Question 9: Why are there differences in estimates of stock of woodland cover and changes in woodland cover obtained from Forestry Commission surveys and CS2000 (including LCM2000)? How are Ancient Woodland Inventory sites represented in the CS2000 field survey sample and LCM2000? What evidence is there in CS2000 for the location and reasons for changes in woodland cover?

David Howard & Geoff Smith

DUE START DATE:

- March 2002

DUE FINISH DATE:

- October 2002

OVERALL PROGRESS

- The Policy Context Statement has been drafted, circulated for comment and re-drafted accordingly
- Under Part (a), meetings have been held with the Forestry Commission, forest cover categories have been identified, datasets have been acquired and formatted, spatial overlays have been completed, national estimates of forest cover have been computed and sources of error have been partitioned.
- Under Part (b), contact has been made with all relevant agencies, datasets have been acquired, spatial overlays have been performed and analysis completed.
- Under Part (c), analysis has been completed and interpretation of results made.

DEFINITIONS

- "Forestry" is a term that can be used as both land cover (wooded, i.e. land predominantly covered by trees) or land use (growing timber and managing woodland).
- National Inventory of Woodland and Trees (NIWT) is the most recent dataset describing woodland extent and characteristics in Great Britain generated by the Forestry Commission. It has evolved since the Commission's inception in the 1920s and now includes the National Inventory of Woodland Digital Map (NIWD) identifying woodland areas over 2 hectares. The dataset consists of three parts, a digital map derived from aerial photographs (identifying the location, size and shape of all woodland polygons greater than 2 ha). This is supplemented by two sample surveys, one of Small Wood and Trees the other of woodland attributes and condition in the 2 ha and larger parcels; the three datasets are combined to produce the complete Inventory. In this project the comparison has been made at a fine resolution with the digital map and at national and regional scales with the full NIWT statistics. The dataset is used for the production of national statistics on forestry. Such descriptions have been generated every 10 to 15 years and updated for

the intervening years using grant and other administrative information. The digital dataset used (NIWD) has a reference date of 31/3/2000 and date to cd of 7/12/2001.

- The Ancient Woodland Inventory (AWI) describes land that has had continuous woodland cover since 1600 AD (1750 AD in Scotland). The sites are divided into *Ancient Semi-natural Woodland* that have retained the native tree and shrub cover that has not been planted and *Ancient Replanted Woodland* where the original native tree cover has been felled and replaced by planting, usually with conifers and usually this century. The AWI dataset is still provisional and only covers woodland over 2 ha. The three AWI datasets (England, Scotland and Wales) are created from a variety of sources identifying historical location of woods and held by the conservation agencies (English Nature, Scottish Natural Heritage and Countryside Council for Wales).
- Countryside Survey (CS) woodland, from both satellite (LCM2000) and field survey (CS2000 FS) is divided across two Broad Habitats *Broadleaved, mixed and yew woodland* and *Coniferous woodland.* These are both identified from land cover characteristics. CS woodland is the aggregation of the two habitats.
- "Stable area" is defined as an area remaining in the same Broad Habitat in the Countryside Surveys. The Surveys took place in 1984, 1990 and 1998 (with a small continuation in 1999). Most of the comparisons are made between 1990 and 1998, but some describe 1984 to 1998.

POLICY CONTEXT STATEMENT

1 It can be argued that woodland covers the two most important Broad Habitats as they represent what would be the climax vegetation covering most of Britain if man was not present. Woodland is managed as a source of timber, wood pulp, charcoal and other assorted commodities, for landscape aesthetics and recreation, and more recently has been recognised as an important sink for sequestering carbon to combat global climate change. There is a long history of woodland being directly cited in British policy (both through royal decrees and parliamentary acts) for reasons ranging from the needs for timber to build ships, through the desire to manage land for game, to the need to provide green-space for the urban population. There is an increasing number of international agreements also making commitments to effective management of woodland.

2 The British Forestry Act of 1919 established the Forestry Commission (FC)[1] to oversee the interests of woodland; the initial intention was to replant 'wasteland' and provide reserves of timber. To carry out its mandate, the FC took its first audit of the nations woodland in 1924; surveys have been carried out at approximately 15 year intervals since. The surveys show that the area of woodland in the UK increased through the 20th century, from around 5 per cent land cover to over 10 per cent.

3 The function and value of woodlands in the landscape may have changed through the years, but their importance is still appreciated. The British Government targeted policies at further increasing the area under trees in the 1990s stating "the most significant alternative land use in the next twenty years is likely to be forestry"[2]. In 1989 the Countryside Agency and the Forestry Commission initiated the Community Forest[3] programme, in response to the national need to diversify land-use. The aim was to use multipurpose forestry to improve the countryside around towns and cities in a variety of ways including restoration of areas scarred by industrial dereliction, creation of sites for recreation and sport, forming new habitats for wildlife and making outdoor classrooms for environmental education.

4 The traditional hierarchy of land use, where the most productive rural land is used for agriculture, less productive land for forestry and un-productive land for nature and recreation is breaking down. There is encouragement to plant trees on more productive land and just over a

third of the target for new planting would be on agricultural land sponsored by the Farm Woodland Scheme[4]. The changes have economic, social and environmental implications for a wide range of policies.

5 The United Nations Conference in Rio in 1992 defined a number of objectives to protect the earth's environment, the details of implementation were further developed in a number of Conference of Parties (COP) meetings leading to agreements such as the Kyoto Protocol and the Marrakesh Declaration which specifically identify the role of forestry in combating climate change. Other developments from Rio, such as Agenda 21 had a wider remit. The 1993 Ministerial Conference on the Protection of European Forests in Helsinki led to the formal adoption of a forest policy to promote sustainability. In 1998, the UK Government published the UK Forestry Standard[5] which defined objectives for and methods of assessing forest management. In 1999 the Government published its strategy for sustainable development called *A Better Quality Of Life*[6]. Four of the 147 key indicators refer to woodland (see Table 1)

Table 9.1. Forests and woodlands in a *Better Quality of Life*

Themes, issues and objectives (Sustainable Development Strategy reference in brackets)	*Key indicators*
Continuing expansion of (UK) woodland area (S10)	Area of woodland in the UK
Protecting ancient and semi-natural woodlands (S11)	Area of ancient semi-natural woodland
Better management of existing woodlands (S12)	Sustainable management of woodland
Sustainable (forestry) management overseas (S13)	Number of countries with national forest programmes

6 The first two objectives are being assessed by statistics of geographic extent. The indicator for the third (S12) is still being finalised, but are likely to be based on the UK Indicators of Sustainable Forestry, making use of information on certification, management plans, grant scheme standards, etc. The fourth woodland theme (S13) is not covered by Countryside Survey.

7 Statistics describing the extent of woodland are key indicators for monitoring this resource with its wide array of uses. Monitoring is also needed to assess progress and success in the achievement of the aims of different policies. However, changes seen in woodland area can be misleading without reference to turnover and condition. Not only do the three indicators (S10, S11 and S12) need to be considered together, but also the relationship between woodland (a land cover) and forestry (a land use) must be recognised. Changes in woodland area do not necessarily mean a change in forestry, as the cycle of ground preparation, planting, felling and restocking may leave a forested area without trees for a period.

8 It is important to recognise effects such as the sensitivity of native woodland flora soil quality and relate them to both changes in land cover and land use. An increase in forest area implies a loss in land cover from other uses. If the gain is predominantly from intensive agriculture, it may not be harmful in an ecological sense, but other ecologically more valuable habitats may be at risk. Examination of the pattern, structure and history of the parcels in the landscape should indicate the shifts in land use and demonstrate the success of policy to steer changes in management. Plans for expansion of woodland area need to take into account possible impacts on soil, water, wildlife, heritage features and landscape aspects.

A variety of organisations produce statistics describing the extent and composition of woodlands:

- The Forestry Commission produces the standard definitive statistics describing woodland in Britain. Annual reports are produced describing the state of woodland and a national database is maintained (including NIWT) and resurveyed approximately every 15 years.
- Other organisations such as the nature conservation agencies and special interest groups (e.g. the Council for the Preservation of Rural England[7] and Woodland Trust[8]) may occasionally produce estimates on different types of woodland.

- Countryside Survey records all types of land cover in rural Britain including woodland and publishes statistics that are apparently equivalent to Forestry Commission figures once every six to eight years. The Survey records all elements of the landscape, allowing interpretations to be made about the fluxes between different land uses. Moreover, it includes valuable information about the environmental condition from vegetation and soil samples which again is set in context of the wider landscape.

9 The figures from the different organisations do not always agree. It would be surprising if the estimates were exactly the same, as contrasting methods and definitions are used. What is important is that the estimates are compared and the differences reconciled, so that the information can provide an effective description of all aspects of woodland and identify which figures are most appropriate for different policy development. It is important to recognise the both the potential and limits of use of the datasets and the synergy gained from their combined application. For example, the Countryside Surveys can provide data describing condition and context according to definitions of Ancient Woodland, both in terms of quantity and quality.

10 Responsibility for forestry policy in Scotland and Wales was devolved in 1999 to the Scottish Parliament and the National Assembly for Wales, implemented through FC National Offices. The aims of forestry policy across the UK remain founded on international commitments to sustainable forest management, but there are different driving forces and priorities in each country. The Forestry Devolution Review in 2002 recommended strengthening the National Offices and giving them full responsibility for Forest Enterprise activities..

SCIENCE OUTPUTS.

Part (a.1) - Differences in estimates -stock

11 The main national datasets for comparison are the two Countryside Survey descriptions of extent of Broad Habitat (Land Cover Map 2000 – LCM2000 and the field survey – CS2000 FS) and the digital map used in the Forestry Commission's National Inventory of Woodland and Trees (NIWD). The latter is supplemented by surveyed information describing woodland composition, character and condition and small woodland below the complete census minimum mappable unit (mmu - 2 ha). The original digital map represented about 95% of the NIWT figure (2545 out of 2665 ha x 10^3) and is held as a GIS dataset making it easy to interrogate. Table 9.2 shows the estimates for woodland area for the three different sources; Countryside Survey woodland is the combination of two Broad Habitats, *Broadleaved mixed and yew woodland* (BH 1) and *Coniferous woodland* (BH 2).

12 Table 9.2 shows the full national estimates from each of the datasets and the estimates produced when the datasets are limited to those parcels larger than 2 ha (the mmu of NIWD). The estimates for woodland in GB are close and if the complete NIWT figure is used they are closer still with only 50,000 ha separating them (under 2% of the woodland area).

13 The breakdown between countries shows LCM2000 and CS2000 FS in approximate agreement for England at about 10% of the land area, two percentage points higher than the NIWD, but for Wales and Scotland NIWD and CS2000 FS show agreement (at 13% and 17% land area respectively) while LCM2000 shows two percentage points higher for Wales and two points lower for Scotland. The differences may reflect the geographic variation in woodland management. England has a more fragmented woodland cover than either Wales or Scotland and so the 2ha mmu would be expected to show greater deviation between the estimates. This is reflected in the published FC statistics that show 7% of the English woodland area to be in units of between 0.1 and 2 ha, compared to 6% of Wales and 2% of Scotland.

14 The breakdown by Environmental Zones shows greater divergence between the estimates generated from the different datasets, but still shows interpretable differences across GB. The two English and Welsh lowland Zones (EZ 1 and EZ 2) have the lowest wooded percentage in GB. EZ 2, land in the lowland west commonly dominated by pastural agriculture, is marginally the lowest, but they both average about 9% of their land area. The English and Welsh uplands have about 13% wooded land cover and the estimate shows the greatest consistency between the three datasets.

Table 9.2 National estimates of woodland area from FC National Inventory of Woodland and Trees Digital Map (NIWD), Land Cover Map 2000 (LCM2000) and CS2000 field survey (CS2000 FS). Areas in thousands of hectares (ha x 10^3)

	NIWD		***LCM2000***		***CS2000***	
	Full	***> 2ha***	***Full***	***> 2ha***	***Full***	***> 2ha***
GB	2641	2568	2832	2390	2845	1462
England	1052	1004	1391	1304	1295	524
Wales	273	268	305	238	256	129
Scotland	1313	1296	1124	847	1298	809
EZ 1	540	511	708	659	631	248
EZ 2	460	441	645	624	613	214
EZ 3	326	320	341	259	307	190
EZ 4	354	346	339	229	289	133
EZ 5	432	427	360	299	422	266
EZ 6	527	523	424	319	583	409

NB NIWD statistics were generated from a digital dataset provided for the project, LCM2000 statistics were derived from CIS and a bespoke digital dataset and CS2000 from the original dataset. English, Welsh and Scottish borders were defined from an independent digital coverage.

15 The Scottish Zones all show greater woodland cover, with EZ 6 (the true uplands) generally showing the greatest percentage (about 16%). However, the estimate is the most variable between the datasets, with LCM2000 showing the lowest of the three values (13%), followed by NIWT (16%) and then with the highest value CS2000 FS (18%). The other two Zones (EZ 4 and EZ 5) show approximately similar levels (13 – 14%) with EZ 4 (agricultural lowlands) having slightly more than EZ 5 (marginal uplands and islands).

16 While the values derived from different datasets show clear differences, the effect can be explained by the methods used to collect and store the different datasets. It is important that the comparisons are made 'like with like' and the first problem is the size of woodland parcels used in generating the estimates. NIWD only includes woods over 2 ha in extent, LCM maps land units down to 0.5 ha and FS maps down to 0.04 ha. If all three datasets are restricted to parcels over 2 ha (>2ha) the results are as expected, NIWD drops slightly, LCM2000 drops by about 15% but the CS2000 FS value halves and becomes markedly lower than the other two estimates. The difference is an effect of the sampling unit in FS. Woodland parcels that extend beyond the sample kilometre square may be over 2 ha, but if the portion within the square is less than 2 ha they will be omitted from the analysis.

17 Information in the three datasets is also influenced by the shape of the woodland parcels. CS2000 FS maps lines of trees as arcs with no area, but maps belts of trees as polygons so long as they have an area of greater than 0.04 ha. LCM2000 relies on pixels (approximately 25 m x 25 m) and individual parcels of woodland may be split into different parts because of the form of the grid structure; it was hoped that CLEVER mapping would reduce this problem, but so long as the tessellations used to define polygons they will still split. NIWT generally requires woodland to have a depth of over 50 metres before it is included.

18 Contextual information, absent from LCM2000 is used in NIWD and to a lesser extent in CS2000 FS. . NIWD is primarily intended to identify woods, but splits them into Interpreted Forest Types (IFT). An area of woodland may include rides, glades, buildings so long as the parcels are below 2 ha.

19 The next problem is the cover types recorded in the three datasets. LCM2000 and CS2000 FS both record land cover as observed at one point in time, NIWD interprets land cover from the aerial photograph into IFT. Three categories can cause particular confusion. Ground prepared for planting is unlikely to be recorded as wooded in either of the CS datasets, felled trees is more likely to be recorded as wooded if felled trees or stumps remain on the ground but may still cause trouble. Finally, scrub and shrub may be given different emphasis in the different datasets.

20 Table 9.3 shows the breakdown of NIWD data across the Environmental Zones. Broadleaves dominate the two lowland zones in England and Wales while conifers dominate all other zones. Zones 5 and 6 show the most dynamic woodland with the largest areas prepared for planting and with young trees. The largest areas of felled trees are in England and Wales (especially EZ 1 and EZ 3). It is possible that there are minor regional differences in allocation to category (for example, scrub and shrub are combined, as there is no shrub in Scotland or scrub in England and Wales).

21 The IFT category of young trees was generated using the standard aerial photographs, but then updated with information about woodland creation between the date of the photograph and 2000. This may lead to additional small differences between zones due to the varying dates of the aerial photography.

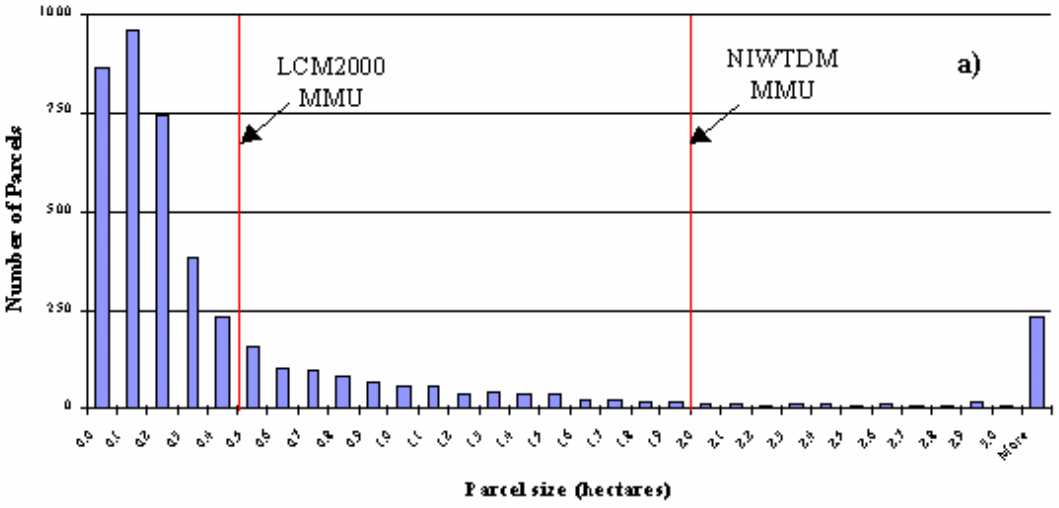
Table 9.3 Breakdown of NIWD data across the Environmental Zones. Areas in ha x 10^3.

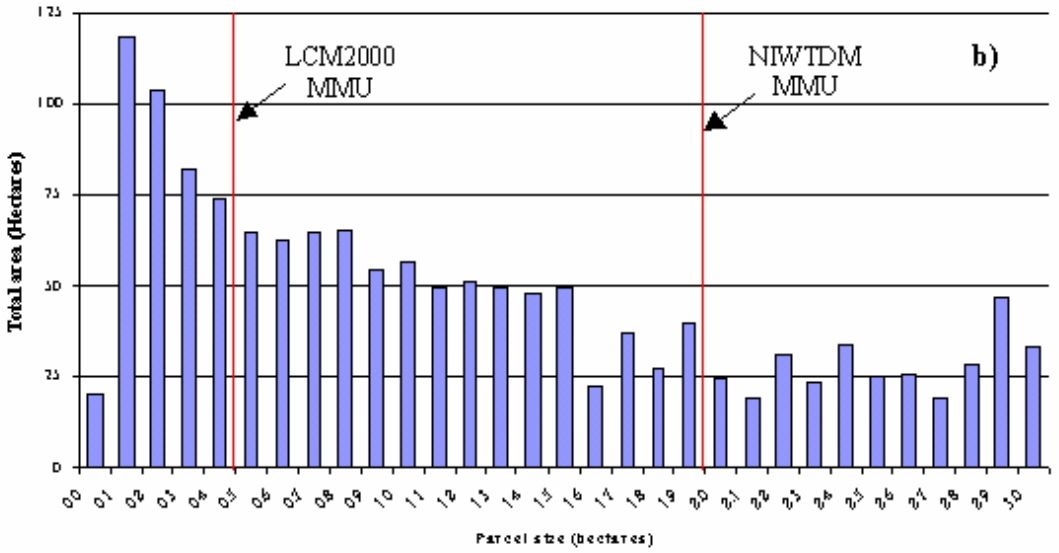
	EZ 1	***EZ 2***	***EZ 3***	***EZ 4***	***EZ 5***	***EZ 6***	***GB***
Broadleaved	261	241	59	35	40	33	669
Coniferous	120	115	205	169	190	268	1067
Coppice	10	1	0	0	0	0	11
Coppice with standards	2	0	0	0	0	0	2
Felled	22	12	19	14	9	8	84
Ground prepared for planting	2	0	2	23	62	64	153
Mixed	87	57	14	49	20	20	247
Shrub/Scrub	8	9	1	5	2	1	26
Young trees	28	24	25	59	109	133	378
Total wooded	**540**	**460**	**326**	**354**	**433**	**526**	**2639**
Non-wooded	6090	5818	2275	1954	2569	2677	21383
Environmental Zone area	6630	6278	2601	2308	3002	3203	24022

22 Figure 9.1a shows the distribution of the number of woodland parcels of different sizes recorded in sample squares of CS2000. The distribution is skewed with a median of between

0.1 ha and 0.2 ha and a very long tail. The vertical lines represent the minimum mapping units (MMU) of the other two datasets and are both well above the median of the distribution. To apply a filter for parcel size would require information about the total area of any parcel that extends beyond the square. Although some information may be available from published maps and aerial photographs it would not match the mapping technique or be contemporary with the field recording.

Figure 9.1 The distribution of woodland parcel sizes from CS2000 FS showing minimum mappable unit (MMU) cut off for LCM2000 (0.5 ha) and NIWD (2 ha). a) shows the numbers of parcels of different sizes b) shows the area of woodland in each size class





23 The presence of a large number of very small parcels within the survey squares may not influence the estimates of extent as it is the sum of their areas that contributes to the total. When the area of woodland in the different size classes is considered (Figure 9.1b), the relationship becomes more even, but the largest category (not plotted) totally dominates the rest. The largest category is parcels larger than 3 ha which has a value of 1963 ha that would render the other categories nearly invisible. However summing the categories in the different minimum mappable unit categories shows the differentiation of the three surveys.

Table 9.4 Area of woodland in the field survey sample in different size categories. FS only describes parcels under 0.5 ha, FS & LCM describes between 0.5 and 2.0 ha and FS, LCM & NIWD parcels larger than 2 ha.

Recorded by	*Area (ha)*	*Percent total*
FS only	398	12
FS & LCM	739	22
FS, LCM & NIWD	2270	67

24 Table 9.4 shows the breakdown of woodland parcels in field survey squares into the three different size classes. It suggests that around two thirds of the woodland in the field survey squares would be recorded by all three methods, just over a fifth would not be recorded by NIWD, but would be identified by LCM2000 and a further tenth would only be recorded by CS2000 field surveyors.

25 Taking into account the spatial resolution of mapping, the figures appear to show acceptable agreement at a national scale. However, this ignores other aspects of co-registration of the information. Tables 9.5 and 9.6 show the results of spatial matching. The relationship between NIWD and LCM2000 (Table 9.5) shows that mature stands of trees (Broadleaf, Coniferous and Mixed NIWD categories) are recorded by both methods between 70% and 80% of the time. Young trees and Ground under preparation for planting show lower correspondence with the woodland Broad Habitats, but if semi-natural habitats, such as grassland, bracken and dwarf shrub heath are added the agreement becomes extremely good.

Table 9.5 The correspondence of the NIWD categories with LCM2000 categories (BH 1 – *Broadleaved, mixed and yew woodland* and BH 2 – *Coniferous woodland*). Values are percent of NIWT category

NIWD	*BH1*	*BH2*	*BH1+BH2*	*BH1+BH2+ semi-natural*[+]
Broadleaf:	63	7	69	85
Coniferous:	10	72	82	97
Mixed:	52	22	74	88
Young trees:	8	41	49	91
Ground prep.:	6	61	66	98
Woodland	**27**	**45**	**72**	**92**

[+]BH6 + BH7 + BH8 + BH9 + BH10 + BH11

26 Table 9.6 shows the correspondence between the NIWD and CS2000 FS. The agreement is better than that for the LCM2000 with a 76% agreement (Mixed) being the lowest match to the sum of the woodland Broad Habitats (*Broadleaved, mixed and yew* with *Coniferous woodland*). Coppice woodland recorded in the NIWD was mapped as *Broadleaved, mixed and yew woodland* with very good agreement (98%). The weakest agreement was with NIWD Young trees, the field survey commonly recorded them as the grassland Broad Habitats (Acid, Calcareous, Neutral or Improved grassland). The field surveyors identified 10% of the Young trees categories as Arable and horticultural land, possibly reflecting the occurrence of bare ploughed land.

27 While there was good agreement between total woodland in the two datasets, the split between coniferous and broadleaf was weaker. The Broad Habitat classification aggregates broadleaf and mixed woodland into a single class, so the 29% of NIWD conifers identified in the category may have been mapped (at least in part) as mixed woodland. The definition does not only depend upon the rules for dominance, but the spatial definition of a stand.

28 Several versions of the statistics can be generated by masking different woodlands by their area or characteristics, but it is not possible to produce exactly comparable definitions. However, the results appear to be consistent in terms of approximate values and general trends.

Table 9.6 The correspondence of the NIWD categories with CS2000 FS categories. Values are percent of NIWD category, highest values are shown in bold.

	Broadleaved, mixed and yew woodland	Conifer woodland	Woodland (BH1 + BH2)	Arable and horticultural	Grassland	Built up and gardens	Other
Broadleaved	**76**	4	80	1	9	3	7
Coniferous	29	**60**	89	1	4	1	5
Coppice	**98**	0	98	0	2	0	0
Felled	**52**	32	84	1	7	1	8
Mixed	**67**	9	76	3	7	9	5
Shrub	**62**	0	62	0	28	2	7
Young trees	25	21	46	10	**35**	1	8
Total	**56**	21	80	2	10	2	6

29 If the correspondences are examined in the opposite direction (percentage of LCM2000 or CS2000 FS), the values include all parcels below 2 ha that are not mapped in the NIWD. The effects of this can be seen in Table 9.7, which shows the extent of overlap of NIWD and LCM2000. The 1047 ha x 10^3 found in LCM2000, but not mapped by NIWD will include woodlots between 0.5 ha and 2 ha.

Table 9.7 Spatial agreement between FC NIWD and CS2000. Areas in thousands of hectares (ha x 10^3)

Source of estimate	*Area*
FC NIWD	2641.3
LCM2000	2832.4
FC NIWD and LCM2000	1785.3
FC NIWD but not in LCM2000	855.1
LCM2000 but not in FC NIWD	1047.1

30 There are several other potential causes of difference between the datasets, which can be divided into definition, methodology, temporal and accuracy.

Definitions

31 The use of common terms by different groups of people often heightens the expectation of agreement. However, the terms need to be clearly defined in order to ensure that the same features are being discussed. As shown above, features such as the spatial resolution of data can lead to a discrepancy. Other terminology also needs to be unambiguously defined and compared. Forestry has a variety of definitions, but should be considered as a land use in which the management of woodland is a major concern. Woodland is composed of trees and shrubs whose canopy form (or will form) an extensive cover.

32 The characteristics of area and composition of canopy that define woodland has already been mentioned. Within CS2000 FS a clump of trees is defined as "a small woodland or group of trees (6 or more) and of less than 0.25 ha". Once greater than 0.25 ha in extent, it becomes woodland/forest, but only as long as its crown cover is greater than 25% of the area. The FC define woodland as "land with a minimum area of 0.1 ha under stands of trees with, or with the potential to achieve, tree crown cover of more than 20%. Areas of open space integral to the woodland are also included". CS2000 FS would map open space of over 0.04 ha as non-woodland. The NIWT field survey records integral open space (down to 0.05 ha) and estimated the area to be 217,000 ha. The figure explains about half the area identified as woodland by NIWD and non-woodland by the FS.

33 The earlier sections dealt with the effect of minimum mappable units, such as the woodland of 2 ha and over, and with a minimum width of 50 m, used for the FC Main Woodland Survey (NIWD). Other woodland and trees are assessed in the Survey of Small Woods and Trees which uses a sample approach and consequently is more difficult to compare in a spatially disaggregated way with other datasets.

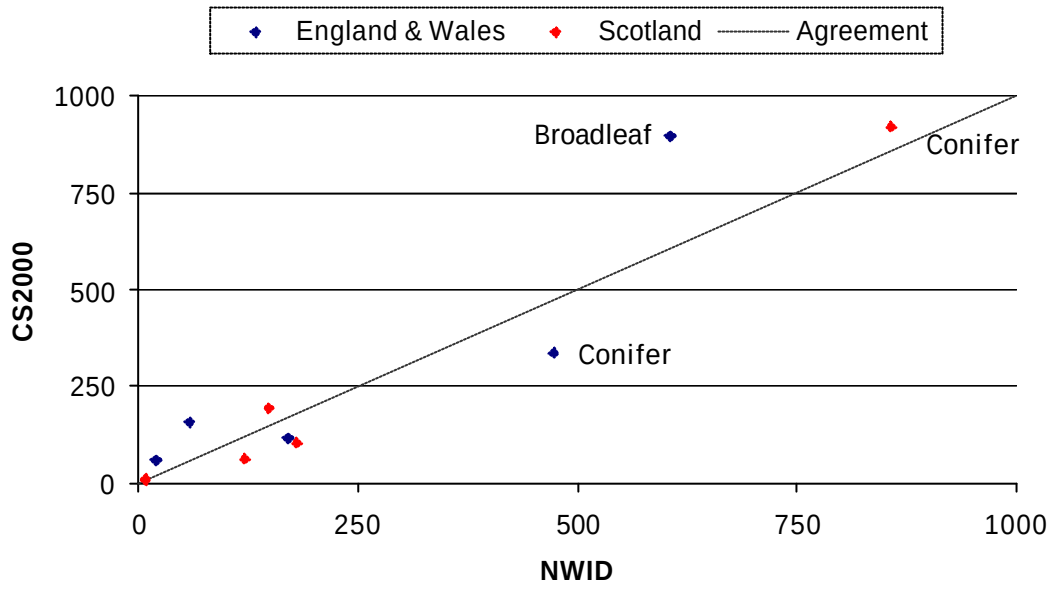
34 FC does not record orchards and urban woodland between 0.1 and 2 ha, while CS2000 FS only omits trees and scrub within curtilage of buildings, but does not survey predominantly urban squares. LCM2000 records all land cover irrespective of location or use. Whilst mapping, FC will omit features such as roads, rivers or pipelines within woodlands if they are less than 50 m in extent; CS2000 FS will record such features, down to the minimum mappable unit, but LCM2000 may miss narrow features due to the 25 m^2 pixel size.

35 The composition of woodland with different tree and shrub species again may be recorded differently. 'Scrubby' vegetation is not defined by FC as a separate category but included in one of the three main woodland types, Conifer, Broadleaved or Mixed. CS2000 FS records dominant tree species where they fill more than 25% of the canopy area; a mixed woodland has to have broadleaves and conifer species each covering 25%. The FC definition is somewhat

sharper, but with a different percentage; conifer is where at least 80% of the canopy is coniferous, broadleaf where at least 80% is broadleaf and mixed where both types fill more than 20% of the canopy.

36 Figure 9.2 shows the matching of categories between the National Woodland Inventory and the CS2000 FS equivalent to produce national estimates. There is a clear relationship, but CS2000 overestimates the extent of Broadleaf woodland in England & Wales which is compensated by the underestimate of Conifer. The Scottish figures show better agreement, possibly reflecting the more polarised nature of woodland with more extensive coniferous areas.

Figure 9.2 Estimates of area of different NIWD categories plotted against the CS2000 FS equivalent (areas in ha x 10^3)



Methodology

37 The three national estimates are produced by three different approaches. NIWD and LCM2000 are both based on interpretation of remotely sensed images, the former using 1:25,000 scale aerial photographs (AP), and the latter satellite imagery (Landsat TM) with a pixel size of approximately 25 m square. The methods of interpretation of the imagery are quite different, with the AP being interpreted by eye while the satellite imagery is classified using an automated classification procedure, with some supervision and a subsequent secondary spatial mapping (CLEVER mapping) (see Annex 9.1).

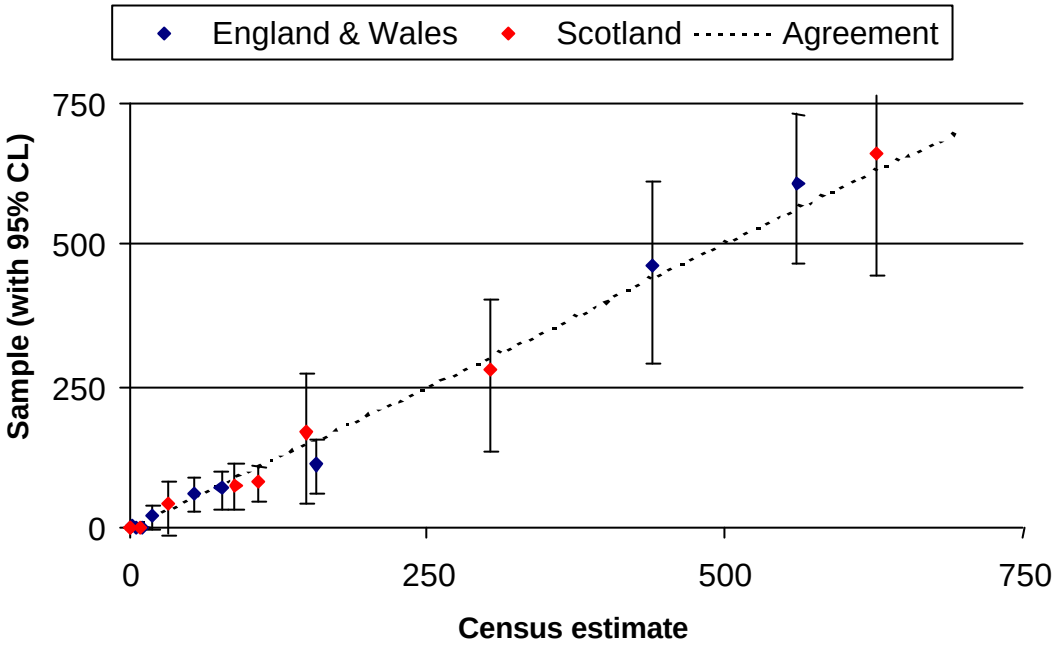
38 CS2000 FS uses a sampling scheme with a sample unit of 1 km^2. Samples are selected using an environmental stratification then mapped and sub-sampled for vegetation, soils and water in the field. National estimates are then produced by calculating the arithmetic mean for each of the strata (land classes), multiplying each mean by the area of the strata and finally totalling the products.

39 The mapping in the FS is guided by OS 1:10,000 scale map sheets so there will be some link to the FC AP, but OS sheets at different scales do not always match perfectly. The satellite map has a tessellated appearance from the edges of the pixels, so the linework is unlikely to match.

40 A major difference between the methods of producing the estimates. LCM2000 and NIWD are census estimates whereas CS2000 FS estimates are weighted totals. The efficiency of the sampling scheme and the size of the sample will affect the accuracy of the result.

41 To test the sampling scheme used in CS2000, the NIWD was sampled in the 569 km squares that were surveyed and national estimates produced. The results for the different woodland categories for England & Wales and Scotland are shown in Figure 9.3.

Figure 9.3 Estimates of area of different NIWD categories estimated using the CS2000 FS sampling scheme (areas in ha x 10^3, 95% confidence limits (CL) produced by bootstrapping)



42 Figure 3 shows that the CS2000 sampling scheme and the sampling intensity are effective for recording all the woodland categories recorded in the NIWD as the line of agreement is within all the 95% confidence bands. The best estimates derived from the sample (identified by the position of the symbols) show some slight deviation from the 'truth' defined by the digital dataset, but generally are very close to the line.

Temporal difference

43 CS2000 FS sample sites were visited predominantly in the summer of 1998, although some squares (mainly in Scotland) were surveyed in 1999. To produce LCM2000, satellite scenes from two different seasons for each site were required; 79 scenes were used from the period 1997 to 2001. The digital woodland map produced in the NIWT survey was made in two parts; England and Wales was derived from aerial photographs flown between 1991 and 2000 that were plotted against OS 1:25,000 map sheets, Scotland was based on the Land Cover of Scotland (1998) dataset flown 1987-1989. The digital map was then updated with supplementary information about changes between the aerial photograph date and first, to the varying NIWT base date (1995-1999) and then to the updated NIWD dataset (in this case 2000). NIWD is consistent in describing 2000, so may differ from the CEH datasets by two years.

44 Although woodland is generally stable, changes do take place within the recording frame of each of the surveys. There has been a long-term trend throughout the twentieth century for woodland area to increase, so the estimates from the two Countryside Survey approaches may be expected to be greater than NIWT.

Accuracy

45 It is accepted that all of the three estimates are produced within certain tolerances of accuracy and efforts are made to quantify the level of confidence that can be placed in the estimate are made. For CS2000 FS, statistical confidence intervals accompany estimates (e.g. Figure 9.3) and quality assurance measures are included in the survey. A sample of the squares was resurveyed during the field season and land cover matched at sites within the square. LCM2000 holds a measure of the heterogeneity of the pixels in each of the clever polygons and has used the FS data to produce a matrix of agreement. NIWD was critically assessed and miscellaneous adjustments prior to release.

46 NIWD provides the most useful and understandable estimates of woodland area, but does not have information describing the surrounding land cover types (as provided by both Countryside Survey estimates), or the potential to estimate changes in ground flora, soil or water conditions (as in CS2000 FS).

Part (a.2) – Differences in estimates - change

47 Countryside Survey relies on repeated visits of sites to record change. The best estimates for each surveyed year uses the complete sample, including those squares surveyed for the first time (Table 9.8). The best estimate figures for GB show a steady increase in woodland area with an approximately even split between *Broadleaved, mixed and yew woodland* and *Coniferous woodland*

Table 9.8 Woodland cover in GB recorded in Countryside Surveys using all data to estimate totals (384 squares in CS1984, 506 squares in CS1990 and 569 in CS2000). Areas in ha x 10^3.

Survey	*Total*	*Conifer*	*Broadleaved*
CS1984	2,560	1,243	1,317
CS1990	2,738	1,369	1,369
CS2000	2,845	1,374	1,471

48 The best CS estimate of change in woodland is generated by examining only the re-surveyed squares even though this involves ignoring sample squares only visited on one occasion so reducing the sample size. Table 9.9 shows the change statistics between the two years. It is possible to test the statistical significance of the changes using bootstrapping. The estimates of change are generally smaller when examining revisited squares than when comparing best estimates for individual years.

Table 9.9 Change in woodland cover in GB between different surveys. Analysed using repeat squares only. Areas in ha x 10^3. Figures in bold are significant at P≤ 0.05

Surveys	*Total*	*Conifer*	*Broadleaved*
CS1984-90	**130**	**65**	**65**
CS1990-98	**58**	-9	**67**

49 The Forestry Commission (FC) woodland area statistics are published annually and are derived by modifying inventory statistics by areas associated with planting grants and other management statistics. The two national inventories that cover the three Countryside Survey estimates are 1980 and 1995-1999. Table 9.10 shows the national statistics for 1984, 1990 and 1998.

Table 9.10 Forest cover 1984 – 1998 Source publication: Forestry Facts and Figures, Figures for Great Britain all based on 1980 census. Areas in ha x 10^3.

	Total	*Conifer High Forest*
1984	2,189	1,423
1990	2,326	1,515
1998	2,440	1,539

50 The FC stock estimates of extent of total woodland for each individual year are consistently lower than the CS estimates by about 400,000 ha. For consistency, the figures used are derived solely from updates of the FC 1980 inventory; differences in methodology used for the FC inventories produce a higher estimate from the 1995-1999 (2,665 ha x 10^3).

51 Change statistics derived from the FC figures (e.g. 251 ha x 10^3 total woodland increase between 1984 and 1998) lie between the CS figures derived by taking the difference between the best annual estimates (285 ha x 10^3) and those produced by only examining revisited sites (188 ha x 10^3). The two datasets appear to be reasonably consistent in reporting net change. The FC statistic for change in conifer high forest also lies between the two CS estimates (difference and repeated squares). Both FC and CS show a reduction in conifer planting in the later period (1990 – 1998). The FC figures may be an overestimate of new conifers as the adjustments do not allow for non-FC confers being replaced by broadleaves at restocking. The mixture of conifer and broadleaf can lead to the figures showing greater difference, as planting of broadleaves within a conifer stand would lead CS to reclassify it as *Broadleaved, mixed and yew* suggesting a loss of conifer, even though the stock has not changed.

Table 9.11 New planting and restocking in the United Kingdom Source publication: Digest of Environmental Statistics, Published November 2001 Areas in ha x 10^3.

Period	*New planting*			*Restocking*		
	Total	*Conifer*	*Broadleaved*	*Total*	*Conifer*	*Broadleaved*
1984-90	152	137	15	76	60	16
1990-98	146	74	72	123	90	33

52 The new planting figures alone are higher than the CS estimates of net increase and show an equal division between conifer and broadleaf for 1990-1998. The CS gross change figures (presented for 1990-1998 in tables 9.33 – 9.41) show a larger gain in woodland area (198 ha x 10^3) than the new planting and a split that shows nearly twice as much broadleaf as confer (131 ha x 10^3 as opposed to 67 ha x 10^3). The CS gross changes between 1984 and 1990 show a similar relationship to the FC figures with a slightly higher figure than the later period (216 ha x 10^3), however broadleaf formed a larger portion of the total (115 ha x 10^3). The difference is probably explained in part by restocking forest land that had been recorded as non-woodland by CS; it may also include some unmanaged woodland expansion. However, not all the restocking would have fallen into this category as, when it is taken into account the coniferous planting exceeds the broadleaf by 50%.

53 The figures do not show land that is felled but remaining in forestry, or land lost to woodland. CS gross figures do show large areas lost to woodland, but this again probably reflects standard forestry practice of harvesting and replanting. Between 1990 and 1998, 141 ha x 10^3 of land that had been recorded as woodland changed to a different Broad Habitat (Table 9.33), these were predominantly grassland types.

54 As an alternative source of statistics the OS derived LUCS data appear to offer some scope. LUCS is an unrivalled source of information for urban land use change. For many forms of rural land-use monitoring, and especially rural land cover monitoring, LUCS is, however, far less tractable than remotely-sensed data (with regard to the estimation of timing and change and the assessment of areas). LUCS describes England only and in its published statistics groups forestry with open land and water. Separate forestry figures are available from the Office of the Deputy Prime Minister (ODPM). It is however difficult to identify estimates that can be compared with

55 The main consequence of OS map revision policy is that 'built up' development (for example, new houses or industrial buildings) tends to be recorded relatively sooner than changes between other uses (for example, between agriculture and forestry), some of which may not be recorded for several years. Hence LUCS provide more timely information on changes to urban uses and on the recycling of land already in urban uses than rural land use changes.

56 From 1985 to 1988, and from 1993 onwards it was intended that years of change should be recorded to the nearest year. However, analysis of results shows that rounding the year of change to the nearest multiple of 5 years still occurs owing to the difficulty surveyors have in estimating an accurate year of change after a long time lag.

57 The changes for England in LUCS that describe forestry, open land and water show:

- Between 1995 and 1998, there was an average net change of 4,900 hectares per year from other uses to forestry, open land and water.
- This was almost entirely from agriculture, with net changes to and from other land use categories being negligible.

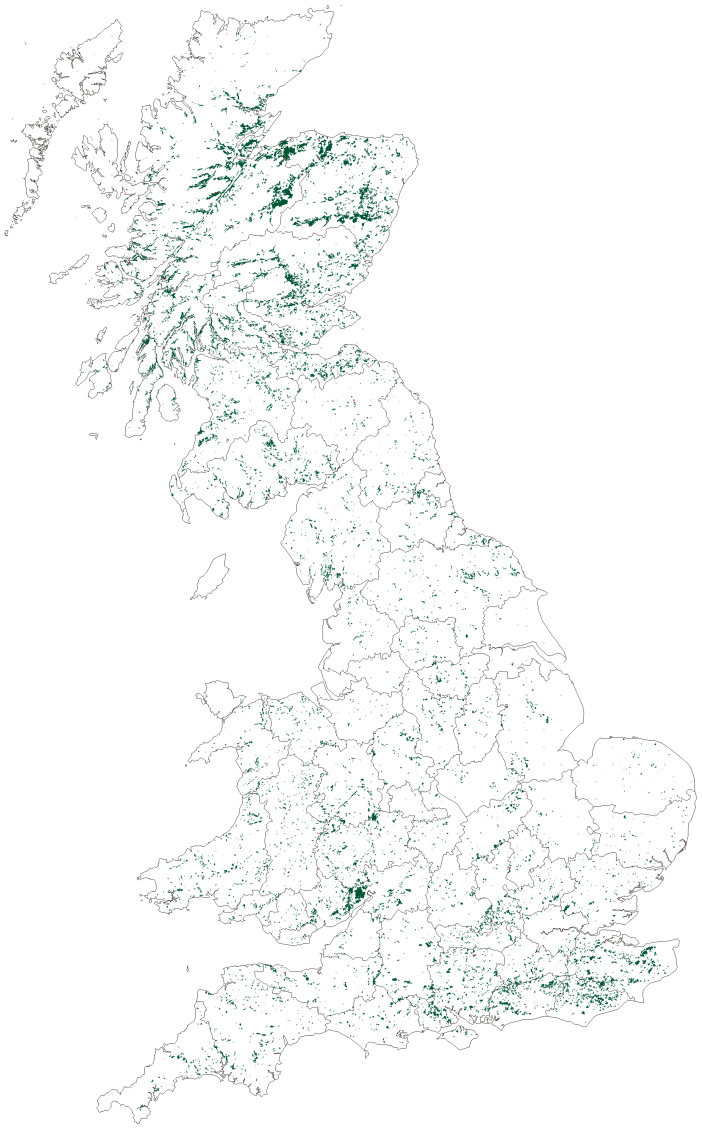
58 This compares to FC figures of 4,600 hectares per year of new planting. For Countryside Survey, the change in England between 1990 and 1998 was just under 20,000 hectares which would have given a change of just over 2,400 hectares per year.

Part (b) - Correspondence with Ancient Woodland Inventory sites

59 EN, CCW and SNH all maintain separate digital cartographic datasets describing Ancient Woodland Inventory sites. A number of characteristics of the woodlands are recorded describing areas that have been continuously wooded since 1600 (or 1750 in the case of Scotland) including any replanting has taken place. GB has about 3% cover of AWI sites, of which just under half (1.4%) is Ancient Semi-Natural Woodland (ASNW). Scotland has just over 4% of land cover, England and Wales both have coverage of around 3%; the difference may be in part due to the use of additional sources of information (Roy maps) to identify Scottish woodland. An example of the details is provided in Annex 9.2, with an excerpt from the English Nature web site.

60 Figure 9.4 shows the distribution of AWI sites throughout GB. In England and Wales there are a lot of small woodlands, with only a few areas (such as the Wye valley and parts of Sussex and Kent) standing out as having dense areas. Scotland has more extensive areas of ancient woodland surrounding the highlands, but then there are few sites at high altitude or over areas such as the Flow Country.

Figure 9.4 Composite map of the distribution of Ancient Woodland Inventory sites using information provided by English Nature, Countryside Council for Wales and Scottish Natural Heritage.



61 Each of the agencies is working with FC to try and coordinate the AWI information with the NIWD. They generally only describe woodland parcels over 2 ha (they were originally selected as areas of 2 ha or greater from a 1920s base map see Annex 9.2) and should correspond to woods in NIWD. Figure 9.5 shows an example of the agreement between the four datasets (NIWD, AWI, LCM2000 and CS2000 FS) for one 1 km square. The figure also includes an aerial photograph and the Ordnance Survey Master Map polygons for the square. The AWI datasets used in this exercise are provisional, but should still provide an indication of the value of the Countryside Survey datasets to investigations of AWI.

62 The analyses undertaken include the production of correspondence between the woodland Broad Habitats in both LCM2000 and CS2000 FS, identifying neighbouring Broad Habitats and the presence of vegetation plots in different types of Ancient Woodland with comparable plots in other woodland. Ancient Woodland sites in CS squares contain a distinctive ground flora; this will not be detectable using the mapping techniques, but can be tested in the vegetation plots.

63 Using the same cookie cutting techniques described for sampling the NIWD with the CS2000 FS scheme, the three datasets were sampled and just over a quarter of the CS2000 sample 1 km squares were found to contain AWI sites (Table 9.12). AWI sites are classified into three groups, ASNW, Plantations on Ancient Woodland Sites (PAWS) and in Scotland woodland on the Roy maps.

Table 9.12 The occurrence of AWI sites in CS2000 sample squares

	CS squares with AWI sites	*% CS2000*
England	72	24
Scotland	52	26
Wales	25	39
GB	149	26

64 Wales has the highest occurrence of Ancient Woodland sites within survey squares at nearly 40%. This does not reflect the proportion of land cover the AWI sites cover in the different countries as Scotland has the highest cover.

65 Figure 9.6 shows the relationship between the estimates of woodland area recorded in CS2000 FS squares and AWI woodland area. About 5% of the squares show more ancient woodland in the square than mapped in the Broad Habitat categories. There are a number of possible reasons for this discrepancy, the most likely being mismatch of boundaries arising from the origin of the maps. AWI is derived from 1:25,000 scale maps while CS2000 FS is 1:10,000 although both have been adjusted using aerial photography. Another, though less likely, reason is the information being recorded for different periods. Ancient woodlands are more likely to be recognised and protected making them a more stable element in the landscape.

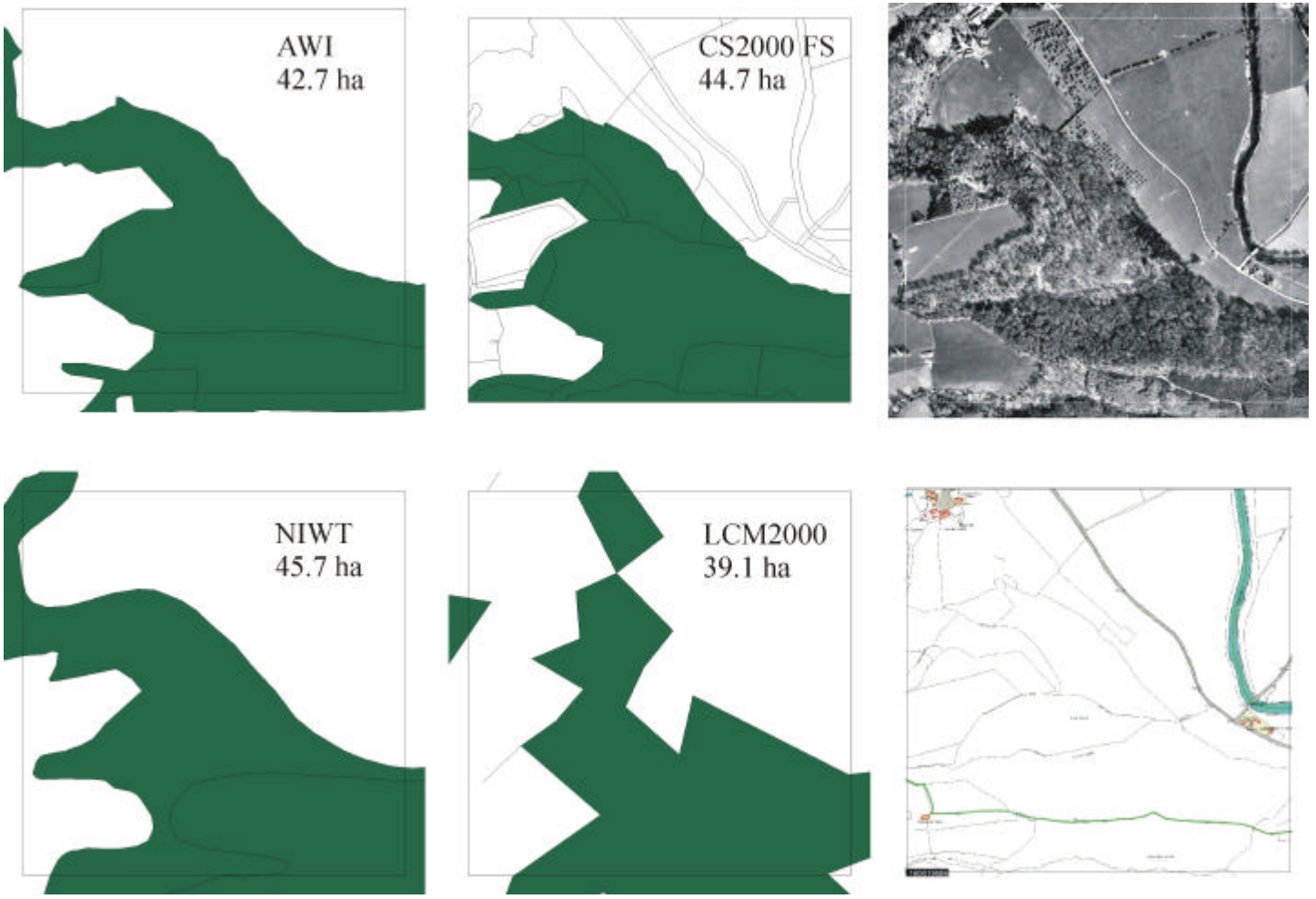
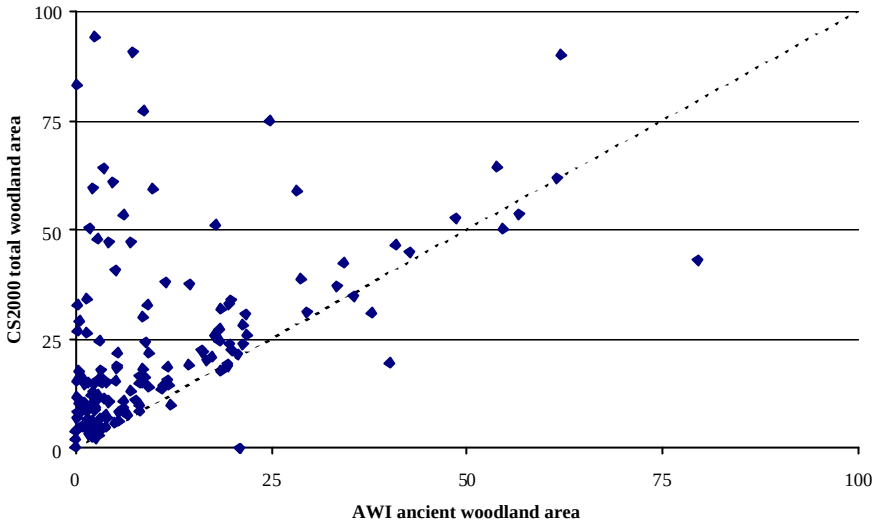


Figure 9.5 An example 1 km square drawn from different data sources. The areas represent total woodland (dark green) The aerial photograph was taken in 1990. The Ordnance Survey data are taken from MasterMap and are Ordnance Survey copyright license no. 100019086.

Figure 9.6 The relationship between AWI woodland area in CS2000 FS squares and the area recorded in CS2000 FS. Each point represents a CS sample square, areas in hectares



66 Table 9.13 shows the distribution of plots in the AWI woodland sites located in the CS2000 survey squares. The distribution is obtained by overlaying the plot location point coverage with the AWI digital map. Some of the occurrences such as plot types U (unenclosed land), A (arable headlands), H and D (hedge and hedge diversity) are likely to be due to mis-registration of the digital boundaries. For the CS2000 squares with AWI sites, the total plots in those four categories (U, A, H and D) represents only 7% compared to over 30% which is there proportion of the total plots in GB. Not surprisingly, the plot type that stands out as being sampled more intensively in the AWI sites than in GB as a whole is the Y plot. This type of plot is a targeted plot designed to record information about habitats that may otherwise not have been collected. There are nearly twice the proportion of Y plots in AWI sites (30%) as there are in GB as a whole (16%)

Table 9.13 Number of vegetation plots found in the AWI sites in CS2000 squares. GB represents the total number of plots in GB (including areas not woodland).

Plot Type	*GB*	*GB AWI*	*England*	*Wales*	*Scotland*
X	2787	93	49	11	33
B	1857	39	25	2	12
H	593	4	3		1
V	1258	39	16	2	21
R	860	23	10	1	12
W	1402	55	21	9	25
S	973	39	16	5	18
Y	2662	135	74	17	44
U	1479	10	4		6
A	552	1			1
D	2466	15	9	2	4

Table 9.14 The distribution of AWI sites in CS2000 sample squares by land class. CS2000 – number of squares surveyed in land class, % Total – percent of GB sample, AWI CS2000 – number of sample squares with AWI sites, % LC sample – percent of sample squares containing AWI sites in the land class, AWI area – average area of AWI sites in land class

LC	*CS2000*	*% Total*	*AWI CS2000*	*% LC sample*	*AWI area (ha)*
1e	30	5.27	13	43	12.86
2e	24	4.22	11	46	12.91
3e	30	5.27	6	20	8.18
4e	14	2.46	2	14	5.24
5e	6	1.05	3	50	19.56
6e	23	4.04	6	26	9.20
7e	16	2.81		0	
8e	10	1.76		0	
9e	22	3.87	7	32	22.17
10e	22	3.87	8	36	5.17
11e	22	3.87	2	9	44.67
12e	10	1.76	1	10	17.35
13e	10	1.76	2	20	3.54
15e	11	1.93	4	36	4.22
16e	15	2.64	4	27	5.99
17e	13	2.28	3	23	5.31
17w1	6	1.05	4	67	8.21
17w2	17	2.99	5	29	10.00
17w3	8	1.41	4	50	6.38
18e	12	2.11	4	33	4.28
19e	19	3.34	6	32	1.40
22e	11	1.93		0	
23e	6	1.05		0	
25e	8	1.41	2	25	11.90
7s	8	1.41	3	38	0.59
13s	8	1.41	4	50	26.50
18s	8	1.41	1	13	3.38
19s	7	1.23	2	29	2.30
21s	19	3.34	5	26	14.74
22s	19	3.34	5	26	14.93
23s	12	2.11		0	
24s	15	2.64	6	40	11.49
25s	19	3.34	10	53	14.36
26s	14	2.46	6	43	10.89
27s	15	2.64	3	20	10.54
28s	13	2.28	3	23	19.58
29s	11	1.93	3	27	19.21
30s	14	2.46		0	
31s	11	1.93		0	
32s	10	1.76		0	

67 Table 9.14 shows the distribution of sample squares with ancient woodland by land class. There is wide range of proportions, from absence from the land class sample (coastal, islands and extreme uplands) to occurrence in two thirds of the squares (67%). The highest is in land class 17w1 which is a marginal upland class found in Wales. The distribution across strata suggests

that the ITE Land Classification would be valuable if it were necessary to target samples within ancient woodlands under different environmental conditions, but the number of samples per land class would be different to that used in CS2000.

68 The average area of AWI woodland in land classes also shows wide variation, but the Scottish land classes (and sites) tend to have more extensive areas of woodland (29 ha per squares compared with 21 ha per square for both England and Wales).

69 Table 9.15 shows a GB estimate calculated from the AWI areas found in the CS squares. The area of AWI woodland in the three digital census coverages (labelled 'Total') lies within the 95% confidence intervals despite a considerable difference from the estimate.

Table 9.15 Estimate of extent of AWI woodland in GB using CS2000 sample sites and methods of estimation. Figures are in ha x 10^3

	Total	*Estimate*	*95% lcl*	*95% ucl*
GB	629	745	572	925

70 Table 9.16 shows the AWI areas found in the census datasets. The English division omits some of the woodland as the format of the different tiles within the dataset is not consistent. The breakdown shows considerable variation in the origin of the AWI, with the more extensive and exposed woodland in the uplands being more commonly ancient replanted woodland.

Table 9.16 Extent of AWI woodland in different countries. Figures are in ha x 10^3

	Ancient semi-natural woodland	*Ancient replanted woodland*	*Roy map*	*Total*
England	150	65		214
Wales	34	28		62
Scotland	148	188	17	353

71 The variation can be examined using the CS methodology estimates to examine the distribution across the environmental zones. EZ 3, the uplands of England and Wales, shows the most consistent estimate which probably relates to the common occurrence of AWI in Welsh squares. EZ 1 (eastern English lowlands) and EZ 6 (Scottish true uplands) show the most variable results, probably reflecting the discontinuous nature of their distributions.

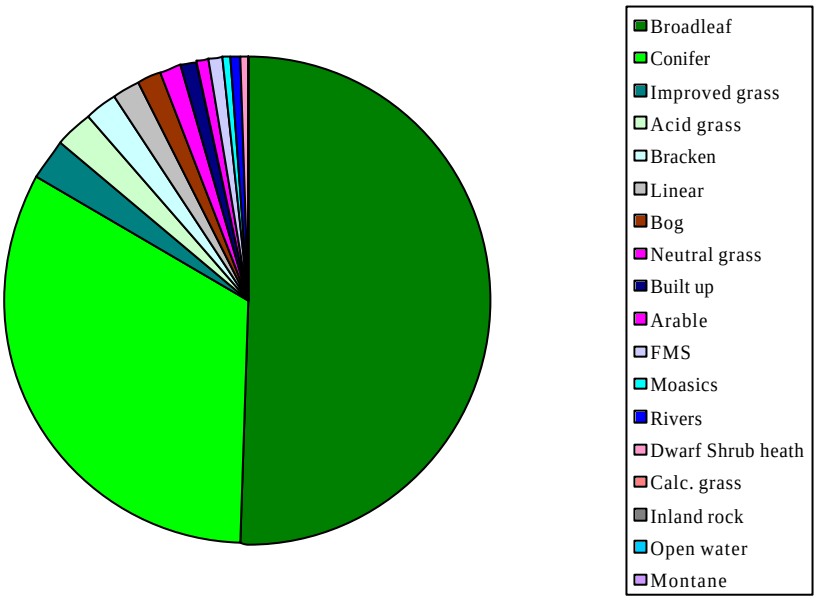
Table 9.17 Estimates of extent of AWI woodland in different Environmental Zones using CS2000 sample sites and methods of estimation. Figures are in ha x 10^3

	Estimate	*SE*	*95% lcl*	*95% ucl*
EZ 1	242	58	137	369
EZ 2	177	39	110	251
EZ 3	44	11	25	66
EZ 4	123	38	60	203
EZ 5	53	32	11	110
EZ 6	106	41	40	200

Agreement with field survey polygons

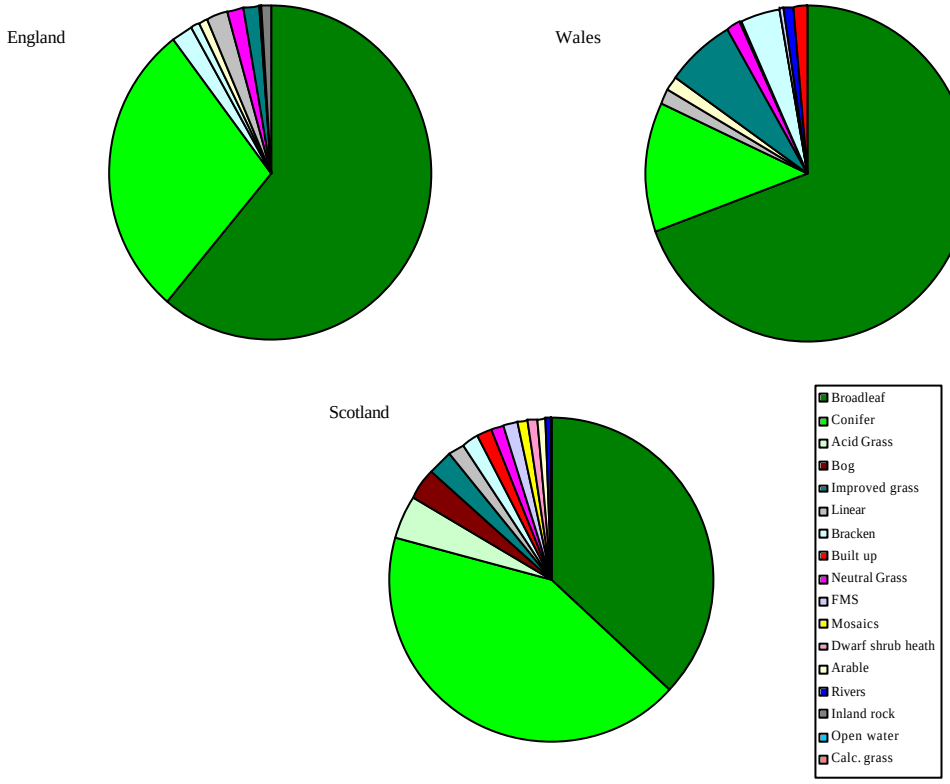
72 The results of a spatial overlay of the CS field squares and the three AWI census datasets are presented in Figures 9.7 – 9. 9. All figures show over 80% agreement between AWI land and the two woodland Broad Habitats. The mis-matches cover a wide range of habitats with none covering more than 5%. *Broadleaved, mixed and yew woodland* usually dominates at least 50% of the AWI sites even in the dataset describing plantation origin.

Figure 9.7 The composition, in terms of Broad Habitat area, of all AWI polygons in GB within CS field squares



73 Figure 9.8 shows the distribution for each of the individual national datasets. The Scottish data show the lowest agreement with *Broadleaved mixed and yew*, but an increased dominance of *Coniferous woodland.* This is reflected in the larger number and area of AWI sites of plantation origin to be found in Scotland and probably represents the Caledonian pinewoods. Wales shows the highest proportion of *Broadleaved, mixed and yew* and the lowest diversity of other Broad Habitats. This probably is the result of the types of AWI site found in Wales – generally small – and the small area of Wales compared to England or Scotland.

Figure 9.8 The composition, in terms of Broad Habitat area, of all AWI polygons presented by country (dataset) within CS field squares



74 Figures 9.9a and 9.9b show the distribution of Broad Habitats in the two types of AWI in England. The greater extent of *Coniferous woodland* in the Plantations on Ancient Woodland Sites is not as high as might initially be expected, but the use of high yielding conifer species only became popular in the 20th century.

Figure 9.9a The composition, in terms of Broad Habitat area, of England Plantations on Ancient Woodland Sites (PAWS) AWI polygons within CS field squares

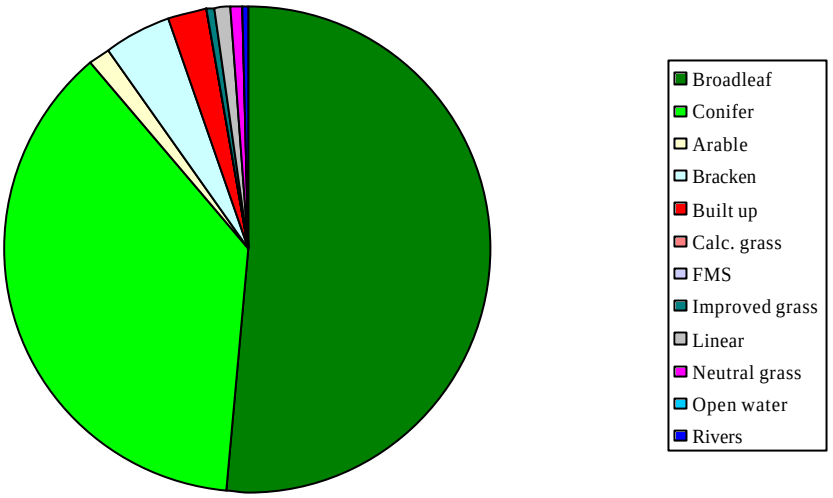


Figure 9.9b The composition, in terms of Broad Habitat area, of England Ancient Semi-Natural Woodland (ASNW) AWI polygons within CS field squares

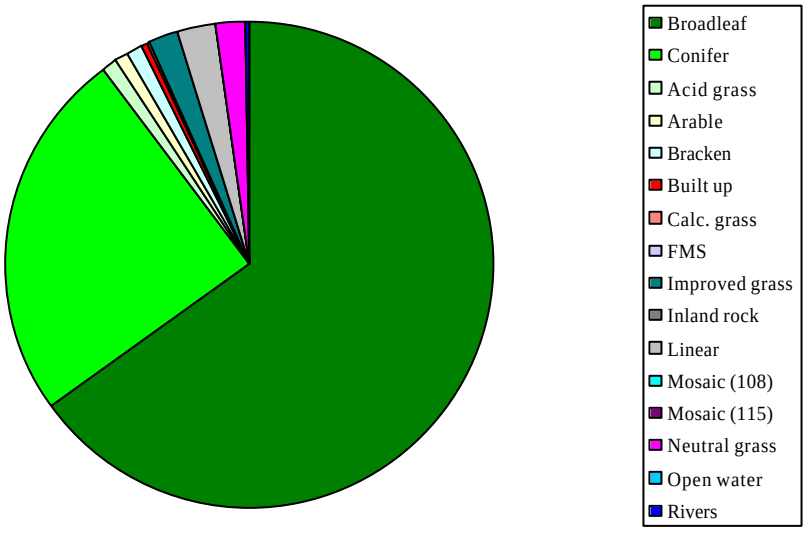


Table 9.18 The agreement between AWI sites and LCM2000 Broad Habitats and sub-categories. Figures are in ha x 10^3

Broad Habitat	*Sub-class*	*Code*	*England*	*Scotland*	*Wales*
Broadleaf, mixed and yew woodland		1.1	203	68	25
Coniferous woodland		2.1	53	155	14
Arable & horticultural	Cereals	4.1	10	5	1
	Horticulture/non-Cereal	4.2	18	11	1
	Non-annual crop	4.3	0	1	
Improved grass	Improved grass	5.1	25	20	10
	Setaside	5.2	3	0	0
Neutral grass	Rough grass	6.1	4	16	1
Calcareous grass		7.1	12	5	3
Acid grass		8.1	2	18	4
Bracken		9.1	1	4	0
Dwarf shrub heath	Dwarf shrub heath	10.1	1	23	1
	Open shrub heath	10.2	1	29	0
Fen, marsh & swamp		11.1	0	0	0
Bog		12.1	0	1	0
Standing open water		13.1	1	2	0
Montane		15.1		0	
Inland rock		16.1	1	2	0
Built up & gardens	Suburban	17.1	6	3	1
	Urban	17.2	2	1	0
Supra-littoral rock		18.1		0	
Supra-littoral sediment		19.1	0	0	0
Littoral rock		20.1	0	0	0
Littoral sediment	Littoral sediment	21.1	0	0	0
	Saltmarsh	21.2	0	0	0
Sea/estuary		22.1	0	0	0
Total			**341**	**363**	**62**

NB the English and Scottish data represents all polygons regardless of type

75 Table 9.18 shows the results of a spatial overlay of LCM2000 on the AWI sites. As with CS2000 FS the two woodland Broad Habitats dominate but only make up about two thirds (68%) of the area and the other habitats and sub-categories are produced by a variety of causes. The consequences of pixelation will produce mis-classifications and there may be problems with the geo-registration of the datasets (see Figure 9.4). The table suggests that English AWI sites occur in a matrix of arable and improved grass types, Scottish sites are surrounded by shrub heath and grassland types, while the Welsh sites are predominantly next to improved grassland.

Part (c) - Location and reasons for change

76 A number of lines of analysis have been pursued to address the questions of where the change is occurring, what are the characteristics of the parcels that have changed and how do they relate to the surrounding landscapes. In order to describe the geographic location of change, and the level of confidence that can be placed in it, it is necessary to first examine the distribution of stock.

77 One part of the analysis is to examine change at the level of counties and Scottish regions. FC publish statistics at this resolution describing stock and it is possible to subdivide Countryside Survey data into the same categories. Table 9.19 shows a correlation matrix for the county estimates from the three sources. All three datasets are highly correlated, but LCM2000 and NIWT are clearly closest.

Table 9.19 Correlation matrix of Countryside Survey Land Cover Map 2000 (LCM2000), field survey (FS) and Forestry Commission National Inventory of Woodland and Trees (NIWT)

	LCM2000	CS2000 Field Survey
CS2000 Field Survey	0.616	
FC NIWT	0.878	0.607

Cell Contents: Pearson correlation

78 The relationship can be examined in detail in the three plots presented in Figure 9.10. LCM2000 and NIWT show the tightest relationship, with NIWT usually under-estimating the LCM2000; this should not be due to differences in minimum mappable units as NIWT combines NIWD data with information from the Survey of Small Woods and Trees. CS2000 FS shows weaker relationships, but in both cases it tends to produce a higher values. The comparison between NIWT and CS2000 FS has just under 20% of the counties under-estimated by NIWT, this probably reflects the land class composition and sample distribution in CS2000.

79 Although it is technically possible to express CS2000 FS for counties, their relatively small areas gives little confidence in the estimates produced. CS2000 Module 9 is looking to integrate LCM2000 and CS2000 FS to allow presentation for areas smaller than counties. For this project, the counties have been amalgamated into the regions FCuse to report. The regions are amalgamations of counties and match the Government Office Regions (GOR) and European NUTS regions; with the exception of London produce areas that can be reported with greater confidence.

80 Table 9.20 gives the estimates for total woodland, *Broadleaf, mixed and yew woodland* and *Coniferous woodland* by region for 1998, along with their confidence intervals. Figure 9.11 shows the stock estimates in graphical format.

81 Change statistics are provided in Table 9.21. Total woodland appears to be relatively stable, with only two regions showing a significant change in area. However, only one of the regions shows an estimated loss while the rest all increase. When the woodland is broken into its two constituent parts, there are many more significant changes. In all regions the area of *Broadleaf, mixed and yew woodland* was estimated to increase and in only three regions was the estimate not statistically significant. Coniferous showed a much less dramatic change, with estimates showing both increases and decreases. However, the only four statistically significant results all showed a decline.

Figure 9.10 Woodland area by county from different sources NIWT, LCM2000 and CS2000 FS. Areas in hectares x 10^3

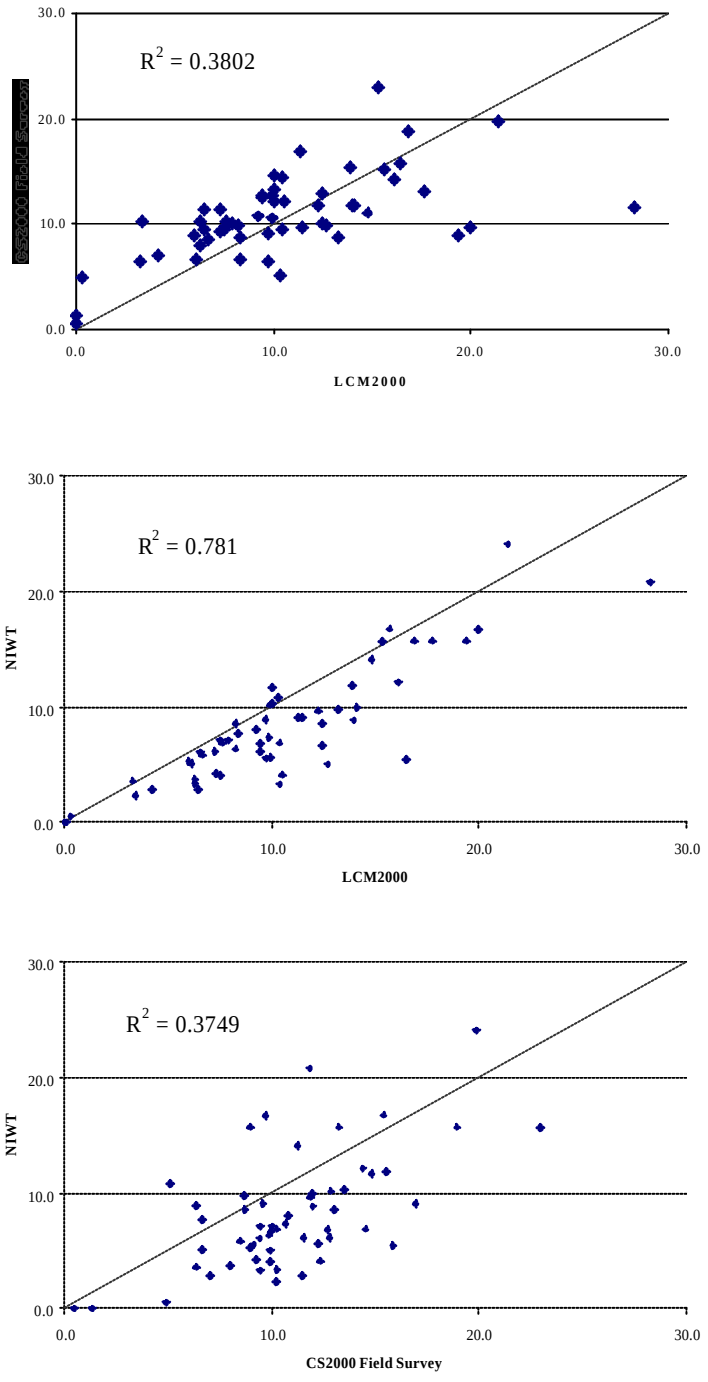


Table 9.20 Extent of woodland in Government Office Regions (and Wales/Scotland) estimated from CS2000 data. Areas in ha x 10^3, standard error (SE) calculated using parametric methods, 95% lower confidence limit (lcl) and upper confidence limit (ucl) calculated from 1000 bootstrapped estimates.

FC Region	*Estimate*	*SE*	*95% lcl*	*95% ucl*
All woodland (BH 1 and BH 2)				
North East	95	16	66	129
North West	125	12	103	152
Yorkshire and Humber	151	15	124	183
East Midlands	134	13	112	161
West Midlands	157	12	135	182
East of England	143	9	125	161
London	8	1	6	10
South East	184	10	163	208
South West	299	24	256	350
Wales	256	39	191	329
Scotland	1294	148	1023	1571
Broadleaf, mixed and yew woodland (BH 1)				
North East	46	6	36	59
North West	81	6	68	95
Yorkshire and Humber	107	10	89	128
East Midlands	111	10	93	133
West Midlands	126	9	109	147
East of England	131	8	115	147
London	7	1	5	9
South East	163	9	145	183
South West	224	13	200	249
Wales	174	26	132	224
Scotland	300	51	217	400
Coniferous woodland (BH 2)				
North East	49	15	23	81
North West	44	9	29	62
Yorkshire and Humber	43	10	26	66
East Midlands	23	5	15	33
West Midlands	30	6	19	44
East of England	12	2	8	16
London	1	0	0	2
South East	20	2	16	26
South West	75	17	48	119
Wales	82	32	33	149
Scotland	993	135	754	1249

Figure 9.11 Box and whisker plots of the extent of woodland in FC regions. Scotland is omitted for clarity of other figures. Area is in ha x 10^3

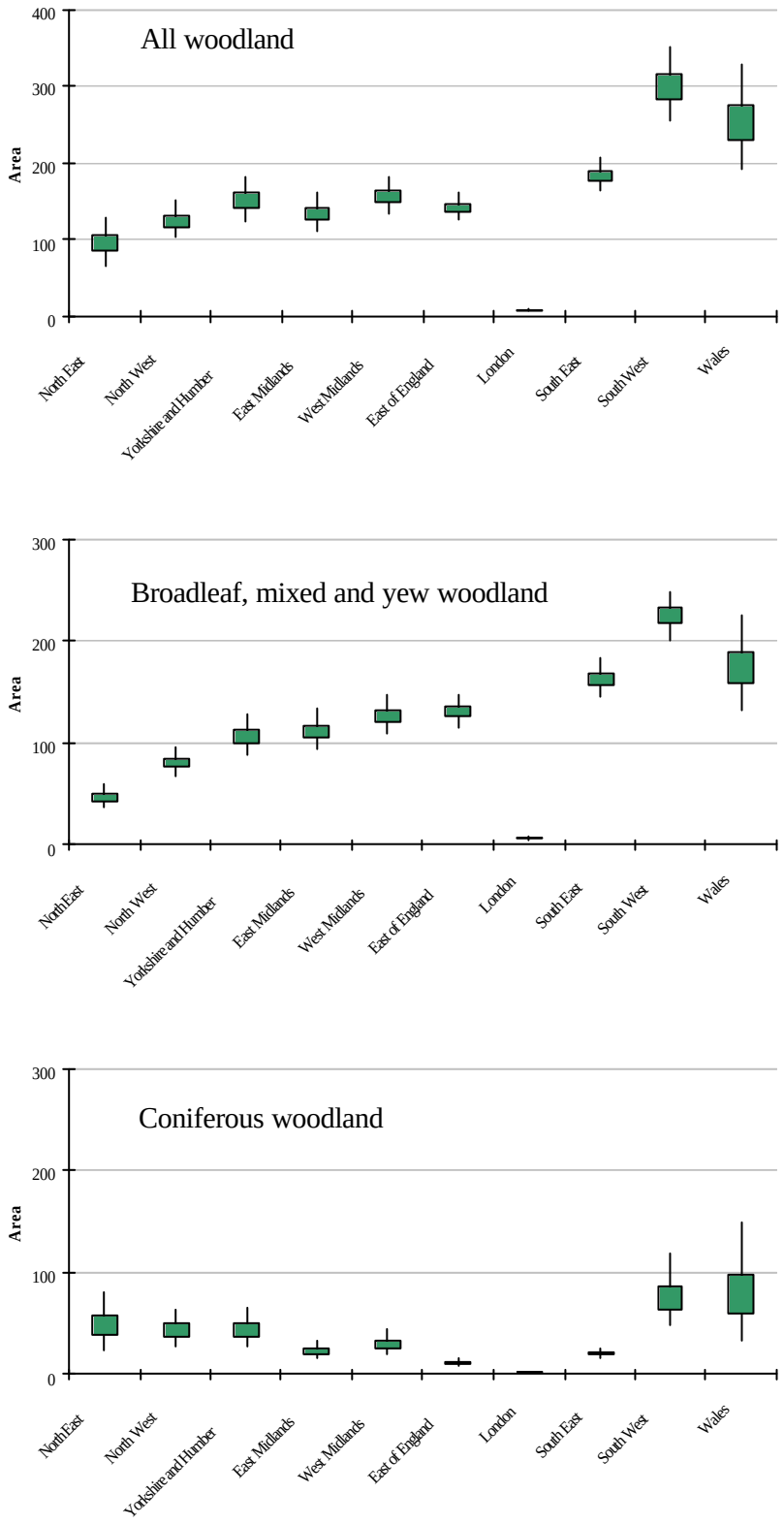


Table 9.21 Change in extent of woodland between 1990 and 1998 for Government Office Regions (and Wales/Scotland) estimated from CS2000 data. Areas in ha x 10^3, standard errors (SE) calculated using parametric methods, 95% lower confidence limit (lcl) and upper confidence limit (ucl) calculated from 1000 bootstrapped estimates. The significance (sig) and probability of change (p) are tested against a null hypothesis of no change.

FC Region	*Estimate*	*SE*	*95% lcl*	*95% ucl*	*sig*
All woodland (BH 1 and BH 2)					
North East	-1.1	2.1	-5.4	2.6	ns
North West	5.5	3.1	-0.4	12.1	ns
Yorkshire and Humber	2.1	2.2	-2.2	6.4	ns
East Midlands	0.5	4.4	-8.1	8.6	ns
West Midlands	3.9	1.5	1.2	6.8	**
East of England	4.3	1.6	1.1	7.3	**
London	0.1	0.1	-0.1	0.3	ns
South East	1.6	1.7	-1.7	5.1	ns
South West	2.6	2.6	-2.4	7.9	ns
Wales	6.6	4.0	-0.2	14.1	ns
Scotland	32.2	35.7	-31.0	98.7	ns
Broadleaf, mixed and yew woodland (BH 1)					
North East	2.7	1.3	0.4	5.2	*
North West	6.6	2.3	2.3	11.0	**
Yorkshire and Humber	5.1	2.0	1.4	9.4	**
East Midlands	3.1	3.9	-4.1	10.8	ns
West Midlands	4.5	1.5	1.6	7.8	***
East of England	3.8	1.4	0.9	6.5	**
London	0.2	0.1	-0.1	0.4	ns
South East	4.6	2.0	1.0	8.6	**
South West	5.7	2.5	1.4	10.9	*
Wales	6.3	3.8	-0.7	13.1	ns
Scotland	25.0	12.9	4.6	54.7	*
Coniferous woodland (BH 2)					
North East	-3.9	2.1	-8.0	-0.5	*
North West	-1.1	2.6	-6.1	3.4	ns
Yorkshire and Humber	-3.0	2.0	-7.5	0.0	*
East Midlands	-2.6	0.8	-4.4	-1.2	***
West Midlands	-0.6	0.5	-1.7	0.3	ns
East of England	0.5	0.5	-0.5	1.6	ns
London	-0.1	0.1	-0.3	0.1	ns
South East	-3.0	1.2	-5.8	-0.9	***
South West	-3.1	1.7	-6.5	0.1	ns
Wales	0.3	1.3	-1.9	2.7	ns
Scotland	7.3	32.5	-49.3	77.8	ns

82 Table 9.22 shows the changes derived from the CS2000 FS summarised as percentages of the CS1990 estimates. There is a clear trend towards expansion of *Broadleaf, mixed and yew woodland* at the expense of *Coniferous woodland* which matches the current policy toward woodland management. Figure 9.12 shows the changes graphically.

Table 9.22 The percentage change in area of woodland in Government Office Regions (and Wales/Scotland). Significant changes are shown in bold

	Woodland	***Broadleaf, mixed & yew***	***Conifer***
North East	-1.0	**6.8**	**-5.1**
North West	4.5	**9.1**	-2.1
Yorkshire and Humber	1.4	**5.3**	**-6.1**
East Midlands	0.4	3.0	**-11.1**
West Midlands	**2.6**	**3.7**	-2.1
East of England	**3.3**	**3.2**	4.6
London	0.8	2.2	-6.1
South East	0.9	**2.9**	**-12.2**
South West	0.9	**2.6**	-4.0
Wales	3.1	4.0	0.6
Scotland	2.6	**9.1**	0.8

83 The FC's own figures (Table 9.23) confirm the trend observed with all regions showing an increase in total woodland and reporting significant expansion of broadleaf area.

Table 9.23 Stock (1999) and change (1980 to 1995-1999) in Government Office Regions (and Wales/Scotland) areas in ha x 10^3

FC Region	***Stock***	***Change***	***Broadleaf increase (%)***
North East	103	8.1	51
North West	96	16.1	41
Yorkshire & Humber	92	6.6	18
East Midlands	80	11.2	40
West Midlands	98	16.4	43
East of England	139	26.0	52
London	6	-	-
South East	270	18.5	26
South West	212	36.9	44
Wales	287	45.0	80
Scotland	1281	360.0	68

Source: NIWT reports (2002)

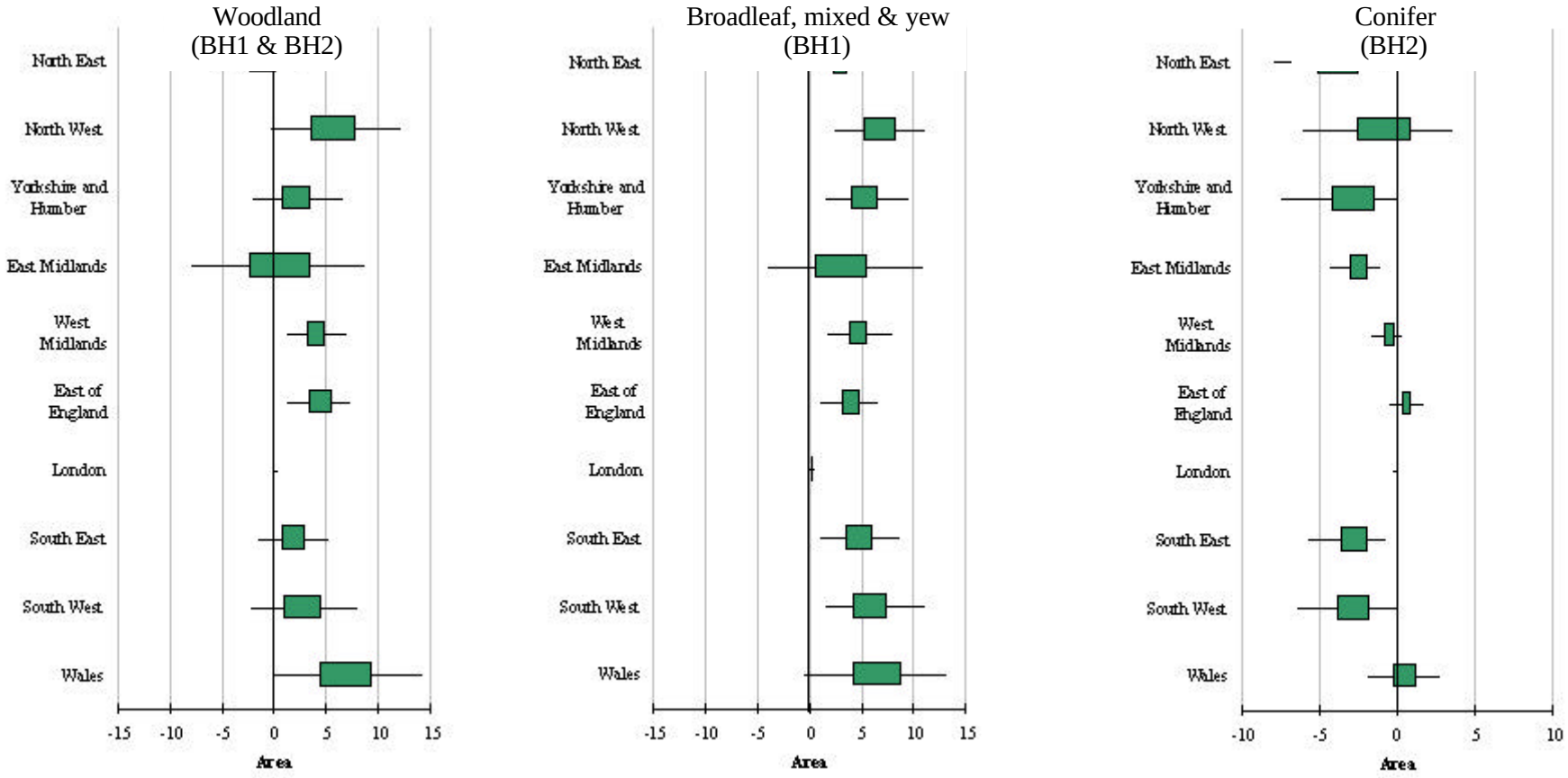


Figure 9.12 Change in extent of woodland are by FC region between 1990 and 1998. Area in ha x 10^3

84 One of the strengths of CS2000 FS is the ability to identify change in land cover in terms of source and destination. Tables 9.24 to 9.32 represent the generalised flows between broad cover types. The source (or cover in 1990) is presented as the rows and the destination (or cover in 1998) is the columns.

Table 9.24 Flow matrix for Great Britain between 1990 and 1998. Areas in ha x 10^3

	Developed land	***Intensive agri.***	***Marine***	***Semi-nat. veg***	***Water bodies***	***Woodland***
Developed land	1710	29	0	25	1	16
Intensive agriculture	73	10368	0	273	2	63
Marine	0	0	298	1	0	0
Semi-natural vegetation	43	337	0	6639	2	120
Water bodies	1	1	0	2	270	0
Woodland	18	31	0	90	1	2597

Table 9.25 Flow matrix for England and Wales between 1990 and 1998. Areas in ha x 10^3

	Developed land	***Intensive agri.***	***Marine***	***Semi-nat. veg***	***Water bodies***	***Woodland***
Developed land	1457	26	0	22	1	15
Intensive agriculture	69	8784	0	214	1	52
Marine	0	0	129	1	0	0
Semi-natural vegetation	25	238	0	2136	1	40
Water bodies	1	1	0	1	164	0
Woodland	14	22	0	45	1	1400

Table 9.26 Flow matrix for Scotland between 1990 and 1998. Areas in ha x 10^3

	Developed land	***Intensive agri.***	***Marine***	***Semi-nat. veg***	***Water bodies***	***Woodland***
Developed land	253	3	0	3	0	1
Intensive agriculture	4	1584	0	59	0	11
Marine	0	0	169	0	0	0
Semi-natural vegetation	18	99	0	4503	1	80
Water bodies	0	0	0	1	106	0
Woodland	4	10	0	45	0	1197

Table 9.27 Flow matrix for Environmental Zone 1 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	610	12	0	13	0	10
Intensive agriculture	29	4629	0	73	1	26
Marine	0	0	12	0	0	0
Semi-natural vegetation	11	42	0	186	0	11
Water bodies	1	0	0	0	96	0
Woodland	7	14	0	13	0	543

Table 9.28 Flow matrix for Environmental Zone 2 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	775	13	0	6	0	4
Intensive agriculture	36	3545	0	105	0	20
Marine	0	0	117	1	0	0
Semi-natural vegetation	12	113	0	529	0	21
Water bodies	0	1	0	0	34	0
Woodland	4	6	0	15	0	569

Table 9.29 Flow matrix for Environmental Zone 3 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	71	2	0	4	0	0
Intensive agriculture	4	609	0	36	0	6
Marine	0	0	0	0	0	0
Semi-natural vegetation	2	84	0	1421	0	7
Water bodies	0	0	0	1	34	0
Woodland	3	2	0	16	0	288

Table 9.30 Flow matrix for Environmental Zone 4 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	172	2	0	2	0	1
Intensive agriculture	4	1120	0	35	0	9
Marine	0	0	8	0	0	0
Semi-natural vegetation	9	33	0	525	0	20
Water bodies	0	0	0	0	12	0
Woodland	2	9	0	11	0	260

Table 9.31 Flow matrix for Environmental Zone 5 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	52	1	0	1	0	0
Intensive agriculture	0	386	0	20	0	1
Marine	0	0	161	0	0	0
Semi-natural vegetation	7	45	0	1558	0	30
Water bodies	0	0	0	0	43	0
Woodland	1	1	0	6	0	401

Table 9.32 Flow matrix for Environmental Zone 6 between 1990 and 1998. Areas in ha x 10^3

	Developed land	*Intensive agri.*	*Marine*	*Semi-nat. veg*	*Water bodies*	*Woodland*
Developed land	29	0	0	1	0	0
Intensive agriculture	0	78	0	4	0	0
Marine	0	0	0	0	0	0
Semi-natural vegetation	2	21	0	2420	0	30
Water bodies	0	0	0	0	51	0
Woodland	1	0	0	28	0	536

85 The tables show that woodlands main exchanges were with intensive agriculture and semi-natural vegetation with a net gain from both categories at a GB level. In England and Wales, there was a net loss of woodland to semi-natural vegetation, but a greater gain from intensive agriculture. In Scotland there was a larger gain from semi-natural vegetation than from

intensive agriculture. The semi-natural vegetation will include some of the ground prepared for planting which is included in the FC figures as it is part of forestry as a land use.

86 The trends across the zones shows the movement in England and Wales to be in the two lowland zones (EZ 1 and EZ 2) where there is a shift from intensive agriculture. The major net change in the Scottish zones was from semi-natural vegetation in EZ 5, but similar sizes of shift could be seen in both directions in EZ 6. These figures match the FC data presented in Table 9.3 that show the greatest area of ground prepared for planting to be in these two zones.

87 It is possible to break the large categories down further into there constituent Broad Habitats. The movements into and out of the woodland categories are shown in tables 9.33 to 9.41. The largest net gain in *Broadleaf, mixed and yew woodland* across Britain was from Arable and horticultural and the movement was strongly directional. There were marked gains from Improved grass and Neutral grass, but these were counterbalanced, to some extent, by a flux in the opposite direction. Table 9.30 shows most Broad Habitats as donors to *Broadleaved, mixed and yew* but two categories (Boundaries and linear features and Fen, marsh and swamp) show some small gains. There is conversion of *Coniferous woodland* to *Broadleaf, mixed and yew*.

88 The shifts in *Coniferous woodland* across GB (table 9.31) show gains from Dwarf shrub heath and Bog with movement to Acid grassland. The largest loss is to *Broadleaved, mixed and yew woodland*, again reflecting the current trends in forestry policy. The figures for England and Wales (tables 9.31 and 9.33) show the change between woodland Broad Habitats to be more important for Conifer than Broadleaf.

89 The movements in the Scottish zones show an interesting division between the donors to *Coniferous woodland.* In EZ 5 the major sources were Bog and Dwarf shrub heath in EZ 6 the gains were all made at the expense of Dwarf shrub heath. Acid grassland was created from *Coniferous woodland* in EZ 6 while existing Acid grassland was converted into Broadleaf woodland. In EZ 5 *Coniferous woodland* was created out of Acid grassland, but there were no flows between Acid grassland and *Broadleaf, mixed and yew woodland.* The flows suggest that poorer land for silviculture (Bog and Dwarf shrub heath) that is wetter and nutrient poor is more likely to remain under coniferous cover, while the better, drier land (Acid grassland) will be replanted with broadleaves.

Table 9.33 Flow matrix into and out of woodland between 1990 and 1998 in Great Britain. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	1277	1277	27	13
Coniferous woodland	13	27	1280	1280
Boundary and linear features	3	0	3	1
Arable and horticultural	4	27	1	2
Improved grassland	18	26	8	8
Neutral grassland	11	22	6	2
Calcareous grassland	1	1	0	0
Acid grassland	10	15	19	9
Bracken	8	15	2	7
Dwarf shrub heath	4	4	6	20
Fen, marsh, and swamp	7	4	9	2
Bogs	1	3	6	15
Standing open water & canals	1	0	1	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	1	0	1	1
Built up areas and gardens	9	14	1	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.34 Flow matrix into and out of woodland between 1990 and 1998 in England and Wales. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	1019	1019	20	10
Coniferous woodland	10	20	351	351
Boundary and linear features	2	0	3	0
Arable and horticultural	3	26	1	1
Improved grassland	17	21	1	4
Neutral grassland	10	17	3	1
Calcareous grassland	1	1	0	0
Acid grassland	6	3	2	0
Bracken	6	10	1	5
Dwarf shrub heath	2	0	1	1
Fen, marsh, and swamp	5	1	5	0
Bogs	1	0	3	0
Standing open water & canals	1	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	1
Built up areas and gardens	8	14	1	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.35 Flow matrix into and out of woodland between 1990 and 1998 in Scotland. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	258	258	7	4
Coniferous woodland	4	7	929	929
Boundary and linear features	1	0	0	1
Arable and horticultural	1	2	0	0
Improved grassland	2	5	7	4
Neutral grassland	1	5	3	1
Calcareous grassland	0	0	0	0
Acid grassland	4	12	18	8
Bracken	2	5	1	2
Dwarf shrub heath	2	4	5	20
Fen, marsh, and swamp	2	3	4	2
Bogs	1	3	3	15
Standing open water & canals	0	0	1	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	1	0	1	0
Built up areas and gardens	1	1	1	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.36 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 1. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	475	475	9	1
Coniferous woodland	1	9	58	58
Boundary and linear features	1	0	0	0
Arable and horticultural	3	20	0	1
Improved grassland	10	5	1	1
Neutral grassland	6	8	0	1
Calcareous grassland	1	1	0	0
Acid grassland	1	0	0	0
Bracken	3	1	1	0
Dwarf shrub heath	0	0	1	0
Fen, marsh, and swamp	2	0	0	0
Bogs	0	0	0	0
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	0
Built up areas and gardens	5	10	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.37 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 2. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	418	418	6	2
Coniferous woodland	2	6	143	143
Boundary and linear features	1	0	0	0
Arable and horticultural	1	5	0	1
Improved grassland	5	11	0	3
Neutral grassland	3	8	2	0
Calcareous grassland	0	0	0	0
Acid grassland	2	0	0	0
Bracken	2	7	0	4
Dwarf shrub heath	2	0	0	1
Fen, marsh, and swamp	2	1	0	0
Bogs	0	0	0	0
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	1
Built up areas and gardens	3	3	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.38 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 3. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	126	126	6	7
Coniferous woodland	7	6	150	150
Boundary and linear features	0	0	3	0
Arable and horticultural	0	1	0	0
Improved grassland	2	5	0	0
Neutral grassland	1	1	1	0
Calcareous grassland	0	0	0	0
Acid grassland	2	3	2	0
Bracken	1	2	0	0
Dwarf shrub heath	1	0	1	0
Fen, marsh, and swamp	1	0	5	0
Bogs	0	0	3	0
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	0
Built up areas and gardens	0	0	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.39 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 4. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	98	98	2	2
Coniferous woodland	2	2	158	158
Boundary and linear features	1	0	0	0
Arable and horticultural	1	1	0	0
Improved grassland	1	4	7	3
Neutral grassland	1	3	1	1
Calcareous grassland	0	0	0	0
Acid grassland	2	1	1	3
Bracken	0	3	0	2
Dwarf shrub heath	0	4	1	1
Fen, marsh, and swamp	1	1	2	0
Bogs	0	1	2	1
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	1	0	0	0
Built up areas and gardens	0	1	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

Table 9.40 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 5. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

	Broadleaf		***Conifer***	
Broad Habitat	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	64	64	3	1
Coniferous woodland	1	3	332	332
Boundary and linear features	0	0	0	0
Arable and horticultural	0	0	0	0
Improved grassland	1	1	0	0
Neutral grassland	0	1	0	0
Calcareous grassland	0	0	0	0
Acid grassland	1	0	1	5
Bracken	0	1	0	0
Dwarf shrub heath	0	0	2	6
Fen, marsh, and swamp	0	2	0	0
Bogs	0	1	1	14
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	0
Built up areas and gardens	1	0	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

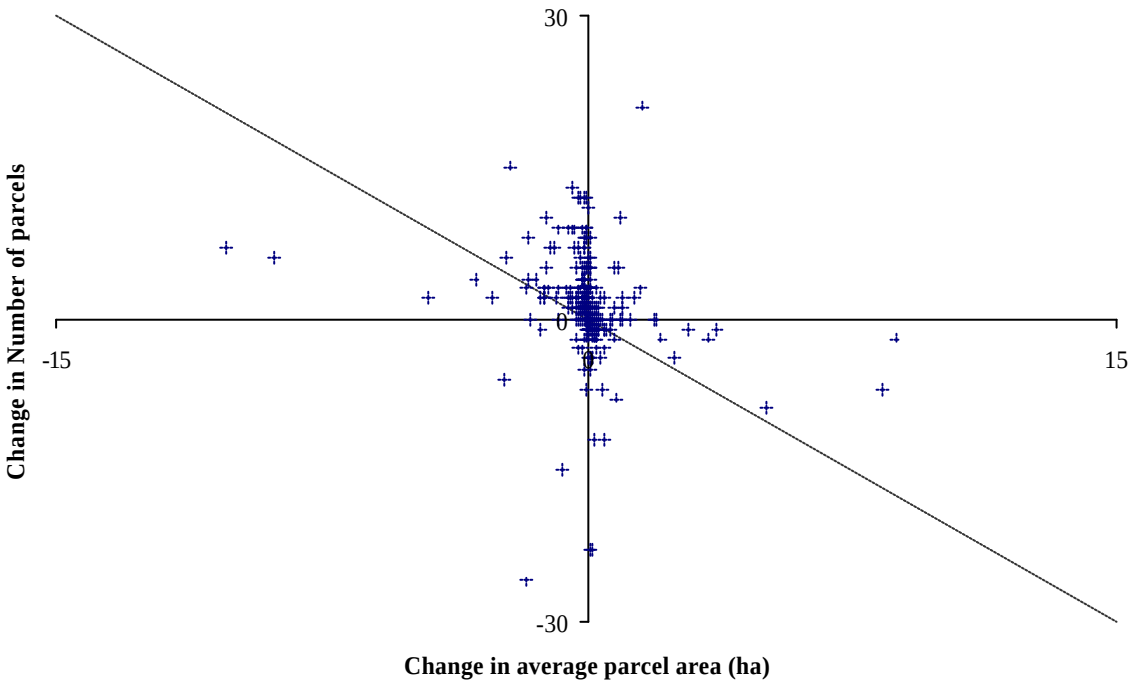
Table 9.41 Flow matrix into and out of woodland between 1990 and 1998 in Environmental Zone 6. 'Into' shows what 1990 woodland became, 'Out of' where 1998 woodland came from. Areas in ha x 10^3

Broad Habitat	***Broadleaf***		***Conifer***	
	Into	Out of	Into	Out of
Broadleaved, mixed & yew woodland	95	95	1	0
Coniferous woodland	0	1	439	439
Boundary and linear features	0	0	0	0
Arable and horticultural	0	0	0	0
Improved grassland	0	0	0	0
Neutral grassland	0	0	2	0
Calcareous grassland	0	0	0	0
Acid grassland	2	11	15	0
Bracken	2	2	1	0
Dwarf shrub heath	1	0	2	13
Fen, marsh, and swamp	1	0	2	2
Bogs	0	1	1	0
Standing open water & canals	0	0	0	0
Rivers and streams	0	0	0	0
Montane habitats	0	0	0	0
Inland rock	0	0	0	0
Built up areas and gardens	0	0	0	0
Supra-littoral rock	0	0	0	0
Supra-littoral sediment	0	0	0	0

90 The changes in woodland can interpreted in terms of different types of process. If the dataset is examined using woodland parcels, rather than simple area, the changes in landscape structure can be identified. Parcels of woodland were generated by combining all adjacent woodland pieces irrespective of their history or type (BH 1 or BH 2). Looking at the changes between 1984 and 1998 to maximise the change, the type of change can be identified by comparing the number of parcels within a square to their average area (Figure 9.13). The hashed line on the figure divides squares that have lost woodland (in the bottom left hand corner) from those that have gained (top right). As already described there has been an increase in woodland in that time and so most of the points lay in the top right hand half. If the losses and gains were by expansion or contraction of existing parcels then the values would be expected to spread along the abscissa. Instead, the spread is greater along the y-axis suggesting that the changes are greater through gains and losses of parcels.

91 Two squares were omitted from the figure to improve the clarity of the other information. One square had a single large woodlot in 1984 that had been divided by a track producing many small polygons, the other had been planted up de-fragmenting several small polygons producing a large change in average parcel area.

Figure 9.13 The relationship between changes in number and area of parcels in sample squares between 1984 and 1998



92 Identifying the changes as events, the relative occurrence can be identified by counting the number of times they occur in a square. The gain of new parcels (proliferation) and complete loss of existing parcels (attrition) can be compared with cases where a parcel has grown in area (expansion) or contracted (shrinkage). Fragmentation and de-fragmentation are a subset of shrinkage and expansion. The results, weighted for GB, countries and zones are presented in Table 9.42 and Table 9.43.

Table 9.42 The relative occurrence of different processes related to parcel change between 1984 and 1998. Values indicate number of events and area per 1 km square.

		England and Wales			Scotland		
		Easterly Lowlands	Westerly Lowlands	Uplands	Lowlands	Intermediate Uplands and Islands	True Uplands
No process	Occurrences	4.3	5.9	2.5	5.2	1.8	1.5
	Area	2.3	3.2	1.4	3.1	1.2	6.1
Proliferation	Occurrences	1.8	2.5	3.1	2.9	0.4	0.2
	Area gained	0.7	0.5	0.7	0.8	0.1	0.3
Attrition	Occurrences	0.9	1.2	1.0	1.3	0.4	0.3
	Area lost	0.3	0.4	0.1	0.2	0.1	0.1
Expansion	Occurrences	1.5	2.4	2.8	2.2	1.4	1.1
	Area gained	0.8	0.7	0.5	2.5	2.4	1.5
Shrinkage	Occurrences	1.5	1.8	2.4	1.9	2.0	1.1
	Area lost	0.5	0.4	0.7	0.7	0.3	0.6

93 It can be seen that proliferation is generally twice as common as attrition, although in the two Scottish zones (EZ 5 and EZ 6) the two processes occur with approximately equal frequency. Expansion and shrinkage are approximately balanced, but once again EZ 5 and EZ 6 differ, showing more shrinkage than expansion. Fragmentation is the result of about one in ten shrinkage events, while de-fragmentation is about twice as common and produced by one in five expansions.

Table 9.42 The relative occurrence of fragmentation and de-fragmentation between 1984 and 1998. Values indicate average number of parcels before (n_i) and after (n_f) each event per 1 km square.

		England and Wales			Scotland		
		Easterly Lowlands	Westerly Lowlands	Uplands	Lowlands	Intermediate Uplands and Islands	True Uplands
Fragmentation	n_i	0.1	0.1	0.2	0.2	0.1	0.2
	n_f	0.5	0.5	0.8	0.8	0.3	0.6
Defragmentation	n_I	0.7	0.9	0.6	1.2	0.6	0.3
	n_f	0.1	0.2	0.1	0.3	0.1	0.1

94 These figures represent complex changes within squares and do not carry any weighting for parcel area. Fragmentation and de-fragmentation cannot be split from expansion and shrinkage as potentially all four processes can occur on one parcel – and several times. However, the analysis does suggest that woodland management differs between the zones. Zones one to four show the creation and loss of parcels to be a more common process than in zones five and six and the latter zones both show more loss processes than gains. However, this does not mean that EZ 5 and EZ 6 are loosing woodland, in fact both gained woodland area. It suggests that the processes represent larger areal effects and probably reflects the reduced pressures coming from other land uses.

SUMMARY

95 The project has acquired and co-registered several GIS datasets describing woodlands in Britain. Comparisons have been made between the datasets to address the three sub-questions posed within the project.

Part (a) - Differences in estimates

96 Although the estimates of woodland extent differ between CS2000 FS, LCM2000 and the NIWT, they does not appear to be any significant difference between the GB estimates of stock when the constraints imposed by different methodologies are taken into account. The agreement, in terms of major woodland types, is over 70% for all NIWD types compared to the two woodland Broad Habitats. The agreement between the individual woodland Broad Habitats is not as good. A number of factors need to be taken into account when comparing the figures, these include definition of terms and units, methodology (both collection and analysis), different times of data collection and accuracy. However, at a local scale there is poor co-registration of information between LCM2000 and the other two datasets.

97 CS2000 FS methodology has been tested using NIWD data and shown to be an unbiased method of producing national statistics. The definition of reporting categories are crucial when comparing statistics so that forestry, a land use including felling, restocking and open space is not simply equated with woodland as a land cover.

Part (b) - Correspondence with Ancient Woodland Inventory sites

98 Just over a quarter of the field squares surveyed in CS2000 contained areas of woodland identified in the Ancient Woodland Inventory (AWI). This is considerably higher than the percent land cover by AWI (just over 3% for all types). A higher proportion of Welsh CS squares contained AWI than the other two home nations. The CS2000 FS methodology was less effective at reproducing the AWI statistics, but still produced estimates whose confidence intervals included the 'truth'. Overlays with CS2000 FS Broad Habitat maps and LCM2000 Broad Habitats and sub-categories show moderate agreement.

Part (c) - Location and reasons for change

99 Change matrices for Broad Habitats show how woodland has changed with respect to other cover types. The processes of change have been identified as attrition, proliferation, expansion, contraction, fragmentation and de-fragmentation. As events, the processes are quite common with one event per square on average every five years. However, the events tend to occur commonly in the same squares and do not reflect changes in woodland area.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

Improvement of agreement with FC and AWI datasets

100 The fine scale disagreement between datasets means that currently the obvious approach would be subjective matching of polygons between datasets. One risk in doing this is if the datasets are changed, the same process must be repeated. As far as the CS field information, it could create problems as the surrounding information would then also need to be reinterpreted. An option that is now available to all three datasets is to use the new Ordnance Survey MasterMap linework. It is a major undertaking for all three datasets, but would then set the information on a footing that would allow it to be integrated with a number of other mapped datasets.

Estimates of habitat volume, canopy structure and density

101 Woodland varies in extent in three dimensions with height varying more than other habitats; the characteristic is important for both single species and community ecology. Woodland volume is important not only for resource estimation (using techniques such as breast height diameters and timber volume tables) but also to quantify habitat. LIDAR and laser reflections can provide estimates of crown height and ground levels (discrete record) or canopy structure (analogue record). Correction factors for different species may be needed to adjust for their reflectance properties. Properties of canopy structure and density are modified by a number of properties (species, management, age, etc.) and are important in quantifying characteristics such as carbon content. Methods of combining LIDAR and field survey, cost effectiveness and ease of capture, additional field observations and accuracy need to be investigated.

Quantification of biodiversity value (published guidelines)

102 Guidelines have been published on recording woodland components that are indicative of biodiversity value. The component list should be examined and critically assessed for inclusion (in part) in the next survey.

Record of woodland management history

103 Some information can only be recorded by either direct questioning or interrogation of other (digital) dataset Grant support (e.g. Farm Woodland Grant). Planting and felling dates may be useful in interpreting change.

Identification of land under forestry management (whether or not it has trees)

104 Using existing ownership information along with maps from previous visits it may be possible to label parcels with there land use rather than simply their land cover. This would only work with owners and managers whose primary objective is forestry, woodlots on farmed land may still prove problematical.

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ANNEX 1

LCM2000

Land Cover Map 2000 (LCM2000) records 27 classes of land cover, on a field-by-field scale, with a minimum mappable unit of 0.5 ha, throughout the UK. Spatial segmentation of satellite images provided a structured picture of the landscape with 'vector' polygons delineating land parcels, treated as 'objects' in a geographical information system. The cover in each land parcel was distinguished using the spectral reflectance data, with additional knowledge-based corrections. Each land parcel carries information about its size, shape, source data, spectral character, lineage, land cover in or around 1998 and a measure of heterogeneity.

LCM2000 records two broad categories of woodland at its Target and Subclass levels which are equivalent to Broad Habitat class (Table 9.1.1). The Subclasses are further divided into Variants giving more thematic detail, but with a reduced accuracy.

Table 9.1.1 LCM2000 classes related to woodland.

BROAD HABITAT	*LCM2000 TARGET & SUBCLASS*	*VARIANTS*
1. Broad-leaved, mixed and yew woodland	Broad-leaved / mixed woodland	Deciduous Mixed Open birch Scrub
2. Coniferous woodland	Coniferous woodland	Conifers Felled New plantation

ANNEX 9.2

Definitions from the English Nature Website

Ancient Woodland.

Land that has had continuous woodland cover since at least 1600AD and may be:

Ancient Semi-natural woodland.
Ancient woodland sites that have retained the native tree and shrub cover that has not been planted, although it may have been managed by coppicing or felling and allowed to regenerate naturally.

Ancient Replanted Woodland.

Ancient woodland sites where the original native tree cover has been felled and replaced by planting, usually with conifers and usually this century.

The Ancient Woodland Inventory for England

The inventory identifies over 22,000 ancient woodland sites in England. Ancient woodland is identified using presence or absence of woods from old maps, information about the wood's name, shape, internal boundaries, location relative to other features, ground survey, and aerial photography. The information recorded about each wood and stored on the Inventory Database includes its grid reference, its area in hectares, how much is semi-natural or replanted, whether any of the wood has been cleared (since 1920 approx), public ownership details where known, and any conservation status. Prior to the digitisation of the boundaries, only paper maps depicting each ancient wood at 1:50,000 scale were available.

Limitations of the Ancient Woodland Inventory.
Only Ancient Woodland Sites that were over 2ha on the 1920's Base Maps are Included on the Inventory Some of these may now be less than 2ha because of subsequent clearance. Woods that were less than 2ha on the base maps are not included even though some of these are ancient. The inventory is classed as "provisional" because it is under a constant system of review and update as new information is received or actual changes are recorded. If you have information that would help us to update the inventory please let us know.

Digital Data Coverage
All existing sites recorded on the Inventory Database have been digitised. Two types of boundaries are depicted: those for semi-natural ancient woodland and those for replanted ancient woodland.

Data Structure
The digital woodland boundaries and a unique identification number for each site are held in a digital graphics database along with other information calculated via the GIS such as grid reference, total area, semi-natural and replanted areas. A wood may have several component parts or polygons, but the same identification number. This unique identification number allows further information about the wood to be retrieved from the Inventory Database. There may be discrepancies between the area figures associated with the digital boundaries and those previously recorded on the Inventory Database. Such discrepancies relate to the methods used to calculate areas: digital versus manual, respectively.

Scale of Data Capture.
The ancient woodland boundaries were digitised at 1:25000 scale. The boundaries will therefore only be precisely comparable with other boundaries at this scale.

Important fields in the dataset:

Field	*Contents*
aw_total_area	The total area in hectares of each site
aw_semi_nat_area	The semi-natural area of a site in hectares.
aw_replanted_area	The replanted area of a site in hectares.
p_wood_type	Whether that part of a woodland site is semi-natural or replanted.
p_semi_nat_area	The area of that semi-natural polygon in hectares.
p_replanted_area	The area of that replanted polygon in hectares.

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