ANNEX A

THE LAND COVER MAP OF GREAT BRITAIN

A DESCRIPTION

INTRODUCTION

The Land Cover Map of Great Britain (LCMGB) was produced using supervised maximum likelihood classifications of Landsat Thematic Mapper data (Fuller *et al.* 1994a). The map, based on a 25 m grid, records 25 cover types, consisting of sea and inland water, beaches and bare ground, developed and arable land, and 18 types of semi-natural vegetation - these are described more fully below. By combining summer and winter data, classification accuracies were substantially improved over single-date analyses (Fuller *et al.* 1994b). In all, 88% of Britain was classified from combined summer-winter images, and 12% from single-date, mostly summer, data. Just 0.4% of Britain was obscured by cloud cover on both summer and winter images. The missing areas of offshore islands represent just 0.1% of Britain. This document aims to give details about the map classes, the map's resolution and the way in which classes are depicted. Further details, which relate the map and its cover types to the results of other surveys, are given by Wyatt *et al.* (1994).

SPATIAL RESOLUTION & REGISTRATION

It has been suggested (Townshend, 1983) that the minimum accurately mappable unit from TM data would be of the order of 3 to 5 ha. In practice, on the LCMGB, most features of 1 ha show clearly, giving a map which records patterns at a field by field scale; and superimposed on this ‘minimum accurately mappable area' is a finer pattern of those smaller features with strong enough spectral signatures to discriminate them from the background cover: for example, roads, farms, shelter belts, water bodies and grass tracks are evident throughout the cover maps. After removal of isolated pixels, these are shown in units as small as 2 pixels (0.125 ha) (Fuller *et al.* 1994a).

Registration of the Landsat-derived raster maps to 143 vector field-maps of 1 km squares showed average displacement to be 0.8 pixels (20 m): 75 out of 143 squares needed no shift to achieve correspondence with vector overlays; 43 squares needed a one pixel shift; 15 squares needed 2 pixels movement and only 10 squares needed more than 2 pixels movement relative to the vectors (Fuller *et al.* 1994a). This positional error is fully acceptable for most applications of the data.

CLASSIFICATION ACCURACY

Quality checks require access to ‘ground truth data', but the accuracy of such data is rarely known (Congalton, 1991). Conventional maps are most commonly used, but their division of a

continuum of landscape patterns into discrete classes, with hard boundaries is not ‘truth' but an artificial generalization, which achieves different results according to the rules and methods employed. A recent study has revealed the wide variations in definitions of land cover (Wyatt *et al.*, 1994). In assessing the LCMGB, it is important to note that the reference surveys also set out with different methods, different objectives and also differing potential in terms of the details they could record. Comparisons can only give indications as to LCMGB accuracy but they help point to sources of error and highlight the impacts of generalization and class definition.

Comparisons with independent ground reference data, for 508 1 km squares, showed correspondences which varied depending on the level of detail at which comparisons were made. Many of the apparent discrepancies are due to significant differences in class definitions. Whereas the Landsat classification, like the Ordnance Survey, used a hydrological definition of bogs (see later), the field survey used a botanical definition which, in contrast, included wet moorlands. There were also differences in how the two surveys divided the continuum from grass, through heather-grass mixtures, to dense shrub heaths. There were differences, too, in dividing the continuum from rough grasslands to managed swards. There are no fixed conventions in such divisions and variations can arise between individual surveyors within a survey: a quality assurance exercise, which re-examined the 1 km field data, showed an average 84% correspondence when the original surveyors' coding of land cover was compared with a quality standard. Allowing for different definitions, the overall correspondence between field and LCMGB samples is 67%.

The biggest component of map error is probably the misclassification of mixed boundary pixels. Some 40% of all pixels adjoin or cross a vector boundary and were thus made up of mixed cover types, and additional boundary features. Correspondence was raised to 71% when boundary pixels were excluded. There are minor discrepancies due to geometry, where a feature was correctly classified but slightly displaced. In dissected landscapes this would have had a major impact. It is desirable, though not easy, to distinguish between misclassification and misregistration. The satellite-derived map might be an accurate measure of cover, pattern and relative distribution, but with minor spatial differences relative to equivalent products.

Other differences reflect changes in cover between surveys, sometimes 2 years apart. For example, a pasture on one date, ploughed on the other. If we allow for likely time-based changes, overall correspondence is measured at 76% including boundary pixels, or 82% excluding boundaries.

Users of the data should be aware that these observations represent average error-rates. As with any average, the value represents a combination of lower and higher figures. Local discrepancies may be observed which seem to suggest higher or lower accuracy rates: this is only to be expected.

As previously noted, no survey could have delivered the 'ground truth' needed for exact validation; but it is possible to assess the probable meaning of results summarised here. If, as seems likely, the original CS90 field survey was nearly ‘as good as' the quality assurance survey and each ‘correctly' recorded 90-95% of the landscape, they would have overlapped by around the measured 84%. If the Landsat survey achieved 80-85% success (a figure regularly achieved

in pilot studies (Fuller *et al.*, 1989a & b, Fuller & Parsell, 1990)), then the correspondence with the field survey would have been around 67-71%. These are the range of figures obtained if we allow for the obvious interpretation differences, with an element of temporal change. In conclusion, a realistic assessment of Land Cover Map accuracy is probably 80-85%.

For more details on accuracies see Fuller *et al.* (1994a) and Wyatt *et al.* 1994. Note too that a publication is in preparation which evaluates the correspondences between ground and satellite surveys in far greater detail.

LAND COVER CLASSES

The following descriptions outline the ITE (now CEH) Landsat-derived cover types used in the Land Cover Map of Great Britain. The choice of classes was based on personal experience within the ITE Remote Sensing Unit, in surveys made from ground, air and space; it was made after consulting other published surveys, and after personal communication with other surveyors. The list represents a compromise between what would be ideal for wide-ranging users, and what was feasible to map, at this scale, from remote sensing. End-users and other surveyors have had the opportunity to comment on, and thereby influence, the final classification - the comments are built into the class descriptions. The numbering of classes reflects the time at which they were added to the classification.

The classes chosen represent an aggregation of many subclasses: for example, wheat, barley and oilseed rape are subclasses of the 'arable' class. These subclasses have been reduced to a short-list of target 'classes' which are considered ecologically meaningful, consistently recognisable from the selected imagery, and realistic in terms of their likely accuracy.

It would be possible to recombine subclasses differently, for example a map of 'graminoids' might be produced by aggregating all grass subclasses, including natural grasslands, agricultural pastures and arable cereals. Very likely, specialist users will require a 'tailor-made' aggregation to meet specific objectives, and this could be done digitally, by reference to the original maps of subclasses. Such users would have to accept that subclasses might not be distinguished consistently (eg not all images were of appropriate date to separate, for example, wheat from barley within the arable class).

The descriptions aim to record any limitations which would prevent further subdivisions to consistent standards. All classes are subject to the provision that they are only mapped if they are above the minimum mappable size, namely two pixels, ie 0.125 ha, though in practice it cannot be said that all 0.125 ha features are shown. In practice, the real value for a minimum accurately mappable area is probably nearer to 1 ha.

At present, the list distinguishes lowland and upland categories which are similar, for example lowland heather and upland dwarf shrub. These classes have spectral characteristics which allow their separation, but not with the same level of accuracy as would be available in separating classes with entirely different characteristic species. Regional upland and lowland masks have been created from the cover-classes and coarsely filtered in order to generalise the classification into lowland and upland types. Some users may feel that other measures of

context (eg altitude) are better criteria for separation, in which case such separations are best made in a geographical information system (GIS).

Agricultural grassland subdivisions have been taken further than spectral signatures may justify, because of the importance and extent of agricultural swards (see later). The situation with grasslands is complex: in addition to the interplay of species and altitude, there are extra difficulties imposed by soil-acidity, wetness and, more especially, by complex and ever-changing patterns of grassland-management. In the continua from lowland to upland, from wet to dry, from basic to acid soils and from natural to intensively managed, many classes might be identified. Agriculturalists and conservationists may not necessarily define the same classes, nor would a class be consistent from one agricultural region to another - a rough pasture in SE England might be considered to be of good quality in montane Scotland for example. It is also true that discrete classes may not be spectrally separable, especially where management (eg mowing) obscures the characteristic appearance of the various components. Those classes which are defined here are thought to be ecologically meaningful and separable with good reliability. They are, most importantly, intended to be consistent throughout Britain.

Some rarer classes are not always mapped consistently: for example 'ruderal weeds' most evident in setaside land and more commonplace in eastern Britain (in 1989-90) did not offer adequate sample data for training on the class in scenes covering northern and western Britain. This circumstance may show up as a reasonably sharp dividing line where eastern and western scenes meet. A simplification to 17 'key' classes (see below) is suggested as being useful to ensure reasonable consistency nationally. Local and regional users, or national users requiring maximum detail despite some regional inconsistencies, may still prefer to use the 25-class dataset.

HOW TO USE THIS CLASS DESCRIPTION

This class description document is structured using the two levels of classification at which the Land Cover Map of Great Britain is being made available as a standard digital product: as either the full set of 25 'target' cover-types, or as an aggregation of these into 17 'key' cover-types. The latter classification recognises that there is sometimes inconsistency in the mapping of certain rarer cover types and provides an aggregation into more consistently mappable types. Table 1 shows the relationship between the 17 key cover-types and the 25 target cover-types. To avoid possible confusion, the 17 key cover-types are referenced by uppercase letters (A - Q), whilst the 25 target cover-types are referenced by the numerical label which the category carries in the 25 m x 25 m digital data.The 25 target cover-types are provided as standard. The 17 key cover-types are provided as an option, but as the standard in the Countryside Information System (Wyatt *et al.* 1994).

The 25-class dataset is available in two resolutions, 25m or 1km summary. In the 25m, 25-class dataset, each 25m grid cell is assigned a value between 0 and 25 which corresponds to one of the target cover-types (see Table). In the 1 km summary data there are 25 layers, one for each target cover-type. Within each layer, each 1km grid cell is assigned a value which represents the integer percentage of that particular target cover-type occurring within that cell. For example: A 1km cell contains 1600 x 25m cells; if 320 of these cells were of key cover-type 10, then in

layer 10 the 1km cell would be assigned a value of 20 (%).
The 17 class dataset is available as 1km summary data. As indicated above ('Land Cover Classes') it is also possible to provide non-standard 'customised' data, eg the data could be provided as a selection of a lesser number of cover-types only.

Table 1. The correspondence between the 25 'target' cover-types and the 17 'key' cover types of the Land Cover Map of Great Britain.

LAND COVER CATEGORY (17 class system)			TARGET CLASSES (25 class system)	
A[a]	1[b]	Sea / Estuary	1[c]	Sea / Estuary
B	2	Inland Water	2	Inland Water
C	3	Beach / Mudflat / Cliffs	3	Beach and Coastal Bare
D	4	Saltmarsh	4	Saltmarsh
E	5	Rough Pasture / Dune Grass / Grass Moor	5	Grass Heath
			9	Moorland Grass
F	6	Pasture / Meadow / Amenity Grass	6	Mown / Grazed Turf
			7	Meadow / Verge / Semi-natural
G	7	Marsh / Rough Grass	19	Ruderal Weed
			23	Felled Forest
			8	Rough / Marsh Grass
H	8	Grass Shrub Heath	25	Open Shrub Heath
			10	Open Shrub Moor
I	9	Shrub Heath	13	Dense Shrub Heath
			11	Dense Shrub Moor
J	10	Bracken	12	Bracken
K	11	Deciduous / Mixed Wood	14	Scrub / Orchard
			15	Deciduous Woodland
L	12	Coniferous / Evergreen Woodland	16	Coniferous Woodland
M	13	Bog (Herbaceous)	24	Lowland Bog
			17	Upland Bog
N	14	Tilled (Arable Crops)	18	Tilled Land
O	15	Suburban / Rural Development	20	Suburban / Rural Development
P	16	Urban Development	21	Continuous Urban
Q	17	Inland Bare Ground	22	Inland Bare Ground
			0	Unclassified

[a] class reference within the 17 'key' cover-type categorisation.
[b] 'band' within the 17 'key' cover-type 1 x 1 km summary data.
[c] label value within the 25 'target' cover-type 25 x 25 metre data.

DESCRIPTIONS OF LAND COVER CLASSES USED IN THE MAPPING OF GB

A SEA / ESTUARY

This category includes all open sea and coastal waters, including estuaries, normally inland to the point where the waterway is constricted to 1 pixel or its continuity is broken by a bridging point. An exception is where waterways open up again into major estuarine features, such as Breydon water near Great Yarmouth or many of the sea lochs on the north-west Scottish coast. The division will be immediately evident by reference to classmaps. It is not intended to accurately show the limit of saline or tidal waters, which may extend much further inland.

Fuller key-name: Sea, coastal waters and estuaries, inland to the first bridging point or barrier.

This category carries the label '1' in the 25 'target' class dataset.

B INLAND WATER

Inland water includes all mappable fresh waters and any estuarine waters which are excluded in the above category. The maps record only those areas which are water-covered on both the winter and summer images. Thus, reservoirs with summer draw-down, or winter-flooded meadows are classified to the summer class (ie bare or grassland in these examples).

Fuller key-name: inland fresh waters and estuarine waters above the first bridging point or barrier.

This category carries the label '2' in the 25 'target' class dataset.

C COASTAL BARE GROUND (BEACH / MUDFLATS / CLIFFS)

The coastal bare ground category includes intertidal mud, silt, sand, shingle and rocks. It also includes bare maritime habitats above the tide-line, such as shingle beaches, mobile sand dunes and bare rocks or soil of coastal cliffs. A covering of sparse vegetation, such as pioneer saltmarsh, dune or shingle species will not put the beach into a vegetated class unless the majority of the substratum is covered.

Distinction of this cover type is dependent on the level of the tide on the days of imaging (the lower tide being used to define the lower limit of the beach). Thus discrepancies can arise where high tides prevailed on imaging.

Fuller key-name: bare coastal mud, silt, sand, shingle and rock, including coastal accretion and erosion features above high water.

This category carries the label '3' in the 25 'target' cover-type digital data set.

D SALTMARSH

Areas of seaweeds are sometimes sufficiently extensive to show as vegetated intertidal plant communities. The may comprise the green alga *Enteromorpha intestinalis* or the brown wracks (*Pelvetia caniliculata, Fucus* spp. and *Ascophyllum nodosum*) growing on rocks, boulders and sometimes gravels, sands and muds. Saltmarshes are intertidal sand-, silt- or mud-based habitats, colonised by halophytic grasses such as *Puccinellia* spp, and herbs such as *Limonium* spp., *Aster tripolium* and *Triglochin maritima*. They remain mostly green in winter. For the purposes of this classmap, only those marshes up to normal high water spring tides (ie those flooded monthly) are included. The upper saltmarsh, inundated only on extreme high-water spring tides, is dominated by coarse grasses such as *Agropyron* spp.. These are classified accordingly as marsh / rough grass (see below).

Distinction of this cover type is dependent on the level of the tide on the days of imaging (the lower tide being used to define the lower limit of the seaweed beds or saltmarshes). Thus discrepancies can arise where high tides prevailed on imaging.

Fuller key name: intertidal seaweed beds and saltmarshes up to normal levels of high water spring tides.

This category carries the label '4' in the 25 'target' class dataset.

F PASTURE / MEADOW / AMENITY GRASS

Agricultural grasslands comprise many types, from newly sown leys, of single species, to largely unimproved swards of indigenous species. This range is subdivided in many different ways by the many different surveys of grasslands (see Fuller 1987). Here we must be constrained by what is possible, with acceptable accuracy, using satellite imaging. Certainly, the class 'pasture/meadow/amenity grass' can be identified with good consistency. It characteristically forms a cropped sward, comprising finer grass species (eg *Festuca, Agrostis, Lolium* and *Poa* spp.) often with many other grasses and herbs. The sward is maintained by mowing and/or grazing, such that coarser species of grass, herbs and scrub cannot become dominant.

In agricultural and conservation terms, there is an important distinction between 'improved' and 'unimproved' swards. Improvement may involve reseeding, herbicide treatments, and/or fertiliser applications which promote the growth of 'preferred' species, especially *Lolium perenne*. Swards which are essentially 'unimproved', or which have reverted, contain a dominant proportion of indigenous species (Fuller 1987).

Improved pastures or close-mown amenity swards are mostly distinguishable on satellite imagery: they remain green in both summer and winter. Unimproved swards are generally used at a low intensity and are typically unenclosed. They are also likely to be discernible from intensive pastures because of their rougher texture, their weed content and the quantity of plant litter they carry in winter (all factors which affect overall reflectance). The problem is that hay meadows, of both the lowlands and the partially improved lower slopes of upland areas, could be confused with either improved or unimproved swards, depending on the stage of management in the particular year of imaging eg growing hay, standing hay, cut hay, aftermath-grazed. This obviously depends on the date of the image available for classification (and only days may separate the four types).

The 25 class classification identifies two types of pasture/meadow/amenity grass, which are be retained as separate class numbers in the database, but could be aggregated to a single colour-class for map and data outputs, depending on the measured accuracy and user requirements. It should be realised that the classes are readily inter-changeable by changing management practices, and such changes may take place on a cyclical basis (eg where swards are mown one year grazed another). The two pasture/meadow/amenity grass subclasses are described below.

Mown / Grazed Turf

Mown/grazed turf grasslands are managed either as agriculturally productive swards or mown as amenity grasslands. They are mostly agriculturally 'improved' by reseeding and/or fertiliser use and would normally contain high quantities of *Lolium perenne* and/or other preferred species. Their key characteristic is that they did not, at either date of imaging (summer or winter), have any detectable quantity of dead plant material, nor a substantial uncropped stand of living material. This implies that the swards were grazed or cut and thus maintained as a turf throughout the growing period. This management prevented the sward from reaching flowering height in summer and ensured that there was little or no standing crop of plant litter to influence the winter-reflectance of the sward.

Fuller key-name: pastures and amenity swards, mown or grazed, to form a turf throughout the growing season.

This category carries the label '6' in the 25 'target' class dataset.

Meadow / Verge / Semi-natural swards

Meadows and verges include grasslands which are managed, but mostly at a lesser intensity than the 'mown/grazed turf' class. Partial improvement favours productive species such as *Lolium perenne*, and herbicide treatment may reduce the content of broadleaved 'weeds' but some of the swards in this category represent the traditional hay meadows which have escaped improvement. The swards may be mown for hay and perhaps aftermath-grazed.

Semi-natural swards may have much the same appearance. *Festuca/Agrostis* swards are typical of the indigenous, essentially unimproved grasslands, of neutral to acid soils, mostly enclosed, formerly covering much of Britain's grazing land, but now restricted to upland margins and odd pockets of lowlands, usually on floodplains. The swards are characterised by *Festuca rubra* and/or *ovina*, *Agrostis stolonifera*, *A. tenuis* and/or *A. canina*, often with substantial quantities of rushes (*Juncus* spp.), sedges (*Carex* spp.) and broadleaved plants. Alternatively, the seminatural grasslands may be agriculturally non-productive swards which are managed by occasional cutting to prevent excessive weed or scrub growth, eg roadside verges, country parks, golf course semi-rough areas.

The key characteristic of this class is that the swards were not a short-cropped turf throughout the year - either they were grazed at low intensity such that patches of unpalatable species became sufficiently dominant to produce a higher standing crop than on pastures. Or the swards were used for hay and appeared as a long grass sward awaiting mowing or grazing: or, perhaps, they had recently been mown for hay. The important characteristic is that they were cropped by the time of winter imaging, to remove much of the standing crop of grass. Thus, by winter they were mostly green rather than a straw-coloured stand of plant-litter as would be typical of natural swards of coarse grasses. This class forms a transition, often in appearance, perhaps in species contents and productivity, often in terms of time (ie improving or reverting) and especially space (a transition zone), between improved pastures and the 'natural' grasslands of heaths and moors.

Fuller key-name: Meadows, verges, low intensity amenity grasslands and semi-natural cropped swards, not maintained as a short turf.

This category carries the label '7' in the 25 'target' class dataset.

G MARSH / ROUGH GRASS

In the 25 class data the marsh/rough grass category comprises three types, separated to distinguish established rough swards from new colonisation. In the 17 class list these are amalgamated.

Ruderal weed

The ruderal weed cover-type is generally bare ground being colonised by annual and short-lived perennial plants, usually with a considerable remnant of bare ground, especially in winter. The ground may be naturally bare, eg shingle beaches, or abandoned arable land, eg setaside, or derelict industrial works such as demolished factories, gravel pits etc. This category is rarely extensive enough to map, was chosen to classify what might have been extensive areas of setaside, and is aggregated with the rough grass class for maps and most data summaries.

Fuller key-name: ruderal weeds colonising natural and man-made bare ground.
This category carries the label '19' in the 25 'target' class dataset.

Felled Forest

Recently felled forest, usually with large quantities of brush-wood etc, comprise this class. As they revegetate, felled areas recolonise with ruderal weeds, and then become rough grassland. Although originally selected in the anticipation that they would be relatively commonplace, felled areas are rare. They will be aggregated with 'marsh / rough grass' class for most display purposes and data-summaries.

Fuller key-name: felled forest, with ruderal weeds and rough grass.

This category carries the label '23' in the 25 'target' class dataset.

Rough / Marsh Grass

This class includes lowland herbaceous vegetation of fens, marshes, upper saltmarshes, and rough or derelict ground. The characteristic feature of this category is that the swards are not significantly cropped by mowing or grazed by stock. In fact most are unenclosed grasslands, abandoned from economic use. The result is that they have a high standing crop of vegetation, most of which dies back in winter, leaving a dense plant litter.

Fuller key-name: lowland marsh/rough grasslands, mostly uncropped and unmanaged, forming grass and herbaceous communities, of mostly perennial species, with high winter-litter content.

This category carries the label '8' in the 25 'target' class dataset.

J BRACKEN

The bracken class is herbaceous vegetation dominated by *Pteridium aquilinum*. It may be upland or lowland, mixed with grass and other species. The obvious characteristic is that the distinctive colour of winter bracken dominates the reflectance of the community. Checks against ground reference data indicate that there may be substantial confusion between bracken and other types of rough vegetation.

Fuller key-name: bracken-dominated herbaceous communities.

This category carries the label '12' in the 25 'target' class dataset.

E ROUGH PASTURE / DUNE GRASS / GRASS MOOR

There are potential problems of confusion between lowland grass heaths and upland grass moors, largely because the species complements are similar. However, there are sufficient differences that spectral separation may be reliable. It has also proved possible to separate the two using a digital mask to correct regional misclassifications (see introduction). Some users of the maps and data may choose to aggregate the two classes, for later separation in a GIS, but using their own contextual definition based on altitude, climate, latitude and longitude or combinations of any such variables.

Grass Heath

This class includes coastal dunes and inland grasslands typically growing on sandy soils, usually acid in character. The species might include, on coastal dunes, *Ammophila arenaria, Festuca rubra* and *Carex arenaria* and a wide variety of herbaceous species, often winter annuals. Inland, and on mature 'grey' dunes, all but *Ammophila* might be present, but acid-loving species are typical, including *Festuca ovina, Agrostis* spp. and *Deschampsia flexuosa* set in a carpet of lichens and mosses (Duffey *et al*. 1974). The latter species are also characteristic of marginal hill-grasslands and a zone of seminatural acid grassland may lie between the agricultural grasslands of lower hill-slopes and moorland communities on the hill tops. These swards are characteristic of north-western Britain, mostly on land between 100-200 m, but right down to sea level in north-west Scotland.

In winter, the lowland grass heaths have substantial quantities of dead plant litter, distinguishing the lowland grass heaths from agricultural swards, but the litter content is less than is typical of coarse rough grasslands, offering a spectral distinction from these.

> Fuller key-name: seminatural, mostly acid, grasslands of dunes, heaths and lowland-upland margins
>
> **This category carries the label '5' in the 25 'target' class dataset.**

Moorland Grass

This class includes upland swards, mostly of deciduous grasslands, often referred to as grass moorland or upland grassy heath. They are typically dominated by *Nardus stricta* and/or *Molinia caerulea*, with *Festuca ovina, Deschampsia caespitosa, Juncus* spp. often including sparse cover of upland dwarf shrubs. These swards form large tracts of mostly unenclosed hill-grasslands, lightly grazed often by sheep.

> Fuller key-name: montane/hill grasslands, mostly unenclosed *Nardus/Molinia* moorland.
>
> **This category carries the label '9' in the 25 'target' class dataset.**

I SHRUB HEATH

In the 25 class dataset dense shrub heath and dense shrub moor are kept separate. In the 17 class data they are aggregated into one class.

Dense Shrub Heath

Dense shrub heath refers to communities with high contents of heather (*Calluna)*, ling (*Erica* spp.) but perhaps mixed with broom (*Cytisus scoparius*), gorse (*Ulex* spp.). It is mostly evergreen, hence different from other scrub communities. Almost invariably, it represents vegetation on sandy soils, in characteristic sites like the Brecklands, and the Dorset and Surrey Heaths, or on extensive coastal dune systems.

Fuller key-name: lowland evergreen shrub-dominated heathland.

This category carries the label '13' in the 25 'target' class dataset.

Dense Shrub Moor

The dense shrub moor communities include heather (*Calluna vulgaris*), ling (*Erica* spp.) and bilberry (*Vaccinium* spp.) moorlands. Though dominated by woody shrubs, these may be mixed with herbaceous species, especially those of the moorland grass. The dense shrub moors may be managed by moor-burning, in which case they may be bare, for most of the first year after burning; then the grass / shrub heath mixture is found until dense shrub growth again dominates the cover.

Fuller key-name: upland evergreen dwarf shrub-dominated moorland.

This category carries the label '11' in the 25 'target' class dataset.

H GRASS / SHRUB HEATH

In the 25 class dataset open shrub heath and open shrub moor are kept separate. In the 17 class data they are aggregated into one class.

Open Shrub Heath

This category complements the above moorland variety of grass /shrub heath. However, because intensive grazing of lowland heaths is no longer practised, the incidence of this class is rare. It will be found where knowledge-correction has identified an area of the grass / shrub heath mixture as being in a lowland zone.

Fuller key-name: lowland, dwarf shrub/grass heathland.
This category carries the label '25' in the 25 'target' class dataset.

Open Shrub Moor

This cover type is fairly commonplace on some marginal hill grazing land, especially in northern and western parts of Britain, where grazing prevents the dominance of dwarf shrub species. It is also extensive in *Calluna* moorland, as a result of moor-burning to maintain young heather regrowth to promote grouse populations. Initial regrowth produces grassy swards, which over a period of years revert to heather-cover. As the heather senesces, so moorland is re-burnt, with a repeat cycle of perhaps 10 years. Whereas other transient cover-features of management (eg haycutting, arable crop-type) are not defined because of their short-lived nature, the 10-year cycle is judged long enough to justify the distinction between currently managed and unmanaged areas. The proportionate cover of *Calluna* which is required to alter the classification from 'burnt' back to 'dwarf shrub' is not yet clear: this will become evident on comparison of classmaps with corresponding 1 km field squares of Countryside 1990.

Fuller key-name: upland, dwarf shrub/grass moorland.

This category carries the label '10' in the 25 'target' class dataset.

M BOG (HERBACEOUS)

Bogs are widespread in upland areas especially to the north and west of Britain. They are also found locally in lowland areas. They are characterised by permanent waterlogging, resulting in depositions of acidic peat. The 'bogs' of this classification are mostly herbaceous communities of wetlands with permanent or temporary standing water (Ordnance Survey maps show the same areas using 'marsh' symbols). Wet heather moorlands, which botanists may refer to as 'bogs', are not generally mapped as such on topographic maps (OS maps show them as 'heaths'), and are mapped by this survey as dwarf shrub categories. As with other heathland and moorland classes in the 25 class data, a distinction is made between upland and lowland variants of this class.

Lowland bog

Lowland bogs are rare in much of Britain, due to drainage and peat extraction. However, local large areas of bog are to be found on the west coast of Scotland. They carry most of the species of upland bogs, but in an obviously lowland context, with *Myrica gale* and *Eriophorum* spp. being highly characteristic.

Fuller key-name: lowland herbaceous wetlands with permanent or temporary standing water.

This category carries the label '24' in the 25 'target' class dataset.

Upland bog

Upland bogs have many of the species of grass and dwarf shrub heaths and moors, but are characterised by water-logging, perhaps with surface water, especially in winter. The water-logging promotes species such as bog myrtle (*Myrica gale*) and cotton grass (*Eriophorum* spp.) in addition to the species of grass and dwarf shrub moorlands.

Fuller key-name: upland herbaceous wetlands with permanent or temporary standing water.

This category carries the label '17' in the 25 'target' class dataset.

K DECIDUOUS / MIXED WOOD

This category comprises all deciduous broadleaved trees, broadleaved and includes mixed stands, where they cannot be separated spatially. The 25 class data identifies two cover types.

Scrub / Orchard

Scrub and orchard areas are deciduous, often with substantial herbaceous vegetation. Typical species include sallow (*Salix* spp.) in wetlands, or hawthorn (*Crataegus monogyna*), brambles (*Rubus fruticosus* agg.) and saplings or small trees: these include, of course, fruit trees. Although commonplace, the scrub category is rarely extensive enough to record more than just a few pixels. The exceptions are in areas of orchards (though these are only found in a few areas), and in semi-natural vegetation, for example, the sallow-carr woodlands of the Broads or hawthorn scrub on chalk downland. For map-production purposes and in most data summaries the scrub and deciduous woodland classes will be amalgamated.

Fuller key-name: deciduous scrub and orchards.

This category carries the label '14' in the 25 'target' class dataset.

Deciduous Woodland

The deciduous characteristic separates it from evergreen species, as it appears bare in winter. However, deciduous woodland has a unique spectral signature which separates it from other deciduous vegetation and from arable land. Mixed woodland may be

included with this category, though continuous evergreen stands, where greater than the minimum mappable area, will be separated.

Fuller key-name: Deciduous broadleaved and mixed woodlands.

This category carries the label '15' in the 25 'target' class dataset.

L CONIFEROUS / EVERGREEN WOODLAND

Coniferous/evergreen woodland comprises coniferous species (including the deciduous larch (*Larix spp.*), plus other evergreens such as holly (*Ilex aquifolium*), Rhododendron (*R. ponticum*), yew (*Taxus baccata*) or Holm oaks (*Quercus ilex*). As well as remaining in leaf all year round, the species generally have very dark leaves or needles, giving them unique signatures in both summer and winter.

Fuller key-name: Conifer and broadleaved evergreen trees.

This category carries the label '16' in the 25 'target' class dataset.

N TILLED LAND (ARABLE CROPS)

Tilled land includes all land under annual tillage, especially for cereals, horticulture etc. It also includes leys in their first year, ie if they were bare at the time of the winter imagery. Other land, vegetated at the time of summer imagery but bare soil during the winter, is also included in this land cover type: hence any temporarily bare ground (eg from scrub-clearance, development, mining or soil tipping) would be classified in this category.

Fuller key-name: arable and other seasonally or temporarily bare ground.

This category carries the label '18' in the 25 'target' class dataset.

O SUBURBAN / RURAL DEVELOPMENT

The suburban/rural development category includes all land where the pixels of the Landsat image have recorded a mixture of built-up land and permanent vegetation. Most suburban and rural developments, where the buildings and associated car-parks etc. remain small enough that they do not fill all of each pixel, are included in this cover-type. Small rural industrial estates, glasshouses, railway stations, larger rural roads, villages, small retail sites are all included in this class.

Fuller key-name: suburban and rural developed land comprising buildings and/or roads but with some cover of permanent vegetation.

This category carries the label '20' in the 25 'target' class dataset.

P URBAN DEVELOPMENT

The urban development category covers all developments which are large enough to completely fill individual pixels, to the exclusion of significant quantities of permanent vegetation. It includes cities, large town centres, major industrial and commercial sites, major areas of concrete and tarmac, plus permanent bare ground associated with these developments, such as car-parks and tips.

Fuller key-name: industrial, urban and any other developments, lacking permanent vegetation.

This category carries the label '21' in the 25 'target' class dataset.

Q INLAND BARE GROUND

The inland bare ground category includes all 'natural' surfaces such as rock, sand, gravel or soil, though their origin has often not been natural: the exceptions are coastal features which classify as beach/mudflat/cliffs. Ground which has been bared by human activities, or by livestock would be included. Imported surfaces of sand or gravel (eg car parks) would also be classed as bare ground.

Fuller key-name: ground bare of vegetation, surfaced with 'natural' materials.

This category carries the label '22' in the 25 'target' class dataset.

UNCLASSIFIED

Within the 25 metre data about 2% of Great Britain remains unclassified, ie. unallocated to any of the 25 'target' cover-types described above. These occurrences represent (i) some small areas within scenes that were either obscured by cloud upon both the summer and winter imagery used for the classification, (ii) some locations for which a single scene of cloud free imagery was not available to the mapping project (eg the island of Tiree), and (c) some areas of unusual cover types that were not defined by the classifier training exercise.

In the 25 metre grid cell data these cells are uniquely labelled, with the value '0', in the same manner as those cells designated to one of the 25 target cover-types. In the 1 km summary data the proportion of each 1 km cell that is unclassified is represented by default, by the difference between the sum of the values for the 17 key cover-types and 100.

Fuller key-name: cover-types which did not fit into the 25 'target' classes

This category carries the label '0' in the 25 'target' class dataset.

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