SECTION 7

Estimation of UK Deforestation Rates

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Peter Levy, Ronnie Milne
Centre for Ecology and Hydrology, Edinburgh, U.K.

Summary
Estimates of the UK deforestation rate are required for reporting under the UNFCCC GHG Inventory and the Kyoto Protocol. The only direct record of deforestation is provided by FC Felling Licences, which give a value of ~500 ha y^{-1} for recent years. This is likely to represent an absolute minimum, as most felling is unlicensed. The deforestation rate can be estimated indirectly by constructing a forest area budget, assuming deforestation is the residual term remaining after the observed change in forest area is subtracted from the recorded area of newly planted forest. The total forest area recorded in FC Facts & Figures cannot be used, as it is an estimate partly based on the new planting data, so it's use would be circular. Independent estimates of the total GB forest area can be obtained from the FC Woodland Census, the National Inventory of Woodland & Trees, and the Countryside Survey. An additional independent source of estimates of the total Scottish forest area is provided by the National Countryside Monitoring Scheme (NCMS). The observed increase in total area in these data does not differ significantly from the recorded planting rate, and a statistically significant deforestation rate is not detectable.

An alternative approach is to use national survey schemes, in which repeated surveys of land use are made in a set of permanent plots. Deforestation rate can be calculated as the sum of transitions from all forest classes to all non-forest classes. Both the NCMS and the Countryside Survey can be used in this way. The NCMS survey can be scaled to give a GB deforestation rate of ~1000 ha y^{-1}, whilst the Countryside Survey gives a value of ~20000 ha y^{-1}. The NCMS value is thought to be more reliable, as the afforestation rate estimatd in this way agrees closely with FC figures, whilst the Countryside Survey overestimates afforestation by a factor of ~2. Various possible reasons for this discrepancy are discussed, including the effect of minimum plot size and methodological differences such as the urban: rural bias in the sampling design. In the absence of better information, our best estimate of the GB deforestation rate is 1000 ha y^{-1}, based on the NCMS Scottish data.

Introduction

Estimates of national afforestation, reforestation and deforestation rates from 1990 are required for preparing greenhouse gas inventories for the UNFCCC. In the U.K., afforestation and reforestation rates have been recorded by the Forestry Commission since the 1920s. However, deforestation rates have never been recorded, and have previously been assumed to be negligibly small. Whilst this may be the case, there is now a need to explicitly quantify the deforestation rate. Here, we examine whether this is feasible using existing sources of data.

Potentially useful data are available from various sources, including:

- **Forestry Commission (FC)**
  - *Felling Licenses*
  - *Annual Report 'Facts & Figures'*
  - *Woodland Census*
  - *National Inventory of Woodland & Trees*
- **CEH Countryside Survey**
  - *1984, 1990, 1998*
- **SNH National Countryside Monitoring Scheme ((Mackey et al. 1999)) Scotland only**
  - *1940s & 1980s*

Felling Licenses

Felling Licenses are issued by the Forestry Commission, where applications are made to fell areas for timber production but without a plan to replant. These provide the only existing direct measure of deforestation, and yield a value of ~500 ha y^{-1} in recent years. However, it is widely recognised that this represents an absolute minimum value, as much unlicensed felling occurs, either in areas small than the threshold, or simply because a license is not sought. This is specifically likely to be the case for building development.

Forest Area Budget – i. FC Facts & Figures

In the absence of direct data, some method for indirectly inferring the deforestation rate from other records is required. The simplest method is to infer deforestation from a budget of the total forest are, ie:

Change in Forest Area = New Planting – Deforestation. [1]

Data for both new planting (afforestation) and the change in total forest area are published annually in an appendix to the FC Annual Report, 'Facts & Figures', so by simple rearrangement, we can estimate the deforestation rate as:

Deforestation = New Planting - Change in Forest Area. [2]

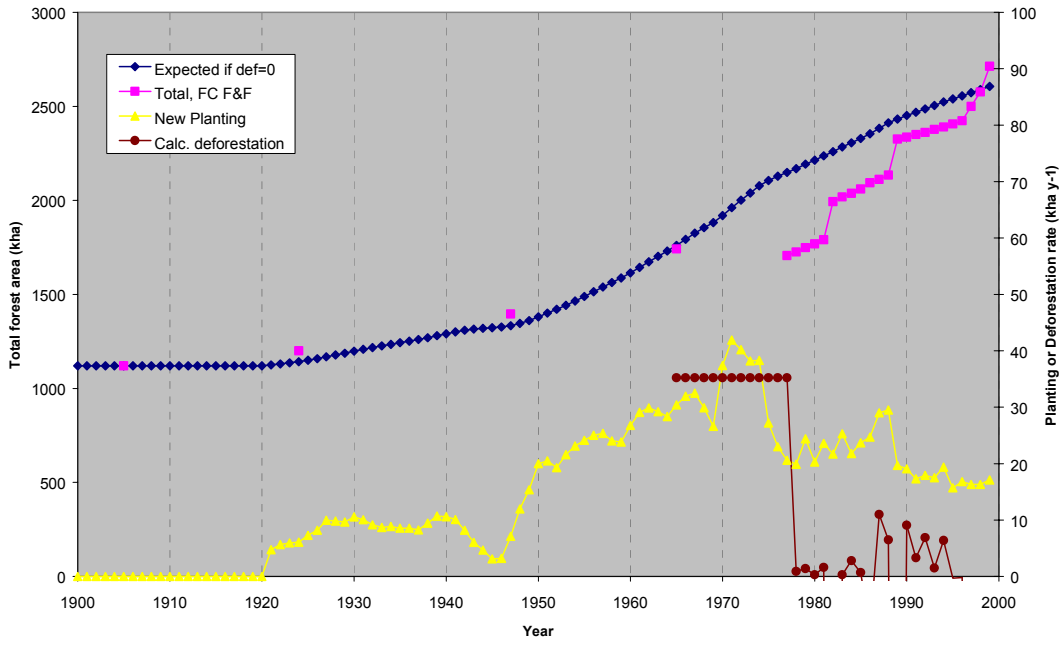

Fig.ure 1. GB Forest area budget from FC 'Facts & Figures', showing the recorded total forest area (pink) and new planting rate (yellow). Calculated from these data are the deforestation rate (brown, eqn 2) and the expected total area if there is no deforestation (blue, eqn 1).

Figure 1 shows that the deforestation rate calculated in this way is extremely variable. The highest values of 35000 ha y^{-1} occur where there is a step change in the estimate of total forest area. These can be discounted, as they are a result of updates to the baseline after each census. The remaining deforestation rate values, from 1977 onward, range from 0 to 12000 ha y^{-1}, with some negative values where recorded new planting is less than the increase in forest area (not shown). Discounting the negative values gives a mean of ~3000 ha y^{-1}.

There are several problems with this method. The accuracy of the deforestation rate estimate depends on the records of new planting and total area, as all the error is combined in the deforestation rate term. More critically, the records of new planting and total area are not independent in FC 'Facts & Figures' data. Although total forest area is measured periodically in a census, the annual figures are updated using an algorithm which uses the new planting data. Thus, the logic behind Equation 2 becomes circular.

Forest Area Budget – ii. Other GB data sources

A second way to apply the same approach is to use the same data for new planting from FC 'Facts & Figures' but to use independent estimates of total forest area. This overcomes the problem of circularity, though independent estimates of total forest area are only available at approximately decadal frequency (rather than annual). GB Data are available from FC Woodland Census (1940, 1965, 1980 (Smith 2001)), the National Inventory of Woodland & Trees (Forestry Commission 2000), and the Countryside Survey (Barr 1993; Haines-Young 2000; Haines-Young et al. 1996, Fig 2a).

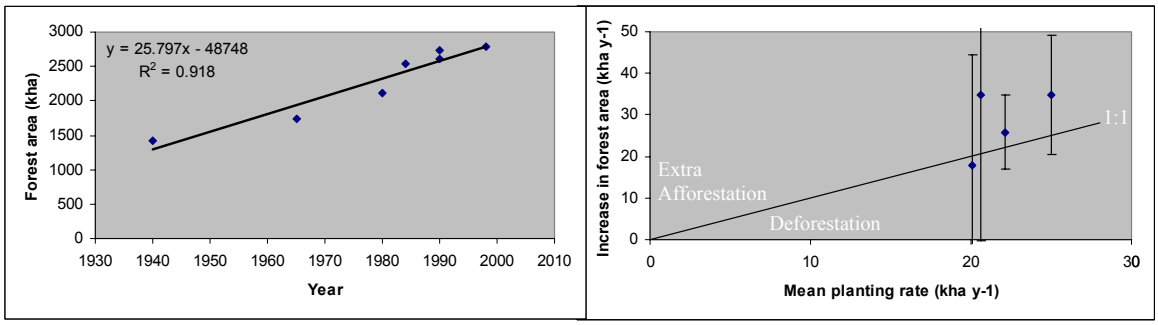

Figure. 2(a) Increase in GB forest area since 1940, from various data sources. A linear regression against time is shown (solid line), giving the mean annual increase since 1940. Three other regressions were calculated, for the periods between the present day and 1965, 1980 & 1984 (not shown). (b) The mean new planting rate over these four periods was calculated from FC 'Facts & Figures' data, and plotted against the observed increase. Error bars show the 95 % confidence interval in the regression slope derived in (a).

Using these data in equation 2 yields values between -9780 and 2280 ha y-1, graphically represented in Figure 2b. Where the points lie below the 1:1 line, deforestation can be inferred. Where the points lie above the 1:1 line, extra afforestation beyond the recorded new planting is inferred. Three out of four fall in this latter category. However, in all cases, the confidence interval overlaps with the 1:1 line, indicating that the observed increase in total area does not differ significantly from the recorded planting rate. A statistically significant deforestation rate is therefore not detectable in these data.

Forest Area Budget – iii. Other Scottish data sources

In principle, we expect this method to work, but be limited by the accuracy of total forest area data. At GB scale, this appears not to be high enough to resolve the relatively small deforestation rate. As a further attempt, we restrict the method to Scotland, where an extra data source is available through the National Countryside Monitoring Scheme (NCMS) of Scottish Natural Heritage (SNH) covering the 1940s, 1970s & 1980s (Mackey et al. 1999) (Fig. 3a). The accuracy of planting data is expected to be relatively high.

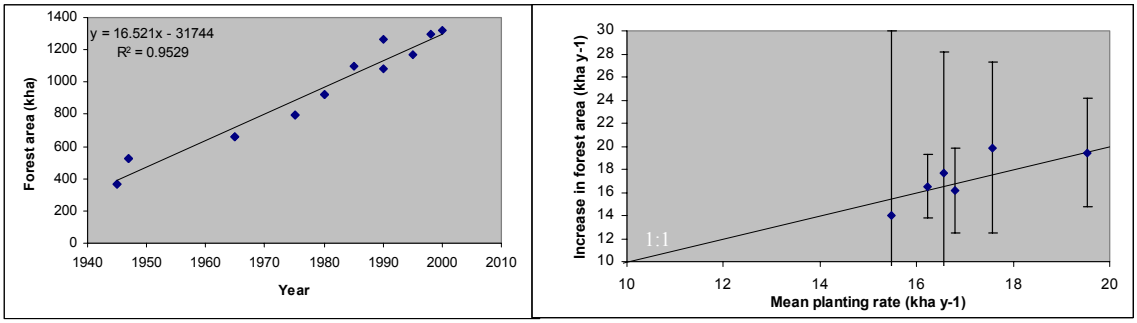

Figure. 3(a) Increase in Scottish forest area since 1945, from various data sources. A linear regression against time is shown (solid line), giving the mean annual increase since 1940. Five other regressions were calculated (not shown), as in Fig 2a. (b) The mean new planting rate over these six periods was calculated from FC 'Facts & Figures' data, and plotted against the observed increase. Error bars show the 95 % confidence interval in the regression slope derived in (a).

Using these data in equation 2 yields values between -2290 and 1510 ha y-1, the latter of which scales to a value of ~3000 ha y^{-1} for GB (Scotland contains 49 % of the GB forest area). As in Fig. 2b, the confidence interval overlaps with the 1:1 line in all cases, indicating that the observed increase in total area does not differ significantly from the recorded planting rate, and a statistically significant deforestation rate is not detectable.

Observed change in sample plots – NCMS

A small number of national-scale schemes have made repeated surveys of land use in a set of sample plots. Plots are allocated into some land use classification scheme, with land use classes such as 'coniferous forest', broad-leaved woodland', or 'arable land'. For each interval between surveys, the data can be used to produce a land use change matrix, quantifying the transitions between land use classes. Deforestation rate can be calculated as the sum of transitions from all forest classes to all non-forest classes.

The first such scheme considered is the National Countryside Monitoring Scheme (NCMS) of Scottish Natural Heritage (SNH), and is restricted to Scotland. The scheme recorded land use in 487 1 x 1 km plots, based on interpretation of aerial photographs. Photographs were taken in the 1940s and the 1980s, with a smaller number analysed representing the 1970s. The scheme defines 45 land use classes, six of which are considered to be forest classes (namely: Broadleaved woodland, Mixed woodland, Broadleaved plantation, Parkland, Coniferous woodland, Young plantation, Coniferous plantation, Felled woodland). The deforestation rates derived from the NCMS over the 1940s-1980s time period is 460 ha y^{-1}. The corresponding value for the afforestation rate is 18032 ha y^{-1}. As a check on the method, this latter value can be compared with FC 'Facts & Figures', which gives a relatively similar value (Table 1). Making the conservative assumption that forests over GB as a whole experience the same deforestation rate as in Scotland, we infer a GB deforestation rate of 940 ha y^{-1} for this time period.

Table 1. Deforestation rates calculated for GB from the two survey schemes. Calculated afforestation rates are also shown, for comparison with the FC 'Facts & Figures' data over the same time period. All values are in ha y^{-1}. *Scotland only.

Survey	Time period	Deforestation	Afforestation	Afforestation FC F&F
NCMS	1940s-1980s	940	18032*	15803*
CS	1984-1990	23750	36250	25306
CS	1990-1998	18353	39263	18942

Observed change in sample plots – Countryside Survey

A second survey scheme is the Countryside Survey, run by the Centre for Ecology and Hydrology. The scheme established 381 1 x 1 km plots throughout the UK (GB??), in which land use was recorded by ground surveys in 1984, 1990 and 1998. The scheme originally defined 11 land use classes, two of which are forest classes (Broadleaved woodland and Coniferous woodland).

The calculated deforestation and afforestation rates are shown in Table 1. The deforestation rates are approximately twenty times larger than those based on the NCMS data, and much higher than the highest value obtained by the forest area budget method (Fig. 4). Although there are few other data for comparison, we suspect that the CS survey deforestation rates are erroneously high, because the same survey also produces erroneously high afforestation rates (Table 1). The calculated afforestation rates are a factor of 1.5 to 2 higher than corresponding values from FC 'Facts & Figures', the latter of which are expected to be reasonably accurate.

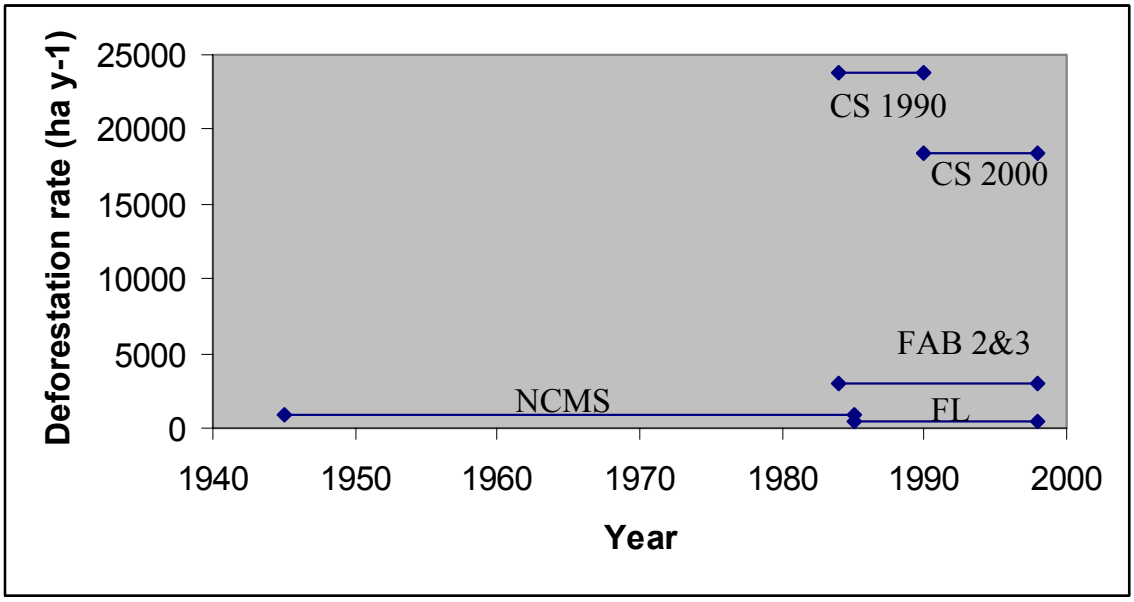

Figure 4. Deforestation rates estimated by the different methods. Lines indicate the time period over which the estimates apply. NCMS = National Countryside Monitoring Scheme; FL = Felling licenses; FAB 2&3 = forest area budget, highest value from methods ii & iii; CS = Countryside Survey.

Discussion

There are clear differences in the deforestation rates estimated by the different methods (Fig. 4). Here we consider some possible reasons that may explain these differences. These will be considered in more detail in the CEH FOCUS project, which aims to investigate several of the questions raised by the Countryside Survey 2000 results (see Appendix).

Plot size

The minimum plot size used in survey schemes will affect calculated deforestation rates. Changes in the minimum plot size used will affect the estimate of total forest area, and therefore, the estimate of change in forest area in equation 1, and the deforestation rate in equation 2. The minimum plot size used in the FC Woodland Census has decreased from 2 ha in 1940 to 0.1 ha in 2000. To investigate this, we used the National Inventory of Woodland & Trees 2000 data to calculate the forest area which would be excluded if larger minimum plot sizes were used (Fig 5). For each minimum value, the total GB forest area was calculated, ignoring areas of forest smaller than this value. Figure 5 shows that around 60000 ha would not be recorded if a minimum plot size of 2 ha were used. Assuming the size distribution of forest areas has remained the same, a correction factor can be calculated to normalise earlier Woodland Census data with larger minimum plot size. This is simply the total forest area calculated with a given minimum plot size, expressed as a fraction of the total calculated with a minimum plot size of 0.1 ha. This changes the 1940 total area estimate by 2.3 %, but all other values by less than 1 %, and does not substantially change the calculated ΔArea or deforestation rate.

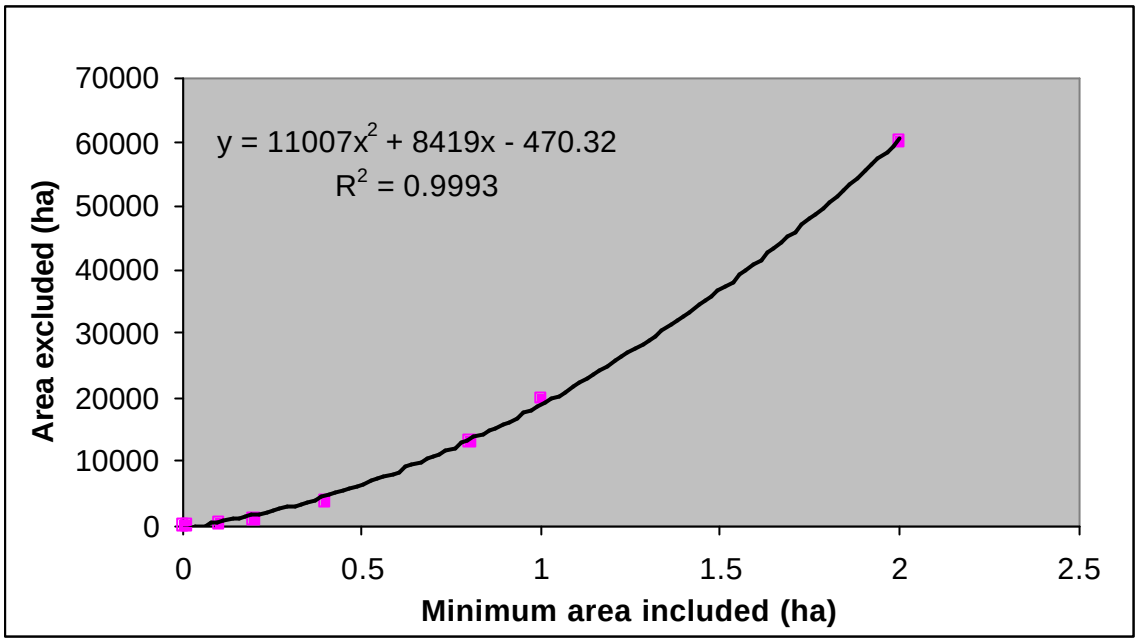

Figure 5. Area excluded from the total GB forest area, calculated using different minimum plot areas with the National Inventory of Woodland & Trees 2000 data.

The minimum plot size used in survey schemes is could also affect the definition of deforestation eg. if deforestation occurred as mosaic of small patches, one scheme may include this as deforestation, another scheme with a larger minimum plot size may exclude it. In general, the turnover rate of small areas is likely to be higher than large
areas. However, the NCMS and the Countryside Survey use similar minimum plot sizes (~0.1 ha).

Other methodological differences
In the NCMS, the earlier (1940s) photograph is available for comparison with the more recent one. It is possible that this allows the observer to recognise areas that have not changed more easily, introducing a systematic difference. In the Countryside Survey, the previous survey data is not so readily to hand, and each survey may be done by different surveyors. Differences between surveyors in the application of the classification scheme would give erroneously high turnover rates. This should be quantifiable if different surveyors survey the same sites.

Both survey schemes are explicitly directed at the 'countryside', and have a bias in the sampling design towards rural areas. However, much deforestation may be at urban edges, and could be missed by the surveys. This could be a systematic difference between survey schemes, depending on differences in their sampling designs. A further difference is that NCMS data cover a significantly longer time period than the Countryside Survey (Fig. 4), and may therefore be expected to give a rather different value. One method to address these weaknesses is to assess direct data on factors which cause deforestation. This would include urban expansion, which could be assessed using local authority planning data.

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Appendix

Causes of discrepancies between Forestry Commission and Countryside Survey estimate of woodland area and flux.

Dave Howard
Centre for Ecology and Hydrology, Merlewood, U.K.

Following the launch of Countryside Survey 2000 (CS2000), the results were compared with published statistics. The figures derived from field survey describing woodland were compared with estimates produced by the Forestry Commission (FC). Whilst the stock estimates are consistent with the FC for both 1990 and 1998, the dynamic flux between the years was considerably higher than expected. A follow-up project – FOCUS – aims to address some of the questions raised by the results of CS2000.

FOCUS is structured around 7 topics with one specifically investigating woodland issues. The woodland topic is asked to address three aspects of the differences between different datasets. The first part is a simple examination of the differences in the estimates of woodland cover. The second part looks at the correspondence with the Ancient Woodland Indicator sites. The third part looks at the location and reasons for change. The project is reasonably short and will present its findings in a final report in December 2002.

There are several possible causes for the discrepancy, predominantly methodological differences. The FC data are derived from two sources; all woodland parcels over two hectares in area are mapped (as a census) in the National Inventory of Woodland Trees (NIWT). Additional area is added from a sample survey of woodland smaller than 2 ha (Survey of Small Woods and Trees). The flux figures from Countryside Survey are derived from the repeated sampling of a stratified sample of 1 km squares.

Different potential causes of differences are being investigated:

- Are the sampling strategy and sample intensity adequate to produce an adequate estimate of the area of woodland? The woodland in the CS2000 sample squares has been extracted from the FC digital dataset describing the NIWT. National estimates for the different forest types have been produced and compared to the 'truth' of the census estimates. The effectiveness of different sampling intensities can also be assessed to match the intensity of the surveys of 1978, 1984 and 1990 when fewer sites were visited.
- What are the consequences of the spatial resolution of the different datasets? The NIWT has a minimum mappable unit of 2 hectares, the Survey of Small Woods and Trees maps any wooded parcel smaller than 2 ha. Countryside Survey has a minimum mappable unit of 400 m^2 (0.04 ha) with smaller areas being incorporated into mosaics. The previous surveys had been performed using different methodologies and had used 0.25 ha as the minimum size for woodland. Clumps of trees below this size were recorded as a separate category making interpretation of change difficult. The distributions of parcels of woodland of different size class is being compared between surveys.
- How are the change statistics derived? The difficulty of deriving simple change statistics combined with the period between surveys (the previous

census had been 1979-82) lead to change statistics being produced from two components FC owned land and private land. Figures for change in private land are obtained from grant schemes with an estimate for areas planted without grant aid (including natural regeneration). Since 1990, over 97% of new woodland planting has been under private management. The normal smallest area capable of receiving a Woodland Grant Scheme Award is 0.25 ha. The density of planting is defined and there are restrictions on species and use (for example Christmas trees will not be funded). Up to 20% of an area receiving a grant may be left without trees.

Losses of land from forestry are more difficult to obtain. Felling and windblow are recorded on FC land, but the land generally remains within forestry as it will generally be replanted. Felling licences provide some information, but are not necessary for small trees and coppice, for urban development (with planning permission), orchards or trees growing in public open space or for a small volume of timber.

Countryside Survey estimates of change are derived from repeat sample sites. The change between 1990 and 1998 should be a conservative estimate as surveyors took previous information and were asked to only report change if they felt it was real. They were also asked to record if they felt the previous information had been incorrectly recorded. The survey records the land cover and the use is then inferred.

Countryside estimates are being reworked omitting changes to parcels of less than 0.25 ha to see if the results better match the FC published figures.

- Does the different terminology influence the statistics? Although the broad level statistics show good agreement, some of the sub-categories show discrepancies. Part of the difference can be explained by the definition of terms and methods of categorising and grouping information.
- Are the same parcels of land mapped in both NIWT and CS2000? GIS overlay is identifying where the information matches and where it differs. The reasons for differences are being examined.
- What are the characteristics of the polygons that have moved into or out of woodland in the Countryside Surveys? A variety of parcel characteristics including size, strength of allocation into woodland category, changes in coding and occurrence in NIWT are being examined.

The project is being carried out in collaboration with Forestry Commission (Simon Gillam and Steve Smith) who are keen to reconcile the two datasets. The project also involves comparison with the satellite derived Land Cover Map 2000, which has also shown differences with the NIWT.

Some of the results of the project will be available for presentation at the meeting, after they have been presented at the FOCUS workshop.