The Sampling Strategy for Countryside Survey
(up to 2007)

Revised and Updated from: 'The Sampling Strategy for Countryside Survey', C.J. Barr, September 1998.
DETR CONTRACT No. CR0212

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September 2011

THE SAMPLING STRATEGY FOR COUNTRYSIDE SURVEY

Introduction

The sampling strategy used for the field survey element of Countryside Survey 2007 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 30 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 (e.g. 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 (e.g. 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).

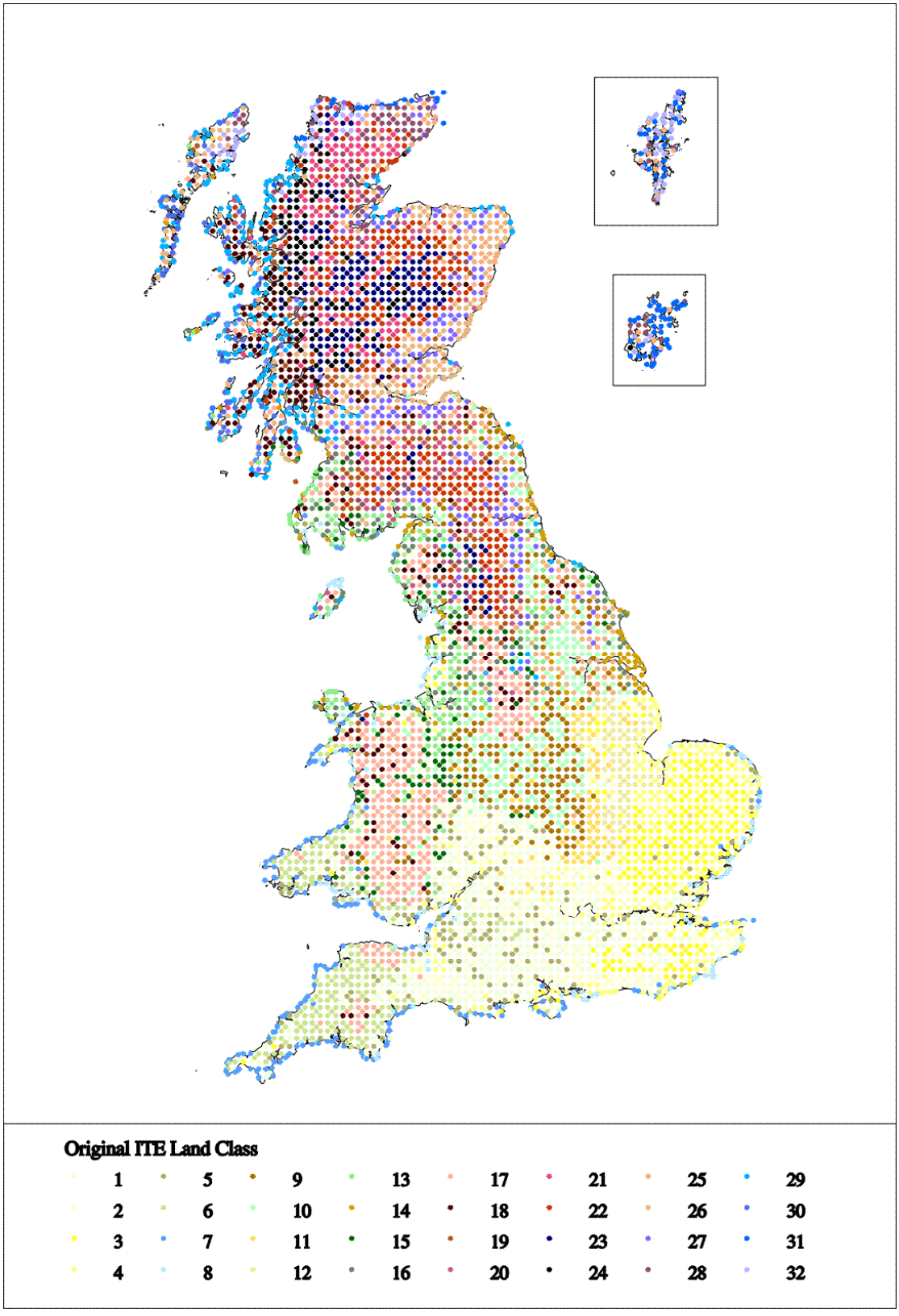
The sampling framework for the first ecological survey of GB in 1978

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

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.	Mid-valley 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' (1978) ITE Land Classification



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 2 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 were 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 Table 2.

Figure 2. Map of 1978, 1984 and 1990 sample squares

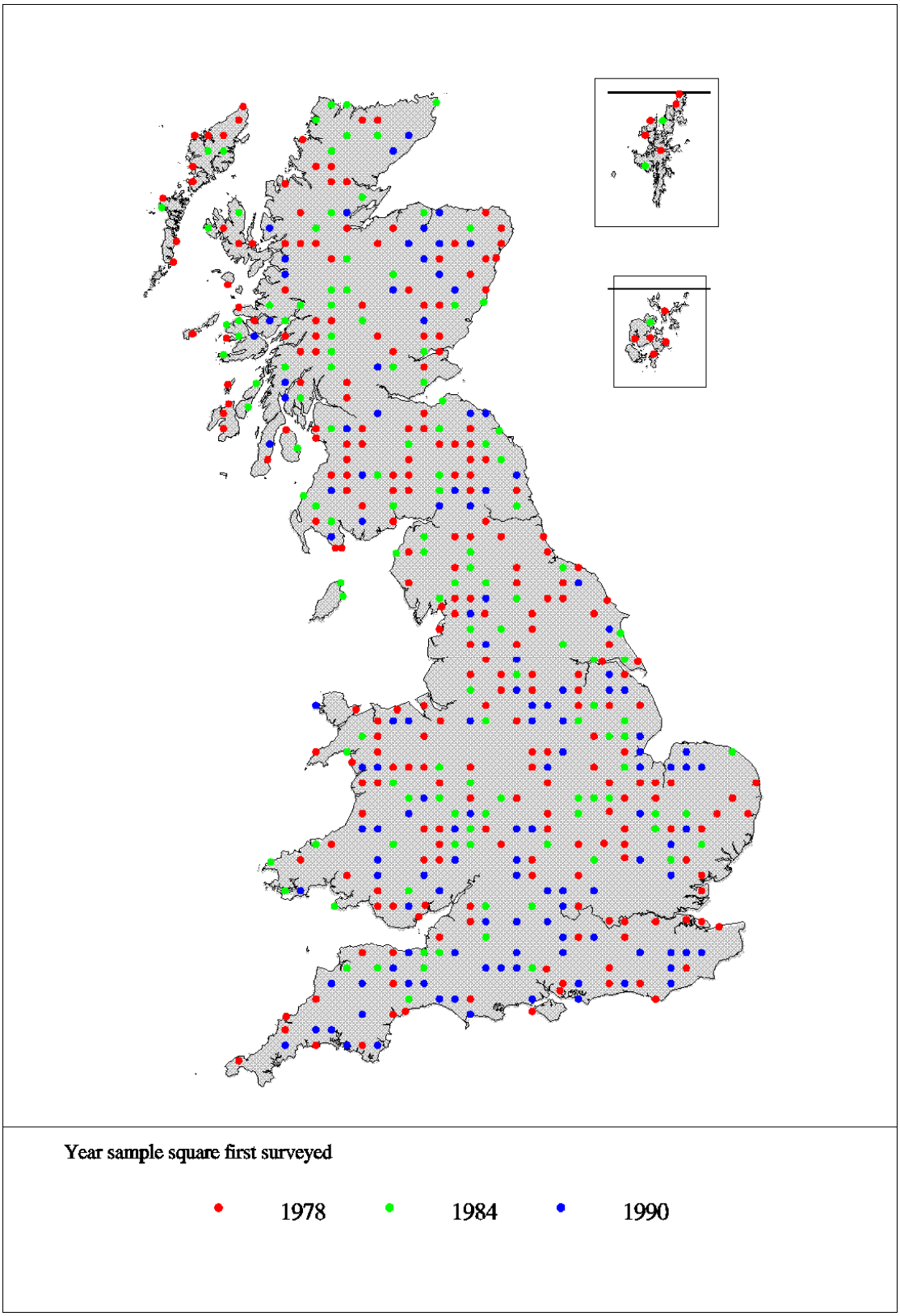
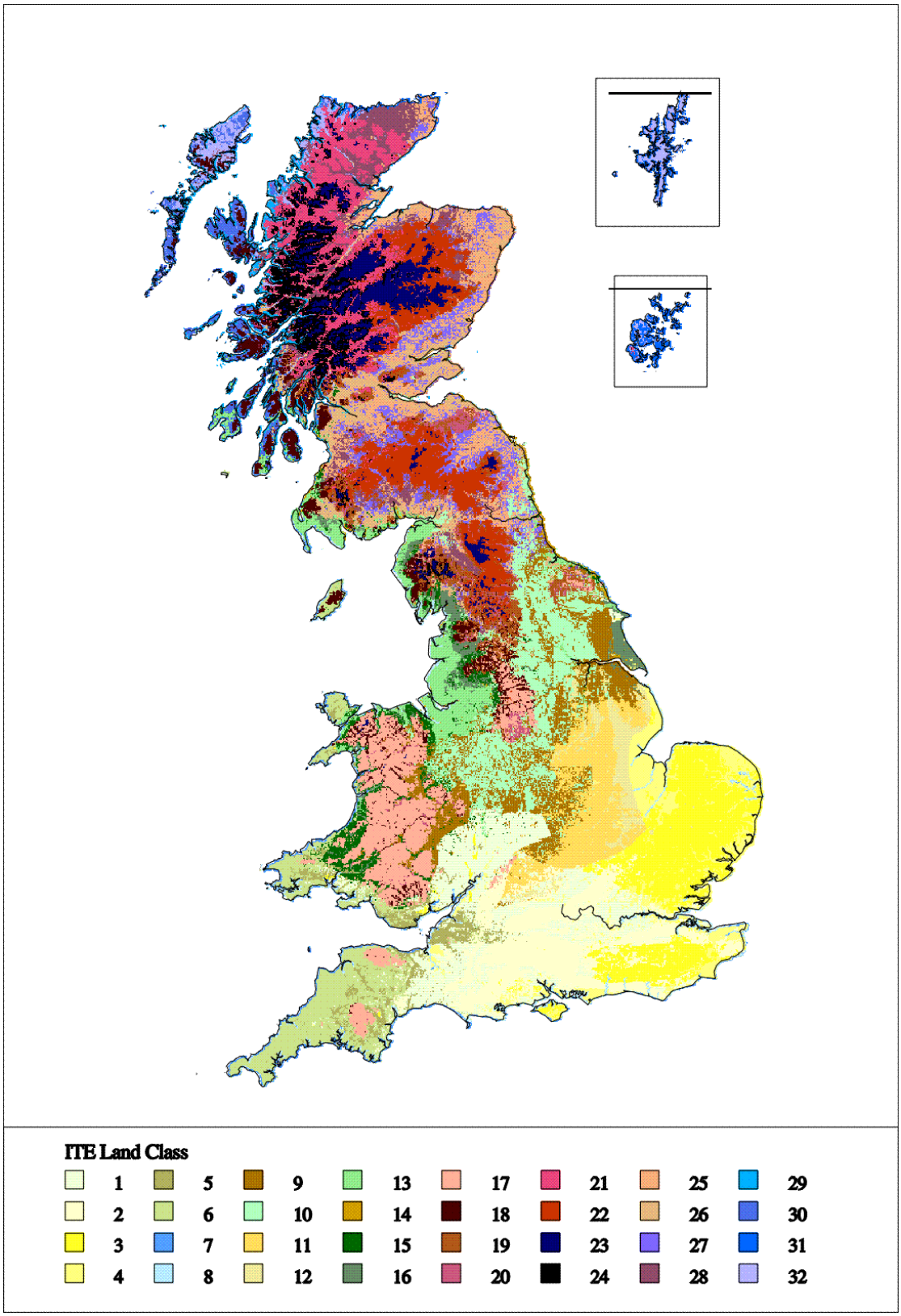


Figure 3. Map of the 'new' (1990) ITE Land Classification.



Developments of the ITE Land Classification for Countryside Survey 2000

During the planning stages of Countryside Survey 2000 (CS2000), there was consideration of sample numbers in connection with several of the component modules. This 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 were 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.

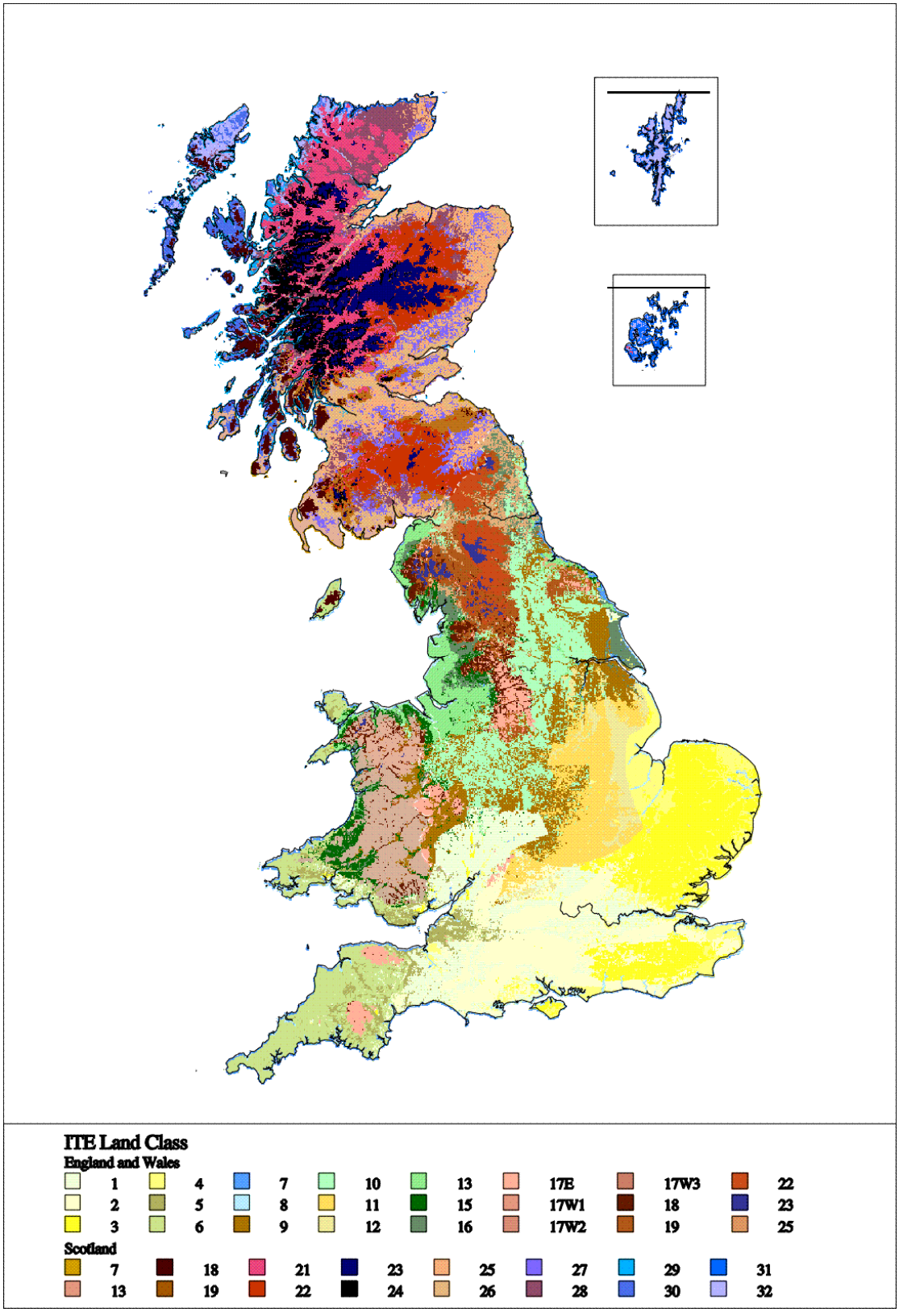
A CS2000 Scoping Study[34] recommended that the sampling framework should be modified to enable reporting on 'country units', being (a) England with Wales and (b) Scotland, separately using only squares which lie in the country for which estimates are to be made.

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 40 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 do 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, included 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 gives 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.

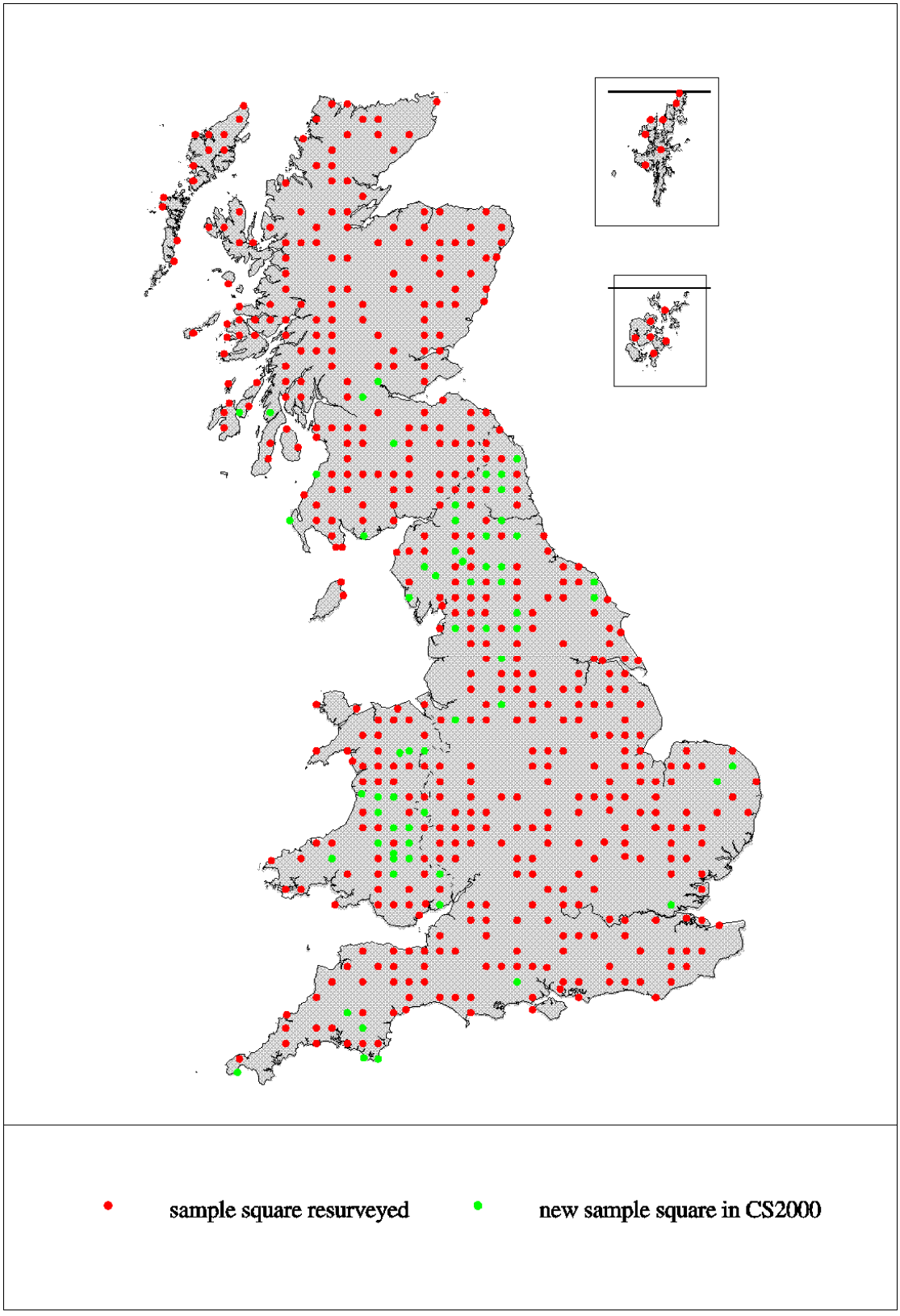
Summary

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

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

Land Class 2000	No. Squares in GB	Sample in 1990	Extra as part of Modules 1 & 4	Sample in 2000	Sampling Rate 1:x
England & Wales					
1e	13477	28	2	30	449
2e	14029	24	0	24	585
3e	15432	30	0	30	514
4e	8278	10	4	14	591
5e	3717	6	0	6	620
6e	9889	23	0	23	430
7e	2755	13	3	16	172
8e	3871	11	0	11	352
9e	11056	21	1	22	503
10e	13397	22	0	22	609
11e	8699	22	0	22	395
12e	3414	10	0	10	341
13e	4939	10	0	10	494
15e	3697	9	2	11	336
16e	4195	11	4	15	280
17e	3934	9	4	13	303
17w1	1941	3	3	6	324
17w2	4978	7	10	17	293
17w3	2082	8	0	8	260
18e	2951	8	4	12	246
19e	5671	9	10	19	298
22e	3308	6	5	11	301
23e	1082	5	1	6	180
25e	2994	6	2	8	374
Tot E&W	**149786**	**311**	**55**	**366**	**409**
Scotland					
7s	842	7	1	8	105
13s	2267	7	1	8	283
18s	3630	6	2	8	454
19s	3214	3	4	7	459
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	8589	19	0	19	452
26s	5335	14	0	14	381
27s	5655	15	0	15	377
28s	6500	13	0	13	500
29s	5455	11	0	11	496
30s	4249	14	0	14	304
31s	3017	11	0	11	274
32s	3779	10	0	10	378
Tot Sco	**84566**	**195**	**8**	**203**	**417**
Total GB	**234352**	**506**	**62**	**569**	**412**

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



Developments of the ITE Land Classification for Countryside Survey 2007

Prior to the 2007 Countryside Survey, it became apparent that in addition to the requirement for Scotland-only results (provided for in the 2000 Land Classification) further adjustments were required to accommodate Wales-only results. Since devolution, there has been an increasing need for the National Assembly of Wales and environmental organisations to have access to habitat status and change information on a Wales-only basis in order to meet the requirements of country-specific environmental policy and legislation.

Welsh-only Estimates

The adjustments in CS2000 included the addition of some Welsh squares, bringing their number up to 64, and making Wales the most intensively sampled of the three individual countries (England 0.22%, Scotland 0.24% and Wales 0.29% of total land area). However, in regard to the precision of national estimates, which depends on absolute numbers rather than proportions, the number of field survey squares in Wales is low compared to the number in Scotland (203) and England (302). A scoping report in 2006[42] concludes that the existing number of 64 squares in Wales was not adequate for Wales-only reporting for the 2007 survey.

As a consequence, the following changes were made to the 2000 sampling framework for 2007:

- *Class sub-divisions* – the ITE Land Classes have been sub-divided into the 'country unit' (England and Wales) versions of the original land classes creating five new classes: 5w, 6w, 7w,15w,18w
- *Number of classes* - the effect of the class sub-divisions is to create 45 strata instead of the earlier 40
- *Additional squares* – to ensure that there is adequate representation of new classes in Wales, a total of 43 additional squares were surveyed in Wales, this gives a minimum of 6 squares in each Welsh class.
- Additional squares in England to compensate for the removal of Welsh squares were not warranted. Two of the English Classes (5e, 15e) are left with only 4 squares per class, however, the 2006 scoping study[42] states the reduction in precision of English estimates is relatively small and the small number of squares in these classes should still be adequate for reporting purposes.

The revised class map for England, Wales and Scotland is shown in figure 6.

Figure 6. Map of revised ITE Land Classes in England, Wales and Scotland – the sampling framework for CS2007

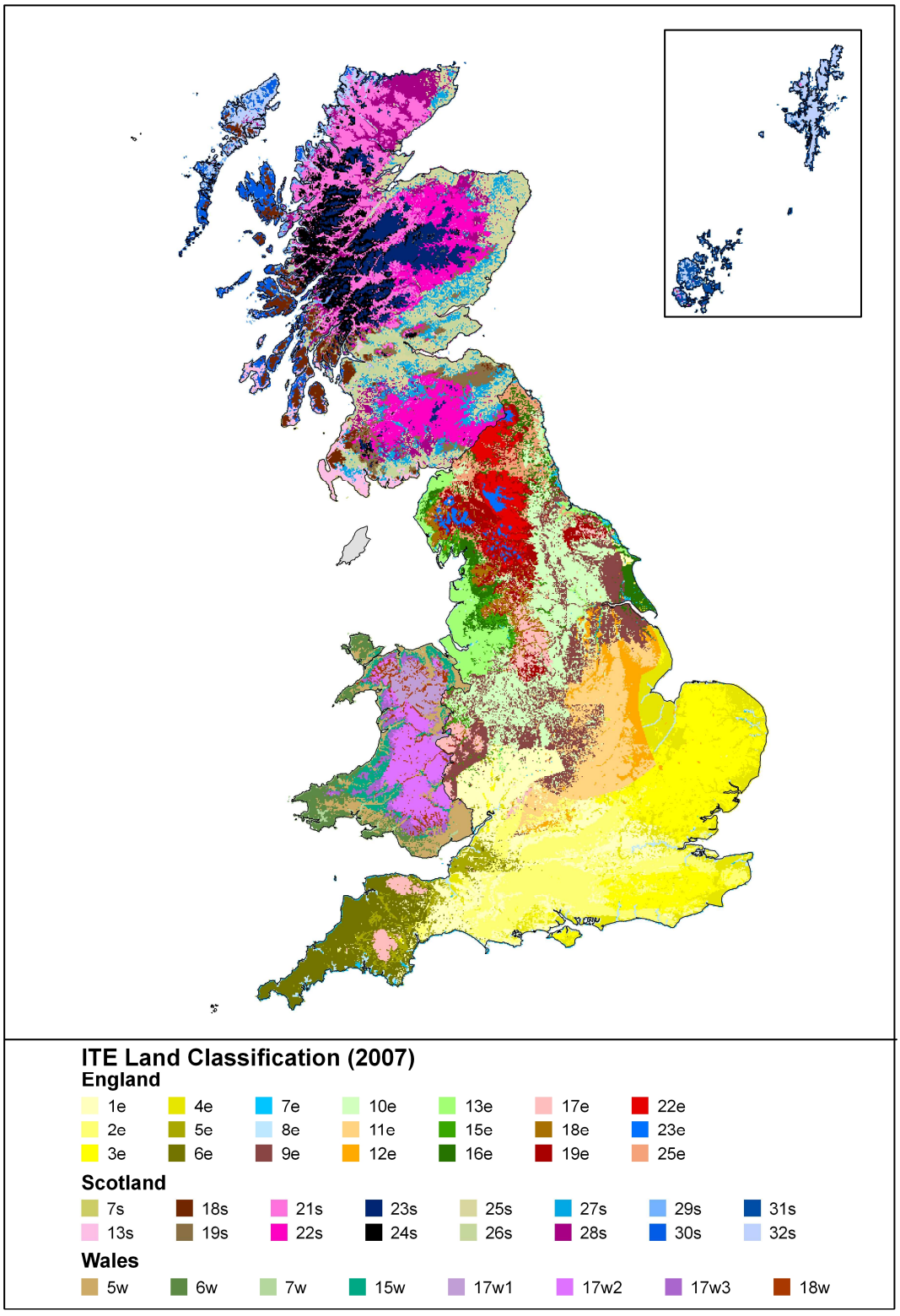


Figure 7. Map of the Countryside Survey sample squares in England, Wales and Scotland.

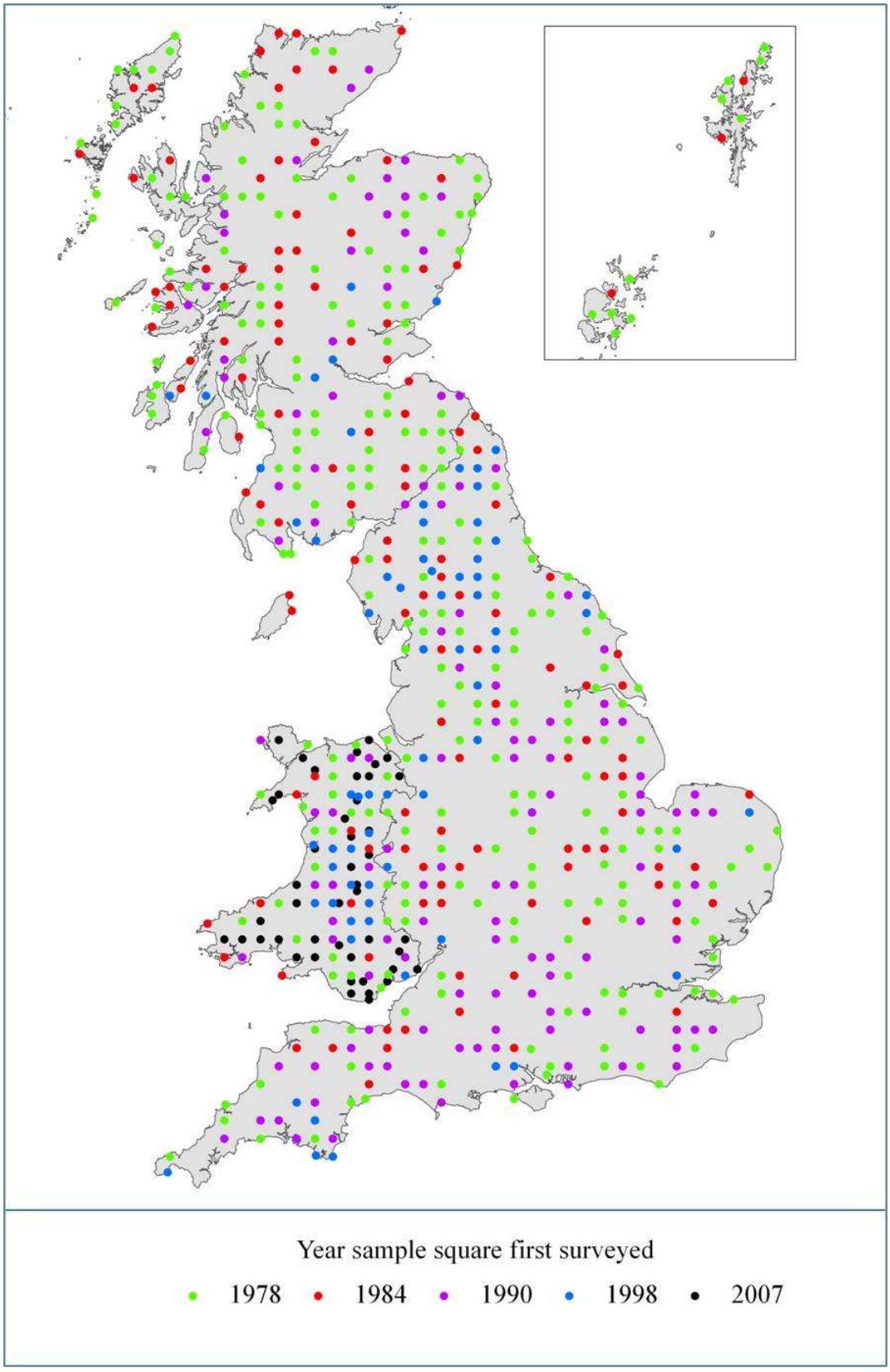


Table 3: Summary of the numbers of squares surveyed as part of CS2007

Land Class 2007	No. squares in GB	Strata Area	No. Sample Squares 2000	No. Sample Squares 2007	Sampling Rate 2007 (1:x)
England					
1e	12427	12422	29	27	460
2e	14025	14024	24	21	668
3e	15341	15338	30	30	511
4e	8223	8044	13	12	685
5e	2381	2376	4	4	595
6e	7191	7177	17	16	449
7e	1897	1436	11	10	190
8e	3046	2812	9	8	381
9e	10357	10311	21	20	518
10e	13263	13251	22	21	632
11e	8699	8699	22	22	395
12e	3414	3413	10	10	341
13e	4288	4246	9	9	476
15e	1269	1266	4	4	317
16e	3873	3866	14	13	298
17e	3934	3934	13	13	303
18e	2024	2024	8	8	253
19e	5384	5384	18	18	299
22e	3305	3305	11	10	331
23e	1041	1041	5	5	208
25e	2994	2917	8	7	428
Tot Eng	**128376**	**127284**	**302**	**288**	**446**
Scotland					
7s	842	646	8	8	105
13s	2267	2200	8	8	283
18s	3630	3630	8	8	454
19s	3214	3214	7	7	459
21s	9708	9706	19	19	511
22s	9250	9249	19	18	514
23s	6066	6066	12	9	674
24s	7010	7009	15	13	539
25s	8589	8545	19	19	452
26s	5335	5262	14	13	410
27s	5655	5620	15	15	377
28s	6500	6411	13	13	500
29s	5455	3043	11	11	496
30s	4249	3650	14	14	304
31s	3017	1918	11	11	274
32s	3779	3680	10	10	378
Tot Sco	**84566**	**79850**	**203**	**196**	**431**
Wales					
17w1	1941	1941	6	8	243
17w2	4978	4978	17	27	184
17w3	2082	2082	8	10	208
5w	4342	4324	7	23	189
6w	2698	2687	6	14	193
7w	1683	1396	7	7	240
15w	2428	2427	7	12	202
18w	1258	1258	6	6	210
Tot Wal	**21410**	**21091**	**64**	**107**	**200**
Tot GB	**234352**	**228225**	**569**	**591**	**397**

Note Regarding the Creation of National Estimates

The 2006 scoping study[42] states that 'changing the basic classification used for estimation of national estimates will have an effect on the consistency of estimates of stock. Estimates for GB for example can be calculated either using the latest classification (effectively three separate classifications for the three countries) or the original (1990) classification. For consistency with in an individual survey the former approach is preferred whilst the latter is more consistent across surveys'. See table 4 for the sample numbers per survey using the Original 1990 Land Classification.

Table 4. Number of Squares per Class in the Original (1990) Land Classification

Land Class 1990	Sample Size CS1978	Sample Size CS1984	Sample Size CS1990	Sample Size CS2000	Sample Size CS2007	Strata Area	Strata Square Count
1	8	15	28	30	33	13392	13751
2	10	12	24	24	21	13836	14208
3	11	18	30	30	30	15524	15941
4	4	6	10	14	14	7628	7832
5	3	4	6	6	11	3586	3682
6	9	13	23	23	30	9934	10201
7	8	12	12	15	14	1281	1315
8	9	11	13	13	12	2383	2447
9	13	16	21	22	22	10989	11284
10	12	17	22	22	22	13274	13630
11	13	19	22	22	22	8623	8854
12	5	9	10	10	10	3384	3475
13	9	14	17	17	20	6395	6567
14	4	6	6	7	7	590	606
15	5	7	9	12	17	3905	4010
16	8	10	11	12	11	3039	3121
17	10	16	28	45	59	13737	14106
18	6	9	13	19	19	6617	6794
19	2	4	7	14	14	5730	5884
20	2	4	4	8	8	2642	2713
21	9	16	19	19	19	10299	10576
22	11	16	25	30	28	13309	13666
23	10	14	17	17	14	7395	7593
24	8	12	15	16	14	7664	7870
25	12	18	24	25	25	10944	11238
26	8	14	15	16	14	6042	6204
27	8	12	15	18	18	6838	7021
28	8	12	14	17	17	7662	7867
29	9	11	11	11	11	2479	2546
30	9	14	14	14	14	3627	3724
31	7	11	11	11	11	1666	1711
32	6	10	10	10	10	3813	3915
	256	***382***	***506***	***569***	***591***	***228225***	***234352***

Acknowledgements (pre-2007 section)

Dr Andrew Stott (DETR) provided helpful comments on the text. Dr David Howard (ITE) produced the colour graphics in the report and Gavin Stark (ITE) synthesised data for Table 2.

Acknowledgements (2007 section)

Thanks to Peter Henrys and David Howard for advice and statistical guidance.

Further reading (References and Bibliography)

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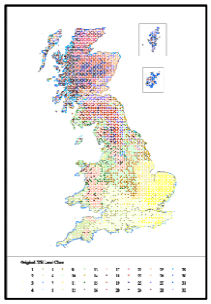
Brief History of the ITE Land Classification

1. 1978 - Initial Land Classification (& 1st Field Survey)



- ISA (*Indicator Species Analysis*) used to create 32 classes from environmental variables from 1228 1km squares (centre squares of 15x15km grid, 1215 of the 1228 were classified).
- Later, 4 squares surrounding original centre square classified. Total: 6039 km squares.
- Area of each Land Class estimated using the 6039 classified squares as proportions of GB.
- 8 km squares per Land Class surveyed (total 256).
- National estimates of habitat areas (from field survey) calculated by:

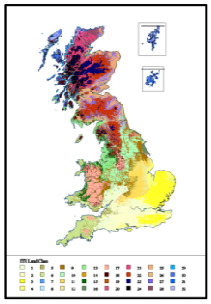
Mean area of habitat per square in each Land Class x area of that Land Class

Estimates later published in: Bunce, R.G.H. & Heal, O.W. (1984) ***Landscape evaluation and the impact of changing land use on the rural environment: the problem and an approach****. Planning and Ecology (eds R. D. Roberts & T. M. Roberts), pp. 164-188. Chapman and Hall, London.*

2. 1984 - 2nd Field Survey

- 2nd field survey, 12 km squares surveyed per land class (total 384).
- National estimate calculations used 1978 Land Classification

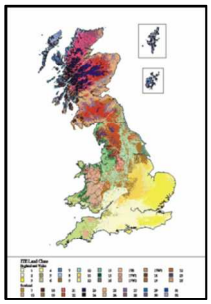
Limited results published in: Barr, C.J., Benefield, C.B., Bunce, R.G.H., Ridsdale, H. & Whittaker, M. (1986) ***Landscape Changes in Britain****. Institute of Terrestrial Ecology.*



3. 1990 - 'All Squares' Land Classification (& 3rd Field Survey)

- Land Classification revised to incorporate data from all 1km squares in GB. Conservative revision, but some survey squares changed class. Urban and sea corrections incorporated.
- 3rd Field Survey, 508 km squares surveyed.
- National estimate calculations used 1990 Land Classification

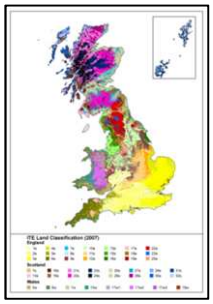
Results published in: Barr, C.J.; Bunce, R.G.H.; Clarke, R.T.; Fuller, R.M.; Furse, M.T.; Gillespie, M.K.; Groom, G.B., Hallam, C.J.; Hornung, M.; Howard, D.C.; Ness, M.J.. (1993) ***Countryside Survey 1990: main report****. (CS 1990 vol.2). London, Department of the Environment, 174pp.*



4. 1998 - Revised Land Classification (& 4th Field Survey)

- 4th field survey, 569 km squares surveyed
- 1990 Land Classification updated to allow separate Scottish reporting of national estimates. Number of Land Classes increased to 40.

Results published in: Haines-Young, R.H. et al (2000) ***Accounting for nature: assessing habitats in the UK countryside,*** *DETR, London ISBN 1 85112 460 8*



5. 2007 - Revised Land Classification (& 5th Field Survey)

- 5th field survey, 591 km squares surveyed
- 1998 Land Classification updated to allow separate Welsh reporting of national estimates. Number of Land Classes increased to 45.

Results published in: Carey, P.D.; Wallis, S.; Chamberlain, P.M.; Cooper, A.; Emmett, B.A.; Maskell, L.C.; McCann, T.; Murphy, J.; Norton, L.R.; Reynolds, B.; Scott, W.A.; Simpson, I.C.; Smart, S.M.; Ullyett, J.M.. (2008) ***Countryside Survey: UK Results from 2007.*** *NERC/Centre for Ecology & Hydrology, 105pp. (CEH Project Number: C03259).*