Forestry Commission

Research Report

National inventory of woodland and trees (1995–99): methodology

Forest Research

Forestry Commission

Research Report

National inventory of woodland and trees (1995–99): methodology

Steve Smith, Justin Gilbert, Graham Bull,
Simon Gillam and Esther Whitton

Forestry Commission: Edinburgh

First published in 2010 by the Forestry Commission,
Silvan House, 231 Corstorphine Road, Edinburgh EH12 7AT.

ISBN 978-0-85538-819-5

Smith, S., Gilbert, J., Bull, G., Gillam, S. and Whitton, S. (2010).
National inventory of woodland and trees (1995–99): methodology.
Forestry Commission Research Report.
Forestry Commission Scotland, Edinburgh. i–iv + 1–60 pp.

Keywords: inventory, woodland, survey, trees, woodland cover, woodland composition, monitoring, Great Britain, Scotland, England, Wales, forest, trees.

FCRP014/FC-GB(CLA)/0K/NOV10

Enquiries relating to this publication should be addressed to:

Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
T: 0131 334 0303
E: publications@forestry.gsi.gov.uk

If you need this publication in an alternative format, for example in large print or in another language, please contact The Diversity Team at the above address. Telephone: 0131 314 6575 or Email: diversity@forestry.gsi.gov.uk.

The authors may be contacted via:

Head of Surveys and Measurement Group
Biometrics, Surveys and Statistics Division
Northern Research Station
Roslin, Midlothian
Scotland, EH25 9SY
T: 0131 334 0303
E: woodland.surveys@forestry.gsi.gov.uk

Contents

1. Introduction

Background

In prehistoric times, Britain was largely covered with woodland. By the end of the first millennium, much had already been cleared to satisfy the needs of an increasing population. This trend continued, and by the end of the 19th century, woodland cover had dropped below 5%. Since then Britain's forest and woodland area has been expanding, until by the end of the 20th century there were almost 2.7 million hectares, equivalent to 11.6% woodland cover. However, in international terms this remains relatively low, compared with an average of 38% for the European Union.

Previous surveys of woodland and trees in Great Britain

The British Boards of Agriculture carried out woodland surveys between 1871 and 1913. The Forestry Commission was established in 1919 and has been carrying out national woodland inventories for Britain on a regular basis since 1924. A new 'Census' or 'National Inventory' is carried out when it appears that the previous one is no longer able to supply the information that is required. This may follow on from some significant event such as a war (the impetus for the 1924 and 1947 Censuses) or the impact of Dutch elm disease (for the 1980 Census). The information from a Census, however, grows increasingly out of date even with such attempts at updating that can reasonably be made.

Each subsequent Census has involved the introduction of changes as survey practice and technology develops. For the purposes of comparison it may be desirable for each survey to change as little as possible from its predecessor but this is unrealistic. Each new survey has introduced changes driven by information needs, technological opportunity and cost factors.

1924 Census

The first Forestry Commission Census was in 1924 and was based on questionnaires sent to owners. The purpose of the Census was to assess the woodland resource after the very extensive fellings of the First World War. The minimum wood size in this survey was 2 acres (0.8 hectare). The total woodland area was 1 197 358 hectares, equivalent to a woodland cover of 5.3%.

1938 Census

The next survey was undertaken when the possibility of war was causing increasing concern as to whether there were adequate stocks of home-grown timber. The survey was only partially completed by the outbreak of the Second World War.

1947 Census

The 1947 Census again followed a period during which the woodlands of Great Britain had been considerably exploited during the Second World War. The importance of this Census is that it was a complete survey and so was unaffected by any of the limitations introduced by sampling. This has the effect of making it a suitable baseline for future surveys. The ravages of wartime demand influenced the classification adopted, with categories including 'devastated' for those areas entirely stripped of their useful timber. The minimum area was 5 acres (2 hectares). The total woodland area was 1 395 533 hectares, equivalent to a woodland cover of 6.1%.

1951 Survey

This was a follow-up survey designed to make some account of woodlands between 1 and 5 acres and also parkland and hedgerow trees. It was a sample survey at a low intensity (1:8000) but gave an estimate that was regarded as being adequate. This, when taken together with information from 1947, gave an overall estimate of woodland area of 1 467 690 hectares or 6.4% woodland cover.

1965 Census

This Census was much less intensive than previous ones with no intention to produce data at a county level, instead using broader marketing regions. It was also the first survey to draw data from Forestry Commission records for the state forests and confine the Census to the assessment of privately owned woodland. The minimum area was 1 acre (0.4 hectare). The sampling for non-woodland trees (isolated hedgerows, park and garden trees, woods less than 1 acre

and linear features less than 1 chain (20.12 m) wide) was restricted to an area south of a line between the River Humber and the River Mersey. The remaining area estimates were based on some very broad assumptions. The total woodland area was 1 742 250 hectares, equivalent to a woodland cover of 7.6%.

1980 Census

This survey was designed to supply information at county level and in greater detail than had been made available from the 1965 Census. It also extended the practice of drawing data from other sources where they could provide detail at greater accuracy than could be achieved by a sample survey. As well as using Forestry Commission records of state forests, the survey used information on private woodlands held by the Forestry Commission as part of its system of grants to woodland owners (Dedicated and Approved Woodlands). This left a remainder of privately owned woodland to be sampled as well as the non-woodland trees. More use was made of aerial photographs for this Census than in earlier work. This was the first use of digital analysis of a map to measure the area of woodlands. The minimum area was 0.25 hectare. The total woodland area was 2 108 397 hectares, equivalent to a woodland cover of 9.4%.

This Census (Locke, 1987) had an operative date of 1980. Despite updates, the information from the 1980 survey had become progressively less reliable. The real need for more accurate information was recognised and a new inventory of woodlands and trees was commissioned.

The 1995–1999 National Inventory

In recent years, forestry policy has had two main aims:

- the protection and sustainable management of existing woods and forests;
- the continued steady expansion of woodland area to provide more benefits for society and our environment.

An important requirement for the formulation and monitoring of these priorities, programmes and forest management strategies is to know the extent and condition of woodland and trees. The development and monitoring of national and regional policies for increasing the woodland area and for developing wood-using industries, for example, require data on aspects such as the extent, distribution, condition and ownership of woodland.

A new survey was required to measure whether the Forestry Commission was achieving its goal to protect and expand Britain's forest and woodland cover. It would also provide a high-level means of monitoring regional and national compliance with the UK Forestry Standard, and provide data for some of the key formal indicators adopted for monitoring and reporting on UK forestry. This survey is the 'Great Britain National Inventory of Woodland and Trees 1995–1999' (NIWT).

The aim of the NIWT was to provide up-to-date information on the extent, size and composition of Britain's woodland (Figure 1). In particular, the aim was to provide an accurate assessment of woodland area, and to estimate other characteristics such as forest type, species, age class, stocking, timber potential and woodland structure. The survey provides information supporting:

- decisions on land use and woodland expansion
- forecasts of timber production
- the targeting of advice and grant aid
- the assessment of woodland as a wildlife and conservation resource
- studies on biomass production and carbon storage
- the monitoring of the sustainability of forest management
- other more specialised woodland surveys

Figure 1 Britain's varied woodlands consist of broadleaves and conifers of both native and exotic species in plantations and semi-natural woods.

A specific aim was the production of a digital map of all woodland of 2 hectares and more, which was incorporated in a geographic information system (GIS) together with the sample data. This allows the sample data to be analysed by any geographically defined area. It also allows for the combination of the data with other geographical datasets, e.g. the Woodland Grant Schemes, or the Ancient Woodland Inventory (AWI).

A series of Inventory Reports has been published for Great Britain, Scotland (national and regional), England (national, regional and county) and Wales (national and county). The reports are in both printed and digital format, with the latter available on the Forestry Commission web site www.forestry.gov.uk/inventory (Appendix 8).

Overview of survey methodology

Figure 2 provides an overview of the NIWT, which began with a pilot survey in Scotland in 1994. The survey progressively covered the rest of Britain, and the last of the fieldwork was completed in England by May 2000.

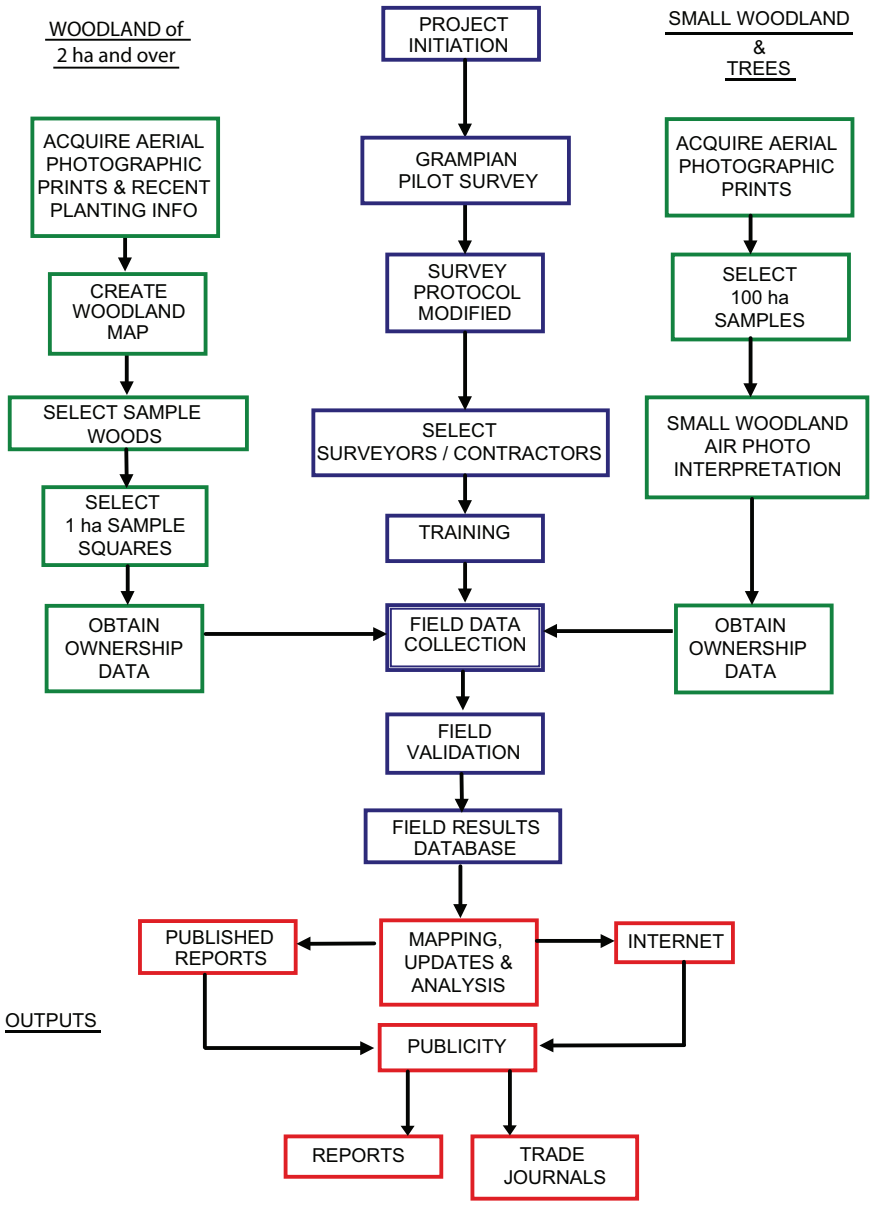
The inventory was in two parts:

- The *Main Woodland Survey*; a survey of woodlands of 2 hectares or more.
- The *Survey of Small Woodland and Trees*; a survey covering woodlands less than 2 hectares, groups of trees, belts of trees and individual trees in the countryside. (For definitions see Appendix 2, Glossary of terms.)

Main Woodland Survey

In England and Wales a digital map of all woodland showing Interpreted Forest Types (Appendix 1) was derived from 1:25000-scale stereo colour aerial photography. This provided the basis for the sampling.

Figure 2 Overview of NIWT project plan.



In Scotland the main survey was based on the Land Cover of Scotland (LCS) 1988[1] project, which used 1:24 000-scale aerial photography to create a land cover map. The woodland components of this dataset were extracted to provide the basis for a digital woodland map showing Interpreted Forest Types. The map was then updated to 1995 for new planting within Woodland Grant Schemes and the Forestry Commission woodlands. The map then provided the basis for sampling.

The digital map gave the extent of all woodland of 2 hectares or more, and this was progressively updated in preparation for survey work. Maps could be produced showing overall woodland cover, woodland by ownership (Forestry Commission or other) and woodland by Interpreted Forest Type. The total area of woodland was obtained from the digital map, with ground sampling undertaken to evaluate a wide range of woodland information such as species, age and stocking.

From the digital map the area of each woodland was recorded and this information was used to determine the intensity at which any selected woodland would be sampled. The sampling scheme is described in Chapter 2.

One-hectare squares were used to sample the selected woodlands on the ground. This was a change of practice from all previous Census surveys, where whole woods had been selected as a basis of the survey. The overall aim was to sample just over 1% of the woodland area.

Survey of Small Woodland and Trees

This survey collected data on small woodland (0.1 – < 2 hectares), linear features, groups and individual trees in the countryside, but did not include the built environment or developed land.

To ensure that both coastal and inland areas were sampled the map area was stratified into coastal and inland 1 km x 1 km squares and a random sample of these squares was then selected, representing around 1% of the land area in each stratum. Aerial photos at 1:25 000 scale were then used to identify features in each sample square. Each 1 km x 1 km square was then divided into 16 parts, and 2 of these were selected at random for field data collection.

[1] The Land Cover of Scotland 1988 (LCS88) Final Report. © Copyright The Macaulay Land Use Research Institute, Aberdeen 1993.

2. Statistical aspects

Main Woodland Survey

Sampling – woodland selection

A digital map of all woodland showing Interpreted Forest Types was derived from 1:25 000-scale aerial photography (directly for England and Wales and using the Land Cover Map of Scotland 1988). The digital map gives the extent of all woodland of ≥2 hectares. This was updated as survey work progressed by adding new planting since the photograph date (using administrative records verified in the field survey) and any woodland that had been obscured by cloud in the photo. The total area of the woodland stratum in each county or district was obtained from the digital map. Forestry Commission (FC) maps, now in digital form, were used to divide the woodland stratum into FC and non-FC ownership.

The woodland map formed the sampling framework for the Main Woodland Survey. No fieldwork for the Main Woodland Survey was undertaken outside the mapped woodland area.

From the digital map, the area of each wood (as defined in Appendix 2) was recorded and this information was used to determine the probability of each woodland being sampled.

A feature code was allocated to the wood according to its size class (see below). Any wood <2 hectares was removed from the data. This dataset was used to select those woodland parcels to be sampled. Within each 100-km tile (as per the Ordnance Survey (OS) tiles, e.g. tile SU) the woods were:

1. Stratified into size classes:
   - 2 – <100 hectares
   - 100 – <500 hectares
   - ≥500 hectares

(Note: Woodlands were split into class sizes in terms of sampling as it related to the woodland area within the OS 100-km tile; reporting was based on country level data after the tiles (and woods) were joined together).

2. Put into ascending order within each stratum, with the sampling for some woodlands split by one or more tile edges.

3. Selected according to a ratio of:

2 – <100 hectares:	1 wood in 5
100 – <500 hectares:	2 woods in 5
≥500 hectares:	all woods

For Great Britain there were about 3 000 woods of more than 100 hectares, together accounting for two-thirds of the total woodland area. There were also about 80 000 woods of 2–100 hectares, together accounting for about 30% of the woodland area. The remaining 5% of area comprised woods of <2 hectares, and these were included in the Survey of Small Woodland and Trees.

Generating the ground samples

Within sampled woodland a number of 1-hectare sample squares were to be selected for field survey work. This was a change of practice from all previous Census surveys, where whole woods had been selected for survey. The aim of the sampling scheme was to obtain information efficiently about variation over all woodlands. Particularly for large plantations, there was expected to be more variation between woods than within woods. The basic survey design, used for woods of 2–100 hectares, was to select one wood in five and apply a sampling grid with 5% density, giving a 1% sample. For larger woods, this design would have given numerous sample squares in the selected woods, and no information from woods not selected, so it was agreed that for them it would be more efficient to select a larger fraction of woods and use a less dense grid. For woods of 100–500 hectares, two woods in five were selected and a 2.5% density grid applied, giving a 1% sample. For woods of 500 hectares or more, all were selected and a 1% density grid applied, again giving a 1% sample.

Various sampling options were devised and tested on a grid (measuring 800 m east and 500 m north – 40 hectares in total) to fit on OS 1:25 000-scale maps. In the sampling grid, the squares were clustered, rather than being spread regularly or randomly over the whole area. The clusters consisted of various configurations of two to five 1-hectare squares in the 800 m x 500 m grid panels, with a random allocation of which panels contained clusters. Trials had established that clustering in this way substantially reduced travel costs for the survey teams, without significant deterioration in the standard errors of the results. Within the grid framework

finally chosen there were various clusters of 1-hectare squares (see examples in Figure 3).

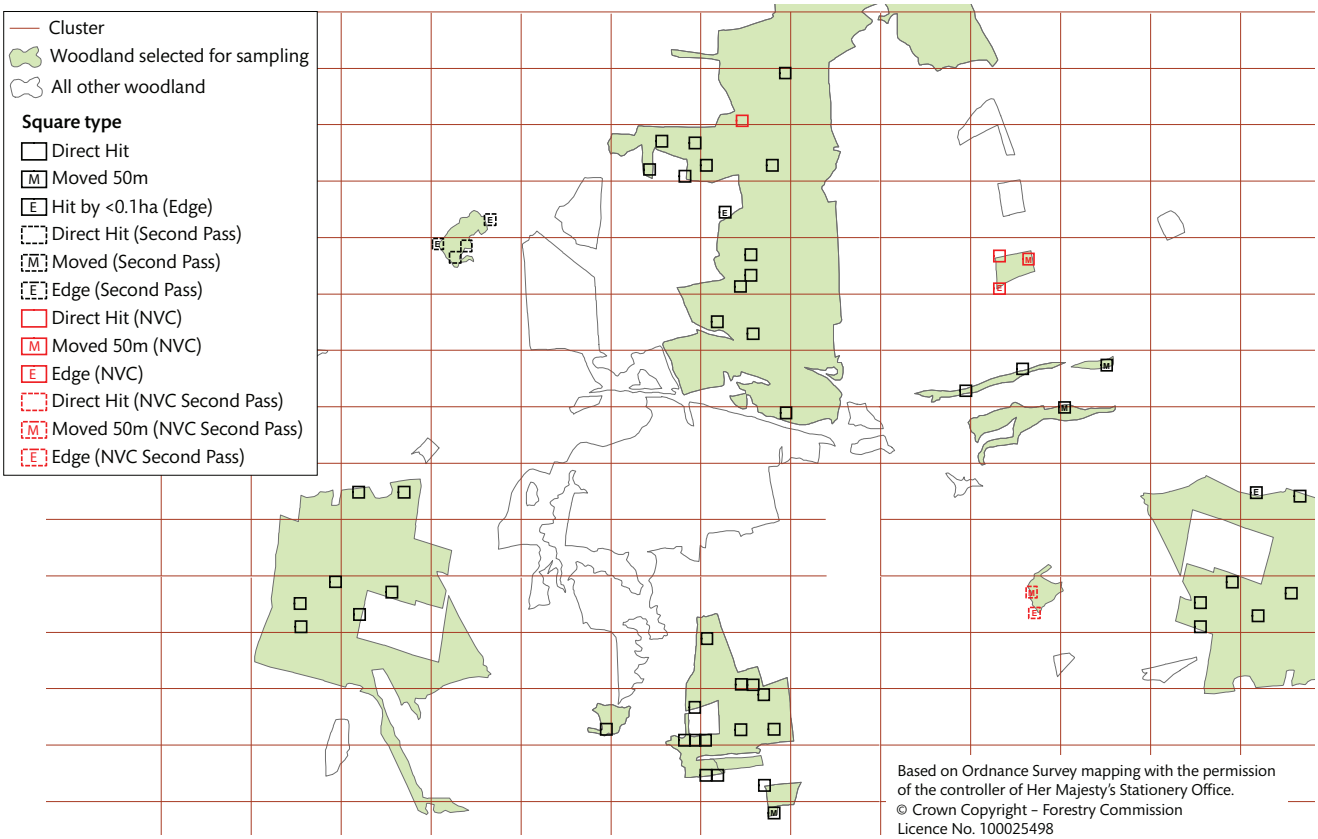
The 1-hectare sample squares could fall in a number of places and were dealt with in different ways:

- 1-hectare squares falling completely outside the woodland were ignored (and not recorded).
- 1-hectare squares with ≥10% of the area falling within woodland were sampled.
- Squares containing <10% woodland were recorded as edge squares, but were ignored by the ground survey.
- If the only squares selected for a wood were edge squares (0.1–0.5 hectare) then one of those squares was randomly selected and moved 50 m towards the centre of the wood. Moved squares were treated as normal during the ground survey, but data from them were given a reduced weight in the aggregation to scaled-up results, roughly balancing the increase in area resulting from the movement. (Note: The idea of the 'move' was to increase the amount of information gathered for the travel costs associated with the survey, but squares were only moved under particular circumstances, i.e. where all the squares for a sampled woodland were 'edge' squares and even then only one square was moved 50 m towards the centre of the woodland, adding up to approximately 0.5 hectare of woodland).

Apart from the under-representation of woodland edge, as a result of moving squares away from the edge and omitting squares, the sampling procedures described up to this point were thought to give an unbiased sample amounting to ≈1% of all woodland of ≥2 hectares. The pilot study indicated that the procedures were generally satisfactory, but there was concern that the cluster grid pattern resulted in many of the selected sample woods of 2–100 hectares not including any squares. This meant that the initial results for woods of 2–100 hectares were based on data from markedly less than the initial selection of one wood in five, because of closer geographical grouping of squares than expected and hence worse precision for the given sample size.

It was therefore decided to boost the sample by a second pass of the sampling grid, which ensured that each of the one-in-five selected woods of 10–100 hectares included at least one sample square. These additional sample squares were treated as normal during the ground survey, but all data from the size class were given a reduced weighting in the aggregation of the results, roughly balancing out the increase in sample area from the additional squares. This resulted in estimates that were still unbiased, but with improved precision from the additional squares and the distribution of squares over more woods.

Figure 3 Example of the distribution of 1-hectare squares on selected woodland.



An initial estimate of the area of the woodland stratum was obtained from the sample results, rating up all areas either by 100 (which assumes that the original data represents 1% of the woodland area) or by an alternative lower weighting to take into account the moved or added squares (as described above). By chance, these sample results could be above or below the actual Forestry Commission and non-Forestry Commission areas for each geographic unit (county or former Scottish district), as measured from the original digital map. The rated sample results for each geographic unit were scaled up or down, to match the areas from the digital map. The National Inventory therefore has an internally consistent set of areas from the digital map and final rated sample data.

The woodland stratum could include some areas incorrectly classified as woodland, e.g. the land cover could be gorse. In addition, some areas could have been felled and permanently converted to another land use since the date of the aerial photography or doubt could have been expressed by the photo interpreter using a non-forest classification. While it was not possible to identify all such areas from field survey, as not all woodland areas were visited, an unbiased estimate was obtained by recording such sections of sample squares as 'non-woodland', leaving them to be rated up in the same way as data from any other sections. The rated-up areas were subtracted from the total areas of the woodland stratum, to produce the final main woodland results for publication. Processing of the Scottish data initially followed a different approach, trying to identify all areas of 'non-woodland' and removing them from the digital map. This may have resulted in a slight overestimate of the true woodland area.

Standard errors and precision

Approximate standard errors were calculated for the main report. Each wood was allocated to one of eight categories, based on the mix of Interpreted Forest Types (see Appendix 1) of all polygons making up the wood in the aerial photographic interpretation. Within each of these categories, the data were treated as if they came from a simple random sample. For any variable of interest (e.g. species), the area and its variance were estimated for each category, added up over the categories, and the overall standard error calculated. In this calculation, the sample size for a category was the total number of sample squares in that category, implicitly including zeros for the many squares that had no area of a given species. Within a sample square it made no difference whether the area was in a single section unit or in more than one – it was treated as a single total for each sample square.

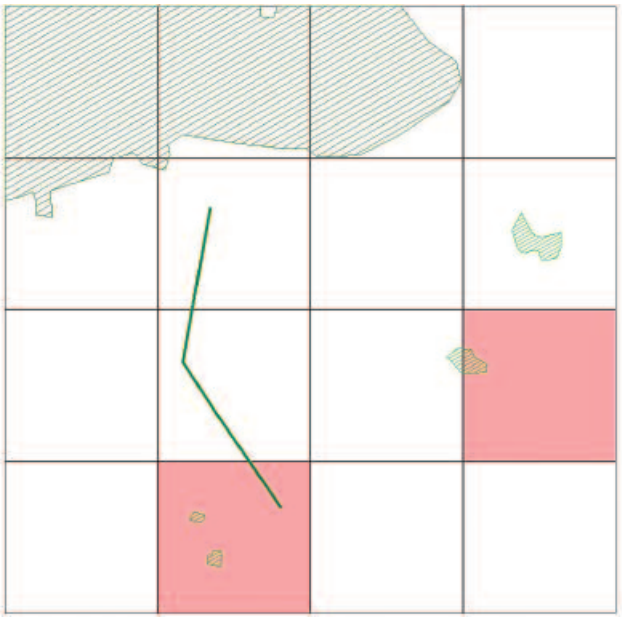
This calculation is likely to underestimate the standard errors, because it ignores the more complicated aspects of the survey design. Sample squares tended to be grouped more closely together than in a random design because of the use of a cluster grid, and also because of the two-stage sample design in which the first stage was the selection of woods and the second stage the selection of sample squares within woods. Also, although rating-up all results to equal the areas from the digital map produced more accurate totals, it produced a small loss of precision in attribute estimates.

Survey of Small Woodland and Trees

The land area of Britain was stratified into coastal and inland 1 km x 1 km squares. A systematic sample of 1 km x 1 km squares was then selected, representing around 1% of the land area of each county or former Scottish district (Figure 4). This was preferred to a regular grid (e.g. choosing the southwest 1 km square from each 10 km x 10 km tile) because it reduced the chance variation in sampling intensity of coast and of each local authority. 1:25 000-scale aerial photo interpretation (API) was then used to identify features in each sample square – i.e.:

- small woodland (0.1 – <2 hectares)
- linear features.

Figure 4 Sample grid square, 1 km x 1 km. This diagram shows an example with one linear feature (green line) and four small woodlands. The large area at the top left is outside the scope of the survey either because it is woodland >2 hectares (and therefore in the scope of the Main Woodland Survey), an urban area (where all woodlands were excluded), an orchard or an area of water.



Each 1 km square was then divided into 16 parts, and two of these (shaded red in Figure 4) were selected for field data collection. The method of selection ensured that the two parts were not adjoining, to limit the effects of clustering of data within the square. The first was selected at random from 1–10 (counting row by row, left to right and starting from the bottom left), and the second added 6 to the count. Although this gives parts 7–10 a higher probability of selection, there was no relationship found between the precise location of grid squares and wood/tree features, so this did not bias the results.

Ground sampling looked at four features and was undertaken to collect information about each feature located in the two selected sub-squares:

1. Small woodlands (0.1 – <2 hectares).
2. Linear features – ≥25m in length and four times as long as wide, separated into:
   - 2.1 narrow linear features (with a width of 16m or less)
   - 2.2 wide linear features (with a width greater than 16 m).
3. Groups – two or more trees with an area <0.1 hectare.
4. Individual trees – a tree with a crown that has no contact with any other tree crowns and which is at least 2m tall, separated into:
   - 4.1 boundary tree (an individual tree on any boundary)
   - 4.2 middle tree (an individual tree not on a boundary).

For small woodlands and wide linear features, each of which had an area of at least 0.1 hectare, this survey collected a similar range of data to the Main Woodland Survey sample, including species, age and stocking. This enabled the addition of the results to those from the Main Woodland Survey, to produce statistics for all woods over 0.1 hectare. A more limited range of data were collected for narrow linear features, groups and individual trees.

The area estimates for small woodlands and wide linear features were rated-up to regional totals by a combination of factors:

- The first factor converted sample results from the two sub-squares to estimated totals for the whole 1 km x 1 km square. For small woodlands, this factor was the total number of small woodlands in the API for the square divided by the number of small woodlands in the sample field survey data. For wide linear features, this factor was the ratio of the total length of all linear features (wide and narrow) in the API divided by the total length of all linear features (wide and narrow) in the sample field survey data.
- The second factor converted estimates for the 1% sample of 1 km x 1 km squares into estimates for the whole region. This was calculated as the total land area of the region divided by the total land area of all sample 1 km x 1 km squares in the region.

Approximate standard errors for the counts of the number of these features and for their total areas were calculated in a similar way to the Main Woodland Survey. The sample size was the total number of 1 km x 1 km sample squares in that region, implicitly including zeros for the many sample squares that contained no small woodlands or wide linear features. As with the Main Woodland Survey, this is likely to underestimate the standard errors because it ignored the complication of the two-stage sample survey, in which the first stage was the selection of 1 km squares and the second stage selection of the two parts for field survey.

3. Pilot surveys

Pilot for the Main Woodland Survey

It had been decided that the NIWT should be based on a new digital woodland map developed from aerial photography. However, there was a lack of recent photography of similar dates that could be digitised to produce a woodland layer. The exception was in Scotland where a Land Cover Map of Scotland was in the process of being compiled from 1987–1989 aerial photography by the Macaulay Land Use Research Institute, on behalf of the Scottish Office.

In 1992, a National Inventory pilot project within the local authority of Grampian Region was started to test map production, woodland sample selection and field methods.

The work carried out for the pilot began on a very small scale with some testing of field methodology. Work began on sample selection once progress on the methodology had been made. The scheme for selection within woodland size strata was already in place (as described in Chapter 2) and the Land Cover of Scotland (LCS) data formed the basis of the sample selection. The LCS project classified all land within Scotland from aerial photographs according to a wide range of categories. Each field, wood or moor from the LCS project was allocated to a category, and other features that could be seen within each were also identified, resulting in a vast jigsaw that covered the whole of Scotland, each piece showing whether the land cover was urban, heather moor or woodland.

Woodland was divided into categories distinguishing broadleaves from conifer, young plantations from recent felling, and so on (see Appendix 1). These categories are referred to as Interpreted Forest Types (IFT), as they result from the interpretation of aerial photographs.

The sampling scheme had been developed based on the total area of an individual woodland. This could not be derived immediately from the LCS data as each woodland was composed of a number of 'jigsaw pieces' that needed to be associated. For each piece, the LCS data provided the grid reference, reference number, IFT and area. In addition there was an accompanying set of maps at 1:25 000 scale for Kincardine & Deeside District in Grampian Region that recorded the interpretation from which all the subsequent data have been derived. Kincardine & Deeside District was initially a manual paper exercise, later converted to a digital dataset based on these paper records.

The stages that followed were:

- to abstract the woodland IFTs from the list
- to use the record map to compile the jigsaw pieces into whole woodlands
- to produce a list of woodlands in order of ascending size
- to systematically select sample woodlands from the list and identify them on the map.

A transparent sheet the exact size of a 1:25 000-scale map sheet showed the clusters of sample squares. By placing this under the map on a light-table, squares could be transferred onto the map for sample woodlands. A list of samples was compiled for each sample woodland at the time. Initially the idea had been to try out this scheme for just four map sheets, but it became clear that it would not be much more work to carry out the sample selection for the whole of Kincardine instead.

This method was successful and was then adapted to a newly developed Forestry Commission digital mapping system for the remaining districts of Grampian Region. It was decided to use the digital local authority administrative district boundaries, e.g. Moray, within Grampian as smaller units of survey (Figure 5).

Within each of the remaining local authority districts the digital woodland parcels would be sampled based on ownership: Forestry Commission (FC) or other. The FC legal boundary was used to 'feature code' those parcels within FC ownership. Where woodland parcels straddled the local authority areas, the whole woodland was allocated to the district in which the majority fell (see examples A and B in Figure 6).

Within each district woodland file, a feature code according to size class was allocated to each woodland parcel as an attribute. This enabled the selection of the chosen sampled woodland within each size class.

During the course of the pilot, it became clear that compared with the travel time to each cluster and with the time taken on other assessments, the actual time taken to

Figure 5 Map of survey areas within Grampian pilot area.

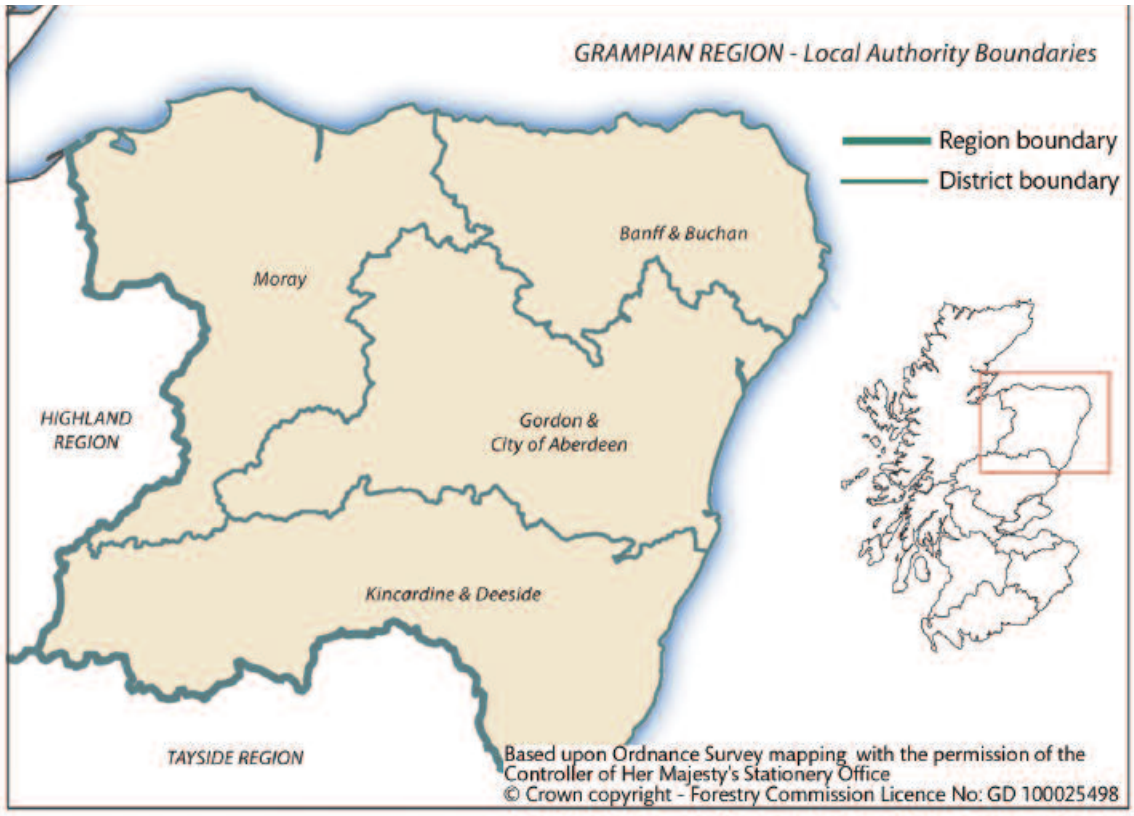
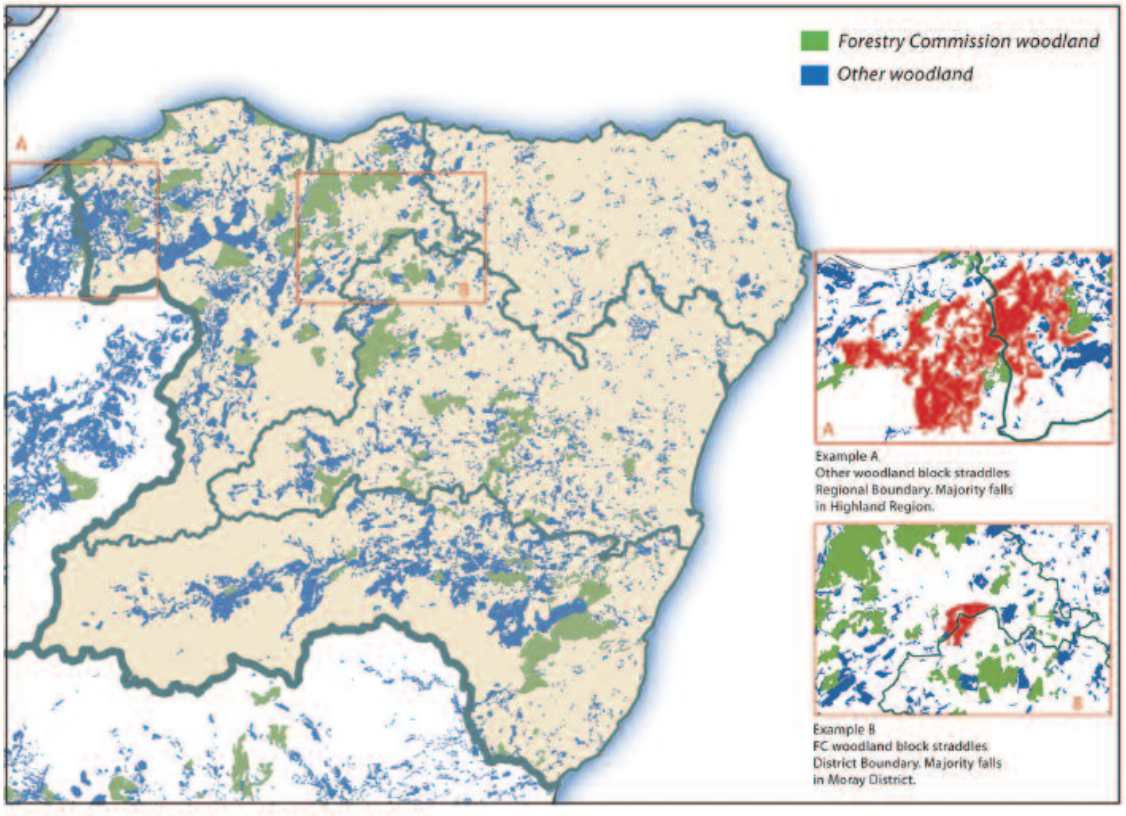


Figure 6 Map showing woodland blocks of 2 hectares or more within Grampian by ownership.



carry out a stand structure assessment was minimal. Therefore, it was decided that a stand structure assessment should be carried out at every sample square. After Grampian was completed, a review of the fieldwork concluded that the assessment of minimum branch height in each structure assessment did not provide any useful information and this was dropped. In all other respects the review of the pilot concluded that the methodology was working well, indicating the quality of the work that had created the original design process. However, there were major pressures from both internal and external stakeholders to complete the survey of Great Britain earlier than had been planned. As a result the sample selections for other regions of Scotland had begun before the work in Grampian had concluded. Two changes were made to the sampling procedure:

- woodland was now sampled as a whole rather than as two distinct strata (Forestry Commission and other)
- the regional woodland sample selection was replaced with a selection based on woodland within an OS 100 km x 100 km grid.

The survey advanced rapidly in response to pressure to provide results for the whole of Scotland. As a result the auditing and quality assurance procedures required to detect problems, shortfalls or other difficulties were not fully in place for the early stages of the survey. The fact that the survey used experienced Forestry Commission field staff helped to minimise the difficulties but improvements to the methodology were necessary as issues were detected and the survey developed.

Pilot for the Survey of Small Woodland and Trees

The pilot for the Survey of Small Woodland and Trees was somewhat different to that for the Main Woodland Survey in that no experimental fieldwork had been carried out prior to the pilot. In effect, the pilot had two main aims:

- to develop a viable field methodology in terms of practicality and the information gathered
- to test out the data collection programme.

The area selected for the pilot was the 100 km x 100 km OS map tile 'TR', which covers East Kent and a part of Essex. It was thought important to pilot this part of the survey in a part of the country other than Scotland, especially given the significance of trees and smaller areas of woodland in lowland Britain.

The TR map tile had a very variable coastline. Selecting from the ≈1 300 inland squares using a simple scheme of every hundredth square gave a good distribution of the 13 land squares. One coastal square was also selected.

Very few changes in the field methodology were needed (see Chapter 5 for a full description). The pilot showed that the design had been successful. No significant problems were found to be present in the data collection software.

However, the pilot did highlight the need to clarify a few of the notes in the surveyors' manual. For example, a question arose of whether smaller tree species such as hawthorn should be counted as trees or not. After some debate, it was decided that they made a real contribution to the landscape and should therefore be included.

The statistical analysis of the results, albeit from a limited number of samples, suggested that the standard error targets for data at a county level used in the 1980 Census might not be achieved in the 1990–1995 survey.

4. Aerial photography and mapping

Introduction

In the NIWT, both the Main Woodland Survey (covering woodland of ≥2 hectares) and the Survey of Small Woodland and Trees made use of aerial photography and digital mapping.

A major component and product of the Main Woodland Survey was the digital map of woodland ≥2 hectares. This was derived from a manual interpretation of 1:25 000- and 1:24 000-scale aerial photography – indirectly through a wider land cover mapping exercise in Scotland and directly from aerial photos in England and Wales.

The Survey of Small Woodland and Trees made use of the same aerial photos for interpretation of features within the 1 km x 1 km sample squares, and also validated the parts of the digital map that occurred within a small woodland sample square.

Initially, digital mapping hardware and software were used to create the woodland maps and a series of associated maps for surveyors. Later in the NIWT programme the digital map was transferred to a geographic information system and combined with the field data (see Appendix 4 for technical details).

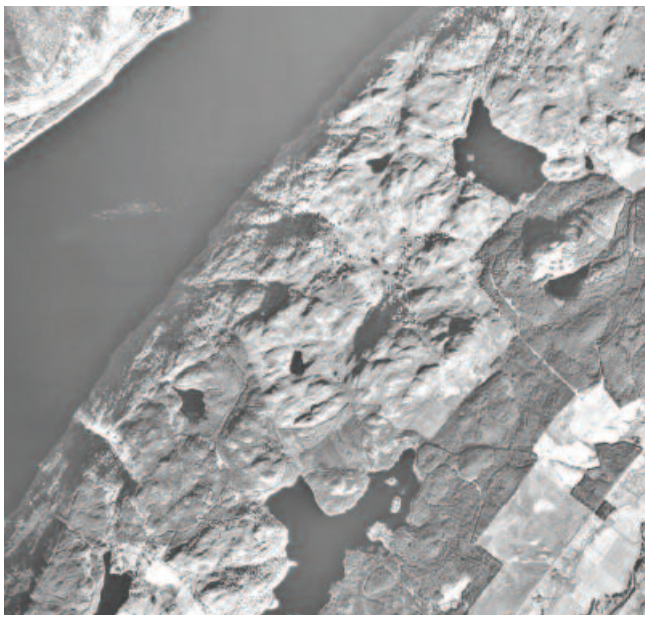
Aerial photography

Scotland

The Forestry Commission had been a sponsoring agency in the Land Cover of Scotland programme in 1988 (LCS88). The LCS88 was the first detailed Census of the land cover for Scotland, and had made use of aerial photographic coverage. The interpretation of these aerial images was transferred to 1:25 000 OS Pathfinder Series base maps to provide the basis for digitising land cover data, and hence producing the Land Cover Map for Scotland.

For the LCS88 survey, medium-scale (1:24 000) black-and-white aerial coverage had been obtained over most of Scotland between the years 1987 and 1989 (Figure 7), while 1:24 000-scale colour coverage had been obtained for a zone through the Central Belt. As a partner in the project, the Forestry Commission was initially provided with mono (single image) coverage for Scotland, but later obtained stereo coverage for the Survey of Small Woodland and Trees 1 km x 1 km sample squares.

Figure 7 Example of the LCS88 1:24 000 aerial photography (Loch Ness) showing plantation and native woodland, moorland and water features.



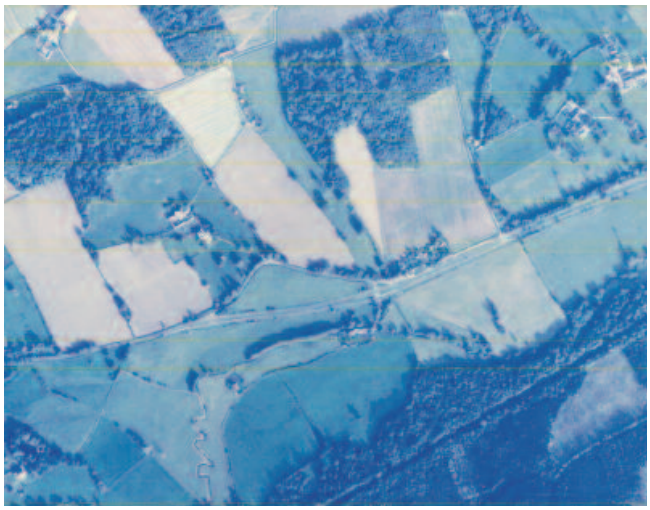
England and Wales

There was no equivalent land cover survey data for England and Wales, so the Forestry Commission investigated what aerial imagery was available 'off the shelf' through aerial survey companies and agencies. The National Remote Sensing Company[2] (NRSC) had a programme to obtain 1:25 000 aerial cover for these countries (Figure 8). Some large areas had been flown by NRSC between 1991 and 1994, with an ongoing programme to fly other areas throughout the countries. The Forestry Commission was able to obtain existing 1:10 000 aerial coverage from NRSC and the Agricultural Development and Advisory Service (ADAS) to fill in some of the missing areas.

For the remainder not covered by the above, the Forestry Commission issued tenders to aerial survey companies and flying agencies to provide the additional 1:25 000 aerial photographic cover, and contracts were awarded.

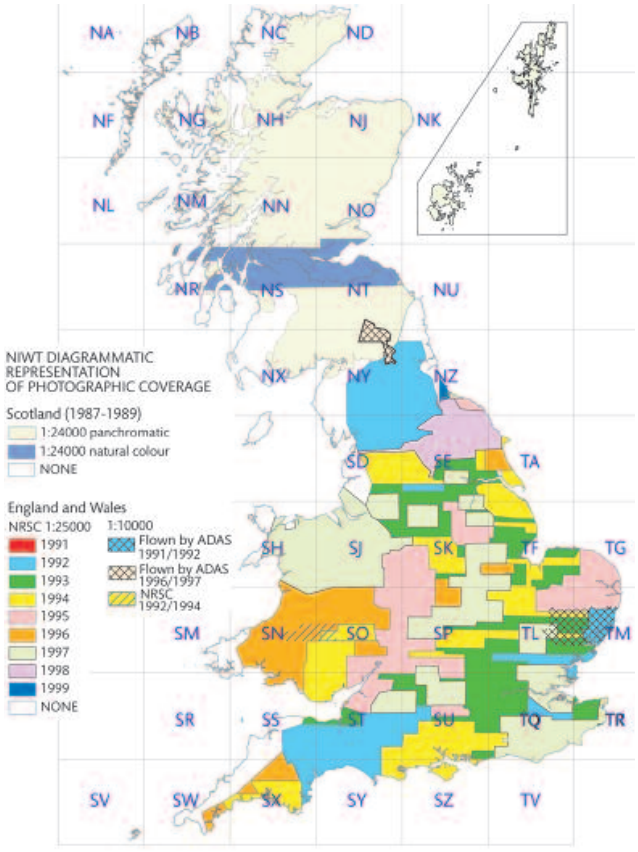
[2] Formerly National Remote Sensing Centre Ltd, Barwell, Leicestershire, now part of Infoterra Ltd., an Astrium Company.

Figure 8 Example of the NRSC 1:25 000 aerial photography showing plantation woodland and small woodland features.



Overall the Forestry Commission was able to obtain stereo colour aerial cover for England and Wales, flown between 1991 and 1999 at mainly 1:25 000 scale (Figure 9). There was a small area in Northumberland that was not covered because of very poor weather conditions for three flying seasons following commissioning of the flying. In this area, ground survey was used to complete the map.

Figure 9 Map showing the dates of aerial photography obtained across Great Britain.



Woodland map for the Main Woodland Survey

The most up-to-date mapping technology available at the time was used to produce the first digital map of woodland for Great Britain. The map covered all woodland of ≥2 hectares, and woodland was classified by major Interpreted Forest Type (IFT). The OS gave permission to the Forestry Commission to scan the 1:25 000 monotone series of maps to be used as a raster backdrop to the NIWT woodland map. The woodland map was used as the basis for all woodland area estimates in the NIWT survey.

Scotland

Using the LCS88 Land Cover Map as a basis, the digital woodland data were extracted for the NIWT survey. The LCS88 woodland classes with a 50% canopy cover were used as the basis for woodland boundaries, and for seven Interpreted Forest Types.

- conifer
- broadleaved
- mixed
- young trees
- felled
- ground prepared for new planting
- scrub/shrub land.

(See full description of IFTs in Appendix 1.)

Any anomalies found during preparation of the woodland map or during the use of the digital data in the field were reported to the LCS88 project team at the Macaulay Land Use Research Institute.

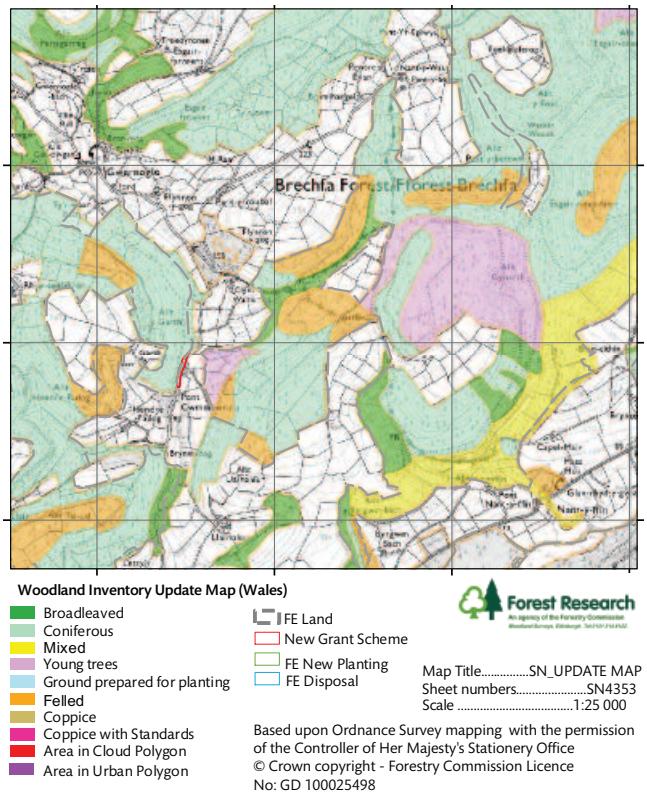
The interpreted woodland data were based on the aerial photographs of 1987–1989. It was therefore decided to update the LCS88 imported woodland data with any new grant-aided and Forestry Commission planting, to create a common base date for the map of 31 March 1995. Additional woodland within the LCS88 urban parcels or beneath cloud cover were added. This provided the most up-to-date woodland data possible before field sampling (Figure 10).

England and Wales

In England and Wales, the woodland map was created from aerial photography flown from 1991 to 1999. Contractors were employed to interpret the aerial photographs for woodland boundaries and for seven Interpreted Forest Types as described above for Scotland, plus coppice and coppice with standards.

Figure 10 Example of the Scotland woodland map by Interpreted Forest Type.

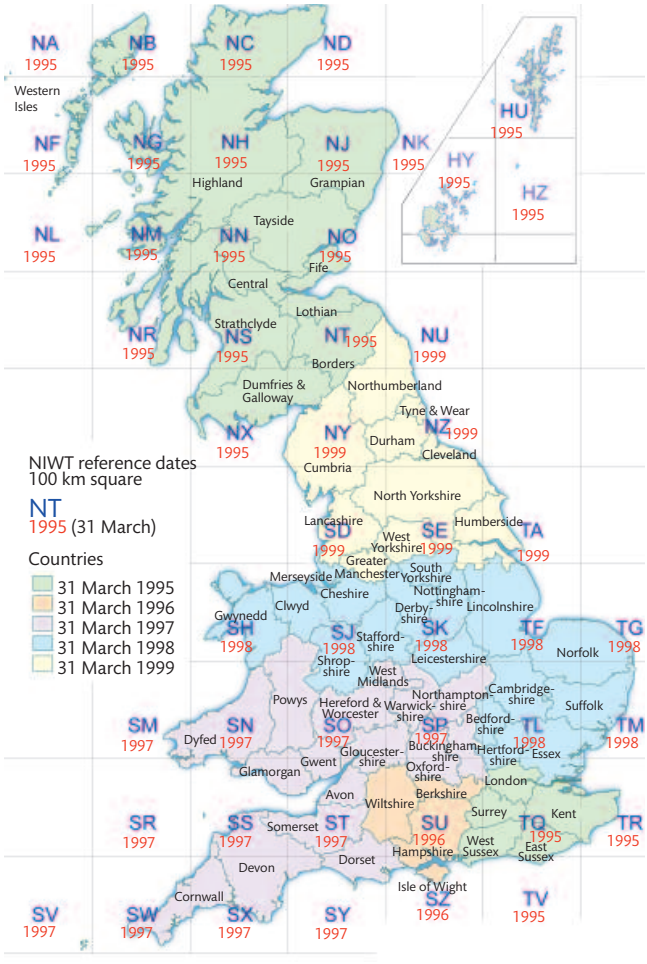
Figure 11 Extract from a Wales update map.



The boundaries were digitised at 1:25 000 scale and the woodland map updated with new grant schemes and Forestry Commission new planting. Woodland found beneath cloud cover was added. Any Forestry Commission woodland areas sold since the creation of the legal boundary were highlighted on the update map to show change in ownership to non-Forestry Commission (Figure 11). Where the contractor was uncertain about the woodland Interpreted Forest Type, the parcels would be labelled as 'unresolved', to be investigated by the field teams at a later date.

With no pre-existing major land cover exercise to utilise, the mapping work in England and Wales progressed more slowly, just ahead of the fieldwork. Map creation progressed by 100 km x 100 km OS tile, starting in southeast England, working up through England and Wales to finish in northeast England. The reference date assigned to a county was defined by the date of the image capture for the bulk of the county mapped. Regional and national reference dates were determined in turn by the reference dates of the component counties/regions.

Figure 12 Map of the survey reference dates against the OS 100 km x 100 km grid.



Based upon Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office. © Crown copyright - Forestry Commission Licence No: 100025498

Great Britain

The overall woodland map for Great Britain was compiled, its component units having reference dates from 1995 to 1999. The field surveys were generally carried out within a year of map creation. Because the map defined the sample framework and woodland area estimates, the survey reference dates became the map reference date. Figure 12 shows the survey reference dates of the OS 100 km tiles, and how this has been applied to the smallest reporting units, i.e. counties in England and Wales, and regions in Scotland.

The two major direct mapping products from the NIWT programme were:

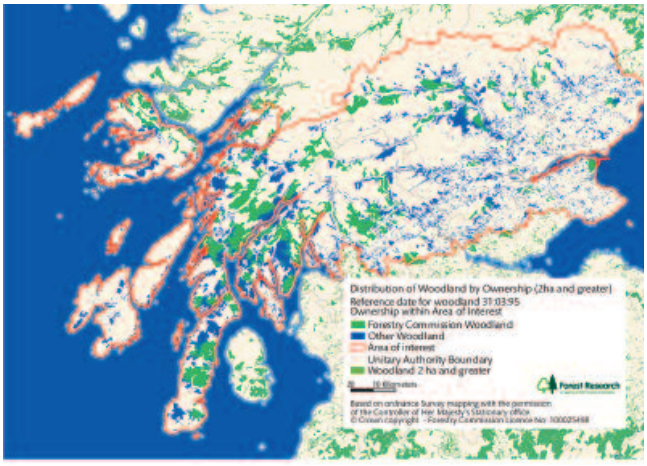
- the map of woodland ≥2 hectares (shown in Figure 13 below);
- the map showing woodland by Interpreted Forest Type (an example of which is shown in Figure 10).

Figure 13 The woodland map of Great Britain.

The former shows the extent and distribution of woodlands and the latter gives a simple view of their composition as interpreted from aerial photographs.

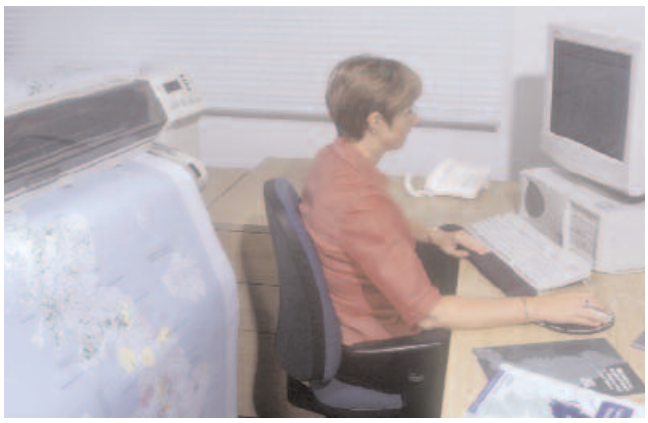
An important component of woodland mapping, i.e. ownership, had been deliberately kept separate. The Forestry Commission's legal boundary was used together with the woodland map to create a new product: the ownership map (Figure 14). The advantage of this separation was that as the legal boundary changed through time (both during and after the survey) an appropriate version could be used.

Figure 14 Map of Perth Conservancy showing woodland by ownership.



The transfer of map data to a geographic information system simplified production of composite maps from a variety of datasets (Figure 15). Figure 14 illustrates the woodland map combined with Forestry Commission's legal boundary and OS vector products to create a useful map for one Conservancy.

Figure 15 Map production on demand from the geographic information system.

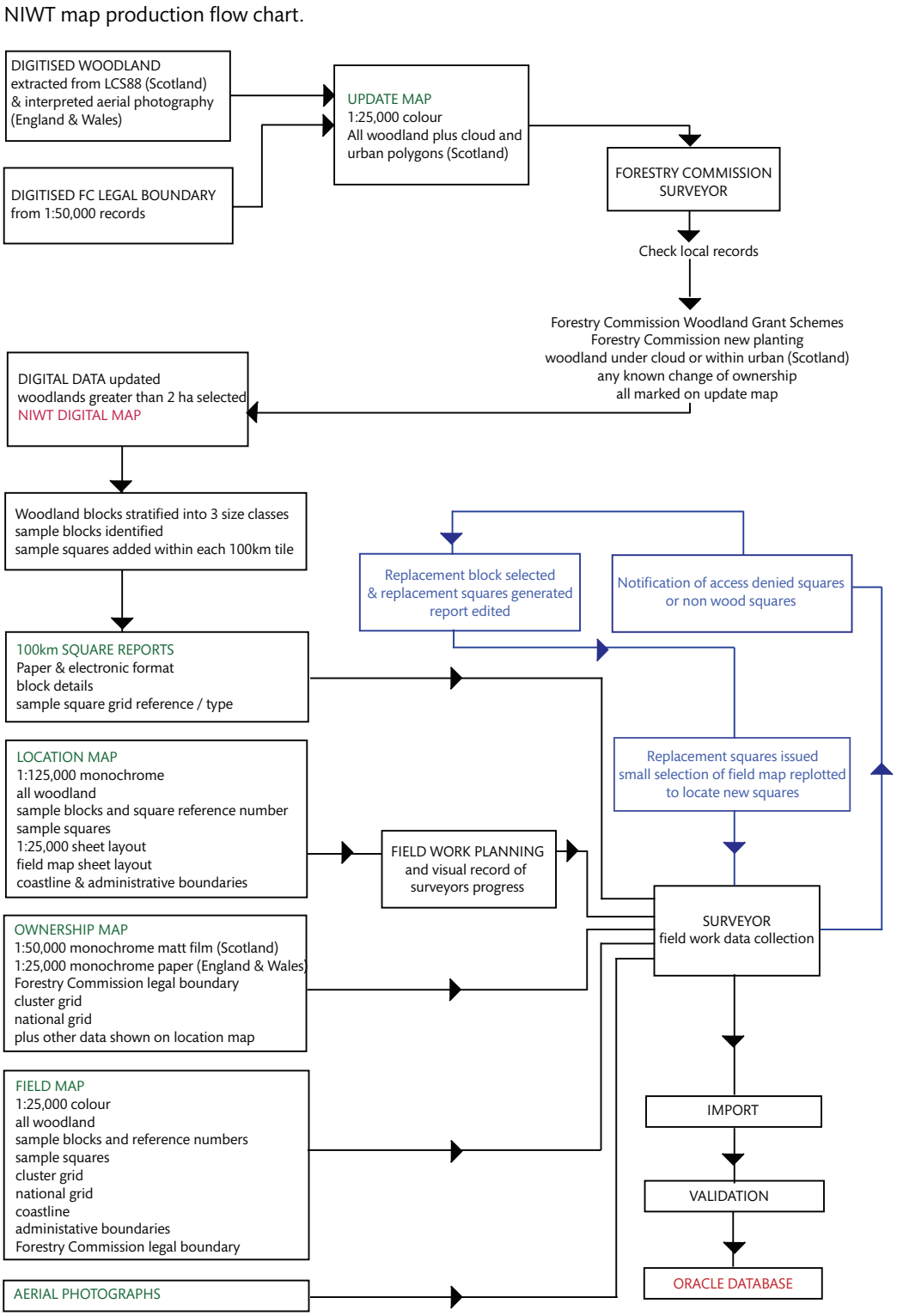


Although the woodland map was a fixed product relating to the NIWT at given reference dates, it was also designed to be continually updated using information on new planting as it became available. This allowed some updates ahead of the next National Inventory mapping exercise. While new woodland was relatively easy to add from Forestry Commission records, updating for fellings and other internal changes was not generally available.

Associated maps

In addition to the maps leading to the creation of the NIWT digital map (see upper third of Figure 16), a series of associated maps were generated for the surveying process; these are shown in the lower two-thirds of Figure 16.

Figure 16 Flow chart of the various maps produced for the Main Woodland Survey.



Woodland block and sample square reports

On completion of the sampling stage, the surveyors were provided with woodland block reports and sample square reports to assist with fieldwork. These identified the sampled woods and squares, and provided additional information (Figure 17).

Within Scotland, there were nine different ways to label the 1-hectare sample squares:

First pass	Second pass	Miscellaneous
• Direct hit	• Second pass direct hit	• Non-woodland
• First pass moved	• Second pass moved	• Access denied
• First pass edge	• Second pass edge	• Replacement square for either non-woodland or access denied square

For the Scottish 100 km x 100 km tiles NS and NC, and for the whole of England and Wales, National Vegetation Class (NVC) data were collected within 1-hectare sample squares falling on known Ancient Woodland areas (from the Ancient Woodland Inventory maps). Where an additional assessment for NVC was to be carried out the square would be coloured red on field maps. All the other 1-hectare sample squares were depicted in black.

Location map

This map was created to show the location of selected sample squares; its main purpose was to assist the surveyor in planning field visits across the whole 100 km x 100 km tile. The map showed the 1-hectare sample squares within the sampled woodland parcels and the layout of the field map sheet lines (Figure 18). At a glance the surveyor could see if squares on adjoining maps could be completed in the same field visit. The surveyors would strike through squares as the field data were collected, providing a visual check of outstanding work.

Ownership map

Knowing which woodlands were within Forestry Commission ownership, and by default the remainder in other ownership, simplified the process of gaining access permission. In Scotland an ownership map was based on the Forestry Commission's 1:50 000 records of Forestry Commission-owned land, which was in turn based on title deeds of acquisitions and disposals. The surveyors checked the map and consulted with the locally held records in the Forest District Offices for any recent changes in ownership. By the time the survey was underway in England and Wales, the Forestry Commission had digital legal boundary information. It was therefore much easier to create the ownership maps (Figure 19), this time based on the OS 1:25 000 mapping.

Finding the owners of the 'other woodland', i.e. non-Forestry Commission, sample squares, proved to be an onerous task, particularly in southern England (see Chapter 5 for more information on finding ownership). No woodland was entered without permission.

Field map

This was the most important map for surveyors carrying out the field survey work. It covered a land area of 20 km x 20 km, equivalent to two standard OS Pathfinder 1:25 000-scale sheets. The OS 1:25 000 map data were shown as a grey backdrop to aid location.

Each sampled woodland block was labelled with a unique reference number within the 100 km x 100 km tile, and its area. Each internal Interpreted Forest Type was colour coded. Woodland parcels that were not being sampled were shown in outline only. A thick broken line showed the extent of land under Forestry Commission ownership.

All the various square types (e.g. direct hits, second pass, etc.) of the 1-hectare sample squares were plotted to scale and given a unique number within the 100 km x 100 km tile. The cluster grid was also shown on the field maps (Figure 20).

Replacement sample squares

Replacement squares were created and produced to maintain the approximate 1% sampling in two scenarios:

- if, on a field visit, a surveyor found that all the selected squares in any woodland were in fact 'non-woodland'
- if a surveyor had contacted the owner or agent to gain access to a non-Forestry Commission woodland for fieldwork but access had been denied to the whole woodland.

A replacement woodland would be chosen as follows. The mapped woodlands were listed in order of increasing area. If a sampled woodland needed to be replaced the woodland with the next highest area on the list was selected as the replacement. New sample squares were selected using the appropriate sample grid (Figure 21). Sometimes more

Figure 17 Examples of a woodland block report and a field square report[3].

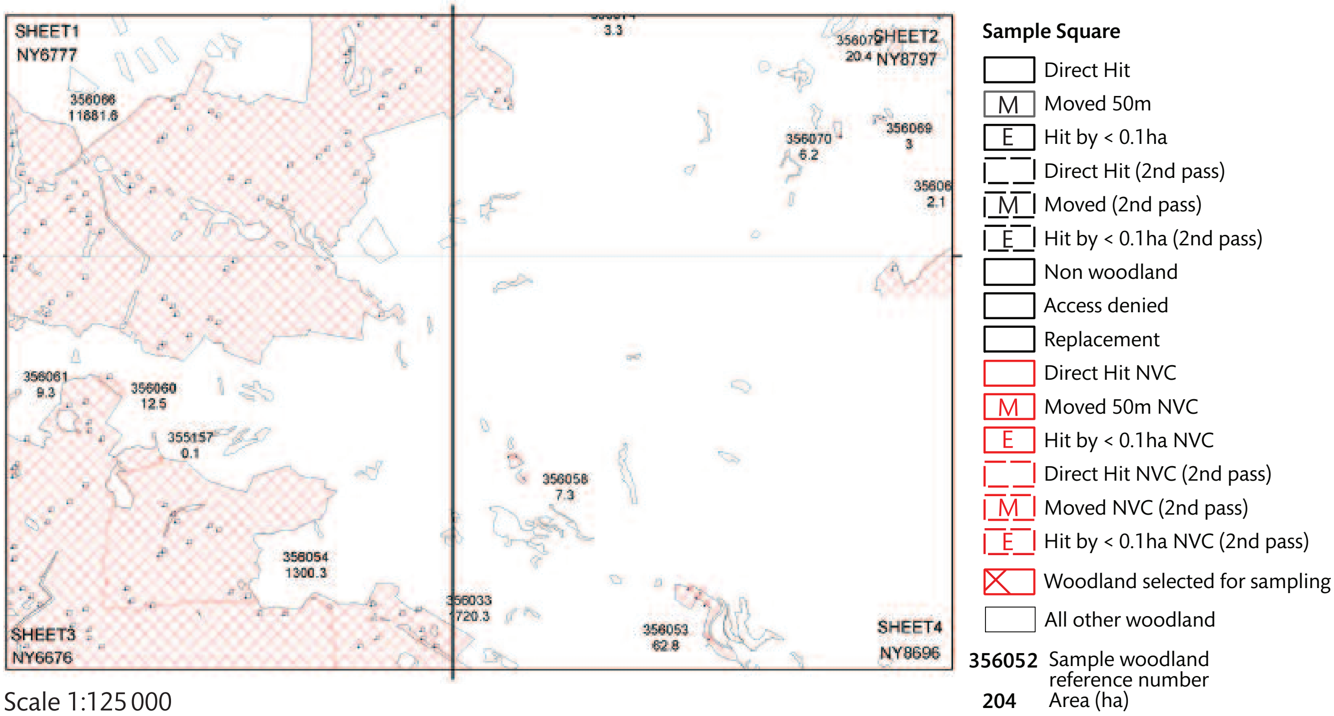
The following blocks are to be sampled in square 45:-

Block Number	FSN	Area (Hectares)	Grid Ref
451001	231	1402.2821	(xxxx yyyy)
451002	215	36.0615	(xxxx yyyy)
451003	223	909.034	(xxxx yyyy)
451004	86	11.5177	(xxxx yyyy)
451005			
451006			
451007			
451008			
451009			
451010			
451011			
451012			
451013			
451014			
451015			
451016			

Block Number	Size Class	Sqr ref	Grid Ref X	Grid Ref Y	IFT	Sqr Type	LCS	NVC	Sampled Area (Ha)
451001	500 plus	0006	xxxx	yyyy	F	1	0084		1.0000
451001	500 plus	0007	xxxx	yyyy	N	1	0085		1.0000
451001	500 plus	0024	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0025	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0026	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0027	xxxx	yyyy	C	3	0070		0.0000
451001	500 plus	0028	xxxx	yyyy	F	1	0084		1.0000
451001	500 plus	0029	xxxx	yyyy	F	1	0084		1.0000
451001	500 plus	0030	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0031	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0032	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0055	xxxx	yyyy	F	1	0084		1.0000
451001	500 plus	0056	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0057	xxxx	yyyy	I	1	0084		1.0000
451001	500 plus	0058	xxxx	yyyy	C	1	0070		1.0000
451001	500 plus	0059	xxxx	yyyy	C	1	0070		1.0000

Figure 18 Extract from a sample square location map.

LOCATION MAP 100 km TILE NY



Scale 1:125 000

[3] FSN, Feature Serial Number; LCS, Land Cover Scotland; IFT, Interpreted Forest Type. Grid references of sample squares have been suppressed to avoid disclosure.

Figure 19 Extract from a Welsh ownership map.

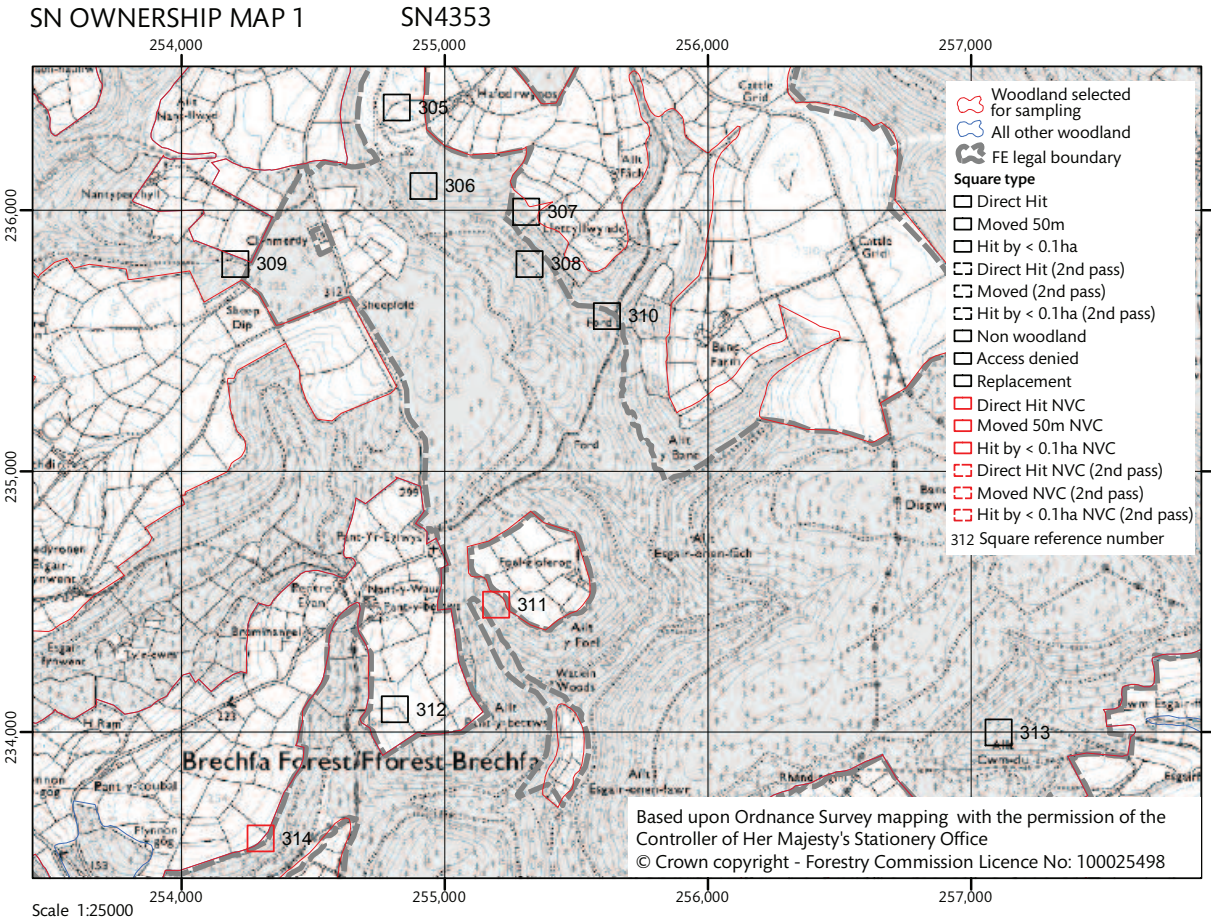


Figure 20 Extract from a field map.

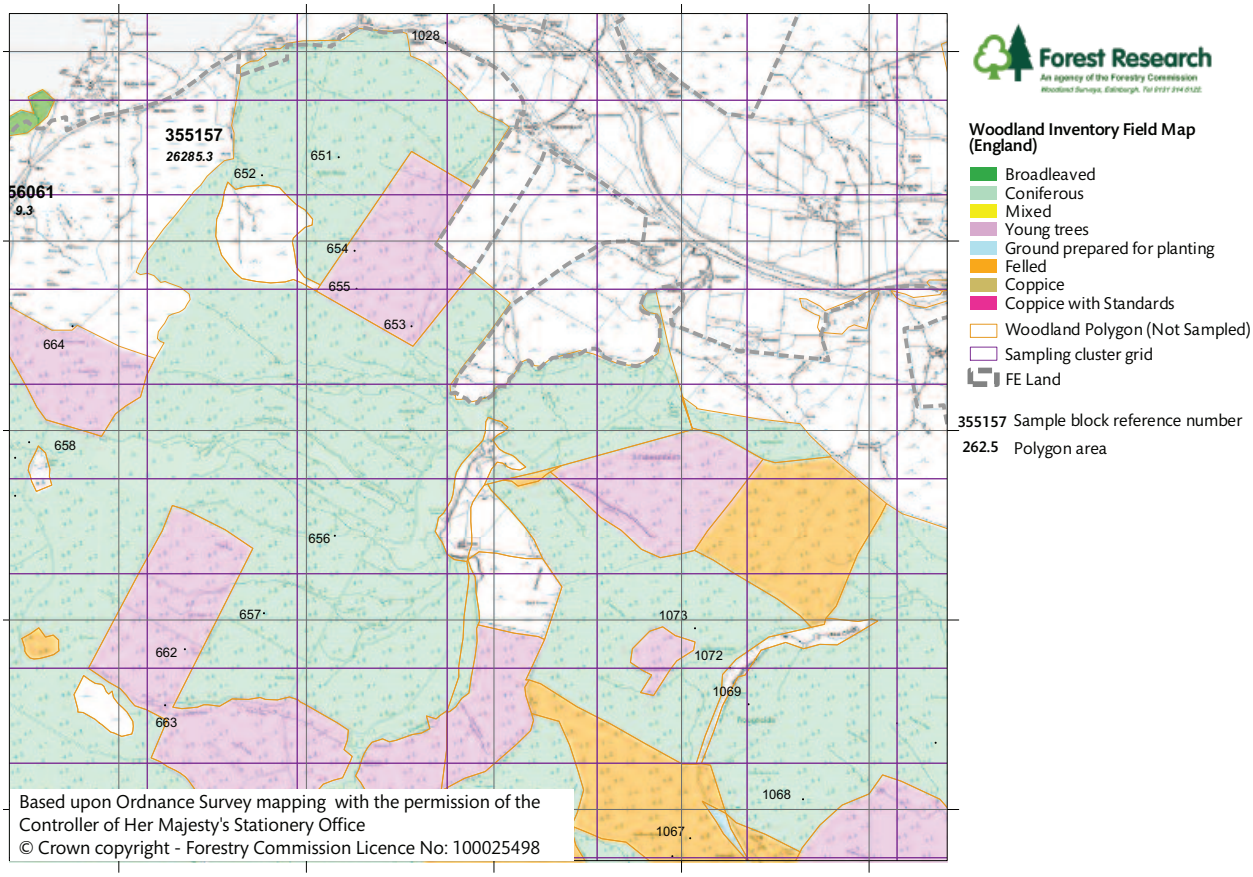
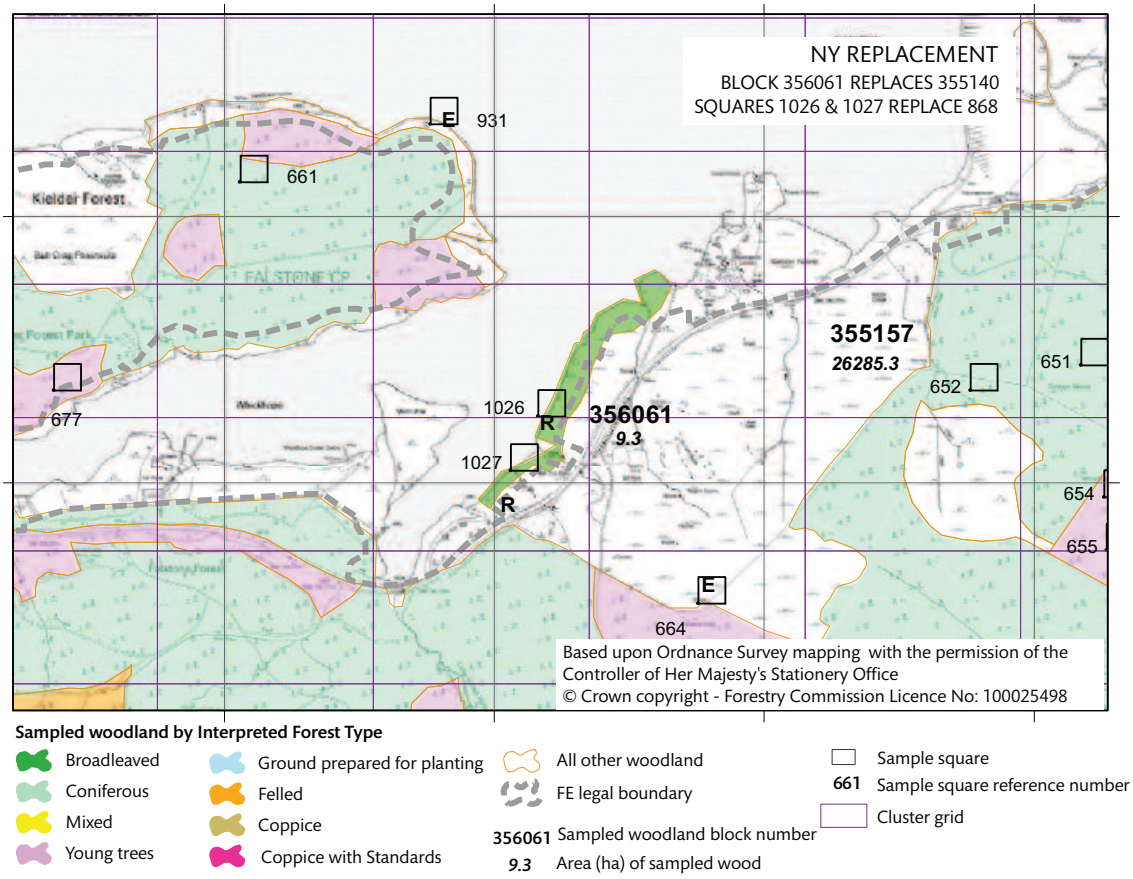


Figure 21 Extract from a replacement square map.



sample squares would be generated than in the original selected woodland but on other occasions there would be fewer.

The only exception to replacement woodland samples was in the woodland size class of >500 hectares, because all woodland >500 hectares had already been sampled and there was therefore no 'spare' woodland over 500 hectares.

Survey of Small Woodland and Trees

The Survey of Small Woodland and Trees in the countryside was sample-based (Figure 22). The land area was stratified into coastal and inland 1 km x 1 km squares and a systematic sample of these squares was selected, representing ≈1% of the land area. Various versions of the inland sample selection were trialled, selecting 1 square in 100 from either north–south axis or east–west, but because of the shape of Britain a regular chevron pattern of samples was generated. The final version selected a separate sample for each local authority.

A coloured map was produced for each 1 km x 1 km sample. The 1 km x 1 km square was further divided into 16 smaller squares of 250 m x 250 m, as shown in the central square of Figure 23. Two of the smaller squares were selected to be visited by the field surveyor. The first square was selected at random and the second square was selected by counting six squares onwards, counting left to right along the rows. For example, in Figure 23, if the first square selected was M2 then the second would be L6, if L6 was first, then L8 would be second. The sample 1 km x 1 km square was plotted at 1:10 000 scale over an OS 1:10 000 raster topographic base, and if any woodland of ≥2 hectares fell within the sample square, this would be colour coded by 'Interpreted Forest Type'.

The map in Figure 23 and the corresponding stereo pairs of aerial photos were used by the field surveyors for the interpretation and identification of the small woodland and linear features within the whole 1 km x 1 km square (Figure 23). Stereo pairs of aerial photographs at 1:25 000-scale were available for all sample squares. Surveyors used the stereo pairs of aerial photography to locate the small woodland and linear features; the stereo viewers aided the height distinction of linear features.

Figure 22 Distribution of sample squares across Great Britain for the Survey of Small Woodland and Trees.

Figure 23 Example of small woodland field map, marked up by a surveyor.

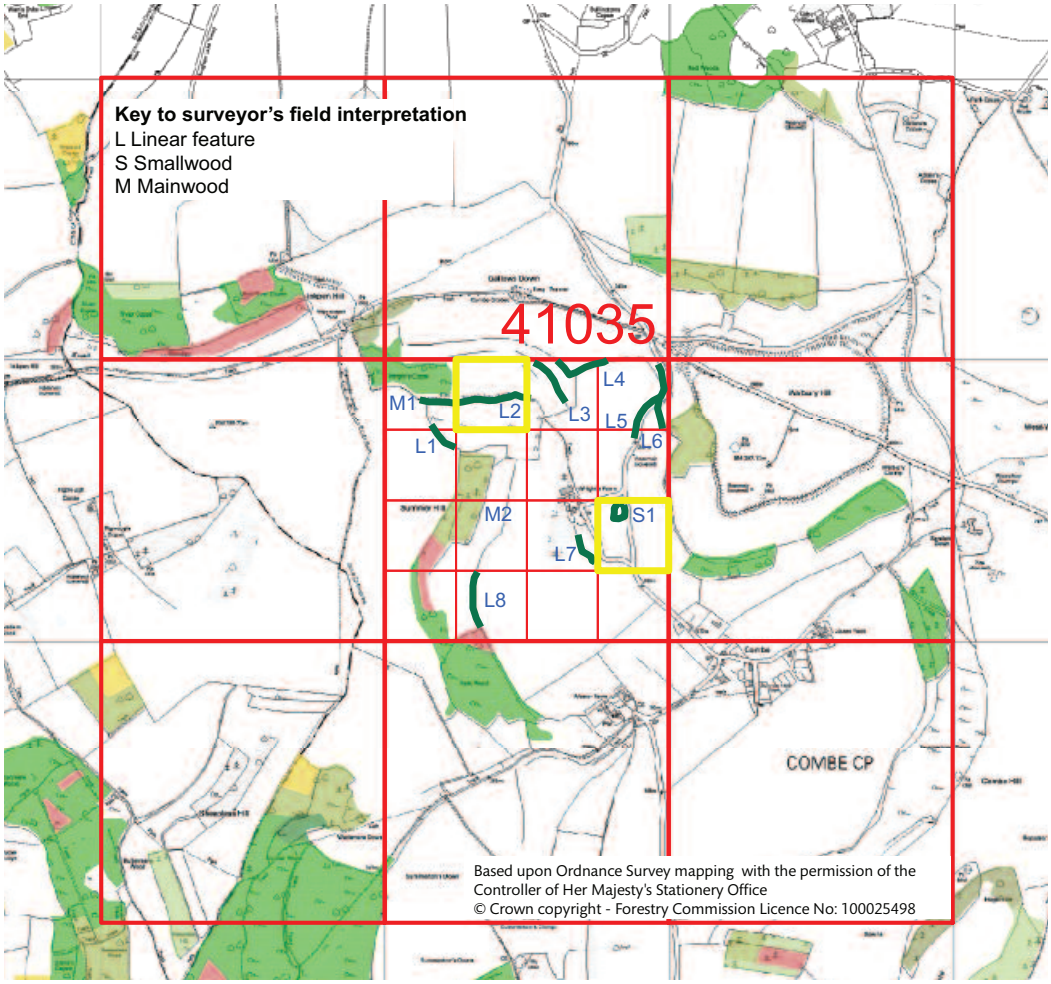
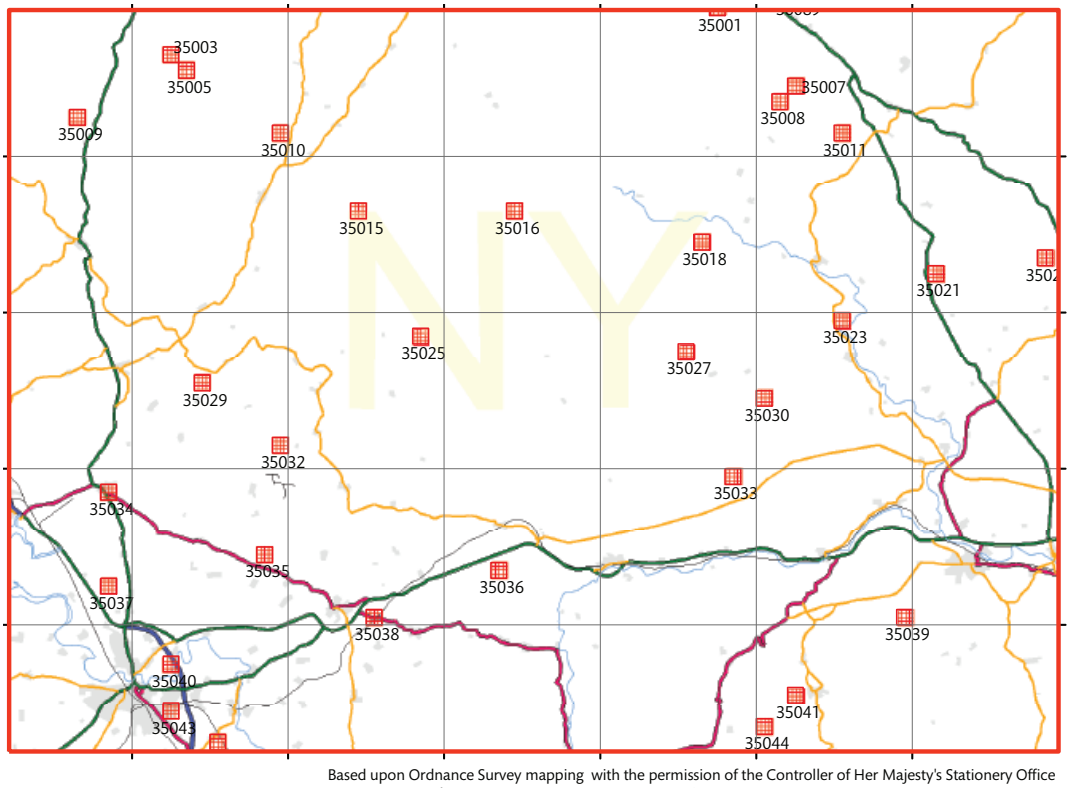


Figure 24 Extract from a 1 km x 1 km sample square location map for the Survey of Small Woodland and Trees.



Based upon Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office
© Crown copyright - Forestry Commission Licence No: 100025498

Surveyors were then issued with a location map for the sample squares (Figure 24). The two selected field plots within the squares were visited to identify and record the small woodland data. Data were collected on small woodlands (0.1 – <2 hectares), linear features, groups and individual trees.

5. Field methodology

Introduction

There were four main stages to the task of collecting the field information. These were:

- mapping and aerial photographic interpretation, tracing owners and seeking permission to carry out the fieldwork;
- carrying out the fieldwork itself and recording data according to the procedures laid down in the surveyors' manuals;
- securing the field data by means of backups of the digital information and passing the information itself on for further processing and analysis;
- validation.

Once the work of the team was underway, all stages of the operation could be undertaken concurrently. While fieldwork was in process for one set of woodlands, permissions could be sought for subsequent work for the team, alongside work on mapping, aerial photographs and validation.

A report generated by a validation programme was passed back to the surveyor for comment and correction, changes were then made to the data to resolve the problems that had been detected.

Preparation, tracing owners and obtaining permissions

Main Woodland Survey

The field team received a package from Forest Research consisting of:

- the field map, showing the sample squares in the sampled woodlands;
- aerial photographs – these were at, or near to, 1:25 000 scale (in England and Wales these were mostly colour, and in Scotland, largely monochrome);
- reports – details of sample woods and squares.

From the beginning of the NIWT, it was made clear to surveyors that no woodland should be visited without the owner's permission. The best starting point was the knowledge of local Forestry Commission staff about the owner, the owner's agent or a management company. Often one contact would lead to other information relating to adjacent properties. Where there were no available contacts, the surveyors would attempt to trace the owner by local enquiry. Generally, access to woodlands was obtained as a result of clear explanations of the purposes of the NIWT and a willingness on the part of the surveyor to fit in with the needs and requirements of the owners. In the rare event that an owner did not wish to be involved in the NIWT, the sample could be replaced if all squares had been lost. No replacement woods were available in woodlands over 500 hectares because of the 100% sample of this size class.

Survey of Small Woodland and Trees

At the preparation stage the biggest difference between the Main Woodland Survey and the Survey of Small Woodland and Trees was the interpretation of the aerial photographs and the recording of features that could be identified.

The features recorded were as follows:

- small woodlands – an area of woodland (>20% potential canopy cover unless felled) with an area of not less than 0.1 hectare but less than 2 hectares
- linear feature – tree features ≥25m long and at least four times as long as they are broad. Linear features could be up to 50 m wide or as narrow as a single line of trees.

Groups and individual trees were not recorded at this stage, as these assessments could not be reliably made from aerial photographs at 1:25 000 scale. For small woodlands, the features recorded were those whose centre points fell within the 1 km x 1 km square. The lengths of linear features that fell within the square were also recorded. It should be noted that the identification of a linear feature refers to the whole extent of that feature within and outwith the square and not just that part which extends into the square. However, the length recorded was only that part which fell within the square. Protocols were included for dealing with features that coincided with the edges and corners of the squares.

At this stage, the surveyor was also asked to look in detail at any woodland over 2 hectares that had been recorded within the 1 km x 1 km square and record any differences between the area on the map and that which could be seen

on the photograph. This procedure provided a check on the main woodland aerial photographic interpretation that had been carried out to produce the digital map.

Field data collection

The data collection for the two separate surveys included within the NIWT contained many common elements. Where practicable the types of information collected, such as forest type, were the same, but sometimes the method of the assessment had to be adapted to take account of the essential differences between the two surveys.

Data structure

In both the Main Woodland Survey and the Survey of Small Woodland and Trees, the data collection was structured to facilitate the collection, recording and analysis of the data. The data structures for the two surveys are illustrated in Figures 25 and 26.

Figure 25 shows the six main levels of data that were recorded and the types of information that were recorded at each level. During the course of the Main Woodland Survey, some amendments were made to the placing of particular data items in the structure. The diagram shows the structure as it was at the completion of the survey in Northern England.

Figure 25 Main Woodland Survey data structure.

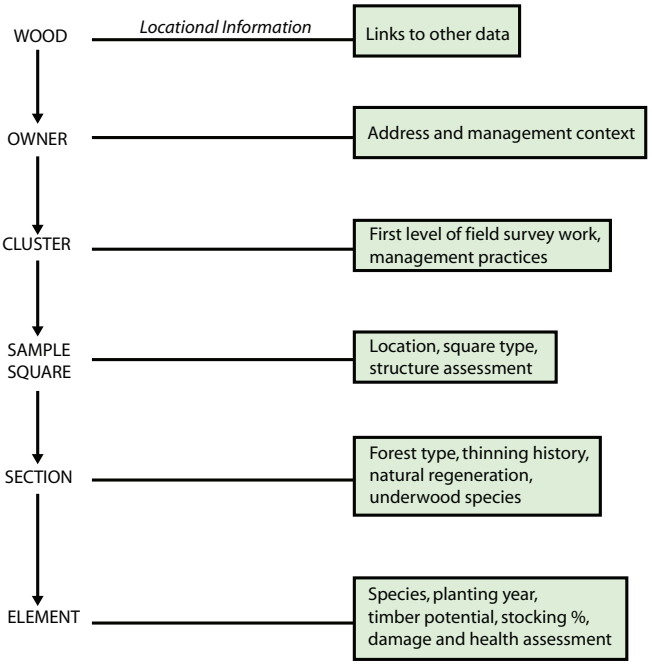


Figure 26 shows that the structure of the small woodland data was very much more complex than the Main Woodland Survey and this reflected the relative complexity of the underlying features. The first part of the data, i.e. down to '1 km square API' and 'small square ground', relates to the data gathered from the aerial photograph and their link to the ground data. The surveyor could also record contact with the owner or his or her representative confirming permission for the ground visit.

The lower part of the diagram summarises the ground data collection for all the features included within the survey. Small woodlands and the wider linear features were surveyed in much the same way as the main woodland was assessed, whereas the other features, from single trees to avenues and copses of less than 0.1 hectare, were surveyed in terms of counts of trees rather than area.

Assessments in the Main Woodland Survey

Data recorder

The device chosen to collect the field data was the Husky Hunter 16/80 with a membrane keyboard (see Appendix 5). This was a rugged, waterproof computer weighing 1.2 kg and was usually kept in a carrying case for field use. The size of the screen and its full keyboard were major advantages in the flexible recording of field data (Figure 27).

Figure 26 Survey of Small Woodland and Trees data structure (API is aerial photographic interpretation).

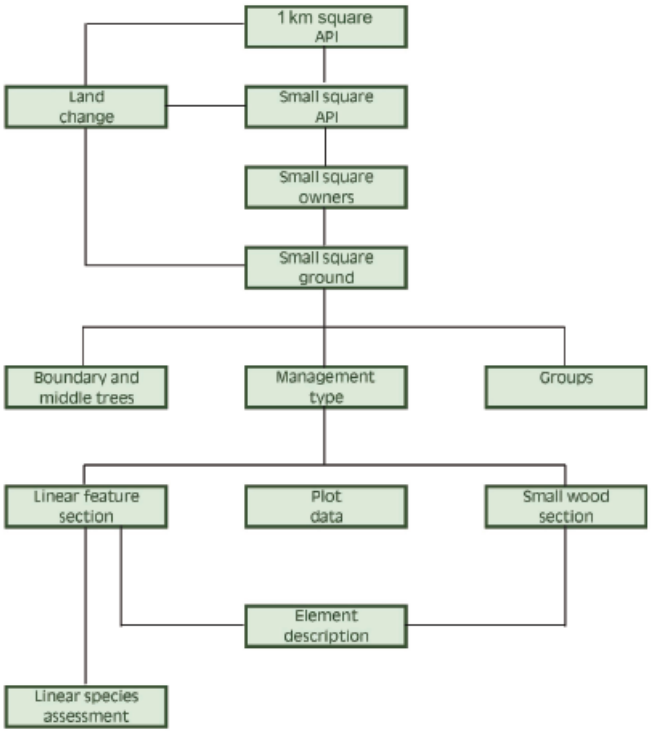
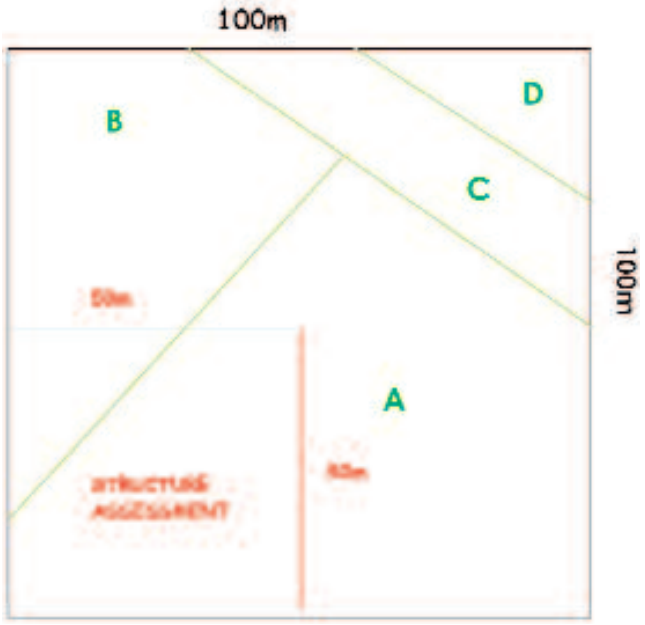


Figure 27 Husky Hunter 16/80 field data collection device.

Figure 28 Example of a 1-hectare sample square.



Section A – Oak, planted 1972
Section B – Scots pine / Corsican pine, planted 1948
Section C – Ride – unplanted
Section D – Sweet chestnut coppice, planted 1992

Input to the Husky could begin in the office, with data entry for the sample wood and its owners. The first stage of recording of actual field data was at cluster level, recording observed management practices. Only management practices for which there was visual evidence on the ground were recorded. Any or all of the codes could be recorded. It should be noted that the data referred to the presence of evidence for a particular management practice somewhere in the cluster. It did not indicate that it was present over the cluster as a whole. These data were usually gathered while the surveyor was travelling to the sample square itself; if the sample square was close to the edge of the wood, for example, the data would not have been gathered from the whole of the 40-hectare cluster.

Within each cluster, the surveyor would assess each 1-hectare sample square. In each of the squares, basic locational information would be recorded along with a structure assessment in the southwestern quarter-hectare. Figure 28 shows a 1-hectare sample square, 100 m x 100 m, oriented to the National Grid, and the 50 m x 50 m structure assessment square in the southwestern quadrant. In this example, four sections within the sample square have been distinguished by the surveyor; each is a different and reasonably homogeneous unit. These sections represent different stands of trees, distinguished by species, age or type of forest (see Figure 28 for an example).

The section records data such as forest type, e.g. conifer or broadleaved, and thinning history. Each of the sections can be described in more detail by 'elements', adding information to the basic species and planting year data for such aspects as health, stocking and timber potential. Both the sections and elements that occur within the square can be used as measures of diversity. The number of sections or elements that are distinguished within the sample square increases with the woodland tree species except where surveyors chose to accept a 'minor tree species' description for a section.

A 'notes' field was provided in the Husky to enable the surveyor to record sporadic occurrences of other trees that were not significant enough to constitute an element. Area is recorded for all sections and for each element used to describe a section. The total of the element areas within a section should tally with the section area and the sum of the sections should be the woodland area for the whole square, usually 1 hectare. If the square overlapped the woodland edge then the area of the square would be less than 1 hectare. The structure assessment square was 0.25 hectare in extent (50 m x 50 m) and where the square was irregularly shaped or smaller than 0.25 hectare then protocols existed to guide the surveyor in placing the structure assessment square. At no time were data recorded from outwith the 1-hectare sample square, except management data which were collected for the cluster.

Diversity data were collected within the structure assessment square. Figure 29 illustrates the allocation of horizontal and vertical diversity.

The layers and height bands that were used to describe the vertical structure for vegetation percentage were as follows:

- upper canopy above 15 m
- lower canopy 5 m–15 m
- shrub layer 2 m–5 m
- field layer 10 cm–2 m
- ground layer below 10 cm.

Figure 29 shows examples of percentage vegetation cover (based on a plan view):

0 – <10 cm:	90% of the ground layer has vegetation
10 cm – <2 m:	55% of this layer contains vegetation (grass and tree stems and crown)
2 m – <5 m:	this layer has 20% vegetation
5 m – 15 m:	75% of the plan area has vegetation cover
15 m+:	30% of this layer has vegetation cover.

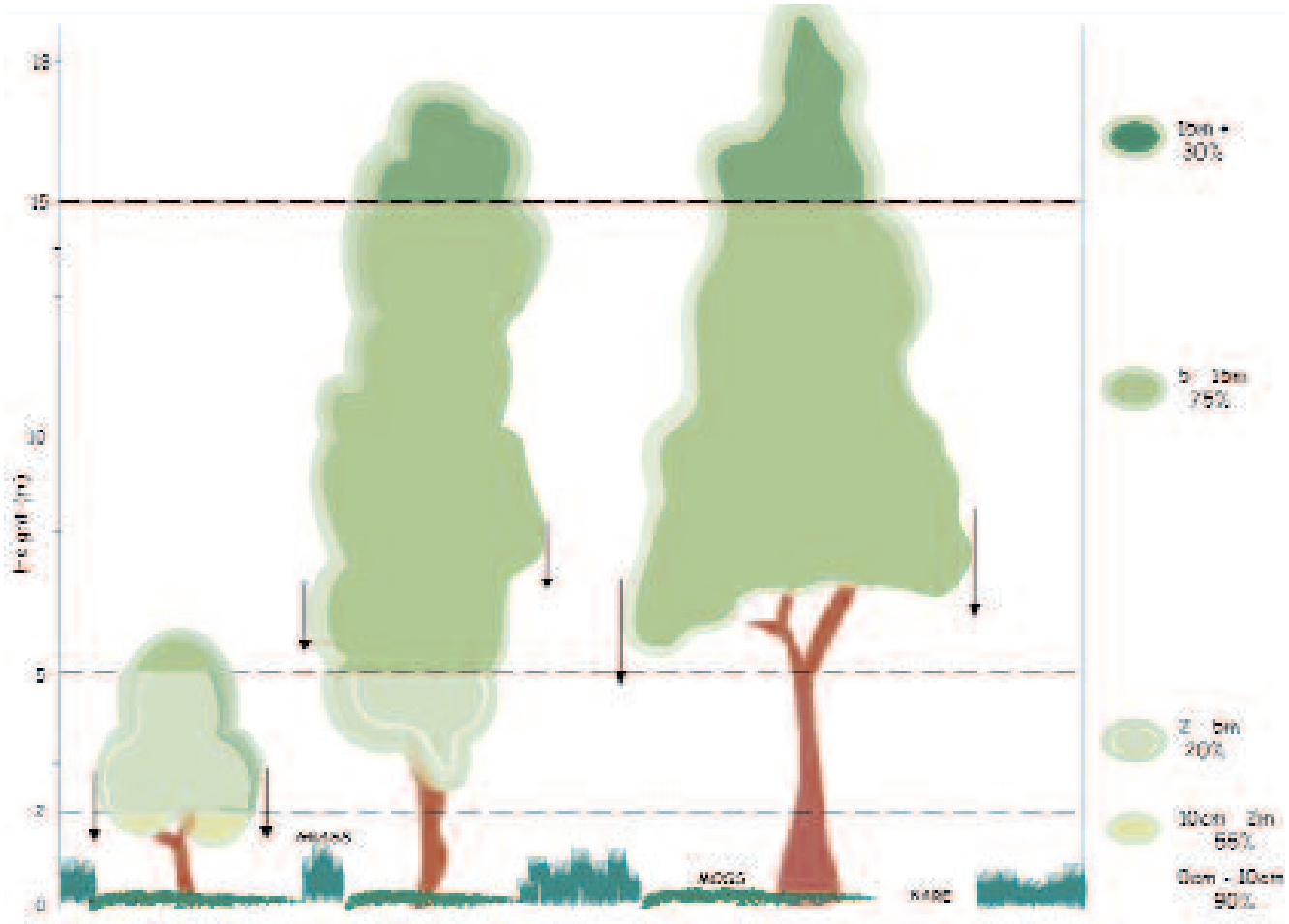
The arrows on Figure 29 indicate the vertical crown boundaries (plan view) of the trees.

The structure assessment described the vertical structure in two ways:

- the presence of species in defined layers
- the vegetation within specified height bands.

It was possible to have more than one section in the structure assessment, and when this occurred it caused some difficulty in analysis. The thinking behind this was that although the structure assessment square covered more than one section, it reflected the structural diversity of the woodland as a whole rather than representing a particular section. Where the assessment happened to be for a single section then some idea of the appearance of the stand could be imagined from the data. If the data covered more than one section the information recorded was a composite from the sections. If interpreted as one stand it could seem to be much more diverse than it actually was. An extra field was added to the data after the pilot survey to record the number of sections included.

Figure 29 Diagram showing the allocation of layers for woodland structure assessment.



As well as looking at the vertical structure, the structure assessment square was also used to assess the occurrence of deadwood. Deadwood was assessed under three headings:

- standing deadwood, dead trees or major limbs over 15 cm diameter, as a percentage of all trees in the structure assessment square
- abandoned timber, the number of pieces of felled and abandoned timber with a minimum diameter of 15 cm and at least 2 m in length
- fallen trees or major limbs, the number of trees by diameter at breast height (dbh) in three classes (7 cm–20 cm, 20 cm–50 cm and >50 cm); the trees or occasionally major limbs may be dead or still living.

Figures 30–38 are examples of land cover relating to the Interpreted Forest Types mapped. These nine forest types were used to describe the woodland areas within the square (full descriptions may be found in Appendix 1).

On survey, some parts of some squares were found to be converted, or in the process of conversion, from woodland to another use. In addition, other areas were found to have been incorrectly interpreted as woodland when the map of woodland was created. Neither of these areas (recorded as sections of two special forest types – non-woodland and felled (permanently)) were woodland and were used to statistically adjust the overall woodland area measured from the digital woodland map.

Visual assessments were made of how many times a section had been thinned and whether or not the produce was extractable. Natural regeneration between 1 and 2 m high was recorded by type (vegetative, seedling or a mixture of the two) and frequency. Regeneration of less than 1 m in height was disregarded because it was much less likely to survive to maturity.

Figure 30 Illustration of 'conifer' forest type.

Figure 31 Illustration of 'broadleaved' forest type.

Figure 32 Illustration of 'mixed' forest type

Figure 33 Illustration of 'windblown' forest type.

Figure 34 Illustration of 'coppice' forest type

Figure 35 Illustration of 'coppice with standards' forest type.

Figure 36 Illustration of 'short rotation coppice' forest type[4].

Figure 37 Illustration of 'felled' forest type.

Figure 38 Illustration of 'open space' forest type.

A section could be described by up to nine elements, accounting for combinations of species, planting years and other factors. If more than one species were present, the type of mixture was described; mixed species of natural, rather than planted, origin were described as 'intruded'. The other descriptors were 'pure' and 'mixed'.

A subjective assessment was made of the stocking of each element recording the degree of understocking taking into account age, mortality and thinning treatments.

[4] Short rotation coppice was recorded as a separate forest type in the NIWT, but its occurrence was so rare that it was not included in the published tables.

Timber potential was recorded in four classes:

- fully productive stands capable of producing or with the potential to produce sawlogs
- stands with the potential to produce sawlogs but with the need for higher management inputs to achieve their full potential
- stands capable of producing, at best, small roundwood with a minimum length of 1 m because of their bent and twisted nature; this includes the timber potential of coppice material
- any other stands that do not meet the categories above including stands producing only firewood.

In practice, there was little distinction between the first two classes and together these made up the Category 1 areas in the reports and were the main timber resource (illustrated in Figure 39). Stands in the third and fourth classes were grouped together as Category 2 (illustrated in Figures 40 and 41).

Figure 39 Illustration of a fully productive stand capable of producing sawlogs.

Figure 40 Illustration of a stand capable of producing small roundwood quality material only.

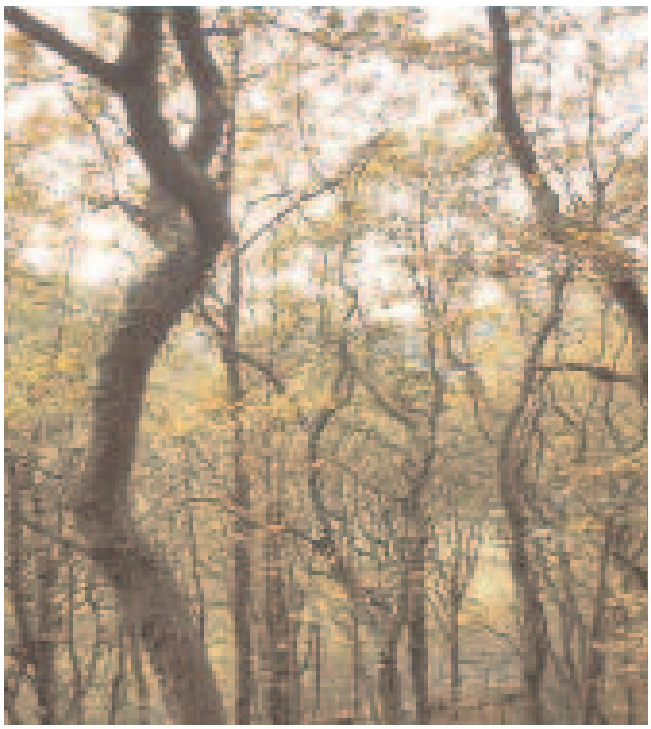


Figure 41 Illustration of a stand capable of producing woodfuel quality material only.

Assessment of planting year can be quite difficult depending on the species and its maturity. Whorl counts on younger conifers can be quite accurate, but as the tree ages the whorls at lower levels become blurred and indistinct. In general, broadleaved trees are harder to assess than conifers but some judgement can be made in relation to stands of known age in the locality. Planting year is recorded, rather than age at the time of survey, because it simplifies the calculation of age by making it relative to the time of analysis rather than the time of survey, which was not fixed.

Mammal damage was recorded as bark stripping or as browsing and was classified as follows:

Bark stripping

- damage (% of the trees in the element)
  - <20% damaged
  - 20–50% damaged
  - >50% damaged
- location (main location of the damage)
  - ground or buttress
  - main stem <1.8 m
  - main stem >1.8 m
- severity (describes the wounds and effect on the trees)
  - <10 cm high and <50% girdled
  - <30 cm high and <50% girdled
  - ≥30 cm high and >50% girdled

Browsing

- damage (% of the trees in the element)
  - <20% damaged
  - 20–50% damaged
  - >50% damaged
- severity of damage to trees which are affected by browsing
  - <20% of shoots browsed, with leader intact

20–80% of shoots browsed or a light browse line on taller trees and shrubs
>80% of shoots browsed, trees hedged, deformed or killed or majority of trees have damaged leading shoot or very distinct browse line on taller trees and shrubs.

The surveyors recorded the presence of health problems under the following headings:

- crown dieback
- general poor health
- stem decay
- windblow.

These were recorded if present within the elements. It was not the intention to assign specific causes to problems, but after the completion of Scotland, the range of data recorded was extended with the addition of 'animal damage' and 'squirrel damage'.

Assessments in the Survey of Small Woodland and Trees

This survey was designed to obtain information on all tree and woodland features in the countryside not covered by the Main Woodland Survey. The range of six features is listed below (and illustrated in Figures 42–47):

- small woodland (0.1 – <2 hectares)
- linear features (length >25 m, and up to 50 m wide, but at least four times longer than wide)
  - wide linear feature (16–50 m wide)
  - narrow linear feature (single tree width to 16 m)
- groups of trees (more than two trees, and less than 0.1 hectare)
- individual trees
  - boundary trees (e.g. field boundary)
  - middle trees (not on a boundary).

Management practice was recorded for each small woodland or linear feature. Where appropriate, small woodlands and wide linear features were divided into sections and described by elements that accounted for the woodland area within that woodland feature. The features data relate to individual trees, groups and lines of trees.

For an individual tree the data collected were:

- species
- live or dead
- height band (Figure 29)
- number of stems
- health problems (see above).

In the Survey of Small Woodland and Trees, the deadwood assessment was limited to the recording of the standing deadwood as a percentage of the total number of stems in each section.

Figure 42 Illustration of a small woodland feature.

Figure 43 Illustration of wide linear features.

Figure 44 Illustration of narrow linear features.

Figure 45 Illustration of a group of trees.

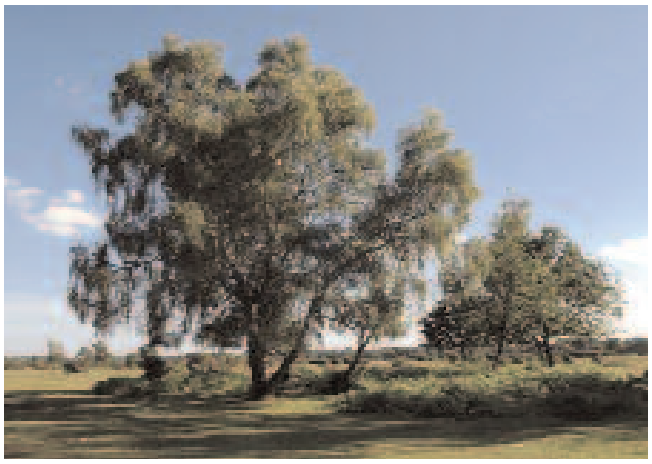


Figure 46 Illustration of an individual boundary tree.

Figure 47 Illustration of an individual middle tree.

The emphasis of the Small Woodland Survey had shifted since the 1980 Census from the potential to produce timber to conservation and landscape considerations. For this reason, the size of the tree (height band) is more useful than an estimate of its age or its diameter at breast height. Some individual trees break from ground level and produce more than one stem but are recorded as single trees. Trees that fork at or above breast height are counted as single stemmed. Whether or not the tree was located on a boundary was also recorded.

Small woodlands, and the wider linear features, were divided into sections using criteria such as species, age and forest type. Narrow linear features can be divided into sections in the same way, but may also be subdivided where there are significant changes in width, i.e. where a change of assessment method may be required. The sections account for the whole of the small woodland and can extend beyond the boundaries of the 1-hectare square in the Main Woodland Survey.

It was recognised that the standing timber in small woodlands might well vary considerably from the stands around which the Forestry Commission's production forecasting system and its underlying yield models had been developed. For this reason, it was decided to put a limited number of plots into sections where there were measurable trees. Species, diameter and top height were recorded, but in practice there were too few plots to produce statistically useful information.

6. Data handling and analysis

Data management

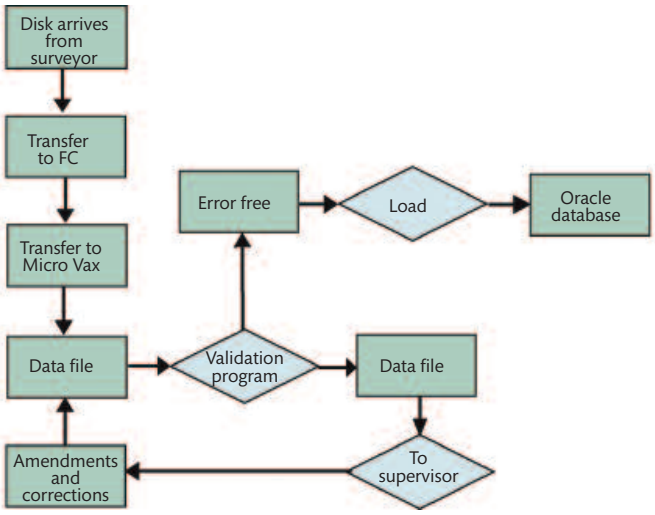
Transmission of data

The fieldwork data were submitted by the field teams on floppy disk, by post or by e-mail. A disadvantage of submitting disks by post was that the data processing team did not know when to expect them. Consequently, it was the field team's responsibility to follow up on a disk if no response from headquarters was received within a reasonable time. A backup disk held at the field station meant that any disks lost in the post could be copied and re-submitted. Unfortunately, the e-mail system, with read-receipt confirmation to the sender, came into use for the transfer of data only towards the end of the fieldwork.

Processing data

Figure 48 summarises the main stages of the procedure used for handling the data from their arrival on floppy disk until they were loaded onto the Oracle database. The arrival of the disk was recorded on a spreadsheet so that it was possible to follow progress on several sets of data at the same time. The validation procedure actually consisted of more than one stage; it was not a single program.

Figure 48 Summary of data handling procedures.



The programs performed the following tasks:

- *locates missing data items* – looked at supplied information and compared that with a table which showed which items should be present, e.g. species present for a section described as 'conifer' forest type. If missing then this was flagged as an error
- *inconsistent data* – the validation checked the data entered and checked associated values against each other, e.g. if forest type was 'coppice' then the thinning category must correspond, i.e. 'coppiced'
- *checks for data that exceeded pre-set limits* – for instance a tree height of more than 65m or too many sections for a square
- *empty records* – empty records were ones that contained no data and were usually deleted by the surveyor
- *checks on the structure of the data* – for example, elements entered for a section that had been inadvertently deleted by the surveyor
- *cross-checks with the database* – could generate messages such as 'This woodland already present on the database'.

Checks on progress were also made, by comparing grid references of squares in the incoming data with those on the list of selected samples. This program provided:

- lists of grid references that did not match selected samples
- lists of squares not yet received for incomplete woodlands
- lists of woodlands for which all squares had been received and work was therefore complete.

The validation system developed as knowledge of the data and their inter-relationships grew. A print of the data was returned to the surveyor with the error listings.

Most errors were caused by the surveyor neglecting to enter values when the data required an input, despite the checks already built into the data collection software. These errors would have been very difficult to correct if the data collection had been entirely electronic, the only other resource being the surveyor's memory of a particular square. However, from an early stage it had proved very useful for the surveyor to sketch map the square and sections as a way of allocating area. This was a valuable resource for correct-

ing the data. Other information, such as timber potential, would not normally have been manually recorded but the Husky had proved insufficiently reliable in the early stages of the survey and surveyors felt more confident if they also had a paper record of the data.

If the errors were relatively few and of a minor nature then the required information could be gathered by a phone call. The data file was corrected by editing the data; there was potential here to create 'new' errors that had nothing to do with the surveyor if the editing was not done with sufficient care.

Loading the data onto the database

When work for a particular area was completed and all the data files were free of errors, the information was loaded onto the Oracle7 database. The procedure for loading the data onto the database rejected any record that appeared to be the same as one that already existed on the database. One way of simplifying the loading of the data for an area was to compile all the data files into one large file; this was easier to work with as it meant that overall there were fewer files to handle and it also gave the opportunity to detect and resolve any duplicated information.

Organisation of data on the database

The description of the field data was set out in six levels as shown in Figure 49. Where surveyors recorded more than one value against a particular item then the structure of data on the database had to cope with the extra information. This was done by establishing another store, or 'table', of information designed to store the values for these particular data items. An example of this would be the breakdown of the area of a woodland by the Interpreted Forest Types, each of which has an area, in contrast to the grid reference for the wood which is a single value. In total, what were 6 levels in the field data become 13 in the database for the Main Woodland Survey. As an addition there were 'look-ups', which stored the codes for all the data and their meanings. A set of 14 tables stored the field data for the Small Woodland Survey (Figure 50).

The database was a good way of storing and organising the data and worked well in conjunction with the validation programs. It was not so good for statistical analysis of the data. A program was written to extract the information in the woodland blocks required for analysis, for example the main woodland data for a particular county. This was then transferred to a PC for further work as a file with one record per element, drawing data from all levels of the hierarchy.

Figure 49 Main Woodland Survey – data table structure.

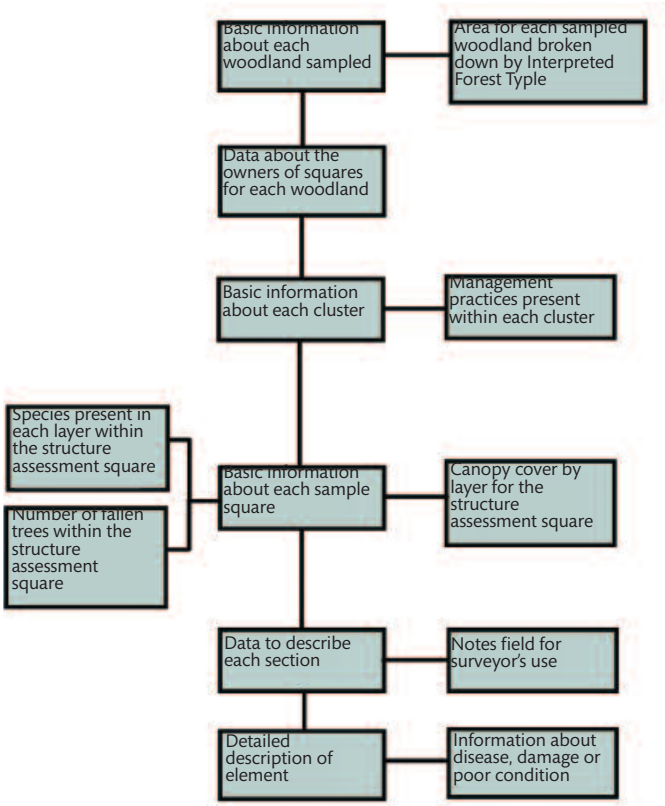
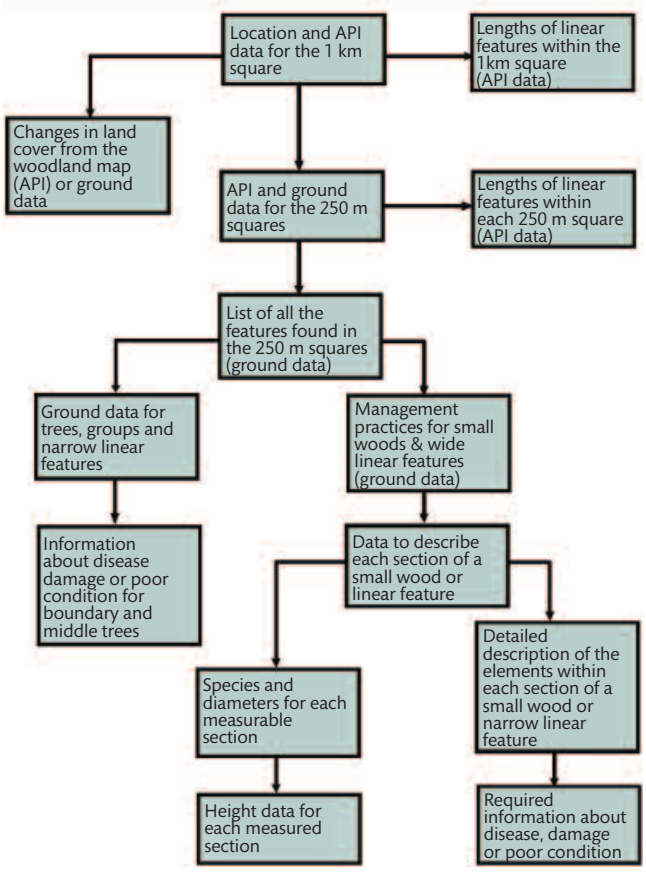


Figure 50 Survey of Small Woodland and Trees – data table structure.



Prior to the information being extracted, checks were made to ensure that:

- the data contained only woods relevant to the appropriate counties or districts
- all the woods for the county or district were accounted for
- each wood had an area on the database that corresponded with the map area
- adjustments were made to 'replacement' woodlands as required for analysis.

Data archiving

The data have been lodged with The National Archive for long-term archiving.

Analysis and production of the results

This section considers a typical Forestry Commission Inventory Report (a list of maps, tables and charts from a typical report is illustrated in Appendix 7), and comments on the analysis of map and field data required to achieve the published results. The headings below follow the Inventory Report headings.

Introduction

Highlights the background of the report and survey methodologies, and notes the main points of the report. Maps of the area are also given.

Summary of results

The first section of a report presents the headline figures for the reporting unit, e.g. region or county, bringing together area data from the Main Woodland Survey and the Survey of Small Woodland and Trees. This enabled the reporting of woodland area to a minimum size of 0.1 hectare. It gave a brief breakdown of the composition of this woodland and a summary of the other tree features in the landscape, i.e. linear features, groups and individual trees.

Assessment of the Main Woodland Survey

The digital map of woodland provided the primary estimate of the woodland area of ≥2 hectares. However, the woodland map was based on aerial photo interpretation and inevitably included some areas that had been incorrectly classified (such as gorse) and were not woodland, and other areas where woodland had appeared on the aerial photographs but had been subsequently converted to other land uses. The field data included information within the sample about these differences, enabling adjustment of the estimate of total woodland area by an appropriate amount. Because the information used to adjust the area was based on a sample it was not possible to adjust the map in the same way. While we knew the location of the samples, this only accounted for 1% (the approximate sampling fraction) of these areas and there was no information on the other 99%.

Standard reports were produced using a reporting and analysis package (SAS Version 6.12) designed to give outputs by 'Forestry Commission', 'other' and 'all ownerships'. These programs, which were written in-house, provided information on the approximate standard errors of the estimates given in the report. The reporting also developed with the progress of the NIWT: early reports for the regions of Scotland were produced when the data for each region was completed. Later, the reports were produced from information for whole countries, giving the opportunity to reconcile the data effectively, prior to publication.

Restricting the data to only those forest types that were included within High Forest (conifer, broadleaved, mixed and windblown plus felled) enabled the production of the species breakdown. Including data on timber potential from the elements meant that the species could be grouped into Category 1 and Category 2 High Forest. An alternative data analysis for Category 1 High Forest produced tables by planting year class.

The principal species for all High Forest were given next. This presentation lists the top three species as defined by the proportion of the area occupied in the planting year class.

The data held within the NIWT for ownership type are distinct from the broad categories of simply 'Forestry Commission' and 'other' and give a more useful breakdown of the different types of owners in the 'other' category. This more detailed information came from a questionnaire that owners or their representatives completed on a voluntary basis.

Assessment of the Survey of Small Woodland and Trees

The sampling scheme broadly aimed to sample 1% of land area in each county of England and Wales, and each region in Scotland. It was hoped that the sampling scheme would generate enough data to support the production of statistics for all the features identified within the survey. This was largely the case except for the small woodlands themselves, and the geographic areas had to be grouped when there were insufficient samples. Within each grouped area, the individual counties or regions were allocated values as a proportion of the whole and there was no distinction between counties in these groups.

Within the Small Woodland Survey, data were summarised in two ways: features were represented as either small areas of woodland or as the number of trees contained in a feature. Linear features would be in both categories, the wide linear features having much in common with woodland. The minimum width used to separate the two categories was 16 m, and the length was collected for both wide linear features and narrow ones (e.g. an avenue).

The analysis of the data was again in two parts and produced information in either hectares or in terms of number of trees. Both produced an estimate of the number of features. The pattern of the data for small woodlands and wide linear features follows the reporting for the main woods with forest type and species.

The features were represented in terms of numbers of trees (boundary trees, middle trees, groups and narrow linear features). Equivalent figures for dead trees recorded in the course of the survey were also given.

For these 'tree' features the emphasis has shifted since the 1980 Census, which regarded them as contributing to the standing volume. However, such timber was often of poor quality with heavy branching and the risk of metal in the butts as a result of use as informal fence posts. To reflect their other values, such as their importance to the landscape, these features are grouped according to size, starting at 2m height, in the tables for individual trees, groups and narrow linear features.

Comparison of results with the 1980 Census and previous surveys

This section of the inventory reports is described in greater detail in Chapter 7.

7. Results and comparison with previous surveys

Overview

The NIWT summarised the woodland picture across Scotland, England and Wales at the end of the 20th century.

The survey found 11.6% of Britain was covered by woodland, totalling over 2.6 million hectares. This represents a more than doubling of woodland area in Britain over the course of the 20th century. While the bulk of this is undoubtedly a real increase, there is evidence to suggest that previous surveys have underestimated the area of broadleaved woodland.

Scotland has the most woodland with 16.4% cover, a high proportion of which is coniferous, followed by Wales with 13.8% and a more even balance between coniferous and broadleaved trees. England has 8.4% woodland cover, with broadleaved woodland the most abundant type and oak the most common tree species.

Dissemination

The results of the NIWT have been made available as a series of inventory reports (Figure 51):

- Great Britain: national report
- Scotland: national report and chart, plus regional reports
- England: national report and chart, plus regional and county reports
- Wales: national report and chart (in Welsh and English) plus county reports.

Copies of the NIWT national, regional and county reports are available from Forestry Commission Publications, or they can be downloaded from the Forestry Commission web site: www.forestry.gov.uk/inventory (see Appendix 8 for list of publications).

A map of the boundaries of the published reporting areas is given in Figure 52 (English county names have been omitted for clarity). These were not always the current local authority boundaries and hence were not always as useful as they could have been. Nevertheless, they were used in the reports as the basis for comparison with the 1980

Figure 51 Examples of Inventory reports and charts.

Figure 52 Map of the local authority boundaries used for published reports.

Census of Woodland, which did use these boundaries. The NIWT is much more flexible than previous surveys and the data can be re-analysed by different geographic boundaries on demand. Many *ad hoc* reports have been produced for local authorities using current boundaries.

Table 1 Woodland area by country.

Country	Woodland area (hectares)	Woodland cover (%)
Scotland	1 281 000	16.4
England	1 097 000	8.4
Wales	287 000	13.8
Great Britain	**2 665 000**	**11.6**

Results and comparison with previous National Inventories

An important part of the National Inventory is to provide data that tell us about changes in the woodland area when compared with previous surveys. With the publication of a new set of data there has been much interest in what it has to say about changes that have occurred in the intervening period since the last survey. Because the 1980 Census and 1999 Inventory were undertaken using very different technology and sampling methods, this is a complex business and an intimate knowledge of both the NIWT and the previous Census surveys' methodologies is required to ensure that the comparisons made are reasonable and appropriate.

Where possible, adjustments have been made to both the 1980 Census and the NIWT to achieve the nearest available comparison. The apparent changes indicated in the tables and charts should therefore be treated with caution, particularly where areas or differences are small. Where a county had a large proportion of developed land (no longer included in the Small Woodland Survey), the comparison is omitted from the report.

Woodland area

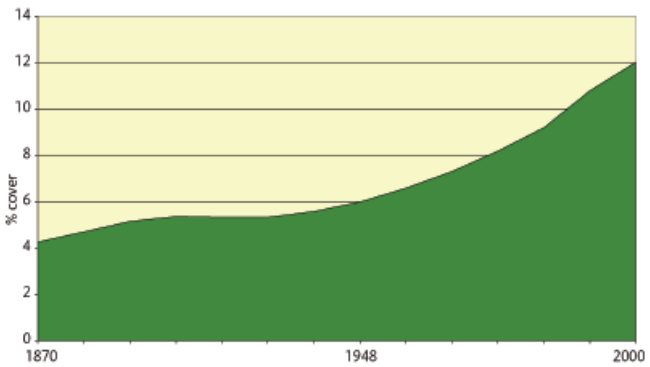
The field survey work in Great Britain was carried out between 1994 and 2000, and an appropriate reference date was applied to each country, region or county. Results show that there were 2 665000 hectares of woodland of ≥0.1 hectare, including an element of integral open space. This represents a woodland cover of 11.6%. This overall average figure hides a large degree of variation within Britain (Table 1). Cambridgeshire, for example, had less than 2% woodland cover, while Dumfries and Galloway had over 26%.

Inventory practice and technology have moved on since the 1980 Census; this inevitably demanded that some changes in sampling methodology, scope and woodland definitions were required. For example, the Main Woodland Survey used the digital woodland map, created from aerial photos, as a basis for sampling, whereas the 1980 Census was based on the woodland shown on the 1:50 000 OS map. The inevitable consequence of this was an increase in woodland area where woodland had existed but was not shown on the 1980 Census maps, a situation that for most parts of the country was far more extensive than woodland loss. In addition, in contrast to the 1980 Census, the Survey of Small Woodland and Trees did not record information within developed land, e.g. residential or industrial areas.

Of the total area of 2 665 000 hectares reported by the 1995–1999 National Inventory, 2 545 000 hectares was from the Main Woodland Survey (≥2 hectares) and 120 000 hectares in features of at least 0.1 hectare from the Survey of Small Woodland and Trees (SSWT). Of this SSWT area, only about 6 000 hectares was in features below the 0.25 hectare threshold for woodland in the 1980 Census. This implies that, in terms of minimum area, NIWT totals from main woods plus SSWT are reasonably comparable with woodland areas from the 1980 Census (only about 0.2% difference). However, any comparisons with 1980 woodland that use only the Main Woodland Survey for 1995–1999 differ by over 4% (and this varies significantly between countries).

Figure 53 shows how the woodland area in Britain has changed over the last century or so. The figure indicates that during the first two decades of the 20th century woodland area was remarkably stable. The woodland area has apparently increased by more than 26% since the last survey in 1980, which surpasses the increase of around 6% between 1965 and 1980 (Locke, 1987). While the detail should be

Figure 53 Great Britain: Woodland cover 1870–2000[5].



[5] This graph links various census results and should not be interpreted as showing an annual profile.

treated with some caution because of the methodological differences between surveys, the upward trend is clear, with a near doubling of the woodland over the last century.

A chart of woodland cover over the last 1 000 years at approximately 50-year intervals is presented in each report for the first time. The data were derived from information from the Board of Agriculture and Fisheries from 1871 and Census data from 1924. A map sequence was also included in the national reports, showing the change in woodland cover by county from 1895. The counties shown are those that were used in 1895 and 1947, the structure being reasonably stable in the decades between. The other reason for using the 'old' county structure was that this was the format of the earlier published information. The data from these counties could not be re-analysed for different geographic areas but the digital woodland map, which forms the basis of the current inventory, could be re-analysed for any geographic area.

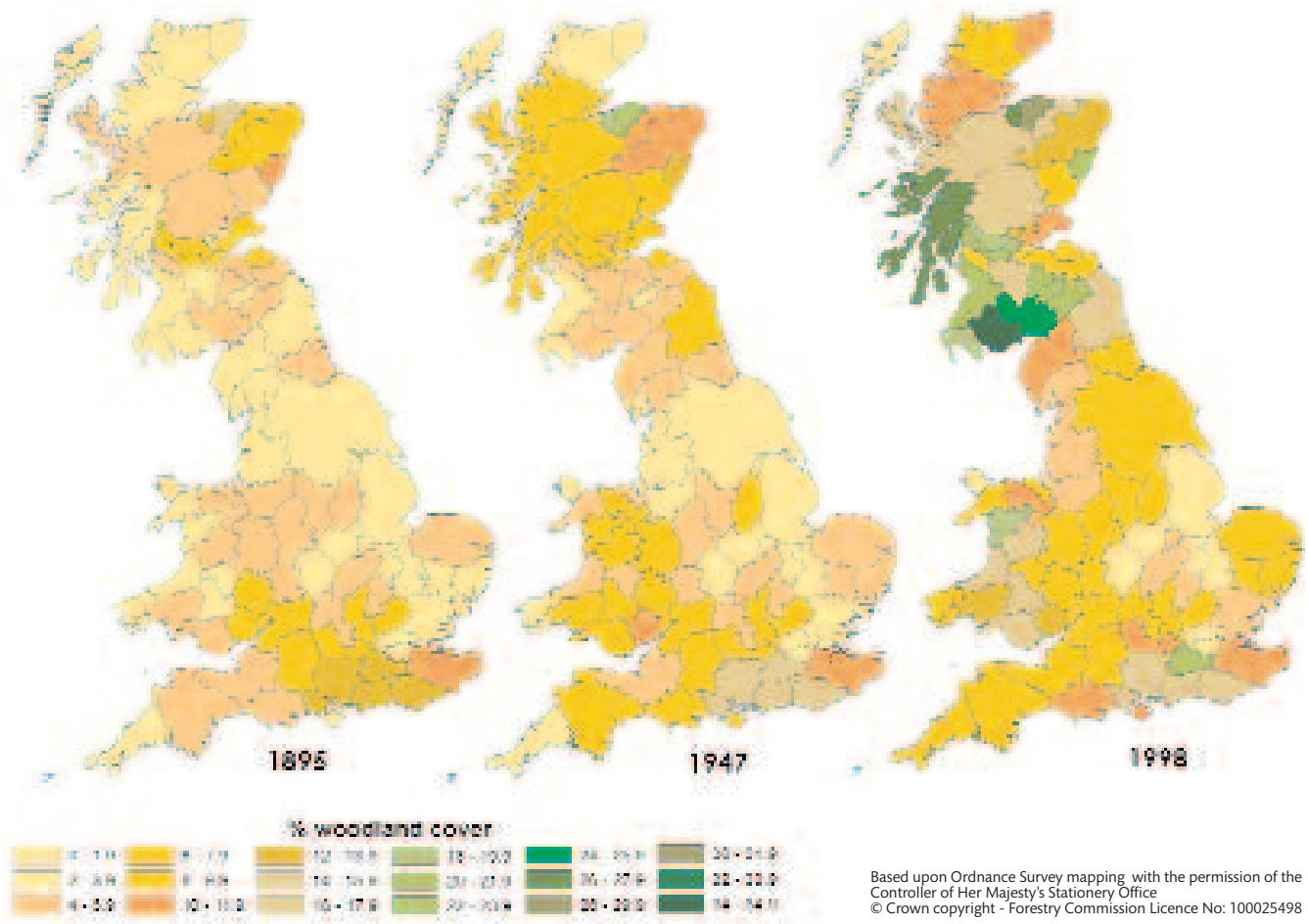
Figure 54 illustrates the use of the old county boundaries at three survey dates. The southeast of England has long been one of the most wooded regions of Britain. The biggest differences occur in southwest Scotland where Kirkcudbrightshire, for example, has increased its woodland since the late 1800s from less than 4% to over 34%. At the other end of the scale, the area of woodland in Cambridgeshire has hardly changed.

The area of woodland as a whole has been increasing but this has been due to an increase in 'High Forest', while the proportion managed as coppice has continued to decline. The area identified as coppice had already dropped from around 142 000 hectares in 1947 to around 39 000 in 1980. Table 2 shows that there has been a further reduction of almost 40% since 1980. (Figures may not add because of rounding.)

Table 2 Changes in the area of coppiced woodland between the 1947 Census, the 1980 Census and the 1995–1999 NIWT.

Census	1947 Census	1980 Census	1995–1999 NIWT
Coppice	49 000	28 000	13 000
Coppice with standards	93 000	12 000	11 000
Total coppice	**142 000**	**39 000**	**24 000**

Figure 54 Great Britain: Woodland cover by county 1895/1947/1998.

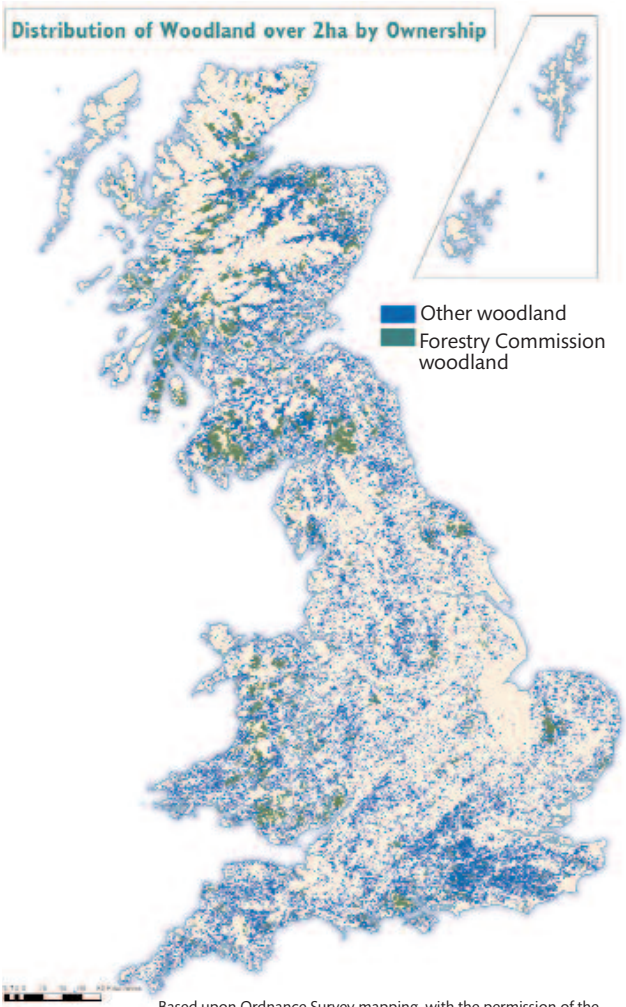


Woodland composition

Ownership composition

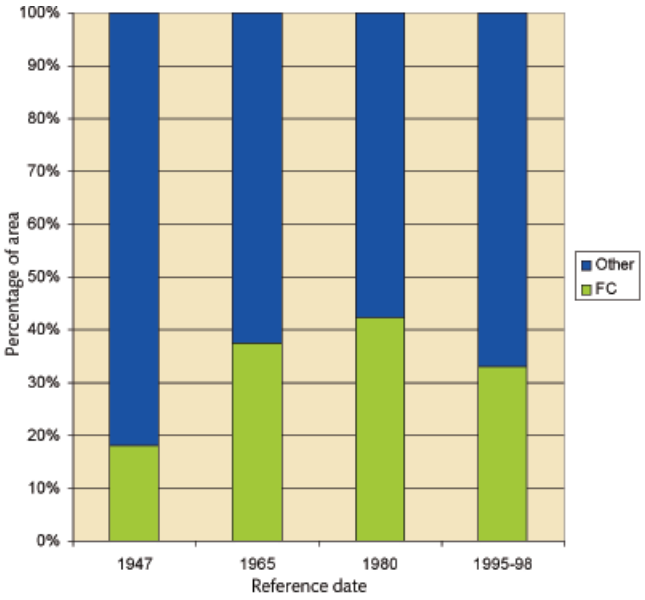
Approximately 881 000 hectares or 35% of woodland ≥2 hectares is managed by or leased to the Forestry Commission, and 1 634 000 hectares or 65% of woodland is in other ownership. Figure 55 shows the distribution of woodland according to ownership.

Figure 55 Map of woodland in Great Britain by ownership.



An analysis of woodland ownership at the last four surveys is given in Figure 56. Forestry Commission ownership as area of woodland and percentage of woodland peaked in 1980. Since 1980, the area of Forestry Commission woodland has declined by 21%. Woodland in other ownership declined in area slightly after 1947, but has been increasing steadily in absolute terms since 1965.

Figure 56 Forestry Commission share of woodland ownership in Great Britain since 1947.[6]



Forest type composition

Conifer woodland was the most abundant forest type and represented 49% of all woodland. Broadleaved woodland represented 32%, mixed woodland 8% and open space within woodlands 8% (see Appendix 2 for definitions).

This is the first National Inventory that has attempted to quantify the integral open space within woodland. The NIWT recorded integral open space as part of woodland, but not allocated to any species. This amounted to 217 000 hectares, or 8% of the total woodland area. In contrast, the 1980 Census included integral open space as part of the species area, and it was not recorded separately. Any comparisons with 1980 should note that an adjustment must be made to compare like with like. Previously conversion of 'gross' woodland area, which includes open space, to 'net' area, which excludes open space within the woodland, had required the use of a conversion factor; by convention this had been taken to be 15%, which also allowed for some understocking. The percentage of open space recorded by NIWT varied somewhat by country: Scotland 10.5%, England 6.5% and Wales 3.8%.

Although conifer woodland is still the dominant forest type, since 1980 there has been an increase in broadleaved woodland across Great Britain (Table 3). Both the area and

[6] The chart of woodland ownership is based on the published figures from each of the surveys. No attempt has been made to compensate for the effects of different minimum areas for each survey, as the difference this would make to the relative proportions would be insignificant. The data for 1995–1999 NIWT had assumed that all woodland less than 2 hectares is in 'other' ownership.

Table 3 Relative percentages of conifer and broadleaved woodland cover since 1980 by country.

Country	Conifer/ broadleaved	1980 Relative proportion of woodland (%)	1995–1999 Relative proportion of woodland (%)
Scotland	Conifer	85	82
	Broadleaved	15	18
England	Conifer	44	35
	Broadleaved	56	65
Wales	Conifer	71	56
	Broadleaved	29	44
Great Britain	**Conifer**	**65**	**59**
	Broadleaved	**35**	**41**

the relative proportion of broadleaved woodland have increased in Scotland, England and Wales since 1980. However, the increases were due in part to the under-mapping of woodland on the 1980 Census maps, which were not based on aerial-photo interpretation. This is discussed below.

A major difference between the NIWT and the 1980 Census is in the apparent scope of reporting of broadleaved woodland. In total for Great Britain, the 1980 Census reported 560 000 hectares of broadleaved High Forest, 146 000 hectares of broadleaved scrub and 39 000 hectares of coppice: a total of 745 000 hectares. The NIWT reported 971 000 hectares of broadleaved woodland and 24 000 hectares of coppice: a total of 995 000 hectares, giving an apparent increase of 250 000 hectares (34%). However, the NIWT reported only 102 000 hectares of broadleaved woodland with planting year after 1980, a figure reasonably consistent with annual statistics for broadleaved new planting and restocking, implying an increase of at most 12%. This indicates that the NIWT identified about 148 000 hectares of broadleaved woodland that had been missed by the 1980 Census.

This is illustrated in Figures 57 and 58, which show planting year classes for conifers and broadleaves. Planting classes are used to indicate the age distribution. Planting year is easier to determine in younger crops, so the oldest planting year classes are wider. Even so there may well be errors in assigning stands to a planting year class, particularly with broadleaved. Nevertheless, it is anticipated that the planting year of stands will generally be estimated within one class. The NIWT found fewer conifers than the 1980 Census in all planting year classes (consistent with the expected pattern, with harvesting reducing the remaining areas planted from the 1920s to the 1960s). By contrast it actually found more broadleaved in all classes less than 85 years old. So the conifer results are consistent, whereas the broadleaved results reveal the anomaly.

Figure 57 Comparison of conifers by planting year in 1980 Census and NIWT.

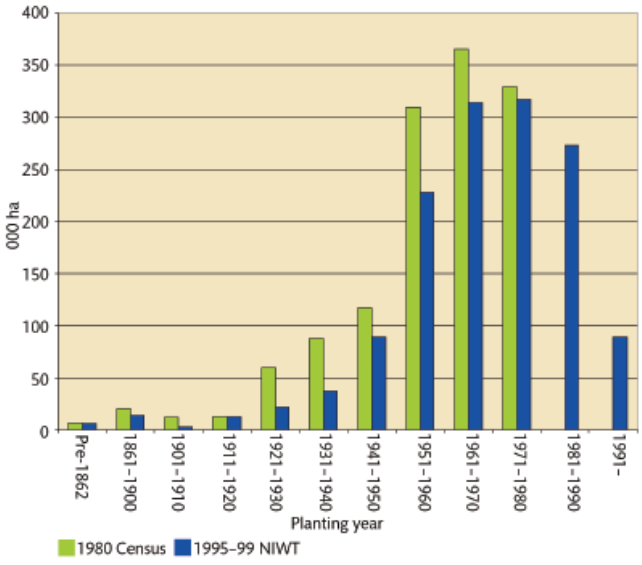
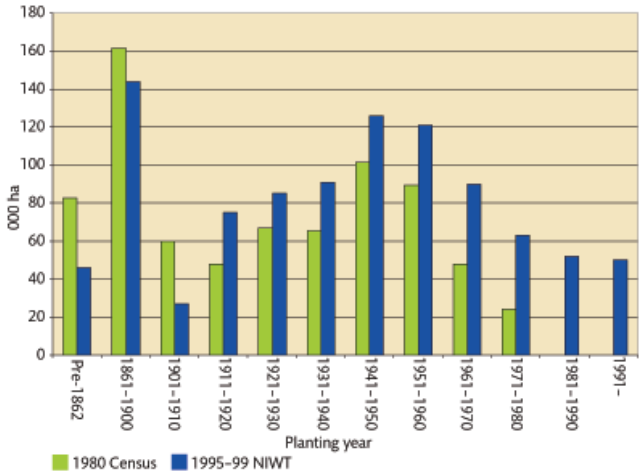


Figure 58 Comparison of broadleaves by planting year in 1980 Census and NIWT.



Another major difference is that the 1980 Census distinguished scrub land (see Appendix 1 for definition) from High Forest, but the NIWT made no distinction (and inventory reports label the total as High Forest). The 1980 Census reported 148 000 hectares of scrub, of which 146 000 hectares were broadleaved. So comparisons of High Forest in 1980 and 1995–1999 do not compare like with like, particularly for broadleaved. Comparisons by species can incorporate a species breakdown of scrub in 1980, but comparisons by planting year cannot include 1980 scrub, because no planting year was recorded.

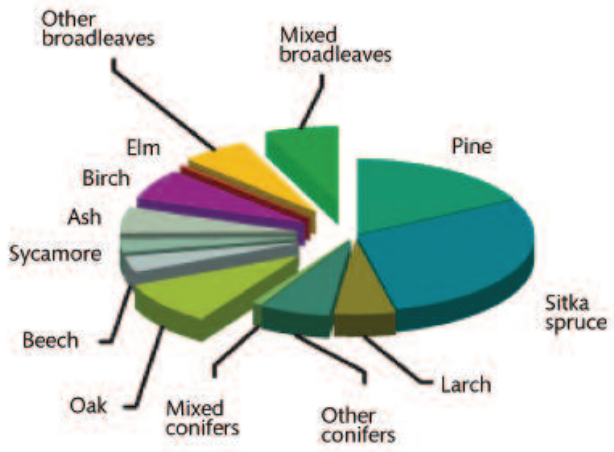
Comparisons with 1980 and previous Census results, reported here and in inventory reports and statistical publications, do not make any adjustment for this difference in

reported broadleaved area. It is therefore recommended that prominence should be given to results that show the evolution of woodland area over the 20th century, rather than specific changes since 1980.

Tree species composition

The main conifer species was Sitka spruce, covering 692 000 hectares or 49% of all conifer species (Figure 59). The main broadleaved species was oak, covering 223 000 hectares or 23% of all broadleaved species. For a full list of tree species recorded and reported see Appendix 6.

Figure 59 Great Britain: Woodland by tree species/groups.



For the most common species, the precision of these results is very high; for example, the standard error was 1% for the overall areas of oak, pine and Sitka spruce. However, the precision of results for the less common species was much lower.

A comparison of the areas of the principal species between 1980 and 1995–1999 is shown in Figure 60. Given the doubts about the actual increase in broadleaved woodland area, it is prudent to limit observations to the relative abundance of the principal species; this seems to have remained fairly constant, apart from a slight increase in the amount described as 'mixed'. Within the conifers, the notable aspect is the increase in Sitka spruce, both actual and relative, while Norway spruce and European larch are the main species in decline.

Looking back over the last four national woodland surveys at the relative importance of individual, conifer and broadleaved species demonstrates some substantial changes since the post-war period, but a more stable situation since the 1980 Census (Table 4).

Figure 60 Comparison of the woodland area (hectares) of principal tree species between the 1980 Census and NIWT.

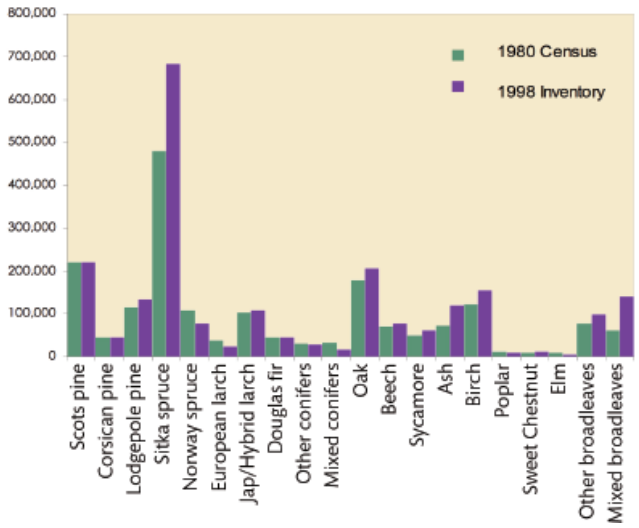


Table 4 Relative ranking of the major woodland species in terms of the area of woodland in the last four national woodland surveys.

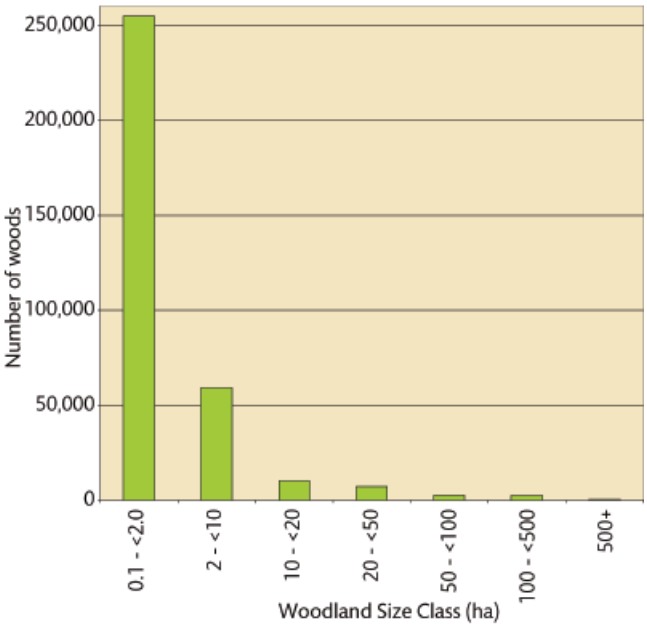
Survey year	Rank			
	1st	2nd	3rd	4th
Conifers				
1947	Scots pine	Sitka spruce	Norway spruce	European larch
1965	Scots pine	Sitka spruce	Norway spruce	Jap/hybrid larch
1980	Sitka spruce	Scots pine	Lodgepole pine	Norway spruce
1998	Sitka spruce	Scots pine	Lodgepole pine	Jap/hybrid larch
Broadleaves				
1947	Oak	Beech	Ash	Birch
1965	Oak	Beech	Ash	Sycamore
1980	Oak	Beech	Ash	Birch
1998	Oak	Birch	Ash	Beech

Woodland structure

Woodland size class distribution

There were 82 829 woods 2.0 hectares in Britain with a mean wood area of 30.9 hectares, and 254 706 woods from 0.1 to <2.0 hectares with a mean wood area of 0.47 hectare (Figure 61). This is the first Forestry Commission National Inventory to incorporate a map of woodland, and hence will provide a better baseline against which to measure future changes. However, with reference to current interest in forest habitat networks, in particular, it is recommended that future surveys map to a smaller minimum woodland size.

Figure 61 Woodland size class distribution in Britain.



Tree features outside woodland

Features with an area of less than 0.1 hectare are not regarded as being woodland within the NIWT but play an important role in the landscape of Great Britain.

Tree numbers outside woodland

There were 123 million live trees and 2 million dead trees outside woodland in Britain. The recorded number of broadleaves increased by 46% between 1980 and 1995–1999, with the relative proportion of broadleaved to conifers increasing from 89% to 94%. Table 5 shows the abundance of broadleaved among trees outside woodland, even in Scotland where the proportion of conifers overall is double that of the rest of Great Britain.

Table 5 Number of live trees outside woodland by country and by conifer/broadleaved.

Country	Conifer		Broadleaved		Total
	millions of trees	% of total	millions of trees	% of total	millions of trees
England	4.3	4.8	84.9	95.2	89.2
Wales	1.0	6.8	14.3	93.2	15.3
Scotland	2.6	14.2	15.9	85.8	18.6
Great Britain	**8.0**	**6.5**	**115.1**	**93.5**	**123.1**

The changes in methodology and the scope of the NIWT when compared with the 1980 Census have been mentioned before but the biggest impact is in the assessment of tree features outside woodland. Even with adjustments to the NIWT, the survey is not directly comparable with the 1980 Census for a variety of reasons:

- The figures for groups included areas of 0.1–0.25 hectare for 1980 but not for the NIWT. If a reasonable adjustment is made to include trees from the appropriate part of the NIWT small woodland data, then the figures for trees in groups show no significant change since 1980.

- In 1980 the survey attempted to record trees in all areas. As a result of problems encountered then and the current availability of other data in many urban areas regarding, for instance, street trees, it was decided to restrict this part of the NIWT to the countryside. For counties with low proportions of urban area the impact of this restriction was relatively small. In other counties, such as the West Midlands (which includes Birmingham and Coventry), the comparison between surveys was compromised and was omitted from the published report. But in the absence of a like-with-like comparison there is no firm basis for judging whether numbers of individual trees have really declined in rural areas or in total.

- For narrow linear features and also other feature types, the addition of small tree species (such as hawthorn and hazel) in the NIWT is likely to have led to a very large increase in recordable features. The comparison in the published report adjusted for this to some extent by excluding hawthorn, blackthorn, goat willow and hazel from the NIWT figures. It is likely that if these features had been assessed according to the protocol that was used in 1980 there would have been two main effects. First, that the smaller trees would not have been recorded, reducing overall tree numbers, and, second, that the other trees would not necessarily have been regarded as belonging to a continuous feature. It is unfortunately not possible to attribute the data from narrow linear features to the other feature types; therefore the apparent increase here contains some of the reductions in the other feature types. So the comparison does not give clear evidence of whether linear features have increased or decreased since 1980.

- The change in threshold from 7 cm diameter in 1980 to 2m height would be likely to lead to a small increase in tree numbers because a proportion of trees of 2m in height would be unlikely to have a diameter at breast height of 7 cm.

Tree species outside woodland

Figure 62 shows the distribution of species for trees outside woodland. The figure shows hawthorn as a distinct species for the first time within National Inventory data. It was the most abundant tree species outside woodland and is worthy of separate representation.

Figure 62 shows very clearly the high proportion that is classified as 'other broadleaves'. The most important species within this category are shown in Table 6 as a percentage of the area of 'other broadleaves'.

Figure 62 Great Britain: Total live trees outside woodland by country and species.

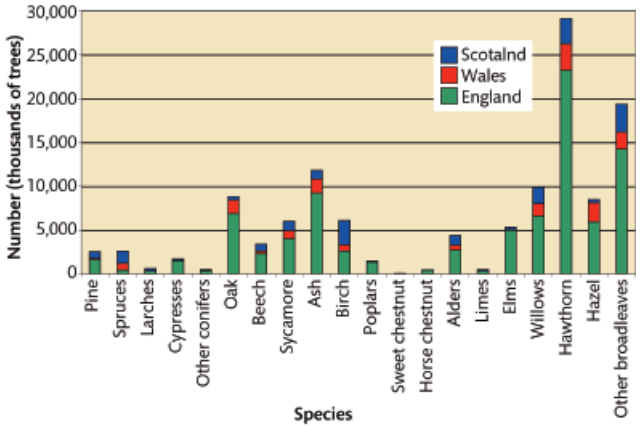


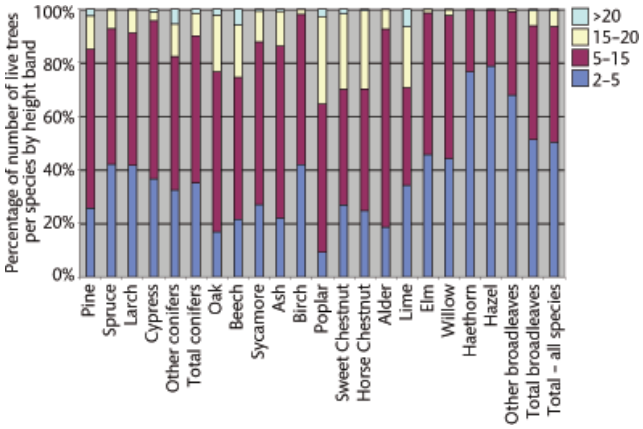
Table 6 'Other broadleaves' broken down by species.

Species	%
Blackthorn	35
Field maple	21
Holly	12
Rowan	10
Wild cherry	4
Other species	18

Tree structure outside woodland

In the landscape, the status of a tree is indicated by its height. Each species has its own distinctive profile and has its own impact. The NIWT data for live trees and height band is illustrated in Figure 63 and shows, for example, that only 2% of oak trees were >20 m tall. In contrast, 7% of limes and 6% of beech exceeded 20 m. Less than 1% of alders were above 20 m but 74% were between 5 and 15 m, the highest proportion in that class. The 1980 data used a breakdown by diameter class, a substantially different measure, and this indicated that a third of non-woodland oak trees were over 50 cm diameter at breast height, the largest category.

Figure 63 Great Britain: Live trees outside woodland by species showing height band percentages.



Management and biodiversity data in the NIWT

There were several new types of data collected in the NIWT, reflecting the rapid expansion in the scope of the survey and, in turn, the growing scope of multi-use forestry since the time of the last Census. New data types included.

- management practice
- thinning history
- horizontal diversity
- vertical structure
- deadwood
- natural regeneration
- bark damage
- browsing damage
- trees showing signs of disease, damage or poor condition.

Analysis of most of the data in the following sections does not appear in the main published inventory report series, but has been published by the Forestry Commission separately (Gilbert, 2007), and is available on the Forestry Commission web site: www.forestry.gov.uk/inventory (see Analysis of Management and Biodiversity Data).

Comparisons with other surveys

Previous chapters have compared this survey with earlier national surveys of woodland and trees in Great Britain. However, it is worth considering how the NIWT results correspond to those of other national surveys that included land use types.

Comparisons with the Countryside Survey

(Source: FOCUS STUDY web site (accessed 2007))

Compared with the NIWT, the Countryside Survey (CS) 2000 and CS Land Cover Map (LCM) 2000 produced similar estimates of woodland area in Great Britain, but there were larger disparities at country level (Table 7).

Table 7 Total Great Britain and country woodland area by survey.

Country	Woodland area (000 hectares)		
	NIWT	CS 2000	LCM 2000
Scotland	1 281	1 298	**1 124**
England	1 097	1 295	**1 391**
Wales	287	256	**305**
Great Britain	2 665	2 845	**2 832**

The spatial co-registration of individual parcels was not always good. Combining all woodland categories, the updated NIWT digital map's spatial correspondence with the CS Field Survey was 80% and with the Land Cover Map 72%.

Successive Countryside Surveys reported net increases in woodland area, of 130 000 hectares between 1984 and 1990, and then 58 000 hectares between 1990 and 1998 (Countryside Survey, 2007). These Countryside Survey net changes have wide ranges of uncertainty, as they are based on relatively small samples of 1km squares. Even allowing for the shorter total period, they are much smaller than the unadjusted increase between the 1980 Census and the NIWT.

Behind these net changes, the Countryside Survey reports much larger gross changes in land cover, to and from woodland. For the period 1990 to 1998, the Countryside Survey showed around 200 000 hectares changing from other broad habitats to woodland, and around 140 000 hectares changing from woodland to other broad habitats. It is not reported how much of this was internal changes within woodland, rather than changes to or from other land uses.

Comparisons with the Ancient Woodland Inventory in England

A study was carried out by the Forestry Commission and English Nature comparing the Ancient Woodland Inventory and the NIWT in England.

The Ancient Woodland Inventory was produced in the 1980s as a provisional listing of woods believed to be ancient. These sites were then split into semi-natural stands and plantations on ancient woodland sites. The boundaries of the sites were subsequently digitised.

The Interpreted Forest Type map produced by the Forestry Commission from the NIWT provided an opportunity to identify obvious discrepancies between the two datasets. In addition it enabled the production of estimates of the extent of different woodland types prioritised in the Biodiversity Action Plan (Kirby, 1999).

Study methods:

- A digital version of the Ancient Woodland Inventory was overlain by the digital version of the NIWT.
- The NIWT included a 1% field sample in which 1-hectare squares were visited and described in terms of broad composition and structure. From its tree and shrub composition each square was classified into Biodiversity Action Plan types, using a simple key. The proportion of squares falling into the different types provides a first approximation of the relative area of these types.
- Digital maps of Sites of Special Scientific Interest were overlain on the two datasets to assess the extent of woodland within the series.

The revised extent of ancient woodland in England

The area of woodland in England on the NIWT map was estimated at 1 026 867 hectares, of which 331 669 hectares are also included on the Ancient Woodland Inventory as ancient woodland (i.e. excluding areas shown on the Ancient Woodland Inventory but not on NIWT). This is very close to the previous estimates at national and local levels.

Nevertheless there are numerous discrepancies at individual site level; for example, 26 834 hectares on the Ancient Woodland Inventory (8.1% of the total) were not classed as woodland in the NIWT. The majority of the 146 813 polygons that make up this total are small (91.9% are less than 0.5 hectare). The Ancient Woodland Inventory did not attempt to map to this level of precision and therefore a large number of these discrepancies are simply differences in the precision of the two datasets.

A total of 191 615 hectares recorded by the NIWT fell into ancient semi-natural woodland on the Ancient Woodland Inventory (excluding discrepancies). According to the Interpreted Forest Types the majority of this area was classed as broadleaved (153 653 hectares, 80%), while 5% of the area was classed as coniferous and 10% as mixed coniferous/broadleaved stands (the remaining 5% was felled, scrub and young woodland).

The work established that the rather crude measures used in the original Ancient Woodland Inventory did give good overall estimates of the area, at least down to sub-regional levels. Errors at the individual site level were always accepted as possible.

The extent of different Biodiversity Action Plan priority woodland types

NIWT sample square data provided an opportunity to improve on these data, first through an estimate of how much of each type occurred in ancient semi-natural woodland, and second through how much might exist in other broadleaved woodland and plantations.

During analyses an anomaly was found with respect to upland ash woodland, which showed a higher area than expected. This is partly an artefact of the way that the upland ash and lowland mixed woodland types were separated in the key using natural areas: some of the upland ash might be better classified as lowland mixed, but this could not be done without site-specific information.

However, this high figure may reflect a real difference between our perception that broad sweeps of woodland in the uplands are 'oak' woods, when often they contain substantial areas of base-rich stands, for example along streams and at the base of slopes, which may be better reflected in the sample square data.

Woodland within designated sites (Sites of Special Scientific Interest)

Comparison of the NIWT and Ancient Woodland Inventory with the boundaries of Sites of Special Scientific Interest (SSSIs) indicate that there are ≈149 000 hectares of woodland within SSSIs, considerably more than previously published estimates of 80 000 hectares (Thomas *et al.*, 1997; Pryor and Peterken, 2001) or ≈120 000 hectares identified in recent SSSI condition reports.

These differences arise first, and primarily, because the area of woodland in SSSIs has increased greatly in the last 5 years to meet the requirements of the regulations introduced to implement the EU Birds Directive that Special Protection Areas (SPAs) must also be SSSIs.

Second, the previous estimates concentrated on sites notified for their woodland interest, and small areas of recent woodland on other sites (part of grassland or moorland mosaics) were underestimated.

Conclusion

The combination of different datasets in general allowed more precise estimates to be made of different types of woodland across the country. The work also uncovered discrepancies between datasets. In some instances these represent real changes in woodland or tree cover, but in most, they are probably due to differences in definitions and technical specifications.

8. Conclusions

Overall woodland picture

Woodland cover across Britain was found to be almost 12%. This represents a doubling of woodland area in Britain over the course of the 20th century.

Woodland character has apparently changed substantially since the previous survey, with relatively more broadleaved woods. This is partly due to planting of broadleaved species, but is more attributable to better survey techniques, which have recorded broadleaves missed by previous surveys.

The woodland age class structure has become more balanced over the last 20 years as the extensive plantings of the 1960s and 1970s are beginning to be felled and restocked. In addition, the age class distribution is now wider than in 1980 as the proportion of ancient and long-term retentions increases and new planting continues.

Were the survey aims achieved?

The NIWT had four main aims:

1. To provide information on the extent, size and composition of woodland.
2. To provide up-to-date information.
3. To provide the survey data to support land use strategy, timber forecasting, etc.
4. To provide a comprehensive woodland map.

1. To provide information on the extent, size and composition of woodland

The survey was successfully carried out across Great Britain. The results were very precise, with standard errors of less than 2% for the major forest types and species, which meant that a high degree of confidence could be placed in all the published results. The sampling regime could have been considered 'over-sampling', but an advantage was that the primary data were often robust enough to produce reasonable results for smaller geographic areas, which was a desired addition in many places.

The basic data collected, such as forest type, tree species and planting year, proved very robust and reliable, but some of the newer items were not so successful:

- Although the basic tree species recording went well, there was too much use of the 'mixed broadleaves' category by some surveyors. This was not initially picked up, mainly because the analysis programs were not in place (see below), and in some areas much of the detail in terms of individual species was lost. More awareness of this as a potential problem could have led to better training, but earlier monitoring would also have helped.
- It would have helped in analysis and in comparison with actual planting data of previous surveys if the field survey had distinguished between new planting and restocking. Collecting only planting year information meant that it was not possible to distinguish between restocking and new planting.
- Understanding the structure assessment was straightforward when the structure assessment square contained only one section, but if there were two or more sections the structure assessment was difficult to interpret. For future surveys, the recommendation is to carry out an assessment in a way that includes only a single section.

2. To provide up-to-date information

This is perhaps the least successful aspect of the survey. While the survey was carried out between 1994 and 2000, the first Inventory Report (Grampian Region) was published in 1997 and the final Great Britain Inventory Report (Great Britain) in 2003. However, some of the new environmental data were not published until 2007. The need to get the survey up and running and pressure of work on the team during the survey meant that not enough attention was paid to the analysis procedures and programs. Future surveys should have all basic analysis programs and data handling systems in place before data collection starts.

3. To provide the survey data to support land use strategy, timber forecasting, etc.

The results have been distributed throughout the Forestry Commission, to other government agencies, to local authorities, to non-government organisations (NGOs) and to a number of other bodies. The results have been used in the formulation of the forestry strategies for the three devolved countries, as well as informing more local land use planning. Although a formal modelling link between NIWT

areas and estimated volume and increment is not yet in place, the data were used in the published forecasts of private-sector timber availability, and formed the basis of the Great Britain Woodfuel Resource Study.

4. To provide a comprehensive woodland map

While the statistics on woodland extent and composition are essential, it is the woodland map that has proved to be the most popular product of the survey to a wide audience of users. For the first time, Britain has had a comprehensive view of the location of woodland. With geographic information system technology now maturing, the potential of combining the NIWT with other spatial datasets has been realised. The map has been provided to partner agencies, such as Scottish Natural Heritage, and licensed to a variety of users from academic bodies to local authorities and private businesses.

Two main aspects caused problems for some users:

- **Minimum size of woodland mapped, i.e. 2 hectares.** Although the survey was designed as a national-level inventory, many users wanted to utilise it at a local level, for example for investigating forest habitat networks. While working to this scale did not miss a large proportion of overall woodland, it did miss a significant number of the smaller woods of less than 2 hectares, which locally could be very important. A recommendation for future surveys would be to map down to 0.5 hectare at least, and down to 0.1 hectare if funding allows.
- **Non-matching boundaries when combining this woodland map with other spatial datasets**. Powerful analysis techniques are available when using spatial datasets in a geographic information system environment, but these can be diminished when two datasets do not match, creating slivers or complete displacement of some objects. This occurred, for example, when using the NIWT map together with the Ancient Woodland Inventory. In future, efforts should be made to conform with mapping to standard boundaries, such as OS MasterMap, where possible.

The map has proved to be one of the most important legacies of the NIWT, and provides a firm baseline for comparison with future surveys.

Bibliography

COUNTRYSIDE SURVEY (2007).
www.countrysidesurvey.org.uk

FOCUS STUDY (2007).
www.cs2000.org.uk/FOCUS_task1.htm

FORESTRY COMMISSION (1984).
Great Britain: Census of Woodland and Trees 1979–82. Forestry Commission, Edinburgh.

FORESTRY COMMISSION (2002).
UK Indicators of Sustainable Forestry. Forestry Commission, Edinburgh.

GILBERT, J. (2007).
The National Inventory of Woodland and Trees: Analysis of Management and Biodiversity Data. www.forestry.gov.uk

KIRBY, K.J. (1999).
Trees, people and profits – into the next millennium: biodiversity and forestry. *Quarterly Journal of Forestry* 93, 221–226.

LOCKE, G.M.L. (1987).
Census of Woodland and Trees 1979–82. Forestry Commission Bulletin 63. HMSO, London.

PRYOR, S.N., CURTIS, T.A. and PETERKEN, G.F. (2002).
Restoring Plantations on Ancient Woodland Sites. The Woodland Trust, Grantham.

PRYOR, S.N. and PETERKEN, G.F. (2001).
Protected Forest Areas in the UK. Report for WWF and the Forestry Commission by the Oxford Forestry Institute.

PRYOR, S.N. and SMITH, S. (2002).
The Area and Composition of Plantations on Ancient Woodland Sites. The Woodland Trust, Grantham.

SMITH, S.M. (1999).
The National Inventory of Woodland and Trees – Scotland. *Scottish Forestry* **5**3(3), 163–168.

SMITH, S. (2002).
The National Inventory of Woodland and Trees – England. In *Forest Research Annual Report and Accounts 2000–2001*, 48–55.

SMITH, S. and GILBERT, J. (2001).
The National Inventory of Woodland and Trees – England. Forestry Commission Inventory Report. Forestry Commission, Edinburgh.

SMITH, S. and GILBERT, J. (2002).
The National Inventory of Woodland and Trees – Scotland. Forestry Commission Inventory Report. Forestry Commission, Edinburgh.

SMITH, S. and GILBERT, J. (2002).
The National Inventory of Woodland and Trees – Wales. Forestry Commission Inventory Report. Forestry Commission, Edinburgh.

SMITH, S. and GILBERT, J. (2003).
The National Inventory of Woodland and Trees – Great Britain. Forestry Commission Inventory Report. Forestry Commission, Edinburgh.

SMITH, S., GILBERT, J. and COPPOCK, R. (2001).
Great Britain: new forecast of softwood availability. *Forestry and British Timber* **30**(4), 20–25.

THOMAS, R.C., KIRBY, K.J. and REID, C.M. (1997).
The conservation of a fragmented ecosystem within a cultural landscape – the case of ancient woodland in England. *Biological Conservation* 82, 243–252.

WRIGHT, D. (1998).
The National Inventory of Woodland and Trees. Forestry Commission Information Note 8. Forestry Commission, Edinburgh.

Appendices

Appendix 1

Descriptions of Interpreted Forest Types as used in NIWT mapping

Broadleaved

The canopy of broadleaved woodland is generally more uneven than that of coniferous woodland, being made up of rounded crowns but with variations according to species, age, height and season. Boundaries with adjacent internal polygons are generally less clearly defined than with conifers and naturally occurring stands may grade into adjacent ones with no sharp division. Some coniferous trees may be present but greater than 80% of the area will consist of broadleaved trees.

Conifer

Coniferous woodland often occurs as large plantations with trees in regular rows and the stand edges may be regular and sharply defined. Some broadleaved trees may also be present but greater than 80% of the area will consist of conifers.

Coppice

The most important characteristic of a coppice area on aerial photographs is its very even, smooth appearance. The coppice area may be made up of a patchwork of different ages (heights) but all show a very even character. Areas recently cut may appear to have a very clear floor with little felling debris.

Coppice with standards

Some areas of coppice also include larger broadleaved trees set in the coppice matrix. These broadleaved trees, often oak, are known as standards and show very clearly over the even coppice as large rounded crowns. The distribution of the standards will also be fairly even.

Felled woodland

Areas of woodland where the trees have been harvested or felled. Stumps or felled trees may be visible and there may be long heaps of felling debris ('windrows'). The edges of the felled area will probably be sharply defined and the canopy cover will be less than 20%. Some standing trees within this limit may also be present but should be disregarded. This category should not be confused with coppice or coppice with standards. The areas concerned may also have been restocked but the new trees are not yet visible.

Ground prepared for new planting

Land in this category is areas recently converted from some other land use to woodland and will show plough furrows or mounding but the new planting (if present) cannot yet be discerned.

Mixed

The interpretation of mixed woodland can be very difficult as it exhibits intermediate characteristics between conifer and broadleaved woodland. The coniferous component may project above the canopy of the broadleaves or a 'striped' appearance may be produced by a plantation of alternate rows of conifers and broadleaves. The proportion of both conifers and broadleaves will be greater than 20%.

Shrub land

This category is intended to include areas that may possibly be woodland, where the growth is close to the ground and shows a rough character but no clear differentiation between conifer and broadleaved can yet be made. Areas being colonised by woody species may fall into this category. The cover will be at least 20%.

Young trees

Areas where planting is clearly visible but the trees cannot yet be allocated between conifer and broadleaved because of their immaturity. These areas can be on either land new to woodland or where a felled crop has been replaced.

Note: orchards and species such as rhododendron are not regarded as woodland and were therefore excluded.

Appendix 2

Glossary of terms as used in NIWT reporting

Feature types

Group
A group containing two or more trees with an area less than 0.1 hectare.

Individual tree
A tree with a crown that has no contact with any other tree crowns and which is at least 2m tall. Two types of individual tree are recognised:

- boundary tree (an individual tree on any boundary)
- middle tree (an individual tree not on a boundary).

Linear feature
A feature with a length of 25m or more and one which is at least four times as long as it is broad. It can be up to 50 m wide or as narrow as a single line of trees. Two types of linear features are recognised:

- narrow linear features (with a width of 16m or less)
- wide linear features (with a width greater than 16 m).

Small woodland
A woodland with an area of 0.1 hectare or more but less than 2 hectares.

Forest types

Broadleaved
Woodland containing more than 80% by area of broadleaved species.

Conifer
Woodland containing more than 80% by area of coniferous species.

Coppice
Crops of marketable broadleaved species that have at least two stems per stool and are either being worked or are capable of being worked on rotation. With the exception of hazel coppice, more than half the stems should be capable of producing 1m timber lengths of good form.

Coppice with standards
Two-storey stands where the over-storey consists of at least 25 stems per hectare that are older than the under-storey of worked coppice by at least one coppice rotation.

Felled
Woodland areas that have been felled or stands where the stocking has been reduced to less than 20% and where it is expected that these areas will be replanted.

Mixed
A combination of broadleaved and coniferous species where each category occupies at least 20% of the canopy (see note on mixtures below).

Open space
Areas ≥1 hectare within a woodland that are not covered by trees but are integral to the woodland, such as open areas, streamsides, deer glades, rides and forest roads.

Windblow
Areas of blown woodland that remain uncleared and not regenerated.

High Forest
All woodland except stands managed as coppice or coppice with standards with, or with the potential, to achieve a tree cover of more than 20%. Two categories of High Forest are recognised:

- **High Forest Category 1:** Stands which are, or could become, capable of producing wood of a size and quality suitable for sawlogs.
- **High Forest Category 2:** Stands of lower quality than High Forest Category 1.

Interpreted Forest Types
The woodland map derived from aerial photographs is differentiated into Interpreted Forest Types (IFTs), which are conifer, broadleaved, mixed, coppice, coppice with standards, shrub land, young trees, ground prepared for new planting and felled. Note that forest types (see above) based on ground survey data are used for reporting purposes because they are more reliable.

Mixtures
Where possible, the species in mixtures are separately recorded. Where this has not been possible, they are described as 'mixed conifers' or 'mixed broadleaves'.

Ownership types

Forestry Commission
Land owned by or land leased to the Forestry Commission.

Other ownership
Woodland other than that owned by, or leased to, the Forestry Commission:

- Charitable organisations – Organisations funded by voluntary public subscription, e.g. National Trust, churches and colleges.
- Community ownership or common land – The common property of all members of the community.
- Local authority – Region, county, district or other council.
- Personal – Types of private occupation, e.g. individuals, private family trusts and family partnerships.
- Private forestry or timber business – Owned by wood processing industry. This category does not include forest management companies.
- Other private business – Occupiers, e.g. companies, partnerships, syndicates and pension funds.
- Other public bodies (not Forestry Commission) – Government department /agency, nationalised industry, etc.

Woodland

In the UK woodland is defined as land with a minimum area of 0.1 hectare under stands of trees with, or having the potential to achieve, a tree crown cover of more than 20%. Areas of open space integral to the woodland are also included. Orchards and urban woodland between 0.1 and 2 hectares are excluded. Intervening land-classes such as roads, rivers or pipelines are disregarded if less than 50 m in extent. 'Scrubby' vegetation is not included as a separate category but as conifer, broadleaved or mixed tree types. There is additional information on the quality of woodland within the inventory database.

Woodland of 2 hectares and over, and with a minimum width of 50 m, is included in the Main Woodland Survey; other woodland and trees are assessed in the Survey of Small Woodland and Trees.

Appendix 3

Management practice descriptions used in NIWT

Agroforestry system

Agroforestry is an intimate mixture of trees with farm crops and/or animals on the same piece of land. In the UK this usually consists of widely spaced individual trees, groups or lines of, for example, poplar or walnut, in grazed or arable fields.

Conservation

Active encouragement for wildlife which may include permitting regeneration and scrub. It includes the opening up of streamsides and the general encouragement of diversity in storeys and species as well as obvious signs, such as bird boxes and ride management for butterflies. The encouragement of deer within woodland is also included.

Forest design

A surveyor's decision representing the cluster, usually based on diversity, ride layout, streamside management, use of open spaces, landscaping and forest block shape. Any evidence that deficient design is currently being rectified was also included.

Game birds

The presence of feeders, pens and game birds within the cluster. Active, deliberate management as opposed to the occasional escapee.

Grazing by domestic animals

The actively permitted and encouraged grazing within the wood of domesticated animals and fowl. This does not necessarily include the presence of sheep or cattle where they have breached the fence, unless the fence has been deliberately allowed to decay without maintenance to permit animal access for shelter.

This classification also included permitting pigs to forage the forest floor and the rearing of 'free range' turkeys within woodland enclosures.

No obvious management

This implies no obvious management practice in all or part of a cluster and usually relates to patches of scrub adjacent to roads or buildings, bearing in mind that screening may be a better choice. Using this management practice does not preclude the use of other practices noted in the cluster.

Ornamental

This management practice included arboreta and woody gardens often found around estate mansions and not accurately covered by the other options.

Public recreation

Signs of deliberate management for the public included resting benches, footpaths, picnic facilities, waymarker posts, stiles, hoof prints (horse riders), bicycle tracks and car parks.

Screening or shelter

This classification may be linked with 'agroforestry' and 'grazing by domestic animals'. A wood that appears to have been planted for the shelter or screening of buildings, factories, stock or wildlife. Any comments made by the owner assisted in deciding the correct allocation of this management practice.

Timber products

The deliberate management, within the surveyed cluster, for timber products including coppice.

Appendix 4

Technical details of digital map production and geographic information system hardware and software

Process	Software	Hardware	Data type	Formats	Storage media/ backup
Data import					
Digitised API	Laserscan Lites2	VAX Workstation 4000 VLC	Vector (lines) Vector (points)	Arc Export .E00	DAT tape & TK50
LCS88	Laserscan Lites2	VAX Workstation 4000 VLC	Vector (lines) Vector (points) Vector (polygons)	ARC Export .E00	DAT tape & TK50
Map production					
Update and creation of digital map	Laserscan Lites2 Digital VMS	VAX Workstation 4000 VLC	Vector (polygon)	.IFF (Internal Feature Format)	DAT tape & Magneto Optical Disk
Sampling main woods and small woodlands	Laserscan Lites2	VAX Workstation 4000 VLC	Vector (polygon) Vector (lines)	.IFF	DAT tape & Magneto Optical Disk
Production of reports and maps for fieldwork	Laserscan Lites2	VAX Workstation 4000 VLC	Vector (polygon) Vector (lines)	.IFF	DAT tape & Magneto Optical Disk
Ordnance Survey raster backdrop	Laserscan Lites2	VAX Workstation 4000 VLC	Raster	.DTI (Digital Terrain Image)	Magneto Optical Disk
Printer		HP DesignJet 750c E/A0 colour			
Digital woodland map data transfer to GIS	ESRI ArcView 3.2	PC	Vector (polygon)	NTF ArcView shapefile and coverage	DAT tape Server
Digital woodland map – area analysis/ mapping	ESRI ArcView 3.2 - ArcInfo 7	PC	Vector (polygon & line) Table	ArcView shapefile and coverage .dbf (dBase file)	DAT tape Server
Presentation of results					
Data analysis results	Microsoft Excel 97	PC	xls workbook	.xls	DAT tape Server
Production of woodland maps for country, region & county reports	ESRI ArcView 3.2 - ArcInfo 7	PC	Vector (polygon & line)	ArcView shapefile and coverage	
	Adobe Illustrator	PC	Raster	.AI (Adobe Illustrator) .EPS (Encapsulated Postscript)	
Provision of data in response to requests	ESRI ArcView 3.2 - ArcInfo 7	PC	Vector (polygon & line)	ArcView shapefile and coverage Arc Export .E00	CD-ROM

Appendix 5

Technical details of field data collection device

The Husky Hunter 16/80

Construction
Die-cast aluminium alloy
Size
216.5 mm x 157 mm x 35.5 mm
Weight
Including batteries 1200 g
Sealing
Waterproof against accidental immersion, -10 to +55°C, up to 100% humidity
Screen
640 x 200 pixel full graphics liquid crystal display with keyboard-controlled contrast adjustment; display area 180 mm x 50 mm
Keyboard
63-key waterproof membrane keyboard
Operating system
MS-DOS 3.3, ROM based
Programming language
GWBASIC interpreter, ROM based

A carrying case for field use included a range of straps, enabling (if desired by the surveyor) its use in front of the surveyor in a horizontal position. Rechargeable batteries were replaced by standard alkaline batteries, which gave better performance.

Husky Oracle GT Disk Drive

Construction
Metal cased with anti-slip feet
Size
200 mm x 140 mm x 30 mm
Weight
1400 g
Disk drive media
3.5" micro floppy diskette, double-sided, double density, 135 TPI
Capacity
1.4 Mb
Baud rate
1 200 to 38 400 Baud
Data format
8 bits, no parity, 1 stop bit

The disk drive was not as rugged as the Hunter 16/80 and gave best results when transferring data if kept plugged into the mains power supply.

Appendix 6

List of species recorded and reported

Common name	Botanical name
Main Woodland Survey	
Scots pine	*Pinus sylvestris* L.
Corsican pine	*Pinus nigra* v. *maritima* (Ait.) Melville
Lodgepole pine	*Pinus contorta* Douglas ex Loud.
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Norway spruce	*Picea abies* (L.) Karst.
European larch	*Larix decidua* Miller
Japanese and hybrid larches	*Larix kaempferi* (Lamb.) Carr., *Larix* x *eurolepis* Henry
Douglas fir	*Pseudotsuga menziesii* (Mirb.) Franco
Other conifers	
Mixed conifers	
Oak	*Quercus robur* L. *Quercus petraea* (Matt.) Lieblein.
Beech	*Fagus sylvatica* L.
Sycamore	*Acer pseudoplatanus* L.
Ash	*Fraxinus excelsior* L.
Birch	*Betulus* spp.
Poplar	*Populus* spp.
Sweet chestnut	*Castanea sativa* Mill.
Elm	*Ulmus* spp.
Other broadleaves	
Mixed broadleaves	
Additional species recorded and reported in the Survey of Small Woodland and Trees	
Cypress	*Cupressus* spp. *Chamaecyparis* spp. x *Cupressocyparis leylandii* (Jacks. Dallim.) Dallim.
Horse chestnut	*Aesculus hippocastanum* L.
Alder	*Alnus* spp.
Lime	*Tilia* spp.
Willow	*Salix* spp.
Additional species recorded but not separately reported	
Other pines	*Pinus* spp.
Other spruces	*Picea* spp.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Red cedar	*Thuja plicata* D. Don
Grand fir	*Abies grandis* Lindl.
Noble fir	*Abies nobilis* Rehd.
Other firs	*Abies* spp.
Japanese cedar	*Cryptomeria japonica* (L. f.) Don
Coast redwood	*Sequoia sempervirens* (D. Don) Endl.
Wellingtonia	*Sequoiadendron giganteum* (Lindl.) Buchholz
Yew	*Taxus baccata* L.
Red oak	*Quercus rubra*
Norway maple	*Acer platanoides* L.
Common alder	*Alnus glutinosa* (L.) Gaertn.
Other alder	*Alnus* spp.
Whitebeam	*Sorbus aria* (L.) Crantz
Wild cherry (Gean)	*Prunus avium* L.
Bird cherry	*Prunus padus* L.
Hornbeam	*Carpinus betulus* L.
Rauli	*Nothofagus procera* (Poepp. and Endl.) Oerst.
Roble	*Nothofagus oblqua* (Mirb.) Bl.
Box	*Buxus sempervirens* L.
Blackthorn	*Prunus spinosa*
Hawthorn	*Crataegus* spp.
Elder	*Sambucus* spp.
Field maple	*Acer campestre* L.
Holly	*Ilex aquifolium* L.
Rowan	*Sorbus aucuparia* L.
Goat willow	*Salix caprea* L.
Other willow	*Salix* spp.
White poplar	*Populus alba* L.
Grey poplar	*Populus canescens* (Ait.) Sm.
Aspen	*Populus tremula* L.
Black and hybrid poplars	*Populus nigra* and *Populus* hybrids

Appendix 7

List of maps, tables and charts within a typical National Inventory Report

Map 1: County Boundaries
Map 2: Distribution of Woodland over 2 hectares
Map 3: Distribution of Woodland over 2 hectares by Ownership
Map 4: Distribution of Woodland over 2 hectares by Interpreted Forest Types

Summary Results of the National Inventory of Woodland and Trees (NIWT)

Tables 1–5
Table 1: Woodland area by woodland size class
Table 2: Woodland area by forest type and woodland size
Table 3: Area by principal species/groups and woodland size
Table 4: Numbers of live trees outside woodland by feature type
Table 5: Lengths of linear features

Results of the Main Woodland Survey (MWS) covering woodlands of 2 hectares and over

Tables 6–12
Table 6: Summary of areas by ownership
Chart: Woodland area by ownership
Table 7a: Size class distribution of woodland
Table 7b: Size class distribution of woodland by ownership units
Table 8: Areas of woodland by forest type and ownership
Chart: Percentage forest type by area – all woodland
Table 9a: Areas of High Forest by principal species and ownership
Graph: Areas of High Forest by principal species and ownership
Table 9b: High Forest – areas by principal species, ownership and category
Graph: High Forest Cat. 1 – areas by principal species and ownership
Graph: High Forest Cat. 2 – areas by principal species and ownership
Table 10a: High Forest Cat. 1 – areas by principal species and planting year classes
Graph: High Forest areas by planting year classes
Table 10b: High Forest Cat. 1 – Forestry Commission – areas by principal species and planting year classes
Graph: High Forest Cat. 1 – Forestry Commission – areas by planting year classes
Table 10c: High Forest Cat. 1 – Other Ownership – areas by principal species and planting year classes
Graph: High Forest Cat. 1 – Other Ownership – areas by planting year classes
Table 11: High Forest – principal species by planting year classes
Table 12: Ownership type by area and percentage

Results of the Survey of Small Woodland and Trees (SSWT)

Tables 13–22
Table 13 Summary of information from the Survey of Small Woodland and Trees
Table 14 Woodland area by feature type and woodland size
Table 15 Woodland area by forest type, woodland size and feature type
Table 16 Woodland area by species and feature type
Table 17 Numbers of live trees outside woodland by species and feature type
Table 18 Numbers of dead trees outside woodland by species and feature type
Table 19 Numbers of live individual trees by species and height band
Table 20 Numbers of live trees in groups by species and height band
Table 21 Numbers of live trees in narrow linear features by species and height band
Table 22 Numbers of groups by group size

Comparison of results with the 1980 Census and previous surveys

Tables 23–26
Table 23 Comparison of woodland area between 1980 census and NIWT
Table 24a Comparison of High Forest area by species between 1980 Census and NIWT
Chart Comparison of High Forest area by species between 1980 Census and NIWT
Table 24b Comparison of Cat. 1 High Forest area by planting year class between 1980 Census and NIWT
Chart Comparison of Cat. 1 High Forest area by planting year class between 1980 Census and NIWT
Table 25 Comparison of numbers of live trees outside woodland between 1980 Census and NIWT
Table 26 Comparison of density of non-woodland features between 1980 Census and NIWT

Woodland cover

Chart	Change in woodland area through time (1870–2000)
Map Series	Woodland cover by county through time (1895–1998)

Appendix 8

List of published reports

All reports can be accessed via the Forestry Commission web site www.forestry.gov.uk/inventory.

Great Britain Inventory Report

England Inventory Report

North East Region Inventory Report
Cleveland County Inventory Report
Durham County Inventory Report
Northumberland County Inventory Report
Tyne & Wear County Inventory Report

Yorkshire and the Humber Region Inventory Report
Humberside County Inventory Report
North Yorkshire County Inventory Report
South Yorkshire County Inventory Report
West Yorkshire County Inventory Report

West Midlands Region Inventory Report
Hereford and Worcester County Inventory Report
Shropshire County Inventory Report
Staffordshire County Inventory Report
Warwickshire County Inventory Report
West Midlands County Inventory Report

South West Region Inventory Report
Avon County Inventory Report
Cornwall County Inventory Report
Devon County Inventory Report
Dorset County Inventory Report
Gloucestershire County Inventory Report
Somerset County Inventory Report
Wiltshire County Inventory Report

East of England Region Inventory Report
Bedfordshire County Inventory Report
Cambridgeshire County Inventory Report
Essex County Inventory Report
Hertfordshire County Inventory Report
Norfolk County Inventory Report
Suffolk County Inventory Report

South East Region Inventory Report
Berkshire County Inventory Report
Buckinghamshire County Inventory Report
East Sussex County Inventory Report
Isle of Wight County Inventory Report
Kent County Inventory Report
Oxfordshire County Inventory Report
Surrey County Inventory Report
West Sussex County Inventory Report

North West Region Inventory Report
Cheshire County Inventory Report
Cumbria County Inventory Report
Greater Manchester County Inventory Report
Lancashire County Inventory Report
Merseyside County Inventory Report

London Region Inventory Report

Wales Inventory Report (English language)
Wales Inventory Report (Welsh language)
Gwynedd County Inventory Report (English language)
Gwynedd County Inventory Report (Welsh language)
Clwyd County Inventory Report (English language)
Clwyd County Inventory Report (Welsh language)
Powys County Inventory Report (English language)
Powys County Inventory Report (Welsh language)
Dyfed County Inventory Report (English language)
Dyfed County Inventory Report (Welsh language)
Glamorgan County Inventory Report (English language)
Morgannwg County Inventory Report (Welsh language)
Gwent County Inventory Report (English language)
Gwent County Inventory Report (Welsh language)

Scotland Inventory Report
Western Isles Region Inventory Report
Highland Region Inventory Report
Grampian Region Inventory Report
Tayside Region Inventory Report
Fife Region Inventory Report
Central Region Inventory Report
Strathclyde Region Inventory Report
Lothian Region Inventory Report
Borders Region Inventory Report
Dumfries and Galloway Region Inventory Report

Forestry Commission

Silvan House
231 Corstorphine Road
Edinburgh
EH12 7AT

www.forestry.gov.uk