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The Sampling Strategy for Countryside Survey 2000

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Introduction

The sampling strategy used for the field survey element of Countryside Survey 2000 is the latest in a series of developments of the ITE Land Classification, first used to stratify a field sample in 1978.

To understand exactly how the present Countryside Survey sampling framework has been derived, it is important to review the concepts and activities that have evolved over the last 20 years since the first survey was carried out. It is possible that if the earlier time-series data were not so valuable as a basis for detecting change, and a fresh start could be made today, then a different sampling strategy might be well be adopted. However, the present Countryside Survey methodology is inextricably linked with its predecessors and an understanding of these is essential.

Early development of the ITE Land Classification

The beginning

In the early 1970s, the idea of widespread ecological survey of areas as big as Great Britain was barely conceivable. However the concept of ecological sampling at a smaller scale (eg individual woodlands), was commonly accepted and it was Bunce and Shaw[13] who developed local regional survey into a national ecological sampling system. The important part of the approach was that the sampled areas should be representative of the whole region and, to ensure this, they employed a stratification system.

The importance of a stratified system

In order to avoid bias in the selection of samples (thereby potentially invalidating the results), any sample should be based on objective (eg random) selection procedures. However, purely random sampling programmes run the risk of selecting, by chance, a number of samples which are at one extreme in a range of variability and therefore not 'typical' of the whole population being sampled. An extreme example would be where a national opinion poll, by chance, only included teenagers in the sample - their voting intentions may not be representative of the voting population at large.

To minimise this risk, stratification systems are used to 'carve up' the population into discreet layers, or strata, so that all parts of the population are sampled. In the analogy above, most national opinion polls sample within different age strata. In ecological terms, it is likely that different species and ecological processes occur in different types of land. A simple stratification might then divide the land surface into different altitude ranges so that uplands and lowlands, which tend to have different ecological characteristics, are adequately sampled.

However, this represents a very simple stratification and, just as opinion polls attempt to sample not just different age strata but also those concerned with gender, social, racial and regional backgrounds, so other factors are important in ecological survey. Land at a certain altitude in north-east Scotland may have different ecological affinities to land at the same altitude in East Anglia. Thus other, secondary strata may need to be introduced. If this

argument is extended to its logical conclusion, then it can be seen that many different strata may need to be created by combining a number of different determining factors. This is the theoretical basis of the ITE Land Classification.

Development of the first version of the ITE Land Classification system.

In the early 1970s, Bunce and Shaw carried out a sample survey of the Lake District National Park. They had spent several years surveying and classifying vegetation in woodlands[13] and elsewhere; this depended on recording plant species in square plots (quadrats) and then classifying the quadrats into groups (vegetation types) depending on which species were present. Thus, all the quadrats in one group tended to have more or less similar species present while those in another group had different species. They used a multivariate classification system called Indicator Species Analysis (ISA)[35] to group the quadrats. Bunce and Shaw realised that the same approach could be 'scaled up' to classify areas of land, except that the quadrats would be larger (eg a 1 km square) and, instead of using species as the basis of classifying, they would use environmental attributes (such as altitude, geology and climate). The work was pioneered in the Lake District National Park and then extended and tested in Cumbria[14], Lancashire and other regions of GB.

In 1975, the Institute of Terrestrial Ecology (ITE), capitalising on the potential of the approach, provided funding for a national ecological survey of GB. The survey had two major prerequisites:

- it should be carried out using field survey (in order to obtain the level of ecological information required),
- it should be carried out within a single field season.

As a result of the earlier work in Cumbria and elsewhere, it was thought that the sample unit of a 1km square was appropriate, being small enough to survey in a reasonable period of time and yet large enough to contain sufficient environmental features to allow differentiation of squares. With over 240,000 1km squares in GB, a sampling approach was an obvious necessity and a stratified, random sampling system was then developed – the ITE Land Classification was born.

In the mid-1970s, when this work was being done, computing power was such that software packages like ISA could only operate on a limited number of datasets. Thus it was not possible to create a classification of all 1 km squares in GB and an alternative strategy had to be found. By taking the centre square of a 15 x 15 km grid across GB, a suitable number of squares was identified for classification (1228). Environmental, physiographic and other mapped data were then collected for each of the 1228 squares and the dataset was analysed using ISA to produce 32 classes (Table 1). Four squares surrounding each of the classified squares were also allocated to classes using the key provided by ISA; thus a total of 6040 squares were classified (Figure 1). Full details of this procedure can be found in Bunce *et al*[6] and Bunce *et al*[7]. The 32 classes were then described based on the average values of the environmental characteristics that were used to generate the classes (for example, average altitude, slope and rainfall, and host of other environmental values).

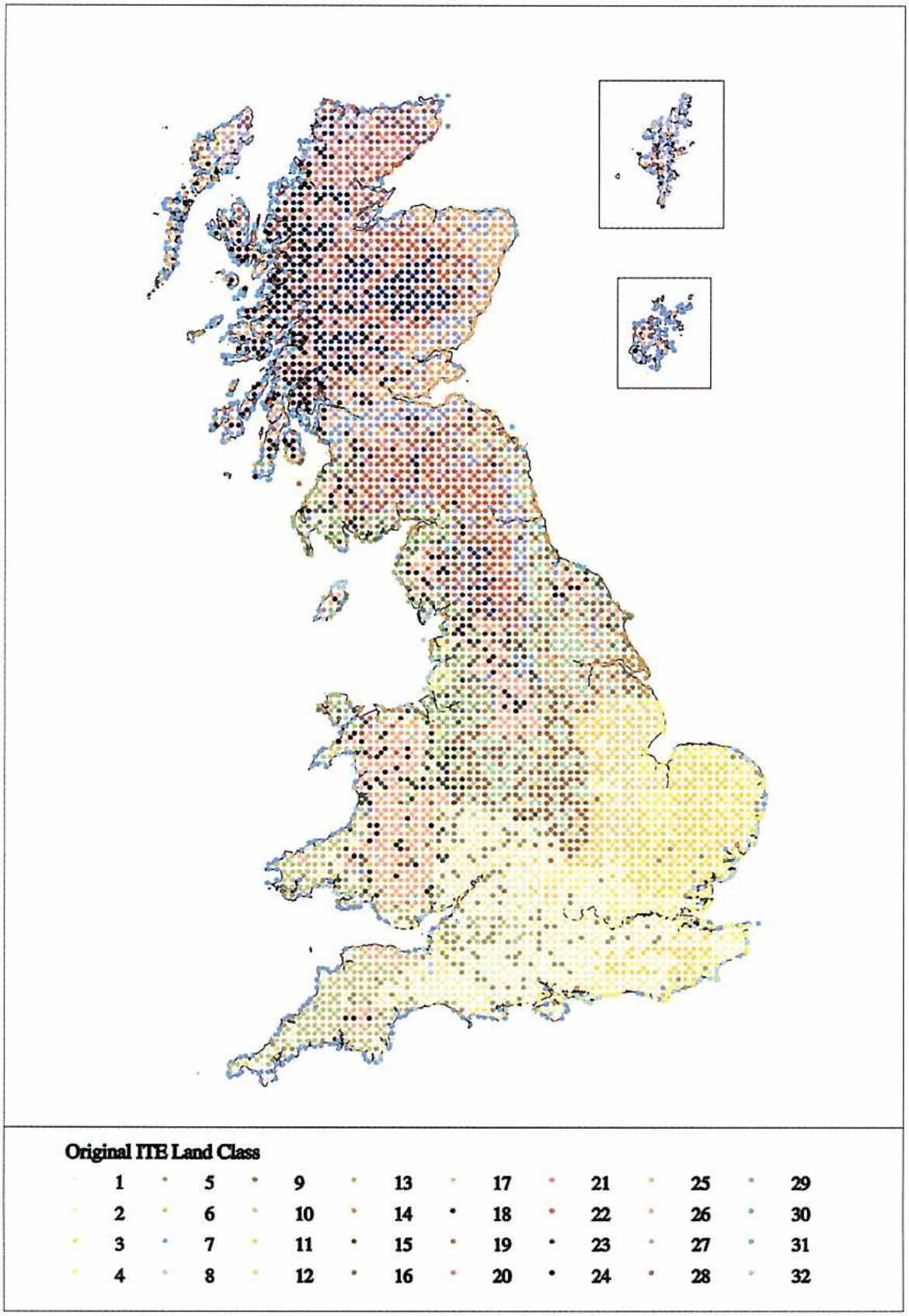
The sampling framework for the first ecological survey of GB in 1978

Having generated the classification which would act as the sampling stratification system, the number of samples to be surveyed was considered. Ideally, this number would depend on the size of the stratum (ie how many 1 km squares of the class occurred in GB) and on the ecological variability within the stratum. Previous work had suggested that for ecological surveys of this type, at least eight samples per stratum were necessary. Since this was the minimum requirement for each class, and resources were not available to survey more squares, then eight were selected at random from each of the classes. These squares were taken from the grid of classified squares and thus the final sample for the first GB survey was a gridded, stratified, random sample of 256 1 km squares. The survey was actually carried

Table 1 Brief descriptions of the 32 ITE Land Classes

No.	*Brief description*
1.	Undulating country, varied agriculture, mainly grassland.
2.	Open, gentle slopes, often lowland, varied agriculture.
3.	Flat arable land, mainly cereals, little native vegetation.
4.	Flat, intensive agriculture, otherwise mainly built-up.
5.	Lowland, somewhat enclosed land, varied agriculture and vegetation.
6.	Gently rolling enclosed country, mainly fertile pastures.
7.	Coastal with variable morphology and vegetation.
8.	Coastal, often estuarine, mainly pasture, otherwise built-up.
9.	Fairly flat, open intensive agriculture, often built up.
10.	Flat plains with intensive farming, often arable/grass mixtures.
11.	Rich alluvial plains, mainly open with arable or pasture.
12.	Very fertile coastal plains with very productive crops.
13.	Somewhat variable land forms, mainly flat, heterogeneous land use.
14.	Level coastal plains with arable, otherwise often urbanised.
15.	Valley bottoms with mixed agriculture, predominantly pastural.
16.	Undulating lowlands, variable agriculture and native vegetation.
17.	Rounded intermediate slopes, mainly improvable permanent pasture.
18.	Rounded hills, some steep slopes, varied moorlands.
19.	Smooth hills, mainly heather moors, often afforested.
20.	Midvalley slopes, wide range of vegetation types.
21.	Upper valley slopes, mainly covered with bogs.
22.	Margins of high mountains, moorlands, often afforested.
23.	High mountain summits, with well drained moorlands.
24.	Upper, steep, mountain slopes, usually bog covered.
25.	Lowlands with variable land use, mainly arable.
26.	Fertile lowlands with intensive agriculture.
27.	Fertile lowland margins with mixed agriculture.
28.	Varied lowland margins with heterogeneous land use.
29.	Sheltered coasts with varied land use, often crofting.
30.	Open coasts with low hills dominated by bogs.
31.	Cold exposed coasts with variable land use and crofting.
32.	Bleak undulating surfaces mainly covered with bogs.

Figure 1 – Map of 'original'ITE Land Classification



out in the summers of 1977 (when a few pilot squares were sampled) and 1978 and focussed on vegetation quadrats and soils.

The sampling framework for the second, land use survey of GB in 1984

In 1984, ITE funded a further GB survey although, by this time, the emphasis had shifted away from ecological features such as soils and plant species in quadrats, to land use, landscape features and habitat mapping. The same sampling framework was used as in 1978 but the sample size was increased by 50% so that 12 squares were surveyed in each of the 32 classes (including the eight squares previously visited). With the benefit of hindsight, there is an argument for having allocated the additional 128 new squares according to land class size which would certainly have reduced the statistical error terms associated with national estimates made from the sample. However, this was not done. Examples of change statistics between 1978 and 1984 were published in Barr *et al.*[2]

Application of the ITE Land Classification to Countryside Survey 1990

By 1990, and following the Ecological Consequences of Land Use Change (ECOLUC) programme carried out by ITE on contract to the then Department of the Environment (DOE)[3], both scientific and policy needs for a further survey were identified. Countryside Survey 1990 (CS1990) was initiated with DOE, NERC, DTI and NCC all contributing funding. The first Land Cover Map of GB, derived from satellite imagery was also linked to this programme.

Again, the ITE Land Classification was used as the sampling framework for a field survey but, in this third survey, additional squares were allocated only to the larger land classes. A total of 508 squares was surveyed and all the features recorded in the 1984 survey, plus a repeat of the 1978 vegetation quadrats, was carried out[3]. The distribution of the squares within the Land Classes is shown in Table 1 and a map of sites is shown as Figure 2.

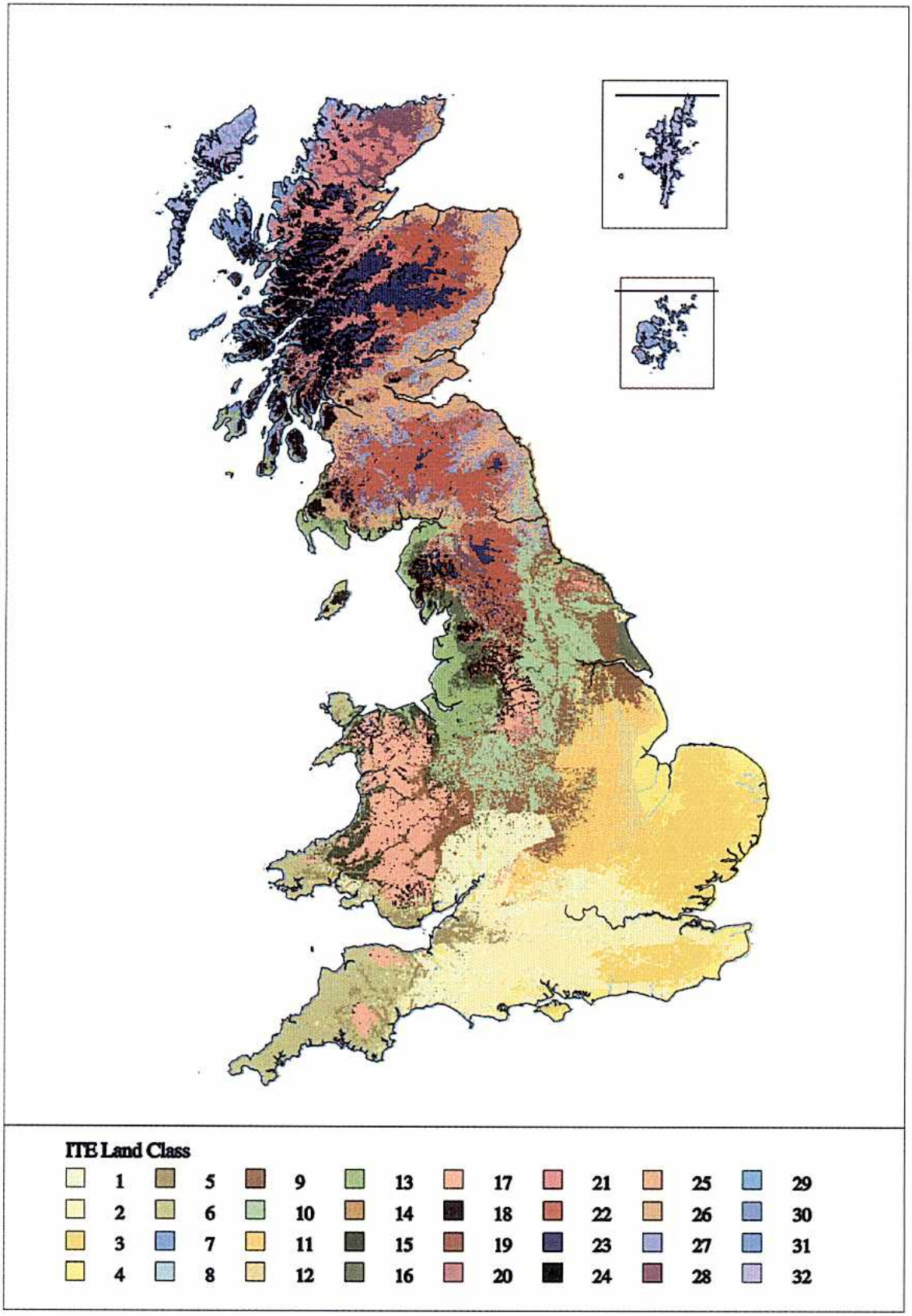
Further development of the ITE Land Classification

CS1990 still used the original, gridded land classification that had been developed in the mid-1970s and results were published based on the use of that system. However, it became apparent that for estimations at the regional and local level, the land classification had to be extended so that every square in GB was classified.

Although computing power had increased considerably since the first classification, it was still an insurmountable task to collect data for every square in GB at the same level of detail as had been done in the original work. Instead, the major climatic, geological and physiographic factors (or valid surrogates for these) were obtained for each square and then a variety of multivariate classification procedures was tested on the resulting dataset. When the classes of the original sample of 1228 squares was compared with the new classification attempts, the best simulation resulted in only a 62% correspondence. However, all of the squares that did not match exactly did fall into neighbouring land classes and the average characteristics of the class remained unchanged, thus the classification was accepted as a reasonable replacement for its earlier counterpart (Figure 3).

The net effect of this on the sampling framework was that as a result of some of the squares changing class, the distribution across land classes was distorted and some classes were not well represented. The effect of this can be seen in column 3 of Table1.

Figure 3. Map of the 'new' ITE Land Classification.



Developments of the ITE Land Classification for Countryside Survey 2000

During the planning stages of Countryside Survey 2000 (CS2000), there has been consideration of sample numbers in connection with several of the component modules. This has involved re-assessment of the existing (CS1990) sample as well as the need for additional 1 km squares. A number of issues have arisen from an independent appraisal of CS1990 for policy purposes. These include:

- the effects of the changed ITE Land Classification.
- the need to produce separate reliable estimates of surveyed features for Scotland and England with Wales,
- the need to provide statistically reliable estimates of upland habitats in England and Wales.

The new ITE Land Classification

As discussed above, the application of the new ITE Land Classification has resulted in some classes being under-represented. To correct this imbalance, a number of new squares have been included as part of CS2000; the details of how these are allocated are presented below, under 'Separate country estimates'.

Separate country estimates

In CS1990, 508 1 km squares were sampled in England, Scotland, Wales and the Isle of Man. The sample of squares was drawn at random from a grid of squares in the 32 ITE Land Classes. As described above, these classes were created using underlying environmental attributes and therefore crossed country (E, S & W) boundaries. Country estimates were derived from the mean characteristics of all squares in each class, irrespective of their country location.

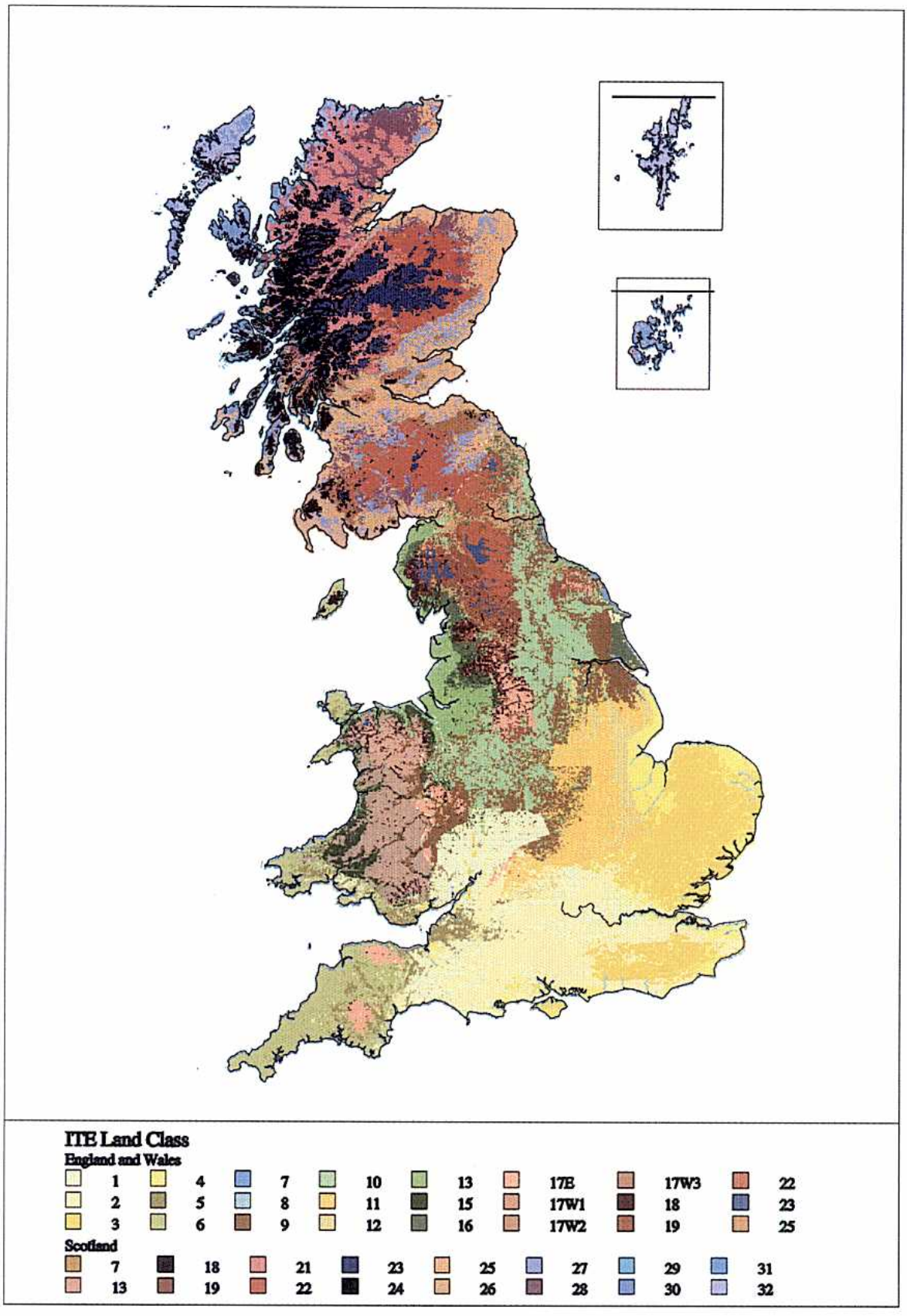
A CS2000 Scoping Study[34] recommended that the sampling framework should be modified to enable reporting on 'country units', being (a) England with Wales and (b) Scotland, separately using only squares which lie in the country for which estimates are to be made.

Additional samples have been deployed to assist with this requirement and the following changes have been made to the sampling framework:

- *class sub-division* - the ITE Land Classes have been sub-divided into the 'country unit' versions of the original classes,
- *class aggregation* - where this has resulted in there being very few squares of any particular class remaining in a country, then this 'rump' has been aggregated with a similar class in that country (the net effect of the class sub-divisions and aggregations is to create 37 strata, instead of the earlier 32),
- *additional squares* - to ensure that there is adequate representation of all new classes in each country unit, 19 additional squares have been allocated and this gives a minimum of 6 squares in each new class. To ensure relatively consistent sampling rates between England and Wales, a further 11 squares (5 in England and 6 in Wales) have been allocated,
- *Land Class 17* - Wales is dominated by Land Class 17 and to help refine the results reported for Wales, a sub-division of Land Class 17 has been carried out in Wales. In the allocation of any new squares in Wales (either detailed above or in any further options), representation of the new sub-classes has been respected.
- *Isle of Man* – the two sample squares in the IOM included in previous surveys so not contribute to estimates for 'country units' and are replaced by two new squares in England.

The revised land class maps for England with Wales and for Scotland are shown as Figure 4.

Figure 4 -Map of revised ITE Land Classes in 'England with Wales' and in Scotland – the sampling framework for CS2000



Survey of uplands in England and Wales

An additional module within CS2000, funded by DETR, MAFF, and WO/CCW, includes surveying an additional 30 squares which have been placed in ITE Land Classes which occur in the uplands and marginal uplands of England and Wales.

This will give better statistical accuracy to the estimates of habitats in the uplands of England and Wales which, due to the need to provide separate, country-based estimates, would otherwise be under-sampled.

Summary

The number of sample squares in CS2000 is shown in Table 2 and is their distribution is shown as a map in Figure 5.

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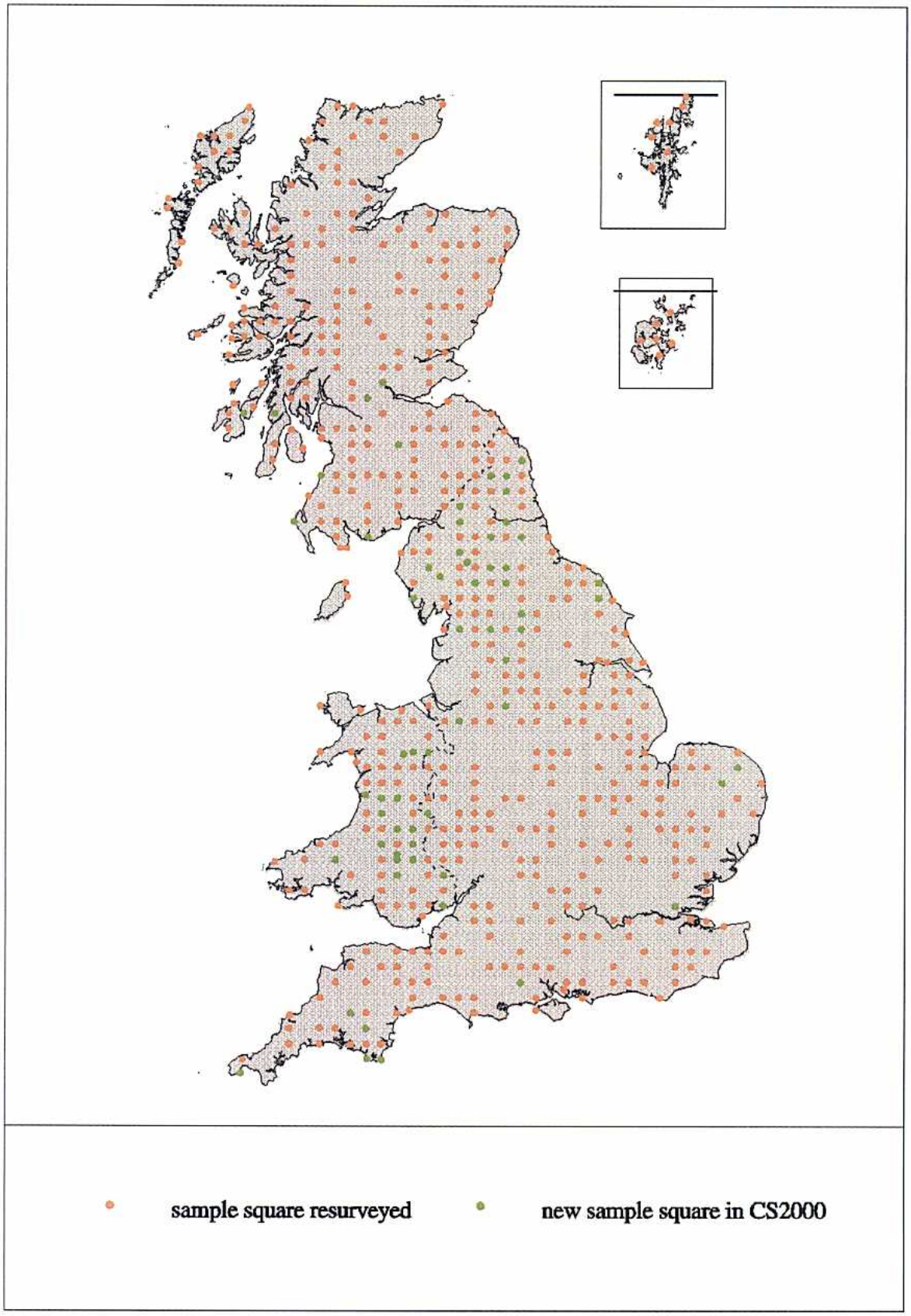
Table 2 Summary of the numbers of squares surveyed as part of CS2000

New LC	No. squares in GB	Sample in 1990	Extra as part of Modules 1 & 4	No. squares in CS2000	Sampling rate (1:x)
England and Wales					
1e	14159	28	2	30	472
2e	14463	24	0	24	603
3e	15452	30	0	30	515
4e	9012	10	4	14	644
5e	3858	6	0	6	643
6e	10011	23	0	23	435
7e	2838	13	3	16	177
8e	4052	11	0	11	368
9e	11728	21	1	22	533
10e	13776	22	0	22	626
11e	8895	22	0	22	404
12e	3542	10	0	10	354
13e	5455	10	0	10	546
15e	3852	9	2	11	350
16e	4273	11	4	15	285
17e	3934	9	4	13	303
17w[1]	1941	3	2	5	388
17w[2]	4978	7	10	17	293
17w[3]	2082	8	0	8	260
18e	3009	8	4	12	251
19e	5677	9	10	19	299
22e	3308	6	5	11	301
23e	1082	5	1	6	180
25e	3205	6	2	8	401
Tot E & W	154582	311	54	365	424
Scotland					
7s	843	7	2	9	94
13s	2267	7	1	8	283
18s	3634	6	2	8	454
19s	3214	3	3	6	536
21s	9708	19	0	19	511
22s	9250	19	0	19	487
23s	6066	12	0	12	506
24s	7010	15	0	15	467
25s	8594	19	0	19	452
26s	5683	14	0	14	406
27s	5697	15	0	15	380
28s	6502	13	0	13	500
29s	5465	11	0	11	497
30s	4254	14	0	14	304
31s	3018	11	0	11	274
32s	3779	10	0	10	378
Tot Scot'	84984	195	8	203	419
Total GB	239566	506	62	568	422

Figure 5 - Map of the CS2000 sample squares in England with Wales, and in Scotland.



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