April was recorded in 7 plots in northern England and Scotland but no other significant climatic damage was noted. Although not directly damaging, the warm and wet conditions which prevailed in spring and early summer are likely to have favoured the development of powdery mildew (*Microsphaera alphitoides*) which was more widespread and severe this year than in the recent past.

CONCLUSIONS

17. Rainfall was well distributed throughout the 2002 growing season and tree growth was generally good. High winds in April caused localised damage to all of the surveyed species but no other forms of climatic injury were important this year. Changes in condition were minor in Norway spruce, Scots pine and beech but marked reductions in crown density occurred in Sitka spruce and oak. The slight deterioration of Scots pine this year was largely due to an increase in the incidence of the needle cast fungus *Lophodermium seditiosum* and continued heavy male flowering on many trees. Crown density in Norway spruce has displayed only minor fluctuations since 1991 and remained virtually unchanged in 2002. A slight decline in the condition of beech was largely associated with heavy mast production and is not necessarily an indication of ill health. The sharp decrease in crown density displayed by Sitka spruce was due to widespread defoliation by the green spruce aphid *Elatobium abietinum*. However, attack was often confined to the lower areas of the crowns of the

surveyed trees and damage was therefore not as severe as recorded after the previous outbreak of *Elatobium* in 1997. The deterioration in the condition of oak which occurred this year was attributable to a minor reduction in the crown density of many trees rather than a notable increase in the incidence of attack by pests or pathogens.

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Enquiries relating to this publication should be addressed to:

Steven Hendry
Forest Research
Northern Research Station
Roslin
Midlothian
EH25 9SY

Tel: 0131 445 2176
Fax: 0131 445 5124

E-mail: steven.hendry@forestry.gsi.gov.uk

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