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ITE/ERM/UCPE contract report
to the
Department of the Environment

Current status and prospects for threatened habitats in England

OVERVIEW

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This Contract Report is one of a series describing work on threatened habitats commissioned by the Department of the Environment. Views expressed in it do not necessarily concide with those of the Department.

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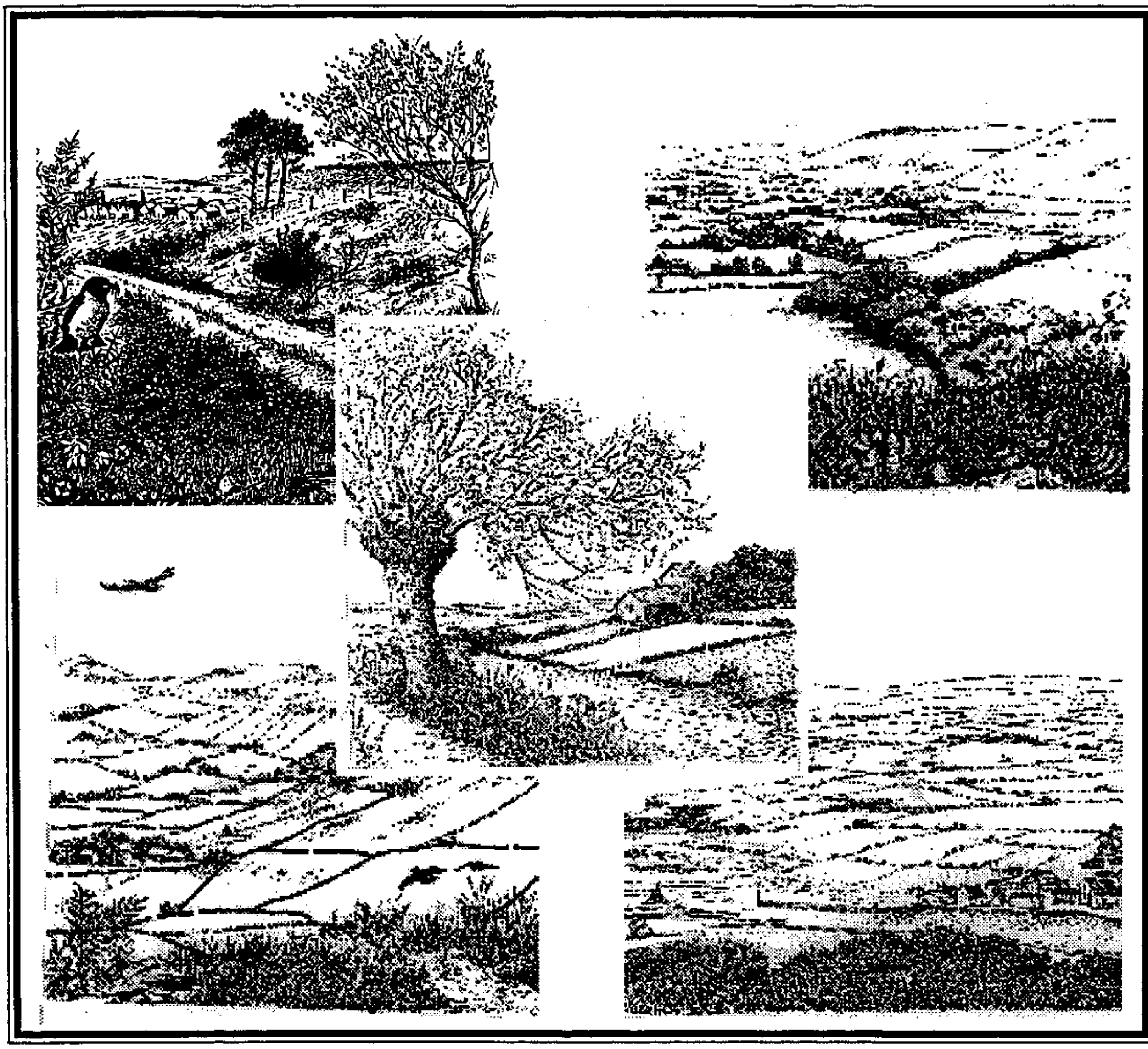

Current status and prospects for threatened habitats in England

OVERVIEW

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1. Executive summary

1.1 Survey

1.1.1 In 1992, the DOE commissioned a research project to investigate the threatened habitats occurring within the landscape type included in the original 'Countryside Stewardship Scheme'. The general aim of the project was to build on the work of the Countryside Survey 1990, to examine in more detail the distribution and quality of these habitats within the landscape types in England. This forms a basis against which future ecological changes, resulting from policies or specific initiatives, may be compared.

1.1.2 The broad geographical extent of the landscapes has been defined to include the remaining area of the characteristic, threatened habitats plus areas which have the potential to support these habitats. The areas of the landscapes were defined using available databases on geology, soils, the coastline and waterways, the combination varying between landscape. The 1 km squares which satisfied the criteria for each landscape formed a database, referred to as the landscape mask.

1.1.3 The landscape masks were then characterised in terms of ecology, landscape features and archaeology. The 1 km squares were stratified according to landscape type (for example the coastal mask was divided into estuarine, soft and hard coasts) and designation (designated or non-designated). Squares in the resultant four or six strata, depending on landscape, were then randomly sampled and land cover, vegetation in quadrats, landscape features and historic features recorded in field survey; the location of the vegetation quadrats was permanently marked to facilitate resurvey. Data on historic feature was also collected for the sample squares from existing archaeological datasets and archives.

1.2 Current status

1.2.1 The masks varied considerably in size, from 2604 km^2 for the coastal mask to 15616 km^2 for the calcareous grassland mask. The proportion of the 1 km squares in the mask which contained some form of designation varied from 56% in the lowland heath landscape to 81% in the uplands. The landscapes as defined included a wide variety of land cover types. A large proportion of the calcareous grassland, lowland heath, coastal and waterside landscapes were under arable crops or managed grassland but only a small proportion of the upland landscape. Only between 1 and 10% of the lowland heath, calcareous grassland, coastal and waterside landscapes were the core threatened habitats. In contrast, about 56% of the upland landscape was estimated to be upland vegetation. In all but the coastal landscape, a large proportion of these core habitats were in squares containing a designation; however, significant areas of core lowland heath habitats are not designated.

1.2.2 Objective measures of the vegetation recorded in quadrats during the field survey have been related to quality criteria, to provide an empirical evaluation of the quality of the vegetation in the respective landscapes and sampling strata. The measures were then combined to provide a ranking of the vegetation quality in each sampling strata and for each landscape. In the lowland heath, calcareous grassland and upland landscapes the designated strata are ranked highest for the majority of the quality measures. In the coastal and waterside landscapes there is less consistency with different strata ranked highest for different quality criteria. In the cases, the variations in divisions between the types of coast or waterside were more important in determining vegetation quality than designation.

1.2.3 Without time series data it is difficult to assess the effect of designation. The higher quality of the vegetation in the designated strata of some of the landscapes could indicate that designation has been effective in providing protection for the core vegetation or that the areas had designated the high quality areas of vegetation. However, this study provides for the first time an essential baseline, necessary to conduct future monitoring of the effectiveness of designations.

1.2.4 The survey data plus information derived from examination of historic records showed that each of the landscapes contained historical/archaeological sites from a wide range of periods. The representation if the various periods differed, however between landscapes. Thus, early medieval sites were relatively scarce in the lowland heath and calcareous landscape and palaeolithic sites in the uplands. The largest frequency of occurrence of sites was found in the coastal landscape, 10.3 per 1 km sample square, and the smallest in the uplands, 5.1 sites per 1 km sample square. The calculated frequencies were higher than the published national average for scheduled ancient monuments of 1.2 per km^2.

1.3 Vulnerability to change

1.3.1 A modelling approach was used to assess the vulnerability of the vegetation in the landscapes, based on the field data, to change as represented by combinations of 'disturbance' and 'eutrophication', two factors which exert a major influence on competition between plant species. The study used the TRISTAR2 model which predicts vegetation response to environmental and/or management change scenarios. Plant species are allocated to one of a series of functional types and the model predicts the response of these different types and the characteristics of the new steady vegetation resulting from the change scenarios.

1.3.2 The results indicated that, overall, the vegetation of the coastal landscape is the most sensitive to the changes considered and the vegetation of the watersides the least sensitive. Four of the five landscapes showed the greatest sensitivity to a scenario of increased disturbance with increased eutrophication. The waterside landscape was the exception, the vegetation of this landscape being characterised naturally by eutrophic conditions and disturbance. Some of the coastal vegetation is particularly vulnerable to changes in disturbance, increases or decreases.

1.4 Threats to the landscapes and habitats

1.4.1 Any change which includes an increase in eutrophication is likely to reduce the conservation value and quality of the threatened habitats in all five landscapes. Conversely changes which involve reductions in eutrophication are likely to improve the quality of the threatened habitats in four of the five landscapes. The threatened habitats of four of the landscapes would benefit from an increase in disturbance in combination with a decease in eutrophication.

1.4.2 The project has carried out an assessment of the possible impact of current and future threats on the threatened habitats. the characteristic soils of the lowland heath, a large proportion of the upland soils and the non-calcareous soils within the calcareous grassland landscape are sensitive to acidification. An assessment based on the critical loads approach indicates that the critical load of acidity for soils is exceeded by the mean 1989-91 pollutant deposition in over 90% of the lowland heath and upland masks. Following planned reductions in emissions of sulphur, the critical load would still be exceeded over more than 40% of the uplands and lowland heath but the calcareous grassland would all be protected.

1.4.3 The threatened habitats in the lowland heath, calcareous grassland and upland landscapes are sensitive to eutrophication. Atmospheric inputs of nitrogen have increased considerably over the last 20 to 30 years and the critical load approach has ben used to assess the possible impacts of current rates of deposition. The critical loads for nitrogen of important habitats are currently exceeded in over 20% of the lowland heath mask, and more than 80% of the calcareous grassland and upland masks. targets for the reduction in nitrogen emissions have not yet been set.

1.4.4 The greatest short term threats to the threatened habitats in lowland heath, calcareous grassland and upland landscapes are changes in land management, particularly changes in grazing and/or burning regimes. Both increased and decreased grazing can have adverse effects but overgrazing is the major threat in the upland heathlands. The threatened habitats in these landscapes are also vulnerable to eutrophication by fertilizer application or runoff from adjacent land. The maintenance of a suitable grazing regime and the prevention of increased nutrient inputs is central to the survival of the threatened habitats in these landscapes.

1.4.5 The threatened coastal habitats, particularly those in the estuarine and soft coasts are particularly vulnerable to changes in the level of disturbance and therefore to coastal developments that affect tidal flows and currents. In the longer term, changes in sea level constitute a significant threat. The key threats to the waterside habitats are associated with the management of the land adjacent to the waterbody and in the wider catchment, and the management of the water channels themselves and of the water flows in these channels; for example, land drainage, the application of fertilizers and pesticides, changes in land use in the catchments, canalisation of waterways and water abstraction.

1.4.6 Areas of the threatened habitats in all three landscapes are still being lost to landtake for agriculture, forestry and development. Recreation forms a significant threat to small areas of each of the landscapes, resulting in erosion and changes in species composition of the vegetation.

1.4.7 The threats noted above rarely operate in isolation. Thus, changes in grazing pressure take place while atmospheric inputs of nitrogen increase; changes in the management of the waterside zone takes place at the same time as water abstraction or canalisation of the waterbody; coastal habitats are affected simultaneously by coastal development, pollution and changes in agricultural management.

1.5 Policy implications

1.5.1 A wide variety of policy instruments and initiatives which can affect/control the impact of the various are now in place. Planning policies and regulations can in principle control the loss of the threatened habitats to development and to some extent forestry but there is less control over agricultural improvement. Non of the planning instruments give complete protection to the various threatened habitats.

1.5.2 It is essential that policy instruments to protect. maintain or enhance the threatened habitats in the lowland heath, calcareous grassland and upland landscapes include mechanisms to influence land management. Land management, including grazing, burning, cutting and fertilizer regimes can be influenced by initiatives such as the Environmentally Sensitive Area, the Wildlife Enhancement and Countryside Stewardship schemes. These are important initiatives but their takeup is currently limited by their voluntary nature, by the total funds available for each scheme and by the magnitude of the grants available to individual landowners. The current structure of these initiatives does not allow key specific sites of the threatened habitats to be targeted

1.5.3 Current targets for control of sulphur emissions will provide protection for large areas of the threatened habitats against acidification but important areas will remain at risk. Controls on nitrogen emissions are needed to prevent eutrophication of the threatened habitats. The agreed targets for reductions in CO_2 emissions are unlikely to affect any changes in climate, or linked sea level changes in the next 20 years but should have am impact in the longer term.

1.5.4 There is a need for an integrated assessment and application of current and proposed agricultural, countryside and pollution control policies and measures. They impact interactively on the threatened landscapes and can have potentially confounding effects. Thus agricultural payments under the CAP can run counter to the aims of countryside or habitat oriented scheme; resulting, for example in increased stocking rates when habitat maintenance requires reductions in stocking. Area based support payments or linking agricultural subsidies to environmental benefits could help to overcome this particular problem. There is also a need for the development of integrated approaches to the management of, particularly the coastal zone and of catchments. Such integrated management is being explored in some areas and the lessons should be applied more widely.

2. Project Background

2.1 Policy background

2.1.1 A great deal of concern has been expressed over recent decades about the loss of semi-natural habitats which are both of high nature conservation value and characteristic of the landscapes in which they occur. There has also been considerable debate about the relative importance of various factors in causing these losses, for example changes in land use or farming practices, atmospheric pollution, or industrial and urban development. In parallel with the development of these concerns, and of the debates about causes, there has been an increasing realisation of the link between policy and changes in these possible causative factors, for example between the Common Agricultural Policy, cropping patterns and farming practices. This latter realisation has led to the development of policy instruments to influence land use and agricultural management to maintain and restore threatened semi-natural habitats, for example the Countryside Stewardship Scheme and the Environmentally Sensitive Areas. However, there is little data, on the national scale of the status of some of these semi-natural habitats, their current distribution, and quality and the rate of loss over recent years which can be used to make informed judgements or evaluations or act as a baseline against which to assess of impact of policy instruments. Information of this type is becoming available through thematic and local surveys, such as the English Nature's surveys and collation of information on lowland heath and calcareous grasslands but national datasets are required, based on standardised procedures so as to facilitate objective comparisons.

2.1.2 To add to knowledge and understanding in these areas, the DOE commissioned a research project to investigate a number of key semi-natural. The approach used was to set these habitats within the context of landscapes in which they are characteristic elements. The original five landscape types included in the Countryside Stewardship Scheme were used as a framework, which comprise:

i. Lowland heath landscapes
ii. Calcareous grassland landscapes
iii. Upland landscapes
iv. Coastal landscapes
v. Waterside landscapes (river valleys, canal and lakesides)

2.1.3 These landscape types, together with their constituent habitats (Box 2.1), are seen as areas which have suffered serious losses and degradation of habitats in the past and appear to be still under threat. They are perceived as having great value for wildlife, landscape, history and amenity/public enjoyment.

BOX 2.1 DEFINITIONS

Landscape type is a conceptual term for geographical area(s) in which lowland heathland, calcareous grassland, upland, coastal or wetland vegetation occurs, has occurred historically or has the potential to occur, and also includes other land cover types (e.g. farmland) which form mosaics with these vegetation types.

The **mask** is a cartographic term which, in this project, is a map which includes both the respective landscape type and areas which have the potential to be included in the landscape type.

Individual **habitats**, occur within the landscape type.

Characteristic habitats are the key, semi-natural habitats of high ecological value that occur within each landscape type.

2.1.4 The aim of the project was to examine the distribution and quality of key semi-natural habitats within target landscape types in England by adding more detail to work of the Countryside Survey 1990. This forms a basis against which future ecological changes, resulting from changing policies or specific initiatives, may be measured and compared. The project has also proposed a methodology for measuring change at the national level and reviews current policy instruments affecting characteristic habitats and considers prospects for the future. The study was restricted to England.

2.2 Research context

2.2.1 "Countryside Survey 1990" (CS1990), a project carried out by ITE, jointly funded by NERC, DOE and the former NCC, was developed from earlier surveys of GB and includes field surveys of land cover, landscape features and vegetation quadrats. It also included soil surveys of all sample squares and was linked to a project mapping the land cover of GB using satellite imagery (Barr et al. 1993). The objective of the Countryside Surveys is to provide stock and change information on land cover, vegetation and landscape features, based on field survey of sample areas at the GB and regional scale.

2.2.2 For the Countryside Survey 1990 fieldwork, a standard survey unit of 1 x 1 km square was used. A total of 508 1 km squares were sampled across the whole of Great Britain.

2.2.3 The 1978, 1984 and 1990 Countryside Surveys provide the most recent information on general changes in the British countryside. The sample-base system used in the surveys was designed, however to yield data on the wider countryside as a whole rather than on rarer, or localised, habitats. Thus, there was a need for information about these those rare and localised habitats perceived to be under threat, or which represent areas of concern to the Department. This study was designed, therefore to provide more detailed information on the characteristic habitats within the five landscape types covered by the 'Countryside

Stewardship Scheme' but using complimentary methodologies to those used in the Countryside Surveys. The use of complimentary methodologies would enable the resulting databases to be integrated and analysed using similar procedures, and enable data for the Countryside Survey 1990 to be utilised in the current study.

2.3 Objectives

2.3.1 The objectives for each landscape type were:

i. Determine the distribution of the landscape type in England;

ii. Survey the habitats (including major land cover types and ecological features such as hedgerows) and historic features within each landscape type.

iii Determine, on a regional basis and in relation to current designations, the composition of each landscape type in terms of the quantity and quality of the surveyed features;

iv. Develop models to predict the effect of environmental and management changes on the distribution and quality of the landscape types and their constituent habitats;

v. In the light of the above, make recommendations on ways in which policy instruments may be refined to further protect, enhance or re-establish the habitats which characterise each landscape type; and

vi. Establish a baseline and develop a methodology for measuring change in these habitats which is sufficiently robust and precise to assess the effectiveness of policies, at a national (England) scale.

3. Approach and methods

The project has used a combination of literature review, field survey, modelling and assessment by expert panels (Figure 3.1).

3.1 *A. Literature review.* An initial literature review was used to give (i) a general definition of each of the landscapes, (ii) their distribution within England, (iii) a summary of their distinctive ecological, scenic, recreational and historic characteristics, (iv) the importance of the landscape and constituent habitats in a national and international context, (v) the factors influencing the formation and maintenance of the landscape and (vi) the threats and pressures for change.

3.2 *B. Creation of landscape masks.* At the start of the project only fragmentary information existed from which to define and map the national distribution of the landscapes. Procedures were therefore developed to create a mask for each landscape which defined those 1 km squares in England which contained the landscape or had the potential for the characteristic habitats. Data on soils, geology, altitude, river systems, the coastline and the ITE Land Classes were combined in various combinations within a GIS to create a map, and database, of the distribution of each of the landscapes (Box 3.1). The masks were not intended to cover squares with only small areas of the various landscapes. The available information on the landscape distributions, although fragmentary was used to check and validate the GIS procedures.

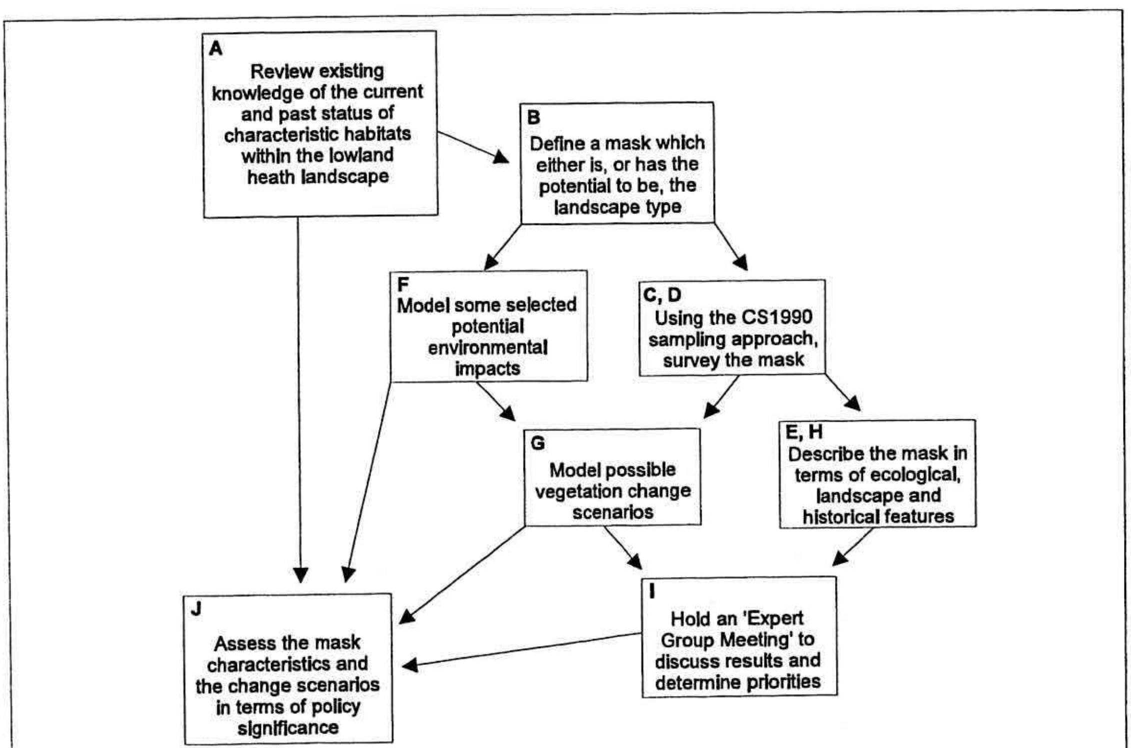

Figure 3.1 The linkages between the main components of the project.

BOX. 3.1 Definition of the landscape masks

Lowland heath - Distribution of soil types characteristic of lowland heath overlain with ITE Land Classes 17-24 and 27-32, to exclude upland heathland. Land classes 17-24 and 27-32 are grouped as being predominantly upland in character, while classes 1-16 and 25 and 26 are predominantly lowland (Barr et al 1994).

Calcareous grassland - Distribution of limestone and chalk bedrock overlain with the distribution of drift deposits and with the addition of adjacent 1 km squares containing steep slopes, to ensure inclusion of limestone escarpments; areas with drift overlying the calcareous bedrock were excluded from the mask.

Upland landscape - ITE Land Classes 17-24 plus 27-28, the land classes considered to be primarily upland in character (Barr et al 1994).

Coastal landscape - All land within 500m of the coastline as defined on the ITE Land Cover map, plus any contiguous areas of coastal vegetation (sand dunes, shingle and saltmarsh) extending seaward of this coastal zone.

Waterside landscape - All land within 150m of all waterways (streams, rivers, canals and lakes) in the 1:250,000 Ordnance Survey 'Strategy' dataset.

3.3 *C. Sampling strategy for field survey.* The database also provided the population of 1 km squares from which a stratified random sample of 1 km squares was subsequently taken for field survey. The field survey was designed to provide data on the distribution of habitats within the landscapes and on the vegetation of those habitats. To derive the sample, the total population of squares in a given landscape was first allocated to a number of broadly defined environmental strata and these strata were then further subdivided into designated and non-designated strata, depending on whether or not any designated land occurred within a square (Box 3.2). It is important to stress that only part of the square needed to be designated for that square to allocated to the designated strata. In this context 'designated' refers to:

Site of Special Scientific Interest
National Nature Reserve
National Park
Area of Outstanding Natural Beauty
Heritage Coast
Green Belt
Environmentally Sensitive Areas.

Sample squares were drawn at random from each of the resultant strata. As in CS 1990, squares which were more than 75% built up were excluded from the sample. A target of at least 10 1 km squares per stratum were selected for field survey. Information from grid squares within a given mask which had been surveyed during CS 1990 was combined with data from the squares surveyed during the current survey.

Box 3.2 Definition of the sampling strata

Landscape type	Basis of environmental Stratification	Strata
Lowland heath	Broad environmental division of the lowlands into two Major types of landscape Using defined groupings of ITE land Land Classes	Designated arable Non-designated arable Designated pastural Non-designated pastural
Calcareous grassland landscape	Limestone type defined using published geological maps	Designated soft limestone Non-designated soft limestone Designated hard limestone Non-designated hard limestone
Uplands	Broad environmental division Between the true upland and marginal uplands defined using groupings of ITE Land Classes	Designated true uplands Non-designated true uplands Designated marginal uplands Non-designated marginal uplands
Coastal	Broad geomorphologically-based division defined using data from OS maps on occurrence of cliffs, sand beaches, mud flats, esturaries	Designated estuarine coast Non-designated estuarine coast Designated soft coast Non-designated hard coast
Watersides	Broad environmental division into landscape types defined using groupings of ITE Land Classes	Designated arable Non-designated arable Designated pastural Designated upland Non-designated upland

3.4 *D. Field survey.* Land cover was recorded at 25 points on a grid within each field survey square, rather than mapping the whole square as in Countryside Survey 1990 (Barr et al, 1993). The land cover of the parcel of land within which the point fell was recorded. The nearest field boundary (within 100m of each grid point) was also recorded. The information was recorded using a standard set of codes.

A number of different types of vegetation quadrats were recorded from the sample squares to provide quantitative botanical information on the habitats within the landscapes (Box 3.3).

BOX 3.3

Main plots. These were recorded at upto 5 randomly chosen grid points within the 1 km squares, to provide a representative sample of the semi-natural vegetation. If the vegetation at these points was intensively managed then no quadrat was recorded. The size of the plots used varied between landscapes. In the Lowland Heath Landscape, 2 x 2 m plots were recorded at each of the 25 grid points, used to collect cover data, that supported or could support characteristic heathland habitats.

Habitat plots. Five plots were recorded in the less common habitats in each 1 km square in which were not represented by the Main plots; the size of the plots varied between landscapes. Habitat plots were not recorded in the Lowland Heath Landscape.

Waterside plots. Ten 1m plots were recorded adjacent to rivers, streams, canals and ditches in each 1 km square surveyed within the Waterside Landscape. The plots were placed parallel to the watercourse to record the meter strip above the running water.

3.5 *E. Vegetation data analysis*. The vegetation quadrats in each landscape were allocate to one of a small number of 'structural types' by the field surveyors. The species data from the quadrats was used to classify the quadrats into, (i) 'plot classes', and (ii) 'species groups' (Box 3.4). The plot classes grouped together quadrats in a particular landscape with similar species composition. The species groups, classified the species data from the quadrats to create groups of species with a similar distribution across all the plots in a landscape.

BOX 3.4 Vegetation classes resulting from analysis of the field plots

The **structural types** are broad types of vegetation, for example dry heath, acid grassland or coniferous woodland (cf. table 4.4) and were determined by the field surveyors.

The **plot classes** were based on species composition and using the multivariate statistical classification, TWINSPAN. The plot classes were given short descriptive names to aid interpretation (cf. table 4.5).

A multivariate statistical classification, DECORANA combined with Ward's Minimum Clustering, was used to group species into **'species groups'** which have similar distributions across the quadrat data set of a given landscape (cf table 4.6).

Vegetation quality in each landscape was assessed using the following criteria: Size/Abundance, Diversity, Naturalness, Representativeness, Fragility, Rarity, Potential value. The structural type, plot class and species group information formed the basis of the assessment. The sampling strata were also ranked, on the basis of the score for each of the quality criteria and the rankings combined to give an overall comparison of the quality between sampling strata..

3.6 *F. Assessment of the impacts of atmospheric pollution.* For those landscapes considered at risk from air pollution, the areas of the landscape at risk from current deposition and future scenarios of deposition have been assessed using the critical loads approach. A critical load is defined as a deposition threshold of a pollutant below which long term damage will not occur to target ecosystems. Critical load maps of acidity for soil have formed the basis for the evaluations of the impacts of deposited acidity. The proportion of the 1 km squares was determined for which the critical load is exceeded by current deposition of acidity and by the modelled deposition in 2010 and 2020, on the bases of planned 70 and 80% reductions in emissions of sulphur to which the UK government has agreed. The future deposition patterns were modelled using the Hull Acid rain model (HARM). The analysis has been used to define those areas of the landscape over which the critical load is exceeded.

The impacts of atmospheric deposition of nitrogen were explored by determining the proportion of the mask for which the current deposition of nitrogen exceeds values similar to the empirically derived critical load for characteristic habitats of the landscape.

3.7 *G. Modelling of impacts of stresses on vegetation.* The TRISTAR (TRIangular STRategic Rules for british herbaceous vegetation) (Hunt et al., 1991) and TRISTAR2 expert system models were used to predict the effect of environmental changes, and changes in agricultural management on the quality of the vegetation in landscapes. the models deal with the fundamental environmental and management processes which control the composition of British herbaceous vegetation. The TRISTAR2 model was developed for this project to extend the modelling approach to enable consideration of climate change scenarios. The vegetation data from the quadrats formed the input to the models. The species in each plot were allocated to one of 19 functional types, dependant upon the likely response of the given plant species to two groups of external factors called *stress* and *disturbance* (Grime et al., 1988) (Box 3.5). The response of a species to combinations of *stress* and *disturbance* allow it to be allocated to one of 19 functional types: competitor, stress tolerators and ruderals, or intermediate classes between these three end members. The weighted abundance of the functional types in each plot were then used to assess the response to a number of environmental and management stress scenarios.

Box 3.5	Definition of terms relating to the modelling of the impact of mangement related environmental change
Stress	includes factors which restrict plant production, such as shortages of light, water, mineral nutrients and sub-optimal temperatures.
Disturbance	is associated with destruction of plant biomass and can arise from grazing, pathogen infestation, mowing , ploughing, frost, drought erosion or fire.
Competitors	are plant species which are able to exploit conditions of low stress and low disturbance
Stress tolerators	are plant species generally associated with conditions of high stress and low disturbance
Ruderals	are plant species characteristic of conditions of low stress and high disturbance
Functional types	are groups of plant species which show similar responses to given combinations of stress and disturbance

3.8 *H. Distribution of archaeological features.* The evaluation of the distribution of archaeological features focused on the 1 km sample squares. Three sources of information were used; (i) fieldwork by the field surveyors (non-archaeologists), (ii) analysis of selective aerial photography - using available photography, and (iii) interpretation of recent edition Ordnance Survey map extracts supplied by ITE, County Sites and Monuments Records(SMRs) and the National Monuments Record.

3.9 *I. Expert groups.* Panels of experts were brought together for each landscape to discuss the likely impacts on the given landscape of a series of "threats" which influence the quality of each landscape. The outputs from the analysis of the data from the field surveys and from the modelling exercise were used as the basis for the round table discussions.

3.10 *J. Assessment.* The outputs from stages D to J were then combined and assessed in the context of current policies and initiatives.

4. The Habitat Resource I: Historical, ecological, recreational and scenic background

4.1 General introduction

4.1.1 The landscapes considered in this study each include a variety of habitats. Thus, for example heathland and calcareous grassland are the core habitats in the respective landscapes but the landscapes also include many non-heathland and non-calcareous grassland habitats. The upland and coastal landscapes include a range of habitats which are characteristically upland and coastal whilst the waterside landscape has characteristic habitats which contain wetland species.

4.1.2 The lowland heath and calcareous grassland landscapes, and their characteristic habitats have been created and are maintained by human influences. Both were forest or woodland until clearance began around 5000 to 6000 BC. Both would revert quickly to scrub or woodland if management were removed. The survival of the distinctive lowland heath vegetation and habitats, dominated by heather and gorse, is dependant on grazing, cutting or burning while grazing is the dominant influence in the maintenance of calcareous grassland.

4.1.3 Much of the upland landscape, now dominated by low growing moorland and bogs, would also have been forested at some point since the last glacial period. Forest clearance probably began in the Mesolithic period and the large moors with which we are familiar probably existed by the end of the Iron Age. Management, grazing and burning are important in maintaining the mix of habitats in the uplands but reversion to scrub or woodland would not take place over all the formerly wooded areas, as a result of peat formation and/or the current extreme climate.

The coastal landscape has been heavily influenced by man but some of the core maritime habitats are formed naturally although the detailed mix of species are inevitably influences by the management and use of the habitats. The characteristic habitats of the waterside landscape contain a mix of those which are natural and others which were created and are maintained by management.

4.1.4 The distribution of the lowland heath and calcareous grassland landscapes, and their characteristic habitats is largely controlled by particular combinations of geology and soils. The lowland heath occurring on acidic, often podzolic soils that are low in nutrients, mainly as a result of soil deterioration in prehistoric times. However, important bog and wet heath habitats in the lowland heath landscape are associated with wetter acid soils. Lowland heath was formerly more extensive in England. The largest remnants are concentrated in the New Forest, Breckland, the Suffolk Sandlings, East Hampshire, and Surrey, Dorset and the Lizard.

4.1.5 Calcareous grasslands are associated with shallow, calcareous soils overlying limestone and chalk bedrock. The type of grassland varies with the type of underlying calcium rich bedrock, with the principle division being between the chalk grasslands on soft limestones in the south and east of England and the limestone grasslands occurring on harder limestones in the north and west of Britain.

4.1.6 The upland, coastal and waterside landscapes are underlain by a range of rock types and soils. In the uplands, the interaction between the underlying soils, geology and climate determine the mozaic of habitats which make up the landscape. The landscape occurs largely in the north of the country in a stretch running mainly from Northumberland to the Midlands (the Pennines, Yorkshire Dales and Lake District) but with important areas in the south west, eg Dartmoor and Exmoor.

Geology is a major factor determining the type of coastal landscape and the constituent habitats, with the major division being between soft and hard rock coasts; the former associated with saltmarshes and low earth cliffs and the latter with rocky foreshores and cliffs. Within these major divisions there is a mozaic of habitat types: some are distinctly maritime (in that salt water influences their ecology to some degree), others are distinctly coastal by virtue of their association with uniquely coastal landforms but not otherwise maritime, while many also occur widely inland.

The waterside landscape also reflects variations in geology, relief and climate with major differences in the topography between the upland and lowland valleys, the type and size of the waterbodies and the associated waterside habitats.

4.1.7 The area of lowland heath and of calcareous grassland in England reached a peak respectively between 1000 and 2000 and c.300 years ago. The subsequent decline of lowland heathland began in the middle ages and was related to a variety of social, demographic and agricultural changes. It became rapid at the end of the 17th century with improvements in farming technology and continued during the 18th and early 19th centuries, when it was linked to parliamentary enclosures. It slowed down during the latter half of the 19th century but speeded up again in this century. During this century, lowland heath has been lost mainly to built development (particularly housing and roads), mineral extraction, arable farming and afforestation. These causes have also led to fragmentation of the lowland heath resource. The decline of the Dorset heaths has been especially well studied. the area has dropped from around 40,000 ha in 1760 to 18,200 ha in 1934 and to 5,700 ha in 1983. The most rapid decline took place during the period 1960 to 1973 when 4,000 ha were lost. Today most areas of lowland heath are used for low intensity grazing, military training and recreation; some areas in the latter two categories areas are unmanaged.

4.1.8 The extent of calcareous grassland probably reached a maximum 300 years ago, since then large areas of have been lost and substantial losses of the surviving grassland have occurred within the last fifty years. The introduction of seeding after 1700 led to a decline in the quality of some chalk grassland. As farming became mechanised in the early nineteenth century many grasslands were ploughed up. During the 20th century calcareous grasslands have been lost to land take mainly for ploughing-up for arable or improved pasture, mineral extraction, afforestation and building development. The Nature Conservancy Council (Keymer and Leach 1990) suggest that between 1968 and 1980 the loss of grassland was about 60% due to ploughing or agricultural improvement, about

30% to scrub encroachment and 1% due to development. The impact of changes in agricultural management is so marked as most calcareous grassland remains in agricultural ownership.

4.2 The landscapes as an ecological and conservation resource

4.2.1 Each landscape contains habitats of high conservation value in a national, and in some cases international context. However, the characteristics of the habitats which give rise to the high conservation value differ. Thus, the calcareous grasslands are chiefly valued for their botanical diversity and the associated invertebrates. In contrast, the lowland heaths are notable for supporting a number of rare insect, amphibian and bird species. The uplands contain a variety of characteristic threatened habitats some of which occur as large expanses but which are rare internationally. Undisturbed maritime coastal habitats represent early successional changes and wetland habitats are nationally scarce. These characteristics and contrasts are considered in more detail below.

4.2.2 **Lowland heath** supports many scarce and locally important species of flora and fauna. Similar types of lowland heath occur in continental Europe but the British heaths are important in conservation terms, firstly because they form such a large proportion of the European resource, Farrell (1989) estimated that Britain had some 18% of the total, and secondly due to the occurrence of certain special wet heath and maritime heath vegetation types which are relatively rare.

4.2.3 **Calcareous grasslands** are botanically diverse, being amongst the most species-rich and species-diverse plant communities in Britain and northern Europe. Within Britain, the large number of plant species occurring in calcareous grassland constitutes a substantial percentage of the total native flora (perhaps 10-20%). Many species can be represented in small areas of turf (ie high species-diversity as well as high species- richness). Thus, Chalk downland turf often contains 30 or even 40 species per square metre. Many of the plant species are scarce native species; a total of 77 protected or listed species occurs in calcareous grassland, of which 50 are restricted to calcareous grassland (Keymer& Leach 1990). In addition, calcareous grasslands (especially the warm South Downs) provide habitats for many invertebrates including ants and a large number of butterflies which are confined to this habitat and are scarce or localised in Britain. In contrast to the lowland heath, England only contains a small part of the European stock of calcareous grassland; such grasslands occur over much of central and northern Europe. However, their rarity in Britain makes then a nationally important resource.

4.2.4 In the **uplands**, the combination of montane and oceanic climatic conditions gives rise to plant communities which are of restricted distribution in Europe. Moreover, the British upland flora contains species that have very diverse geographical distribution patterns in mainland Europe (Atlantic species, Alpine species etc) and the mixture of species in the British vegetation is therefore unusual. The habitats are relatively species poor but are often present as large unfragmented blocks extending over large expanses of land. Such large expanses are rare in Britain. They support, for example species of birds that might not persist in smaller, more fragmented habitats: hen harriers, peregrine, merlin, chough and raven, as well as breeding waders. The extensive habitats would not be of great conservation interest in smaller patches. The ecological importance of the uplands is therefore related to three features of the vegetation and bird communities it supports. Firstly, there are certain uncommon species-rich plant communities which are only found in the uplands. Secondly, some of these plant communities are of international importance and thirdly the uplands are important ecologically because they are so extensive and unfragmented.

4.2.5 Most **coastal** habitats are extremely dynamic compared to the habitats in the other landscapes, not only do they change continually but often they change catastrophically in response to extreme events, both climatic (storms) and geomorphological (changes in currents or sediment supply, landslips); geomorphological factors exert a much stronger control than in the other landscapes studied. Early successional plant communities are therefore particularly important in the coastal zone, relative to the other landscapes. Many of the habitats in the coastal landscape are of restricted occurrence and also contain rare species (Stewart et al (1994) estimate that at least 20% of the Nationally Scarce Plants in Britain are coastal. A number of the coastal habitats are also relatively natural with early successional communities developing without interference from man; some are also extensive and unfragmented. A number of English estuaries are of international importance as habitats for wading birds.

4.2.6 The characteristic habitats of the **waterside** landscape support aquatic plant and animal communities, water margin communities and swamps. Some of the wetland habitats are nationally and internationally important, especially the flood plain meadows, fens and mires. Stewart et al (1994) estimate that at least 14% of the Nationally Scarce Plants in Britain are usually associated with watersides. The habitats are also important for a range of fauna including the otter, water vole and water shrew. Wetland habitats also provide feeding areas for bats, due to the presence of large numbers of invertebrates, and feeding and nesting habitats for a large number of bird species. Many of the bird species have low and declining populations in England.

4.3. The landscapes as scenic and aesthetic resources

4.3.1 The lowland heath, calcareous grassland and upland landscapes are all highly valued scenically. The lowland heathland areas are characterised by a feeling of wilderness that is unusual in lowland England. Typically they lie within open, sweeping landscapes on flat, gently undulating or rolling topography, with long views and large skyscapes. The uplands are also characterised by a feeling of wilderness but are much more rugged and dissolute. The upland landscape also contains a wide variety of scenic aspects including remote, windblown moors, with exposed stones, steep scree escarpments, and jagged hills with waterfalls, small valleys and gorges. The moorlands are valued for their long uninterrupted views in extent, uniformity and simplicity of landform. They create a sense of space and freedom. The calcareous grassland is found in a number of scenically different types of landscape. Often on steep scarp slopes which provide dramatic viewpoints. The harder limestones feature caves and, swallow holes and characteristic limestone pavements.

4.3.2 All the above three landscapes are characterised to a greater or lesser extent by a mozaic of land cover types which enhance them scenically. Thus, the calcareous grassland landscape can include woodlands and scrub, agricultural land, hedges and water meadow as well as stone walls, barns and villages. The heathland habitats have contrasts between heathland and adjoining woodland, as in the New Forest which create attractive edge landscapes that many people find appealing (Land Use Consultants 1986). The valleys which dissect the uplands are valued for their enclosed, sheltered and domestic landscapes with many patterns and textures in the walled meadow and pastures.

4.3.3 The coastal belt provides a variety of scenically different landscapes, from dramatic coastal cliffs, to the wide flat expanses of some of the larger estuaries, coastal mud-flats and beaches, and mosaics of beach, agricultural land and villages. All offer the broad vistas out to sea. The waterside landscape includes a mix of agricultural and semi-natural habitats, a mozaic of meadows, crops and tress with the waterbodies themselves.

4.4 The landscapes as a recreational resource

4.4.1 Each of the landscapes being considered here are widely and heavily used for recreation. Some activities are common to all the landscapes, eg walking and picnicking, while others are limited to one or two of the landscapes, eg climbing in the uplands and on coastal cliffs, watersports on in the waterside and coastal landscapes.

4.4.2 The intrinsic recreational value of the heathland and calcareous grassland in southern England is heightened by their proximity to large urban populations and where they lie within the urban fringe they may be very heavily used indeed. The National Park, Green Belt and Heritage coast designations of many of the areas of heathland and calcareous grassland underline the recreational importance. Although much of the uplands is more remote than the lowland heathland from large urban areas they are readily accessible by road and honey pot areas are now under enormous pressure.

4.4.4 The coastal and waterside areas are heavily used for a wide variety of recreational activities, particularly the coastal zone. For example, beach based activities such as swimming, picnicking and sun bathing; water sports which affect coastal habitats through land take for moorings and related facilities; walking, especially on coastal cliffs; wildfowling, mainly in estuaries; scramble biking, mountain biking, riding and 4 x 4 vehicle driving; golf courses, mainly on dune grasslands. The watersides are also used for walking and in connection with watersports such as sailing, canoeing, waterskiing and fishing.

4.5 The landscapes as a historic resource

4.5.1 The lowland heaths and calcareous grasslands are ancient landscapes created and shaped by human activity. Archaeologically they are among the most important land cover types for the range of monuments represented and the excellent state of preservation at most sites (Darvill 1987). The heaths often contain groups of interrelated sites representing successive periods of use and scheduled monuments are relatively dense. The formation of the calcareous grassland often involved setting aside large areas of landscape, thus whole areas have been preserved providing information about the setting, extent and interrelationships of sites. Furthermore, monuments under established grassland can often be seen as surface features at ground level.

The uplands are important for archaeological remains as they have been subject to very low intensity management, compared with the lowland heaths or calcareous grasslands for example, over a long periods. As a result there are many upstanding remains which tend to be in better conditions than examples in other land usage. Other monuments have a thin soil cover and are thus easy to see and excavate. Settlements are the most numerous remains with field systems also common.

5. The Habitat Resource II: Results of the Field Survey

5.1 The landscape masks

5.1.1 The landscape masks created varied considerably in size from 2604 km^2 for the coastal landscape to 26 343 km^2 for the calcareous grassland landscape (Figure 5.1). This reflects the large areas of England underlain by calcareous rocks but also the different methods used to define the masks. The uplands, lowland heath and calcareous grassland masks are built up of complete 1 km squares, whereas the coastal and masks are narrow zones around the coast and waterbodies respectively. The proportion of the 1 km squares within each mask which contained some form of designation also varied widely, from 56% in the heathland landscape to 81% in the upland landscape (Figures 5.1 and 5.2). This variation reflects to some extent the location within England of the different landscapes and the type of designation. For example, the national parks are large blocks of country and the scenic and recreational basis for the designation results in them almost all being in the uplands.

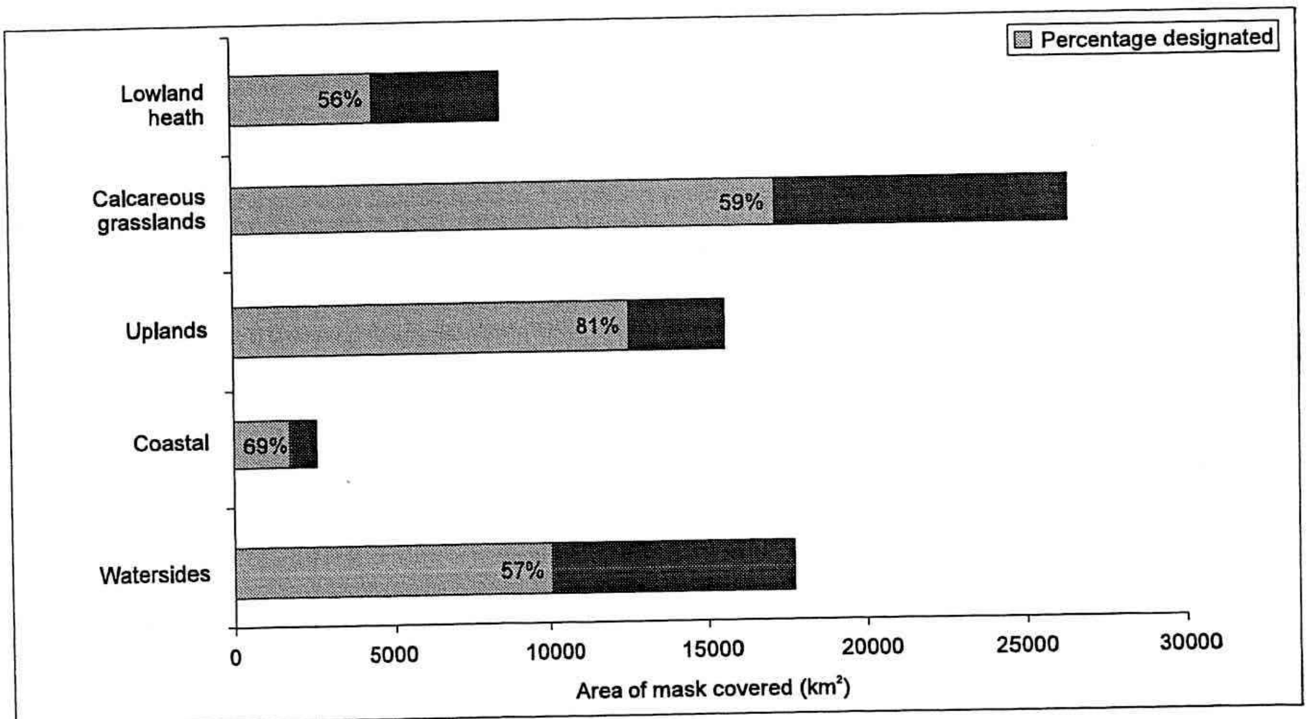

Figure 5.1 Areas of the landscape masks and the proportion designated

5.2 Characteristic habitats

5.2.1 In the lowland heath, calcareous grassland, coastal and waterside landscapes, only a small proportion of the landscape was estimated to be the characteristic semi-natural habitats (Table 5.1). The large proportion of the upland landscape which comprises characteristic habitats reflects the less intensive use of the uplands and the extensive nature of a number of the characteristic upland habitats.

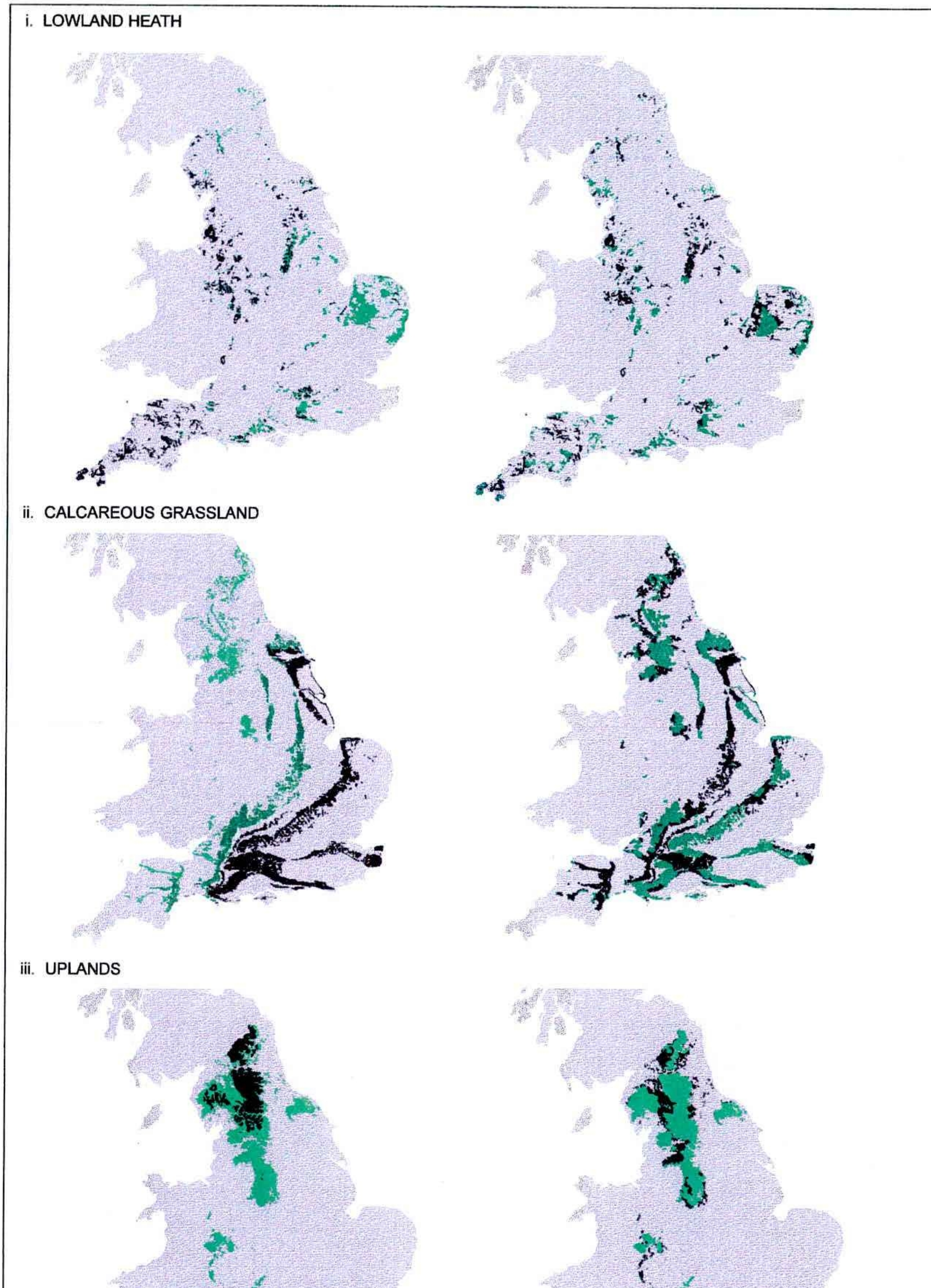

Figure 5.2 The lowland heath, calcareous grassland and upland masks

i. The lowland heath mask. Left - pastural strata in black and arable strata in green. Right - areas with some designation status green and areas without designation status black.

ii. The clacareous grassland mask. Left - soft limestone strata black, hard limestone strata green. Right - areas with some designation status green and areas withour designation status black.

iii. The upland mask. Left - true upland strata shown in black and marginal uplant strata in green. Right - areas with some designation status green and areas without designation status black.

Table 5.1 Proportion of the landscape masks in characteristic habitats

Landscape	Proportion of the mask in characteristic habitats (%)	Proportion of the characteristic habitats covered by a designation (%)
Lowland heath	5	74
Calcareous grassland	2	90
Upland	56	93
Coastal	8	15
Waterside	3	66

5.2.2 A high proportion of the characteristic habitats in most of the landscapes however, occurred in designated strata (Table 5.1). The clear exception is the coastal landscape where only a small proportion of the core coastal habitats are covered by a designation.

5.2.3 The occurrence of the characteristic habitats varied between the environmental strata into which the landscapes were divided, as well as between designated and non-designated strata. Thus, a larger area of calcareous grassland was recorded on the soft as opposed to the hard limestones and it also formed a larger proportion of the total area of the mask on the soft limestones, 1.7% compared to 1.1% on the hard limestones. This is largely because the hard limestones tend to occur as small, often linear outcrops while the soft limestones of the chalk outcrop over large areas.

5.2.4 Similarly, in the waterside landscape the characteristic wetland vegetation is most common in the uplands (9%), with less in the pastural (3%) and the arable lowlands (<1%). This reflects the more intensive agricultural use of the land in the pastural and particularly the arable landscape where the waterbodies are generally surrounded by intensively managed agricultural land. These figures emphasise the scarcity of wetland vegetation, which only forms a small component even within river corridors and lake margins. However, some of the damp mixed grasslands and meadows which are not regarded as core habitats here, can also have a high conservation value. The amount of maritime vegetation varies considerably between the coastal types, being least extensive on the hard coasts (3%) and more widespread in estuarine (13%) and soft coasts (16%). Designated coasts have a higher proportion of maritime vegetation (15%) than non-designated coast (4%)

5.2.5 The great majority of the calcareous grassland and upland vegetation is, therefore covered by one of the designations considered here. While much of the heathland vegetation is in designated areas, there is still a significant area of heathland which is not covered by any of the designations included in this study. This is also true of moorland grassland and acid grassland which may have been heathland in the past. However, nearly all the wet heath and lowland bogs within the lowland heath landscape occurred in squares in the designated strata. Only small areas of the characteristic coastal and waterside habitats are within designated areas.

5.3 Land cover

5.3.1 A large proportion of the total area of the calcareous grassland, lowland heath, coastal and waterside landscapes were under arable crops or managed grassland, reflecting the predominantly lowland distribution of these landscapes (Figure 5.3). In contrast to the other landscapes only a small proportion of the upland landscape area was under crops but a large proportion of the area was semi-natural vegetation; crops were only recorded in the marginal upland strata. The largest area of buildings and roads was found in the coastal landscape showing the extent of development in the coastal zone. The largest area of woodland and scrub occurred in the lowland heath mask and the smallest in the coastal mask.

5.3.2 There were marked differences in cover between the strata of the various landscapes (Figure 5.3). Thus, for example crops covered a much larger area of the soft limestone (42%) than the hard limestone (9%) in the calcareous grassland landscape, reflecting the more intensive management in the lowland chalk areas. Similarly, in the waterside landscape the uplands contained a larger proportion (80%) of semi-natural vegetation than the pastural (c.12%) or arable areas of the lowlands (c. 20%), reflecting the more intensive agriculture management in the lowlands. Woodland and scrub were more widespread in the arable than the pastural strata of the lowland heath.

5.3.3 There were also differences in the distribution of the various cover categories between designated and non-designated strata. The designated strata contained a higher proportion of semi-natural vegetation in four of the landscapes, the exception being the watersides.

5.3.4 A more detailed examination of the cover types shows that there were marked differences in the distribution of the semi-natural cover types between strata in the landscapes. Thus, in the calcareous grassland mask, acid vegetation occurred mainly in the hard rather than the soft limestone; this reflects the occurrence of large areas of the hard limestones in upland areas and surrounded by acid soils. However, 52% of the heathland cover category within this landscape occurred in the soft limestone mask, indicating the location close together of the suitable geology and soils for these two habitats in parts of the south of England .

5.3.5 There was a considerable higher proportion of shrub heath vegetation in the marginal upland strata than the true upland. In contrast, bog vegetation was mostly found in the true upland strata reflecting the more widespread occurrence of peats compared with the marginal uplands.

5.3.6 The Heathland landscape included modified heathland vegetation types which had been colonised or planted with trees, but still contained a recognisable heathland flora; these were estimated at 674 km2, nearly twice the area of existing heathland. These modified heathland areas occurred throughout the lowland heath landscape, though they seem more common in designated areas and on drier soil. These areas provide the best opportunity for heathland restoration.

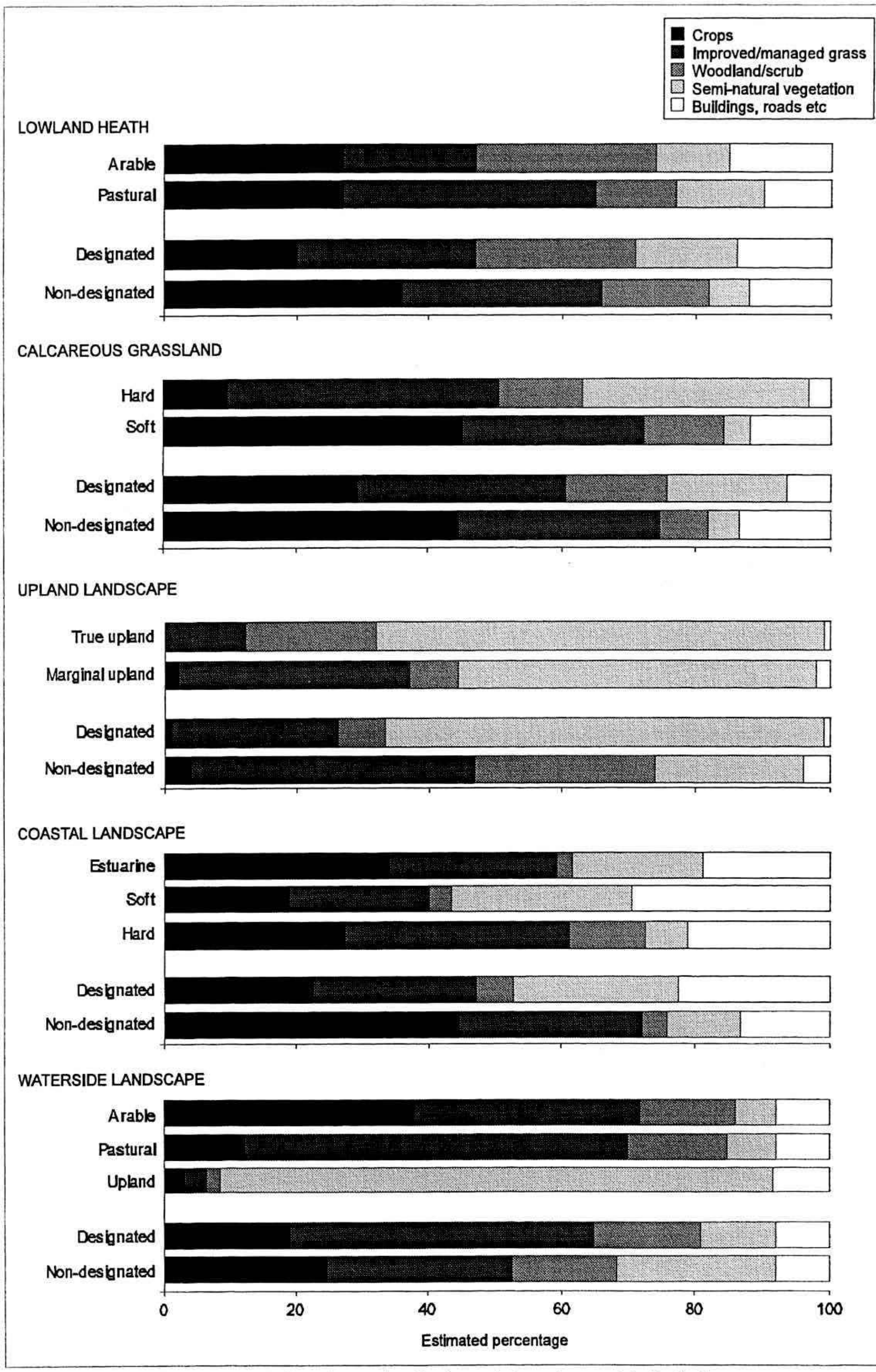

Figure 5.3 The distribution (percentage) of broad categories of land cover in the main strata of the five landscapes

5.4 Vegetation characteristics and quality

5.4.1 The descriptions of the vegetation quadrats and the species data collected from the quadrats during the field survey have been used to derive a series of 'structural types' of vegetation, 'plot classes' and 'species groups' (Box 3.3). These have been used to define and evaluate the characteristics and quality of the vegetation of the landscapes and, in particular the characteristic habitats within the landscapes. The 'structural types', 'plot classes' and 'species groups' defined for each landscape are listed in Tables 5.2 to 5.4. It is important to note that a given structural type, for example woodland, plot class or species group does not necessarily imply a similar species composition when used in the context of different landscapes.

Area and abundance of the structural vegetation types

5.4.2 It is usually considered a positive quality for a habitat to exist as large areas, for a number of reasons. Each species has a minimum area (or resource) which is necessary to maintain a viable population. There is a relationship between area and species diversity affected by population size, extinction and immigration rates. Large sites provide a buffered 'edge' between the central core of the site and adjacent land which helps to protect the core from disturbance, run-off, spray-drift etc. Large sites usually (but not always) contain a greater range of local environments, reflected in a greater diversity of species.

5.4.3 Size/abundance was assessed in the study using the frequency of recording of main and habitat plots and the frequency of occurrence of the different structural vegetation types in the various sampling strata of the landscapes. The main plots were only recorded if semi-natural vegetation was present at the site of the plot whereas the habitat plots were deliberately placed in semi-natural vegetation not sampled by the main, randomly placed plots.

5.4.4 The frequency of recording of the main plots (Figure 5.4) indicated that semi-natural vegetation was most widespread in the uplands. It occupied smaller areas in the other landscapes and was so fragmented in the waterside landscape that it was not recorded by the randomly placed main plots. Very few main plots in absolute terms were recorded in the calcareous grassland indicating the scarcity of semi-natural vegetation in this masks although suitable soil and geological conditions occur over large areas.

Frequency of occurrence of main and habitat plots in characteristic structural types as an indicator of the extent of these habitats

5.4.5 The distribution of characteristic vegetation types showed marked differences between designated and non-designated strata in the lowland heath, calcareous grassland, upland and coastal landscapes, suggesting that larger areas occur in the designated strata (Figure 5.5). Thus, for example, in the heathland landscape there was almost twice as much heathland and acid bog vegetation in the designated strata compared to the non-designated

Table 5.2 Structural types into which the vegetation quadrats of the five landscapes were grouped on the basis of the field surveyors quadrat descriptions

LANDSCAPE	LOWLAND HEATH	CALCAREOUS GRASSLAND	UPLANDS	COASTAL	WATERSIDES
STRUCTURAL TYPES	Dry heath	Verges	Bog	Salt marsh	Ditch-side
	Wet heath	Calcareous grassland	Flush	Maritime grassland	Stream-side
	Bog	Neutral/improved grassland	Wet heath	Other maritime vegetation (including cliffs, dunes and foreshore)	River-side
	Bracken	Unmanaged grassland/tall herbs	Dry heath		Canal-side
	Acid grassland	Acid grass/dry heath	Moorland grassland	Calcareous grassland	Aquatic margins
	Scrub	Wet heath/bogs	Acid grass/Bracken	Neutral/improved grassland	Marsh
	Woodland edge	Marsh/flushes	Calcareous grassland	Unmanaged grassland/tall herb	Flush
	Woodland deciduous	Aquatic/streamsides	Neutral/improved grassland	Acid grass/heath/bog	Acid grass/heath
	Plantation (conifer)	Trees/scrub/hedges	Woodland/scrub	Marsh/aquatic macrophytes	Managed grass
		Woodland/glades	Other	Scrub	Unmanaged grass
				Woodland	Tall herbs
					Woodlands

Table 5.3 Vegetation **plot classes** for each of the five landscapes derived from multivariate analysis of quadrat data collected during the field survey. Shaded areas represent the core, characteristic plot classes in each landscape

LOWLAND HEATH

PC A	Bog
PC B	Wet heath
PC C	Ultra-basic wet heath
PC D	Very acid heath
PC E	Southern damp heath
PC F	Dry heath
PC G	Damp heath (incl. plantation)
PC H	Dry heath often planted
PC I	Grassy heath
PC J	Southern dry heath
PC K	Plantation over heath
PC L	Plantation over bracken/heath
PC M	Damp acid grassland
PC N	Southern acid plantation (dense)
PC O	Plantation often open
PC P	Dense rhododendron
PC Q	Midland plantation over bracken
PC R	Dry mildly acid grassland
PC S	Plantation over grass/bracken
PC T	Woodland over bramble

CALCAREOUS GRASSLANDS

PCA	Fertile grassland, with annual weeds
PCB	Fertile grassland, overgrown, often shaded
PCC	Calcareous woodland, eutrophic, often woodland edge
PCD	Tall, coarse grassland, open
PCE	Eutrophic grassland, often neglected
PCF	Intensive grassland, Lolium-dominated, often disturbed
PCG	Eutrophic grassland, overgrown, tall herbs, often shaded/wet
PCH	Fertile grassland, short, often disturbed
PCI	Calcareous woodland, mainly ash
PCJ	Neutral/basiphilous grassland, tall with herbs
PCK	Neutral/basiphilous grassland, short, mown or grazed
PCL	Basiphilous/calcareous grassland, tussocky with herbs
PCM	Basiphilous woodland, more open, grassy
PCN	Neutral permanent pasture
PCO	Calcareous grassland, short-turf, grazed, with small herbs
PCP	Neutral grassland, semi-improved, grazed or mown
PCQ	Neutral grassland , unimproved, light/no grazing, some shading
PCR	Marsh/rushy pasture
PCS	Neutral/acid woodland, bramble-dominated
PCT	Northern calcareous
PCU	Northern, damp pasture, often with flushing/streamsides
PCV	Acid grassland, often rushy
PCW	Dry grassland/heath
PCX	Bracken/dry heath, often shaded
PCY	Moorland grass, moist
PCZ	Mossy heath, often planted with Sitka
PCAA	Mire
PCBB	Wet heath/bog
PCCC	Mostly saltmarsh

UPLANDS

PC A	Neutral/calcareous woodlands (mainly ash)
PC B	Neutral permanent grassland
PC C	Moist woodlands (mainly alder)
PC D	Semi-improved grassland
PC E	Limestone grassland
PC F	Marshy streamsides
PC G	Acid woodlands (oak, sycamore and birch)
PC H	Enriched flushes
PC I	Acid grassland - short fine turf
PC J	Wet rushy pasture
PC K	Damp acid pasture
PC L	Upland grassland
PC M	Acid flushes
PC N	Moorland streamsides
PC O	Moorland grass
PC P	Sitka planted on to moorland
PC Q	Dry heath
PC R	Mossy moorland
PC S	Acid wet heath (*Juncus squarrosus*)
PC T	Blanket bog
PC U	Wet heath/bog
PC V	Northern bog

COASTAL

PCA	Lower saltmarsh
PCB	Spartina saltmarsh
PCC	Mature saltmarh
PCD	Immature saltmarsh
PCE	Maritime/freshwater interface
PCF	Foreshore
PCG	Cliff top
PCH	Tall/overgrown grassland
PCI	Neutral/semi-improved grassland
PCJ	Neutral/calcareous meadows
PCK	Heathland
PCL	Scrub

WATERSIDE

PCA	Woodland on heavy soils
PCB	Basic/eutrophic woodland
PCC	Open/disturbed woodland
PCD	Coarse grassland
PCE	Tall herb
PCF	Waterside tall herb
PCG	Disturbed eutrophic water edge
PCH	Water edge/marsh
PCI	Semi-improved grassland
PCJ	Improved grassland
PCK	Neglected grassland
PCL	Damp neutral grassland
PCM	Damp acid grassland
PCN	Short-term grassland
PCO	Wet heath
PCP	Acid grassland

Table 5.4 **Species groups** derived from the vegetation quadrat data for the five landscapes using a multivariate analysis (DECORANA)

Species group	Example species
LOWLAND HEATH	
Bog species	
Wet heath species	
Moss/lichen heath species	
Vascular heath species	
Damp acid woodland species	
Forest tree species	
Acid grassland species	
Mildly acid grassland species	
Acid woodland species	
Mildly acid woodland species	
CALCAREOUS GRASSLAND	
Grassland groups	
Eutrophic coarse grassland species	*Arrhenathrum elatius, Elymus repens*
Annual weeds in *Lolium*-dominated grassland	*Lolium perenne, Plantago major, Poa annua*
Basiphilous shaded grassland species	*Rubus fruticosus, Potentilla reptans, Glechoma hederacea*
Neutral managed grassland species	*Poa trivialis, Cirsium arvense, Phleum pratense*
Moist tall herb grassland species	*Lathryus pratensis, Filipendula ulmaria*
Tall calcareous grassland species	*Medicago lupilina, Bromopsis erecta*
Managed grassland species from heavy soils	*Agrostis stolonifera, Holcus lanatus, Ranunculus repens*
Grazed/mown mesotrophic grassland species	*Dactylis glomerata, Festuca rubra, Taraxacum* agg.
Semi-improved neutral grassland species	*Trifolium repens, Cerastium fontanum, Agrostis capillaris*
Heavily-grazed calcareous grassland species	*Prunella vulgaris, Senecio jacobaea, Carex flacca*
Grazed calcareous grassland species	*Lotus corniculatus, Briza media, Ranunculus bulbosus*
Mildly acid marsh species	*Cirsium palustre, Calliergon cuspidatum*
Acid flush species	*Juncus effusus, Cardamine pratensis*
Grazed low-nutrient grassland species	*Festuca ovina, Veronica officinalis*
Woodland groups	
Calcareous species	*Rubus fruticosus, Fraxinus exelsior, Hedera helix*
Calcareous species, on clays	*Fagus sylvatica, Melica uniflora,*
Disturbed eutrophic species, on humus-rich soils	*Urtica dioica, Galium aparine, Geum urbanum*
Woodland clearing species	*Agrostis stolonifera, Holcus lanatus, Rosa* sp.
Woodland edge species, disturbed	*Dactylis glomerata, Taraxacum agg., Veronica chamaedrys*
Basiphilous species, on heavy soils	*Mercurialis perennis, Hyacinthoides non-scripta*
Mildly acid species, on gleys	*Viola riviniana/reichenbachiana, Quercus sp., Dryopteris dilatata*
Mildly acid species, on brown earths, often moist	*Holcus mollis, Silene dioica*
Acid species	*Oxalis acetosella, Digitalis purpurea, Stellaria holostea*
Acid vegetation groups	
Scrub/bracken/shade-tolerant species	*Pteridium aquilinum, Rumex acetosella*
Acid grassland species	*Festuca ovina, Galium saxatile, Agrostis capillaris*
Moss/lichen heath species	*Lophocolea bidentata, Cladonia cholorophaea*
Moorland species	*Deschampsia flexuosa, Vaccinium myrtillis, Pleurozium schreberi*
Sphagnum lawn species	*Sphagnum recurvum, Aulocomnium palustre*
Mire species	*Polytrichum commune, Juncus squarrosus, Carex nigra, Molinea caerulea*
Blanket bog species	*Calluna vulgaris, Eriophorum angustifolium, Eriophorum vaginatum*
UPLANDS	
Neutral grassland species	
Grassland species on thin mineral soils	
Marsh/streamside species	
Bracken/shady banks species	
Peaty flush species	
Acid grassland species	
Woodland species/humid mosses	
Moorland/bog species	
COASTAL	
Low/Mid Saltmarsh species	*Aster tripolium, Plantago maritima*
Foreshore/Strand species	*Elymus pycanthus, Halimione portulacoides*
Grassland/Maritime interface species	*Agrostis stolonifera, Cirsium arvense*
Maritime Grassland/Low Herbs species	*Festuca rubra, Hypochaeris radicata*
Weedy, short-term grassland species	*Lolium perenne, Trifolium repens*
Semi-improved grassland species	*Holcus lanatus, Plantao lanceolata*
Calcareous grassland species	*Galium verum, Thymus praecox*
Woodland/scrub species	*Rubus fruticosus, Poa trivialis*
Acid grassland/heath species	*Agrostis capillaris, Teucrium scorodonia*
WATERSIDE	
Eutrophic woodland species	*Geranium robertianum, Silene dioica*
Bramble/tall herb species	*Rubus fruticosus, Heracleum sphondylium*
Waterside species	*Epilobium hirsutum, Phalaris arundinacea*
Coarse grassland species	*Arrhenathrum elatius, Elymus repens*
Woodland species on heavy soils	*Dryopteris dilitata, Hyacinthoides non-scripta*
Ruderal species	*Stellaria media, Plantago major*
Moist grassland species	*Agrostis stolonifera, Flipendula ulmaria*
Impeded drainage/marsh species	*Juncus effusus, Deschampsia cespitosa*
Managed grassland species	*Dactylis glomerata, Cirsium arvense*
Acid grassland species	*Agrostis capillaris, Galium saxatile*

strata. In contrast to the other landscapes, the differences in the proportions of characteristic vegetation types between designated and non-designated strata are less than those between the environmental strata in the waterside landscape, suggesting that inherent environmental differences between strata are more important than designations in influencing the range of vegetation present.

5.4.6 Differences in the occurrence of the characteristic vegetation types within the landscapes which are not related to designations occur in the upland, coastal and waterside landscapes (Figure 5.5). Thus, the data from the main plots suggests larger areas of the characteristic maritime vegetation types in the estuarine and soft coasts than in the hard coasts, and larger areas of calcareous grassland in the soft than the hard limestone strata. No characteristic waterside structural vegetation types occurred in the main plots of the waterside landscape, confirming its relative scarcity and occurrence as small areas.

5.4.7 The characteristic structural vegetation types of the calcareous grassland and waterside landscapes occur as small relict stands as indicated by the higher frequency of their occurrence in the habitat plots than in the main plots (Table 5.4). This indicates the scarcity and largely fragmented distribution of unimproved calcareous grassland even in areas with suitable geology and the way in which wetland habitats have been fragmented. Although habitat plot were not recorded in the lowland heath landscape, the plot data show that lowland heathland was similarly fragmented and scarce. The characteristic vegetation types were well represented in the main plots in the uplands showing that they occur as relatively large areas.

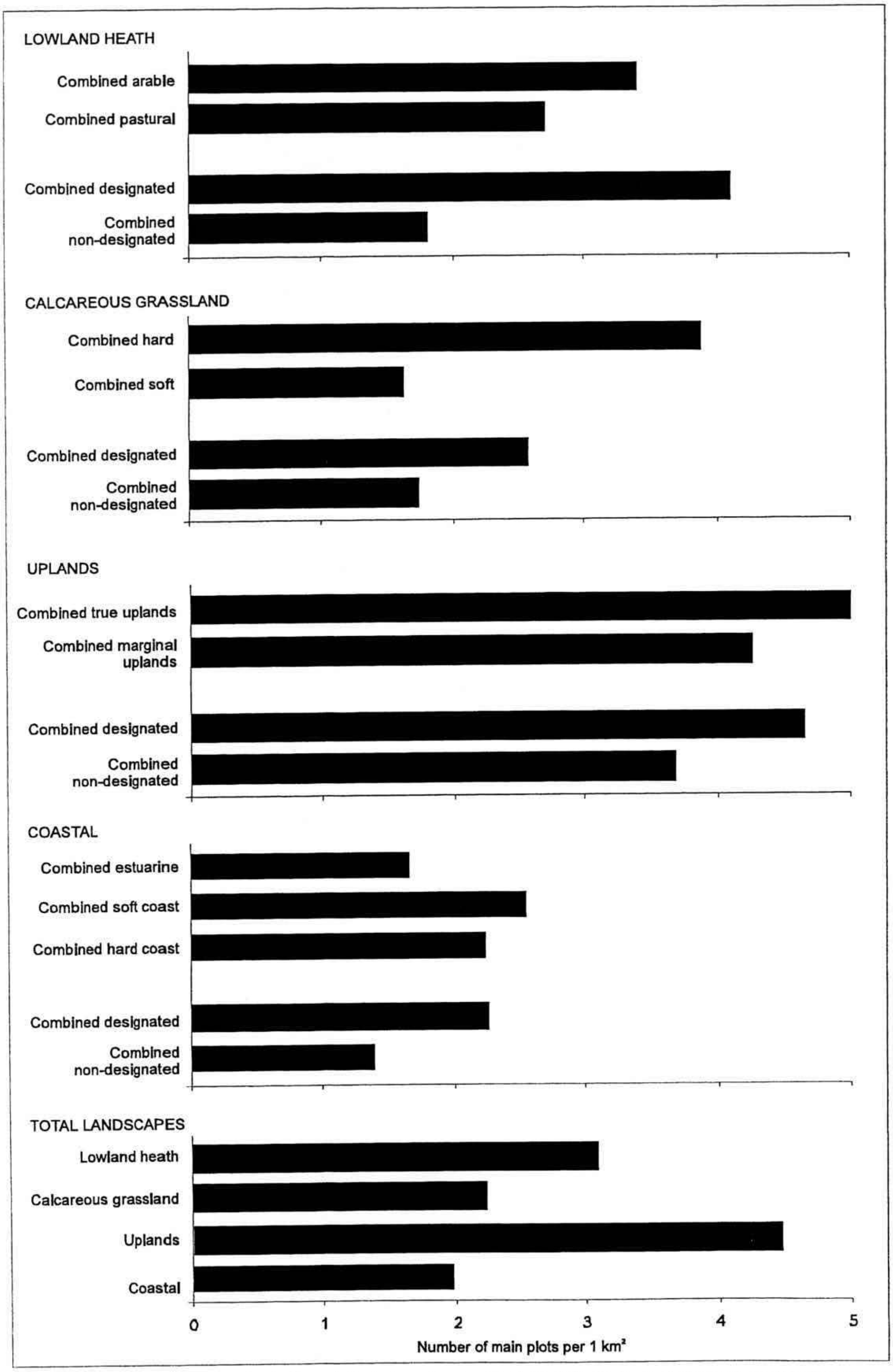

Figure 5.4 The size of areas of semi-natural vegetation in the main sampling strata of the five landscapes as measured by the mean number of main plots per 1 km² in the sampling strata of each landscape (maximum = 5). No main plots were recorded in the Waterside landscape as none of these random plots fell in semi-natural vegetation

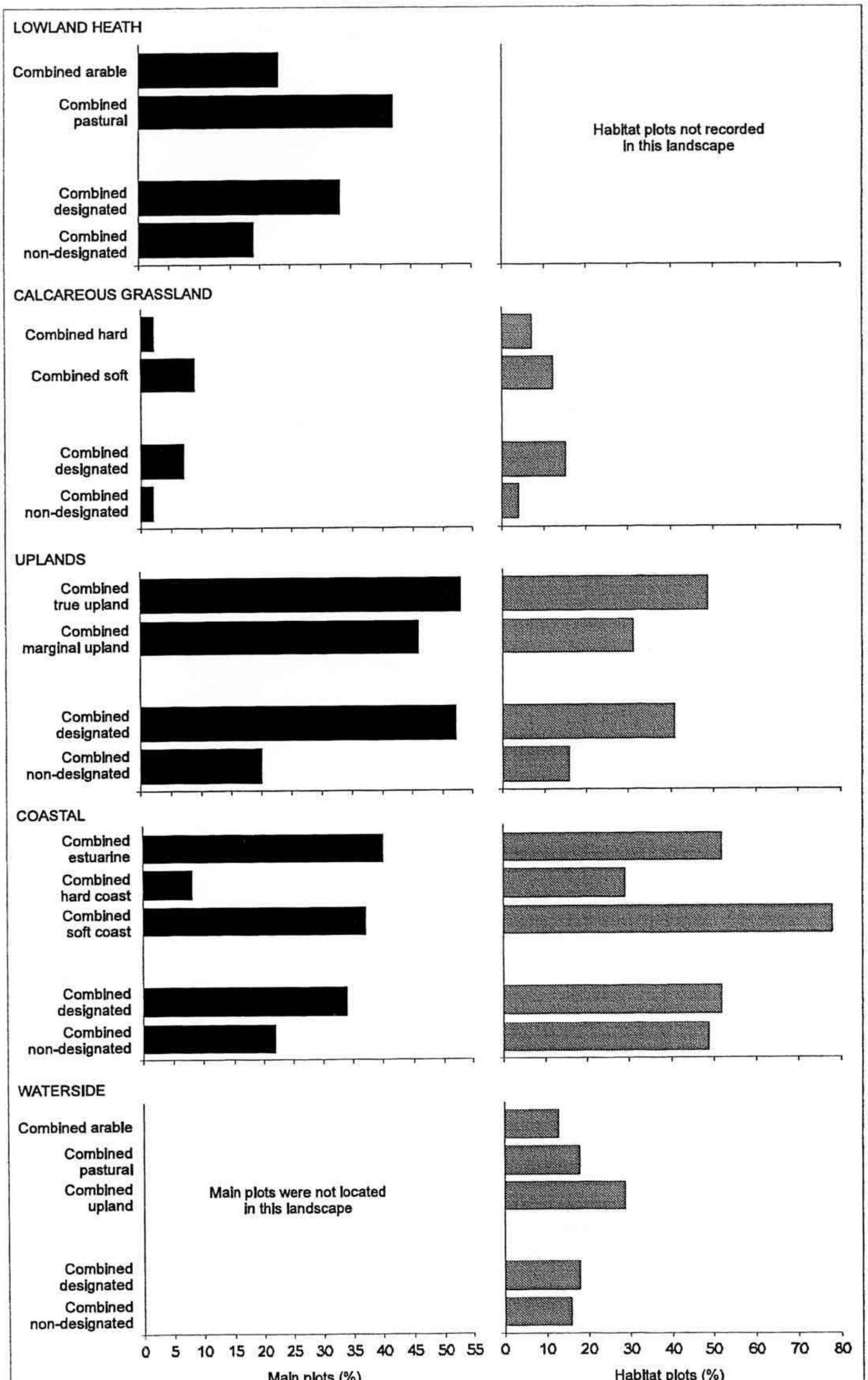

Figure 5.5 The size of patches of the charactertistic vegetation types of each landscape as measured by mean percentage of the main and habitat plots representative of characteristic vegetation types of each landscape recorded in the main sampling strata of the five landscapes

Diversity of vegetation

5.4.8 Diversity can be expressed both as the variety of vegetation types and the range of plant species within a site, thus reflecting the range of variation in physical variables as well as the species richness associated with each vegetation type. The number of different 'plot classes' present indicates the diversity of different vegetation types or habitats; the number of different 'species groups' recorded is used to assess the species richness. The number of species recorded in quadrats is not reported since it cannot be directly related to quality, without taking account of the type of species present, eg thus in the lowland heathland, high species number may reflect either a 'high' quality heathland site or one which is being invaded by grassland and/or woodland species.

5.4.9 The combined designated strata of the landscapes generally contained a larger number of different plot classes, characteristic plot classes, species groups and core species groups than the non-designated strata (Figures 5.6 and 5.7). The largest difference in terms of plot classes was found in the lowland heathland landscape and in terms of species groups in the calcareous grassland landscape.

5.4.10 The individual designated strata in the lowland heath, calcareous grassland and upland landscapes also contain more core plot classes than the non-designated strata but this is not true for the arable and pastural waterside landscapes. The core plot classes were too rare in the waterside landscape to be recorded in the main plots. Individual designated strata in all landscapes contain a wider range of species groups and core species groups than the non-designated strata.

5.4.11 These data indicate that the designated strata are more diverse in terms of both the range of broad vegetation types and the core vegetation of the landscapes. This could reflect a greater variety of environmental conditions in the designated strata or that these areas have maintained natural diversity.

5.4.12 Although there are the above differences between designated and non-designated strata, the largest differences in diversity within the calcareous grassland, coastal and waterside landscapes are between the environmental divisions. Thus, in the calcareous landscape, the various criteria being used here suggest greater diversity on the hard limestones than on the soft. However, the number of core species groups was very similar across the four strata in this landscape.

5.4.13 In the waterside landscape, the pastural strata showed the greatest diversity. The reflects a combination of less intensive agricultural management and less disturbance than in the agricultural lowlands plus a wider range of environmental conditions than in the uplands. The data from the linear waterside plots showed that they had the greatest range of species groups, both overall and for the wetland and wet grassland species groups, indicating that there is a very narrow corridor alongside the waterbodies containing wetland habitats. Most of the vegetation associated with wet or waterlogged land is concentrated immediately adjacent to water courses.

5.4.14 In coastal landscape, the sample squares on the soft coasts were more diverse in terms of both broad vegetation types and core plot classes and species groups than the hard and estuarine coasts. The estuarine squares had the smallest range of species groups in main plots but the largest range of characteristic species groups in the habitat plots, implying that squares in the estuarine strata are uniform in terms of the major habitats but include a variety of small patches of other vegetation types.

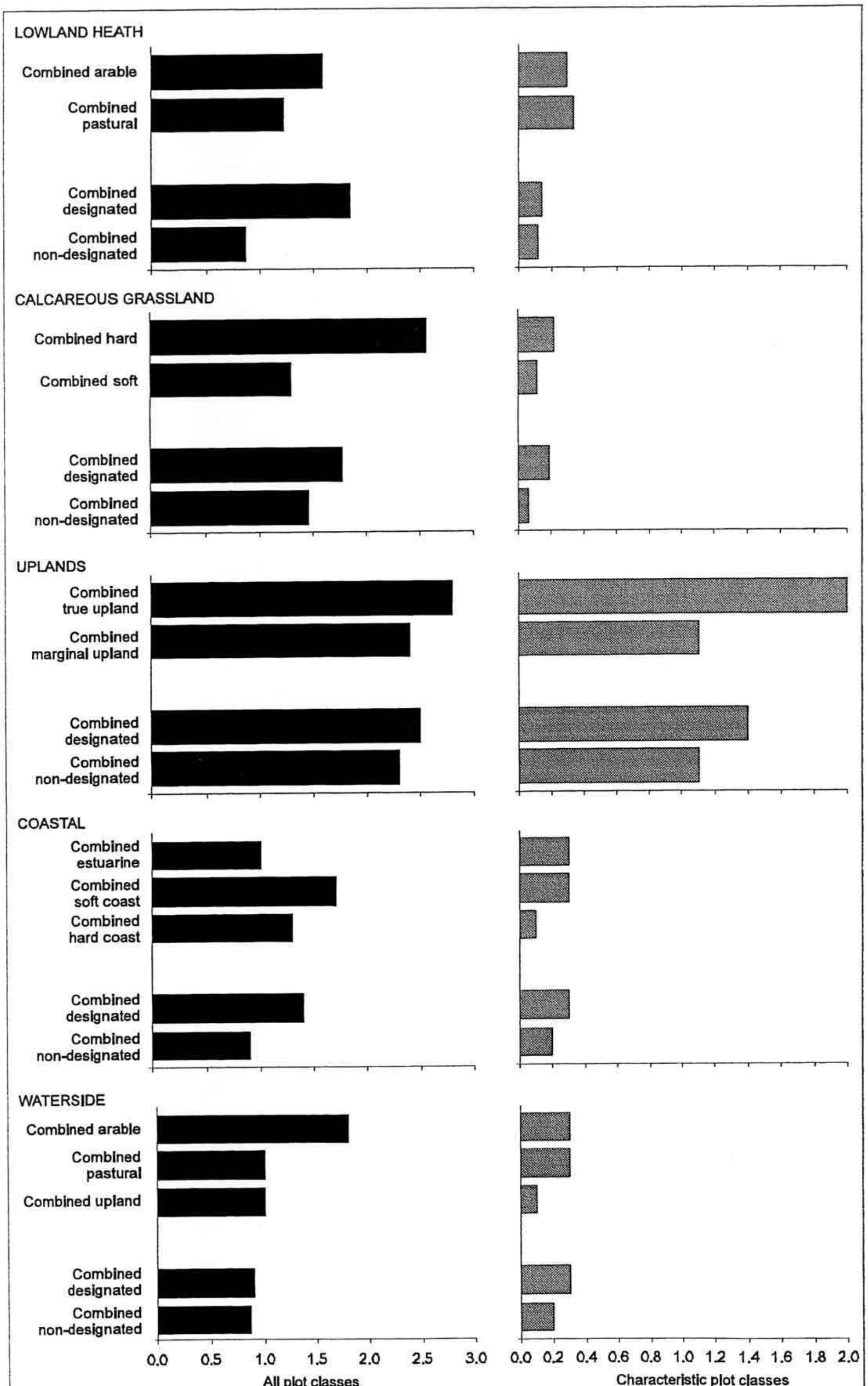

Figure 5.6 The diversity of the semi-natural vegetation occurring in the sampling strata of each landscape as measured by the mean number of plot classes and characteristic classes represented in main plots per 1 km square in each landscape

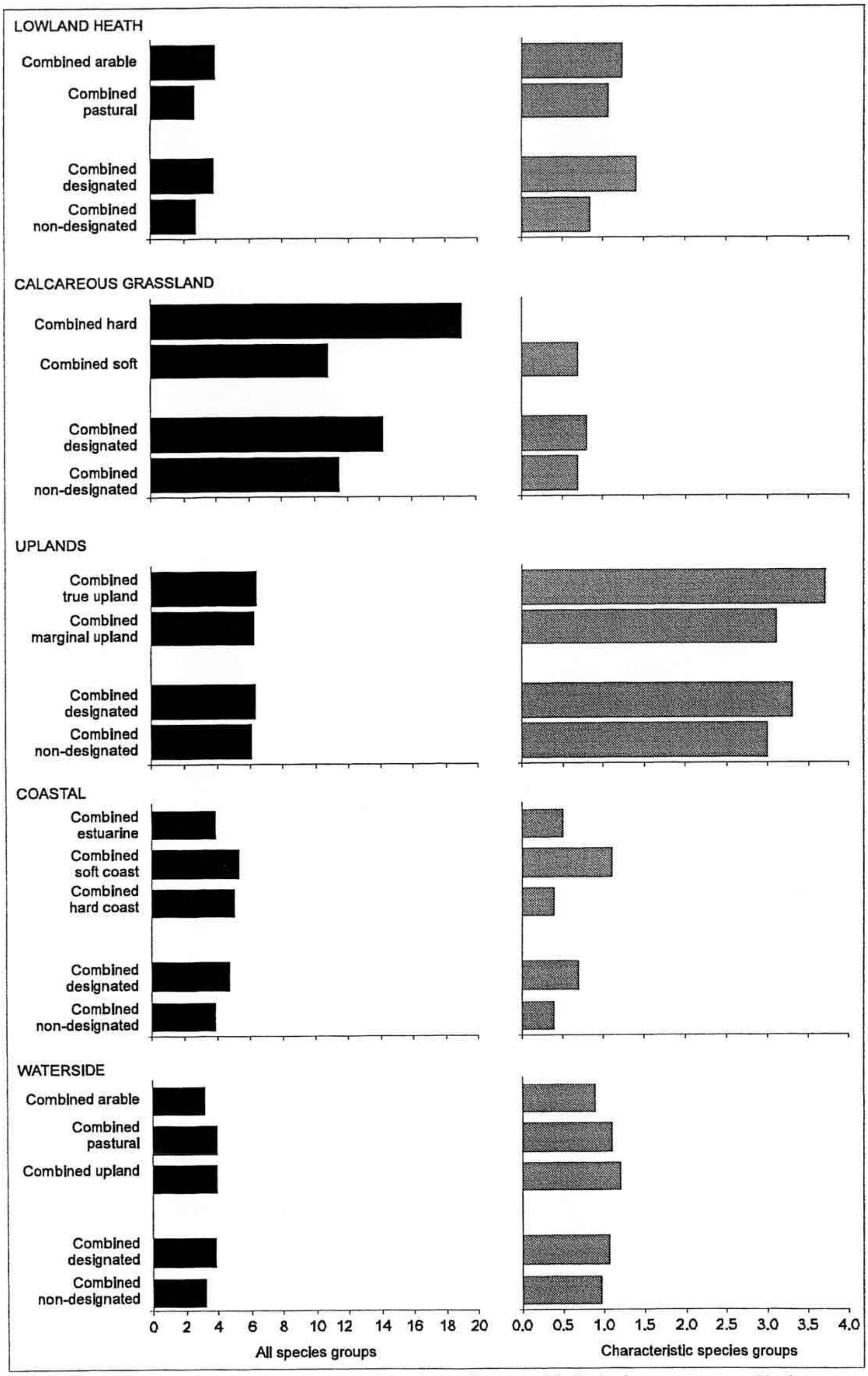

Figure 5.7 The diversity of the semi-natural vegetation in the main sampling strata of the five landscapes as measured by the mean number of species groups represented in main plots per 1 km square in each landscape

Habitat indicator species - a measure of naturalness

5.4.15 'Natural' is a term sometimes applied to vegetation which is considered to be unmodified by human influence - it cannot be strictly applied to any habitat in England, certainly not to sub-climax vegetation created and maintained by human activities. However, in this context, naturalness is used as a measure of the extent of modification or disturbance away from the optimum required to maintain an area as the characteristic habitats in the various landscapes. Such modification is indicated by the presence of species which are not normally associated with the threatened habitats of a given landscapes. In this study, the presence of 'habitat-indicator' groups of species (Table 5.5) are used to assess naturalness; a more frequent occurrence of indicator groups from the characteristic than the non-characteristic habitats of a landscape indicating less disturbance.

5.4.16 There were larger proportions of characteristic habitat-indicator groups in the combined designated compared with the combined non-designated strata of the calcareous grassland, lowland heath, upland and coastal landscapes (Table 5.5). This suggests that the designated strata as a whole are less disturbed than the non-designated.

5.4.17 The landscapes also show differences in occurrence of characteristic habitat-indicator groups between the environmental strata in the landscape. Thus, species from the moorland indicator species group were more common in the true uplands than the marginal uplands, indicating less disturbance and more 'natural' vegetation in the true uplands. Similarly, the results suggest less disturbance and more natural vegetation in the soft and estuarine coasts than the hard coasts, in the pastural than arable strata of the lowland heathland, and in the soft than the hard limestone strata in the calcareous grassland landscape.

5.4.18 Results from the calcareous grassland landscape also demonstrate the scarcity of 'Calcareous grassland species'; only 3% of records from the main plots were of species from this group. They were most common in the designated soft limestone strata. Of the 38 calcareous and base-rich grassland species, most (92%) were found in the designated, soft limestone strata, rather fewer (55%) in the non-designated soft limestone stratum and many fewer in the designated (37%) and non-designated (37%) hard limestone stratum.

5.4.19 The results from the waterside landscape suggest that wetland and wet grassland species have largely disappeared from the majority of the waterside landscape but that these species types are rather more common in the pastural strata. The habitat and waterside plots contained more records of waterside and wet grassland species showing that these groups are still present but fragmented and/or in a narrow waterside zone. The lack of difference in the proportion of waterside and wetland species between the designated and non-designated strata suggests that wider countryside policy and management is required to maintain and enhance waterside vegetation.

Table 5.5 The naturalness of the semi-natural vegetation in the main sampling strata of the five landscapes as measured by the percentage of species from characteristic habitat indicator groups occurring in main and habitat quadrats

LOWLAND HEATH

	Heath specialist	Heath generalist
Combined arable	4	30
Combined pastural	7	48
Combined designated	8	48
Combined non-designated	3	33

CALCAREOUS GRASSLAND

	CALCAREOUS GRASSLAND		BASE-RICH GRASSLAND	
	Main	Habitat	Main	Habitat
Combined hard	1	2	4	6
Combined soft	3	4	8	9
Combined designated	4	4	7	9
Combined non-designated	1	1	5	7

UPLAND

	BOG/ACID FLUSH SPECIES		MOORLAND SPECIES		UPLAND GRASS SPECIES	
	Main	Habitat	Main	Habitat	Main	Habitat
Combined true upland	14	6	36	28	16	16
Combined marginal upland	5	14	25	21	17	14
Combined designated	9	12	30	24	17	15
Combined non-designated	6	6	22	18	16	13

COASTAL

	MARITIME SPECIES	
	Main plots	Habitat plots
Combined soft	12	15
Combined estuarine	12	20
Combined hard	1	4
Combined designated	10	15
Combined non-designated	8	15

WATERSIDE

	WATERSIDE SPECIES			WET GRASSLAND SPECIES		
	Main	Habitat	Waterside	Main	Habitat	Waterside
Combined arable	1	3	9	2	2	3
Combined pastural	0	7	7	1	5	4
Combined upland	0	4	2	0	6	8
Combined designated	1	4	7	1	4	4
Combined non-designated	0	6	7	1	4	5

Representativeness of the vegetation

5.4.20 Representativeness involves using a classification of the range of vegetation being considered, to ensure that examples of the full range of types present within a region are conserved as well as giving emphasis to those which are 'typical' or characteristic. The range of vegetation present is described here using the classification of quadrats into 'plot classes', and of species into 'species groups'; the plot classes have, in some landscapes been grouped into plot class groups.

5.4.21 The characteristic plot classes and the occurrence of species from characteristic species groups showed different distributions across the various strata in each of the landscapes (Figures 5.8 and 5.9). The environmental variations seem to be the dominant controls within the landscape but the effect of designation can also be seen in most of the landscapes, the exception being the waterside landscape.

5.4.22 In the lowland heath, the characteristic heathland plot classes were more common in designated squares, and in the pastural strata. The latter probably reflects the less intensive agricultural management in this part of the lowlands. Dry heath types were more evenly distributed geographically and in terms of designation status. Bog and wet heath species were also most strongly represented in the designated strata, whilst the 'vascular heath species' were more widely spread. The designated strata include examples of the whole range of the heathland plot classes and species groups.

5.4.23 The classification into plot classes split the calcareous grasslands into three types, which have different distributions. The 'northern calcareous' grassland type was more common on hard limestone, whilst the 'basiphilous/calcareous grassland, tussocky with herbs' was more common on soft limestone. The classification into species groups produced three types of calcareous grassland species. The 'tall calcareous grassland species' were more common in soft limestone. The shorter 'grazed calcareous grassland species' occurred on both soft and hard limestone but were more often in designated areas. The heavily grazed calcareous grassland occurred in similar, low frequencies in all strata.

5.4.24 The uplands were dominated by moorland and bog vegetation, and acid grasslands, but also include a variety of more lowland habitats. The true uplands were dominated by specifically upland plot classes, whilst the non-designated marginal upland stratum had a higher proportion of vegetation types which are also found in the lowlands. The designated strata had higher proportions of moorland vegetation than the non-designated. The species groups also showed more moorland and bog species in the true uplands and more neutral grassland species in the marginal uplands.

5.4.25 All the maritime plot classes recorded in each coastal type were represented in the designated strata. In the soft coast squares, quadrats in maritime plots were largely restricted to designated strata. However, in the estuarine strata there were many maritime plots in non- designated squares. A similar pattern is shown by the species groups; specifically maritime species were recorded in both designated and non-designated strata, but in the soft coast squares were more common in designated squares. The designated areas seem therefore to cover the full range of coastal vegetation although most types still occur in non-designated squares.

5.4.26 The randomly-located main plots did not include waterside nor wetland habitats indicating their scarcity. A range of plot classes from these habitats were recorded in the waterside and habitat plots. Most plot classes were recorded in all strata, with the exception of the wet heath and acid grassland classes which were restricted to the uplands. There was little difference between the designated and non-designated strata. In the lowlands, waterside and wet grassland species were recorded more frequently in waterside plots compared to main and habitat plots, showing that these species are largely restricted to within a few metres of the water edge. Waterside and wet grassland species were recorded most often in main plots in the uplands.

5.4.27 In most of the landscapes the vegetation in the designated areas contains a higher proportion of the plot classes indicative of the characteristic habitats; the vegetation of the designated strata could be said to be more 'natural' and from that standpoint of higher quality. However, in the waterside landscape, environmental factors and plot type have far more influence on the proportion of wetland and wet grassland vegetation types and species than the presence of a designation. This conclusion contrasts with those reached for other characteristic habitats studied in this project in which the habitats were more strongly associated with designation.

Rarity

5.4.28 The survey strategy employed for this project is designed to record representative examples of vegetation and not rare vegetation types or rare species. Although rare species may occur within the sample, it is not possible to make any general statements about their abundance or distribution.

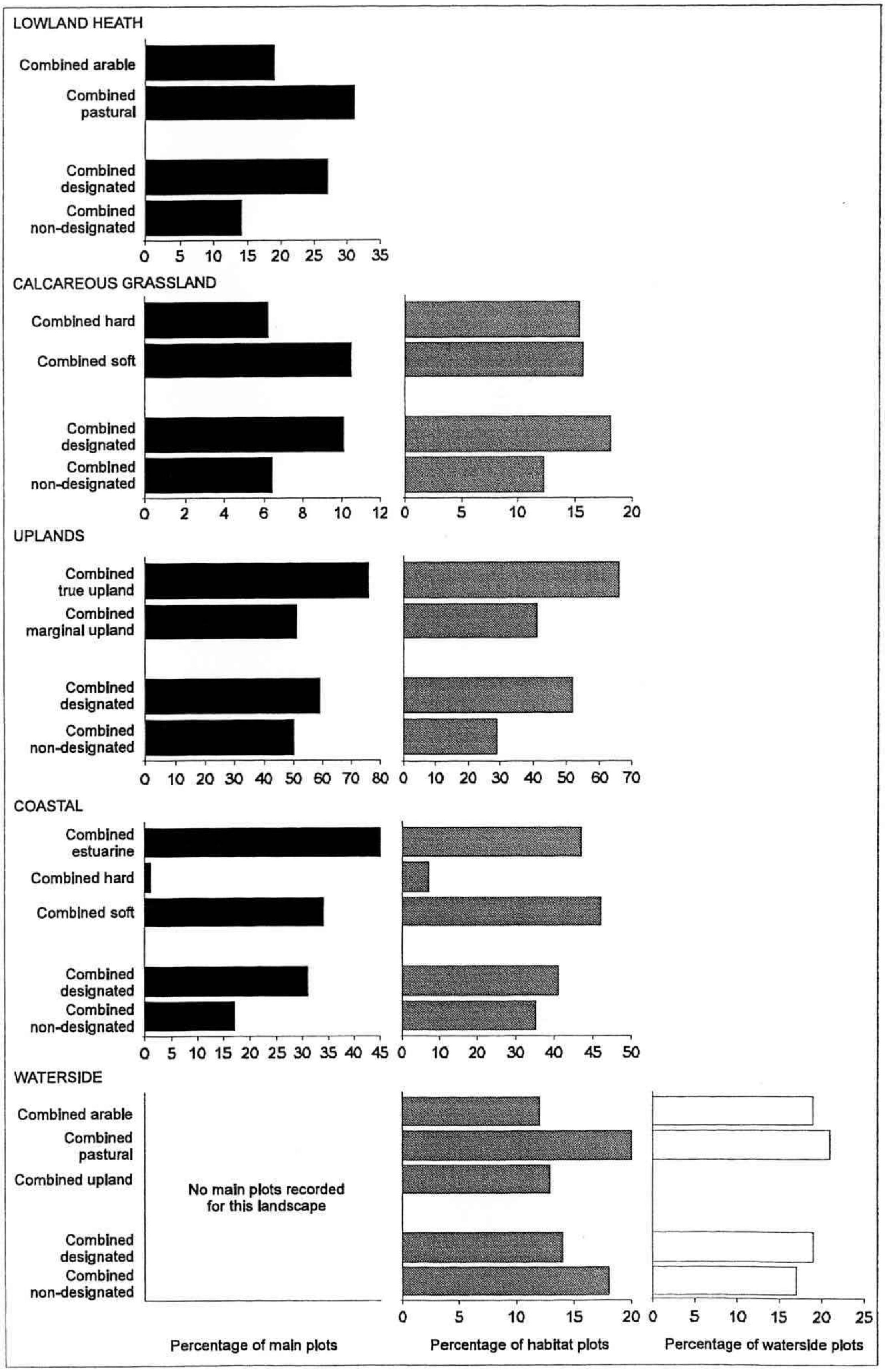

Figure 5.8 The representativeness of the semi-natural vegetation in the main sampling strata of the five landscapes as measured by the percentage of main, habitat and waterside plots occurring in the characteristic vegetation plot classes.

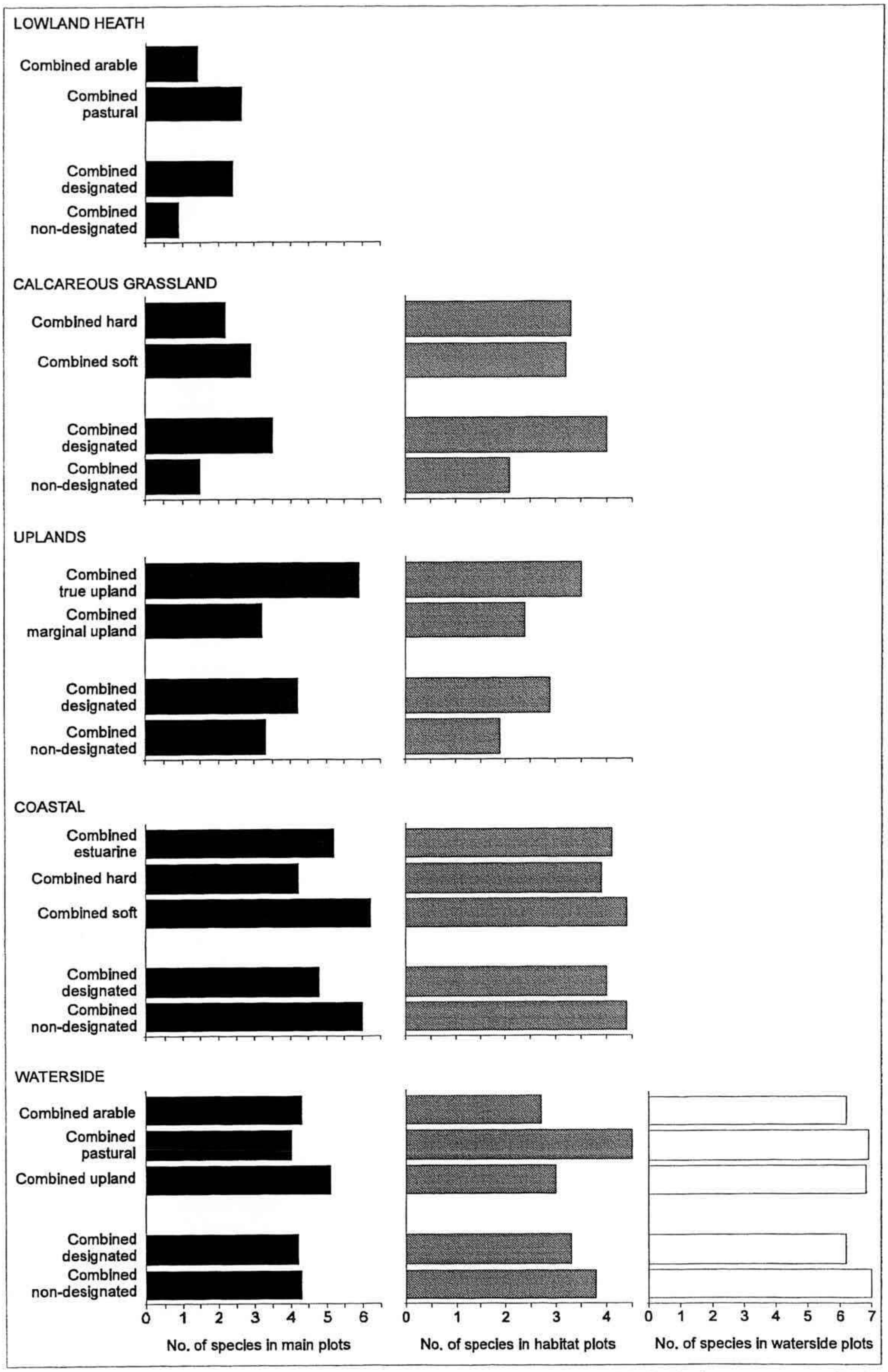

Figure 5.9 The representativeness of the semi-natural vegetation in the main sampling strata of the five landscapes as measured by the mean number of species per quadrat in the characteristic species groups of each sampling stratum of the five landscapes

Fragility

5.4.29 Plant species from each landscape known to be sensitive to particular kinds of management-related environmental change (Table 5.6) were used to measure the fragility of the vegetation. An analysis of the species data was carried out to assess the numbers of these sensitive species still present in the plots. This provides a measure of the vulnerability of the vegetation to the hypothetical changes, and of the extent of changes the vegetation has already experienced.

5.4.30 In the characteristic habitats in the calcareous grasslands, lowland heathland and uplands, the plots in the designated strata contained more species sensitive to change than those in the non-designated strata (Table 5.7). Thus, in the calcareous grasslands, there were more species sensitive to succession or eutrophication in the designated than the non-designated strata. Similarly, the designated strata in the lowland heathland contained a higher proportion of species sensitive to drying out, succession, grazing or eutrophication. In the uplands species sensitive to succession, grazing, drying out and eutrophication were more common in the plots from the designated strata. These data suggest that the characteristic habitats of these landscapes have suffered less disturbance in designated than non-designated areas. The characteristic habitats in the designated areas could also be said to be vulnerable to change in that the changes could result in the loss of key indicator species.

5.4.31 In the coastal and waterside landscapes, the main differences in the frequency of occurrence of species sensitive to change were found between the environmental divisions rather than between designated and non-designated strata. Thus, the plots in the characteristic habitats on the soft coasts contained more species sensitive to drying out, succession or grazing, but particularly the first two stresses than the habitats on the hard coasts and estuaries. This reflects the importance of the early successional stages in the soft coastal habitats and the importance of periodic inundation. The plots on the hard coasts contained the smallest number of species sensitive to the three stresses, suggesting greater stress and disturbance in this coastal type.

5.4.32 The frequency of occurrence of sensitive species in the waterside landscape varied with both with environment and stress type. Thus, species sensitive to drying out or eutrophication were least common in the arable areas and most common in the pastural areas of the lowlands. This indicates more drainage or water abstraction and a greater influence of fertilizer runoff or drift in the arable areas.

Table 5.6 **Threats to which species recorded in the vegetation quadrats were identified as being sensitive; presence of species from 'sensitivity - indicator groups' (to these threats) were used as an indication that vegetation in which they occurred had not been subjected to these pressures**

LANDSCAPE	LOWLAND HEATH	CALCAREOUS GRASSLAND	UPLANDS	COASTAL LANDSCAPE - MARITIME SPECIES	WATERSIDES
THREATS	(i) drying out (ii) succession, ie colonisation by tree species resulting in scrub or woodland (iii) grazing, leading to dominance of granuraceous species (iv) eutrophication through run-off or deposition	(i) succession, ie colonisation by tree species resulting in scrub or woodland (ii) eutrophication resulting from atmospheric deposition, run-off or application of fertilizers	(i) drying out due to drainage or climate change (ii) succession, ie colonisation by trees (iii) grazing leading to domination by graminaceous species (iv) eutrophication through atmospheric deposition or run-off	(i) succession, ie colonisation by tree species (ii) reclamation, of marshes, eg by drainage (iii) grazing, leading to dominance of graninaceous species, affecting marshes	(i) drying out due to drainage or climate change (ii) bank maintenance (iii) use of aquatic herbicides (iv) eutrophication through run-off or deposition

Table 5.7 The fragility of the semi-natural vegetation in the main sampling straa of the five landscapes as measured by the mean number of species sensitive to selected stresses per plot for each fragility/stress type

LOWLAND HEATH

	ARABLE	PASTURAL	DESIGNATED	NON-DESIGNATED
Drying out	0.36	1.20	1.30	0.27
Succession	1.23	2.75	2.65	1.56
Grazing	0.68	1.45	1.50	0.70
Eutrophication	1.08	2.28	2.17	1.39

CALCAREOUS GRASSLAND

		HARD	SOFT	DESIGNATED	NON-DESIGNATED
Succession	Main	0.5	0.9	1.0	0.5
	Habitat	1.2	1.5	1.7	1.0
Eutrophication	Main	0.6	1.3	1.3	0.9
	Habitat	1.5	1.8	2.1	1.3

UPLANDS

		TRUE UPLAND	MARGINAL UPLAND	DESIGNATED	NON-DESIGNATED
Succession	Main	0.95	0.83	0.93	0.60
	Habitat	0.42	0.37	0.40	0.29
Grazing	Main	0.45	0.35	0.43	0.14
	Habitat	0.30	0.25	0.28	0.19
Drying out	Main	4.87	2.40	3.09	3.07
	Habitat	3.42	2.59	2.97	2.16
Eutrophication	Main	14.05	9.98	11.33	10.23
	Habitat	8.33	6.42	7.21	5.89

COASTAL

		ESTUARINE	SOFT	HARD	DESIGNATED	NON-DESIGNATED
Drying out	Main	1.62	1.46	0.25	1.21	1.36
	Habitat	1.29	1.40	0.44	1.10	1.13
Grazing	Main	0.89	0.97	0.15	0.74	0.72
	Habitat	0.75	0.78	0.24	0.64	0.62
Eutrophication	Main	1.20	1.85	0.29	1.09	1.21
	Habitat	1.19	1.49	0.59	1.08	1.14

WATERSIDE

		ARABLE	PASTURAL	UPLAND	DESIGNATED	NON-DESIGNATED
Canalisation/dredging	Habitat	0.26	0.67	0.18	0.37	0.48
	Waterside	1.17	1.04	0.20	1.01	0.94
Drainage/drying out	Habitat	0.93	2.33	1.98	1.47	1.90
	Waterside	2.85	3.26	2.87	2.85	3.25
Eutrophication	Habitat	1.32	2.74	2.54	1.96	2.24
	Waterside	2.71	3.27	4.69	3.00	3.50
Aquatic herbicides	Habitat	0.07	0.24	0.15	0.07	0.26
	Waterside	0.36	0.27	0.17	0.32	0.27

Potential value

5.4.33 The vegetation plot classes from each landscape have been plotted against the first and second gradient of variation using the score from the DECORANA multivariate analysis. Plot classes from broadly related vegetation types, cluster in a similar area of the plot and the tightness of the cluster is an indication of the similarity of the plot classes. The distance between groupings on the plot is an indication of the similarity between them and can be used as a means of identifying those non-characteristic plot classes which are closely related to, or still contain elements of, the core vegetation and which could most readily be restored to the characteristic vegetation.

5.4.34 Using this approach, vegetation with the most potential for restoration or recreation of characteristic vegetation can be identified in the lowland heath, uplands and waterside landscapes. Thus, in the lowland heath vegetation found in woodland plantations has close affinity with that of the characteristic heath plot class and offers the potential for the restoration of heathland by removing the trees. In the uplands, there is the opportunity for restoration or conversion to heather moorland of 'moorland grass' and 'mossy moorland' by a reduction in grazing pressure and of 'Sitka on moorland' by removing trees. In the waterside landscape, two of the grassland plot classes, 'damp mixed grasslands' and 'meadows' had a number of species in common with the waterside vegetation plot classes and could be restored to characteristic waterside vegetation by modifying drainage; the restoration would be most likely to be successful if it were concentrated on areas adjacent to existing fragments of wetland vegetation.

5.4.35 The approach was less successful in the calcareous grassland and coastal landscapes. Although a number of non-calcareous grassland plot classes within the calcareous grassland landscape plot close to the core calcareous grassland classes, they probably occur on unsuitable substrates for restoration of the core grassland classes. In the coastal landscape the current vegetation is a poor indicator of potential for restoration. Instead, the potential of land for restoration of maritime vegetation is dependant more on current land use and on topography.

Overall ranking of vegetation quality

5.4.36 The vegetation in each sampling stratum of the five landscapes was ranked in terms of each of the quality measures obtained from the criteria discussed above. In the lowland heath, calcareous grassland, upland and coastal landscapes the combined designated stratum is ranked highest for the large majority of the quality measures (Table 5.8). In the waterside landscapes, however the combined non-designated stratum ranks higher overall than the designated.

5.4.37 There are also differences in the overall rankings between the environmental divisions of the landscapes; the most consistent trend is for the higher quality vegetation to be in the less intensively managed, less disturbed strata. Thus, in the lowland heath landscape, the pastural areas rank higher than the arable areas of the lowlands and in the uplands the true uplands rank higher than the marginal uplands.The vegetation in the pastural areas of the

Table 5.8 Number of quality measures for which each stratum ranked first within the respective landscape

LOWLAND HEATH		CALCAREOUS GRASSLAND		UPLAND		COASTAL		WATERSIDES	
Combined arable	1	Combined hard	4	Combined true upland	16	Combined estuarine coast	4	Combined arable	6
Combined pastural	10	Combined soft	13	Combined marginal upland	1	Combined hard coast	0	Combined pastural	10
						Combined soft coast	11	Combined upland	4
Combined designated	11	Combined designated	17	Combined designated	13	Combined designated	11	Combined designated	5
Combined non-designated	0	Combined non-designated	0	Combined non-designated	4	Combined non-designated	4	Combined non-designated	15

waterside landscape is of higher quality overall than in the arable and upland areas; probably reflecting a combination of a lower intensity of agricultural management than in the arable areas but a larger range of environmental conditions than in the uplands. In the coastal landscape, the soft coasts have the highest quality vegetation overall; the soft coasts include a relatively high proportion of maritime vegetation and a range of different habitat types.

5.4.38 The ranking of the four survey strata within the calcareous landscape showed that the designated soft stratum had the greatest amount and the highest quality of calcareous grassland. However, this stratum did not have the highest ranking in terms of the number of species per plot. The designated hard limestone stratum scored second for most quality criteria. This suggests that most high quality sites are in designated areas but some in non-designated strata may be of high quality even if they are smaller in size.

5.4.39 For most criteria, the designated true uplands stratum is ranked the highest, with the non-designated true uplands second. In three criteria involving habitat plots the non-designated true uplands ranked top, suggesting that where semi-natural upland vegetation exists in this stratum it is of similar quality to that in the designated areas.

5.5 Historic and archaeological sites

5.5.1 Each of the landscapes contained historic/archaeological sites from a wide range of periods but the representation of the various periods varied within and between landscapes (Table 5.9). Thus, Early Medieval sites were relatively scarce in the lowland heath and calcareous grassland landscapes and Palaeolithic sites were scarce in the upland landscape.

5.5.2 The frequency of occurrence of the sites varied between landscapes (Table 5.xx); being largest in the coastal and smallest in the upland landscapes. The calculated frequencies are higher than the national average of 1.2 sites per km2. Only a small proportion, less than 7% of the sites identified in any of the landscapes in the present study were Scheduled Ancient Monuments (Table 5.10). A study published in 1986 (Inspectorate of Ancient Monuments 1986) estimated that an average of 4.2% of archaeological sites recorded in county Sites and Monument records were scheduled and 2% of all known sites. Preliminary results from the Monuments at Risk Survey suggest that 5.5% of monuments are now scheduled nationally and that c30% of scheduled sites are within areas covered by non-archaeological designations, eg SSSI, AONB, National Park (G.Fairclough, pers comm).

5.5.3 In the heathland and coastal landscape there were higher frequencies of sites in the designated than the non-designated strata. In the calcareous grassland landscape the frequency of occurrence of sites was similar in designated and non-designated strata and in the uplands the non-designated strata contained a higher frequency than the designated strata. The latter is surprising as a very large proportion of the uplands was covered by some form of designation.

5.5.4 In the lowland heath landscape, the major difference between designated and non-designated strata was shown for prehistoric sites and those from the Early Medieval and Medieval periods. There was no difference in the frequency of occurrence of Roman and post Medieval sites between designated and non-designated strata.

Table 5.9 Numbers and proportions (%) of archaeological features identified from each archaeological/historical period. (a) = % of total sites; (b) = % of sites assigned to a known period

	LOWLAND HEATH			CALCAREOUS GRASSLAND			UPLANDS			COASTAL		
	Number	(a%)	(b%)	Number	(a%)	(b%)	Number	(a%)	(b%)	Number	(a%)	(b%)
Modern	4	<1	<1	2	<1	<1	0	0	0	18	3	4
Post Medieval	129	17	31	82	20	41	39	27	50	227	30	48
Medieval	51	7	12	32	8	16	8	5	10	63	10	13
Early Medieval	10	<1	<1	8	2	4	0	0	0	14	2	3
Roman	38	<1	1	30	7	15	6	4	8	36	6	8
Iron Age	20	<1	<1	14	3	7	2	1	3	27	4	6
Bronze Age	65	9	16	13	3	7	11	8	14	25	4	5
Neolithic	25	<1	6	4	<1	2	1	<1	<1	6	1	1
Mesolithic	23	<1	6	6	1	3	4	3	5	6	1	1
Palaeolithic	6	<1	<1	0	0	0	0	0	0	4	<1	<1
Prehistoric	45	6	11	10	2	5	7	5	9	50	8	11
Unknown	336	45	-	218	52	-	68	47	-	152	24	-
TOTAL	752			418			146			628		

Table 5.10 **Mean number of archaeological sites identified per sample 1km square and the 4 landscapes and in designated and non-designated sample strata, and the % of sites which are scheduled ancient monuments**

	LOWLAND HEATHLAND	CALCAREOUS GRASSLAND	UPLAND	COASTAL
Designated strata	10.2	9.5	4.6	11.2
Non-designated strata	6.6	9.5	6.3	9.5
All sample squares	8.4	9.5	5.1	10.3
% Scheduled	6.1	3.0	4.0	1.9

6. Sensitivity to change

6.1 Modelling of the impacts of change

6.1.1 The inherent vulnerability of the habitats within the various landscapes to stresses arising from a number of changes was assessed in the study using the TRISTAR model (Paragraph 3.7), with the species data from the vegetation plots recorded during the field surveys used as input to the model. The TRISTAR model was used to explore the response of the vegetation plot classes, by examining the response of the constituent species, from each landscape to a range of scenarios comprising combinations of change characterised as *disturbance* and *eutrophication.* These two factors encapsulate the major, widespread stresses influencing competition between plant species. Six combinations of no change, increase and decrease in the levels of disturbance and of eutrophication were considered (Table 6.1).

Table 6.1 Change scenarios considered in the modelling studies

Scenario 1	Decreased disturbance with no change in eutrophication
Scenario 2	Decreased disturbance with increased eutrophication
Scenario 3	No change in disturbance with decreased eutrophication
Scenario 4	No change in disturbance with increased eutrophication
Scenario 5	Increased disturbance with decreased eutrophication
Scenario 6	Increased disturbance with increased eutrophication

6.1.2 The causes of changes in the level of disturbance and eutrophication could, as noted above differ between landscapes and there could be more than one possible cause in any given landscape. The possible causes of change as they would affect the core vegetation plot classes in each landscape are given in Table 6.2

6.1.3 The changes in the balance of the functional types (cf Paragraph 3.7 and box 3.5) in response to the various change scenarios were determined for each plot class and an 'index of vulnerability' calculated for each combination of landscape, plot class and change scenario. The indices of vulnerability for all the plot classes in each landscape were combined to give a mean 'index of vulnerability' for the vegetation of the landscape to each change scenario (Table 6.3).

Table 6.2 Possible causes of the changes in 'disturbance' and 'eutrophication' as considered in the modelling study, as they would affect the characteristic vegetation plot classes in each landscape

	DISTURBANCE		**EUTROPHICATION**	
	Increase	**Decrease**	**Increase**	**Decrease**
Heathland	Increased grazing; increased incidence of fires; increased recreation pressure	Cessation/reduction in grazing; reduced incidence of fires; reduced recreational pressures	Increased fertilizer runoff; increased atmospheric deposition	Reduced fertilizer runoff; reduced atmospheric deposition
Calcareous grassland	Increased incidence of fires; increased grazing; increased recreational pressure	Cessation/reduction in grazing; reduced incidence of fires; less recreational pressure	Increased fertilizer runoff; increased atmospheric deposition	Reduced fertilizer runoff; reduced atmospheric deposition
Uplands	Increased cutting or grazing; increased recreational pressure; increased incidence of fire (grasslands and shrub heaths)	Cessation/reduction in grazing or cutting; reduced incidence of burning; reduced recreational pressure; cessation of flooding (wetlands only)	Increased flooding (wetlands only); increased fertilizer runoff; increased atmospheric deposition	Reduced fertilizer runoff; reduced atmospheric deposition
Coastal	Increased effects of tidal activity; increased recreational pressure	Reduced tidal activity; colonisation by cord grass (*Spartina anglica)*; less recreational pressure	Increased fertilizer runoff; increased atmospheric deposition	Reduced fertilizer runoff; decreased inundation by nutrient rich waters; reduced atmospheric deposition
Waterside	Increased grazing or cutting; increased recreational pressure	Cessation of flooding (particularly severe floods); reduced grazing or cutting; reduced recreational pressure	Increased flooding; increased fertilizer use or runoff; increased atmospheric deposition	Reduced fertilizer use or runoff; decreased deposition of nutrient rich mud and silt; reduced atmospheric deposition

6.2 Overall vulnerability of the vegetation in the 5 landscapes

6.2.1 The mean indices of vulnerability indicate that, overall, the vegetation of the coastal landscape is the most sensitive to change of the five landscapes, with a moderate index of vulnerability for 4 of the 6 scenarios (Table 6.3). Overall the vegetation of the waterside landscape is the least sensitive to change, with a low index of vulnerability for 5 of the six change scenarios and negative scores for three of the scenarios.

6.2.2 The vegetation in the various landscapes as a whole is most vulnerable to the scenario of increased disturbance combined with increased eutrophication, scenario 6. Four of the 5 landscapes have moderate indices of vulnerability for this scenario. The exception is the waterside landscape, which has a low index; this reflects the fact that the vegetation in this landscape is naturally characterised by eutrophic and disturbed conditions.

6.2.3 Three of the landscapes also show moderate indices of vulnerability to scenario 5, which represents increased disturbance with decreased eutrophication. Together, the modelled responses to the two scenarios which include increased disturbance show the importance of disturbance as a factor influencing the vegetation. Again it should be stressed that the cause of the disturbance, in this context would vary between landscapes.

6.2.4 In addition to the variation in overall vulnerability of the vegetation of the landscapes between scenarios there are important variations in the responses of the various plot classes in a given landscape to a given scenario. However, in most of the landscapes, at least half of the various plot classes show at least moderate vulnerability to scenario 6, again indicating that the vegetation is most vulnerable to changes which involve increased disturbance and eutrophication. In these cases the scenario is predicted to result, over the longer term, in large changes in species composition in at least some of the plot classes, in terms of the balance between the different functional types, which would be difficult to reverse. Most frequently, this scenario would lead to a loss of stress tolerators and an increase in ruderals and competitors. Such changes would reduce the conservation value of the habitats.

Table 6.3 Mean index and ranking of vulnerability of the full range of vegetation plot classes in each of the five landscapes to the six scenarios of change

Scenario	Lowland heath	Calcareous grassland	Upland	Coastal	Waterside
1	-0.01(l)	-0.01(l)	-0.13(l)	0.16(l)	-0.04(l)
2	0.05(l)	0.01(l)	0.13(l)	**0.24(m)**	-0.07(l)
3	0.03(l)	0.07(l)	-0.13(l)	**0.22(m)**	0.07(l)
4	0.08(l)	0.05(l)	0.13(l)	0.12(l)	-0.04(l)
5	0.16(l)	**0.22(m)**	(0.00(l)	**0.32(m)**	**0.20(m)**
6	**0.25(m)**	**0.28(m)**	**0.20(m)**	**0.33(m)**	0.11(l)

(l = low; m = moderate)

A negative score indicates that the vegetation is likely to 'benefit' as a result of the changes considered in the scenario.

6.3 Vulnerability of the characteristic plot classes in the 5 landscapes

6.3.1 The characteristic vegetation plot classes of the various landscapes generally show similar indices of vulnerability to the 6 scenarios as the vegetation of the landscape as a whole. There are however, important exceptions and particular characteristic plot classes can show greater or lower vulnerability than the rest of the vegetation in a given landscape.

6.3.2 In the upland landscape, the characteristic vegetation plot classes are more sensitive to change than the non-characteristic plot classes while, in contrast, in the waterside landscape the characteristic plot classes are less sensitive to change than some of the non-characteristic plot classes.

6.3.3 The characteristic plot classes of the uplands are also more sensitive to change than the core plot classes in the other landscapes. The 'species rich wet flushes' have a moderate index of vulnerability to 4 of the 6 scenarios, the 'limestone grassland' for 2; this suggests that these are the two most vulnerable vegetation types to change in the upland landscape. Overall the plot classes representative of wet habitats are the most vulnerable to change in the uplands.

6.3.4 The assessment of fragility based on the vegetation data from the field survey suggests that the upland vegetation has been most influenced by grazing, which equates with disturbance in the vulnerability modelling, as species sensitive to grazing occur less frequently than species sensitive to the other stresses considered. The modelling suggests low vulnerability to increased disturbance with unchanged eutrophication but moderate vulnerability to combined increases in disturbance and eutrophication. Species sensitive to eutrophication were found to be still relatively common in the field survey.

6.3.5 In the waterside landscapes, only one plot class, 'eutrophic/disturbed water edge' has a moderate score for any of the scenarios, scenario 5. The characteristic vegetation in the watersides is therefore relatively insensitive to change. Similarly only one characteristic plot class of the heathland, 'wet heath' and coastal, 'maritime/freshwater interface.' landscapes have a moderate index for any of the scenarios, again in both cases scenario 5.

6.3.6 In the calcareous grassland the characteristic plot classes have a low index of vulnerability to 4 of the 6 scenarios, one plot class, 'basiphilous calcareous grassland, tussocky with herbs' has a moderate index for scenario 5 and a high index for scenario 6, as has the plot class 'northern calcareous' for scenario 6. The basiphilous grassland is therefore the most vulnerable plot class to change in the calcareous grassland landscape.

6.3.7 These data show that, as with the vegetation of the landscapes as a whole, the characteristic plot classes are most sensitive to change which involves an increase in disturbance.

6.4 Variations in vulnerability between plot classes within landscapes

6.4.1 Within the lowland heathland landscape, the grassland classes are most vulnerable to the increase in disturbance and eutrophication, the woodland habitats least vulnerable and heathland habitats intermediate. In the calcareous landscape, the greatest vulnerability is shown by the plot classes associated with tall little-managed vegetation (tall, coarse grassland and neutral basiphilous grassland) and with unproductive conditions (short turf, grazes calcareous grassland with small herbs and northern calcareous grassland); the already eutrophic and disturbed group of fertile grasslands show the lowest vulnerability. In the uplands, some of the eutrophic grasslands and wetlands have the highest vulnerability while in the coastal landscape, the largest responses are predicted in the grasslands and acidic vegetation with small responses by salt marsh and other maritime vegetation.

6.4.2 The changes in the balance of functional types to scenario 6 are also predicted to differ between the groupings of plot classes within landscapes. Thus, the most common trend overall in the uplands is predicted to be towards an increase in ruderals and a reduction in stress tolerators but there are significant differences between the woodland, wetland and acidic vegetation groups of plot classes. The woodland plot classes are predicted to show an increase in ruderals and competitor-ruderals at the expense of stress tolerator-competitors and stress tolerators. The wetland plot classes, in contrast show an increase in ruderals and competitor-ruderals at the expense of competitors, stress-competitors and competitor-stress-ruderals while in the acidic group of plot classes the greatest loss is predicted for stress tolerators.

6.4.3 In the calcareous grassland landscape as a whole, increases in the level of disturbance and/or eutrophication are indicated as having larger impacts on the plot classes than reductions in these two types of stress. The results suggest that increased disturbance with either increased or decreased eutrophication would have major impacts on the vegetation with respect to functional types. There would be losses of stress-tolerator type species and gains in ruderals, particularly if the increased disturbance created gaps. In the less productive grassland plot types, increased eutrophication would tend to produce a move from stress tolerators towards competitors and ruderals

6.4.4 The more productive grassland and maritime vegetation classes of the coastal landscape are predicted to be amongst the most responsive plot classes in any of the landscapes to changes in levels of disturbance. In these plot classes, changes in disturbance are predicted to produce large short term responses in the balance between functional types. The changes in the balance of the functional types is however predicted to differ depending on the direction of change. Thus, a reduction in disturbance would lead to an increase in taller, fast growing vegetation and competitors but a reduction in ruderals and stress tolerators while increased disturbance leads to an increase in ruderals. In contrast the low growing, less productive grassland and acidic habitats are predicted to show small responses to changes in disturbance. These latter habitats are more responsive to increases in eutrophication. As noted above, the saltmarsh and maritime habitats tend to show small responses to the changes in disturbance and eutrophication; they tend to be naturally eutrophic habitats.

6.4.5 Overall therefore, vegetation in waterside landscapes is the least vulnerable to change driven by the combination of scenarios examined. and the vegetation of the coastal landscapes the most vulnerable. Some of the coastal plot classes are particularly sensitive to changes in disturbance, increases or decreases. The plot classes in the calcareous landscape are most sensitive to increases in disturbance and/or eutrophication. The core plot classes show similar trends in vulnerability.

6.5 Comparison with assessment of fragility

6.5.1 The fragility analysis of the vegetation data from the field survey (4.2.29) included an assessment of the occurrence of species sensitive to a range of management related environmental changes. These results were compared with the outputs of the modelling exercise to examine the consistency of these two independent assessments of vulnerability of the vegetation to environmental change. This comparison could only be carried out at a broad level as the results are not entirely comparable Ideally comparisons should also be carried out at the level of the individual plot class or groups of closely related plot classes rather than across the whole range of vegetation in a given landscape as individual plot classes within a landscape can respond differently to a given stress.

6.5.2 The data from the lowland heath landscape suggest that grazing and drying out may have had a greater impact on the vegetation in the lowland heath landscape than succession or eutrophication as species sensitive to the first two stresses occur more frequently than those sensitive to the latter stresses. These results reflect similar trends to those predicted by the modelling. The two modelled scenarios which include increased disturbance, which could equate with increased grazing have the highest overall scores for vulnerability in the lowland heathland landscape. The two scenarios which included increased eutrophication without increased disturbance had much lower scores.

6.5.3 Overall, the results from the modelling and the fragility assessment appear contradictory in the case of the calcareous grassland landscape. The fragility assessment indicates that eutrophication has had a greater impact than succession, based on the frequency of occurrence of species sensitive to these two stresses, whereas the two modelled scenarios which include increased eutrophication had low vulnerability scores. However, a more detailed examination of the model outputs suggests that increased eutrophication would lead to a decrease in stress tolerator species, which would include the species considered as fragile to eutrophication in the field survey assessments.

6.5.4 Succession and grazing are indicated as having impacted more on the upland vegetation than drying out or eutrophication. Again this apparently contrasts with the modelled results as scenarios with increased eutrophication had higher vulnerability scores than those with unchanged or decreased levels of eutrophication. Again, interpretation of the model outputs at the plot level indicate that eutrophication would encourage fast growing perrenials and annuals at the expense of the slower growing species of,conservation interest and which would include the species considered fragile to eutrophication in the field survey.

6.5.5 The modelling suggests that the coastal vegetation is most vulnerable to changes in disturbance while the field data suggests grazing has had more impact than succession or drying out. Grazing is one form of disturbance but the field survey would only assess the impact of increased grazing whereas the 'disturbance' in the modelling studies covers any form of disturbance. Succession would indicate a reduction in disturbance. The field survey results could be said to indicate that increased disturbance, as represented by increased grazing has had more impact than reduced disturbance. the modelling studies also indicate that the grasslands within the coastal landscape are more vulnerable to grazing than some of the core maritime habitats.

6.5.6 The assessment of the impact of stresses on the occurrence of fragile species based on the field data suggest that in the waterside landscape, canalisation/dredging and aquatic herbicides have had a greater impact than drying out or eutrophication. Canalisation/dredging would reduce disturbance. The modelling showed the highest scores for increased disturbance but the lowest scores for changes in eutrophication unless combined with increased disturbance. Thus, the results from the two approaches are broadly coincident.

6.6 Summary of the scenarios likely to reduce or improve habitat quality in the five landscapes

6..6.1 It is possible from the modelling studies to identify those scenarios which are likely to reduce or enhance the nature conservation interest of the threatened habitats in the five landscapes (Table 6.4). The table shows for each of the 5 landscapes whether the conservation value of the characteristic vegetation would be likely to be improved (√)

Table 6.4 Change scenarios which might improved (✔) or reduce (✘) habitat quality and nature conservation interest in the five landscapes

		Lowland heathland	Calcareous grassland	Upland	Coastal	Waterside
1	Decreased disturbance, no change in eutrophication	✘	✘	✔	✘	✘
2	Decreased disturbance, increased eutrophication	✘	✘	✔	✘	✘
3	No change in disturbance, decreased eutrophication	✔	✔	✔	✔	✔
4	No change in disturbance, increased eutrophication	✘	✘	✘	✘	✘
5	Increased disturbances, decreased eutrophication	✔	✔	✔	✔	✔
6	Increased disturbance, increased eutrophication	✘	✘	✘	✘	✘

or reduced (**x**) by the combination of disturbance and eutrophication states represented by each of the 6 modelled scenarios. It must be stressed again that the causes of the disturbance or eutrophication can vary between landscapes (Table 6.3).

6.6.2 Table 6.4 shows that any change which includes an increase in eutrophication is likely to reduce the conservation value and quality of the characteristic habitats in all the five landscapes. Conversely, changes which involve reductions in eutrophication are likely to improve the quality of the habitats in four of the five landscapes. Increased eutrophication would benefit fast growing competitors at the expense of the slow growing stress tolerators which are generally the species of conservation interest.

6.6.3 In contrast to the likely impacts of an increase in eutrophication, four of the landscapes are considered likely to benefit from increased disturbance if accompanied by reduced eutrophication (Scenario 5). The vegetation of four of the landscapes would, however also be damaged by decreased disturbance with no change in eutrophication (Scenario 1). This clearly underlines the importance of disturbance, grazing, fire, tidal disturbance or flooding in the relevant landscapes in the maintenance of the quality of the characteristic habitats.

6.6.4 The calcareous grasslands are suggested as being the one landscape in which habitat quality is likely to improve as a result of increased disturbance with increased eutrophication. However, the beneficial effects would be limited to certain habitats and limited in duration as the increased eutrophication would eventually lead to an increase in weed species of low conservation interest.

6.6.5 The results emphasise the need to control both disturbance and nutrient availability or inputs in order to maintain or enhance habitat quality. As noted earlier, the causes of disturbance or nutrient input/availability will vary between landscapes and the control measures will therefore need to vary to ensure influence over the relevant causes for a given landscape.

7. Threats

7.1 Current and future threats to the threatened habitats

7.1.1 The current section brings together the results of the assessments of pollution impacts, carried during the project, the modelling studies and the work on fragility, with the outputs from the expert group meetings and published material to consider the principal current and future threats to which the threatened habitats are exposed.

7.1.2 Table 7.1 lists the main current and future threats likely to affect the five landscapes and attempts to identify the key two or threats for each landscape in the short to medium term. The table shows that the threatened habitats in the various landscapes are subject to a wide variety of threats, the importance of which vary between landscapes. It also shows that some of the landscapes are subject to a wider variety of threats than other landscapes.

Table 7.1 Threats (O) affecting the five landscapes, with ● representing the most important threats over the short to medium term

	Landtake: Intensive agriculture	Landtake: Forestry	Landtake: Development	Grazing	Burning	Eutrophication	Acidification	Climate change	Sea level change	Recreation	Canalisation	Drainage
Lowland heathland			O	●	O	●	O			O		●
Calcareous grassland	O			●		●				O		
Upland		O		●		O	O	O		O		●
Coastal	●		●						O	O		
Watersides	●									O	●	●
Equivalent stress in the modelling studies: (D) disturbance, (E) eutrophication				D	D	E			D	D	D	D

(The 'threat' from grazing could represent an increase or decrease in grazing pressures)

The habitats can be largely lost from a given location as a result of land take for agriculture, forestry or development. They are also sensitive to a number of less dramatic changes than landtake but which can lead to a gradual, but equally important losses of characteristic species and habitats. These include changes in land management and in the management of water courses, atmospheric pollution leading to acidification and increased deposition of nitrogen, and short and long term changes in climate.

7.1.3 Changes in land management can have a variety of impacts. In the modelling exercise discussed in section 6 the scenarios were built around changes in the level of disturbance and eutrophication, both of which types of change result from modifications in land use and management. Thus, changes in the level of disturbance result from increases or decreases in grazing or cutting intensity, frequency of fires, recreational activity, or ploughing. Reductions in disturbance of coastal habitats can result from land reclamation and the building of sea defences, and in riverside wetlands as a result of canalisation and drainage. Eutrophication can arise from nutrient rich runoff from adjacent agricultural fields or wind drift of fertilizers during spreading; eutrophication can also arise from atmospheric inputs of nitrogen. Changes in soil water levels can arise from drainage or water abstraction, or from natural changes in the courses of rivers or coastal channels. Changes in coastal currents, and hence levels of disturbance in the coastal landscape can result from construction of sea defences and coastal engineering works.

Climatic influences can range from short term extreme events, such as unusually cold winters or hot, dry summers to the predicted long term changes resulting from global warming.

7.2 Acidification by atmospheric deposition

7.2.1 The base poor soils of the characteristic habitats of the lowland heath and upland landscapes are vulnerable to enhanced soil acidification as a result of atmospheric inputs of acidic atmospheric pollutants and such inputs are a significant threat to these habitats. The soils of the characteristic habitats of the calcareous grasslands are well buffered and therefore unlikely to be affected by the effects of enhanced acidification. The soils of the waterside and coastal landscapes will also be more resistant to acidification while being less well buffered than the calcareous soils.

7.2.2 The current and future threat to the various landscapes from acidification due to atmospheric inputs has been assessed using the critical loads approach (3.6). The analysis was carried out for the calcareous grassland, lowland heath and upland landscapes.

7.2.3 The calcareous grassland landscape was the least sensitive with the lowland heath and upland landscapes being similarly and highly sensitive (Figure 7.1 and 7.2). Thus, the critical loads are calculated to be exceeded by 1989-91 deposition for only 18% of the 1 km squares in the calcareous grassland landscape mask as against 95% in the upland and 93% in the lowland heath masks. A higher proportion of squares within the calcareous grassland landscape showed exceedance in the massive limestones areas of the north west of England (32%) than in the soft limestone areas of the south east (7%). There was little difference in the proportion of the area of the marginal and true uplands which showed exceedance. In the lowland heath landscape, only small areas of the Brecklands and the Lizard peninsula are in non-exceeded areas.

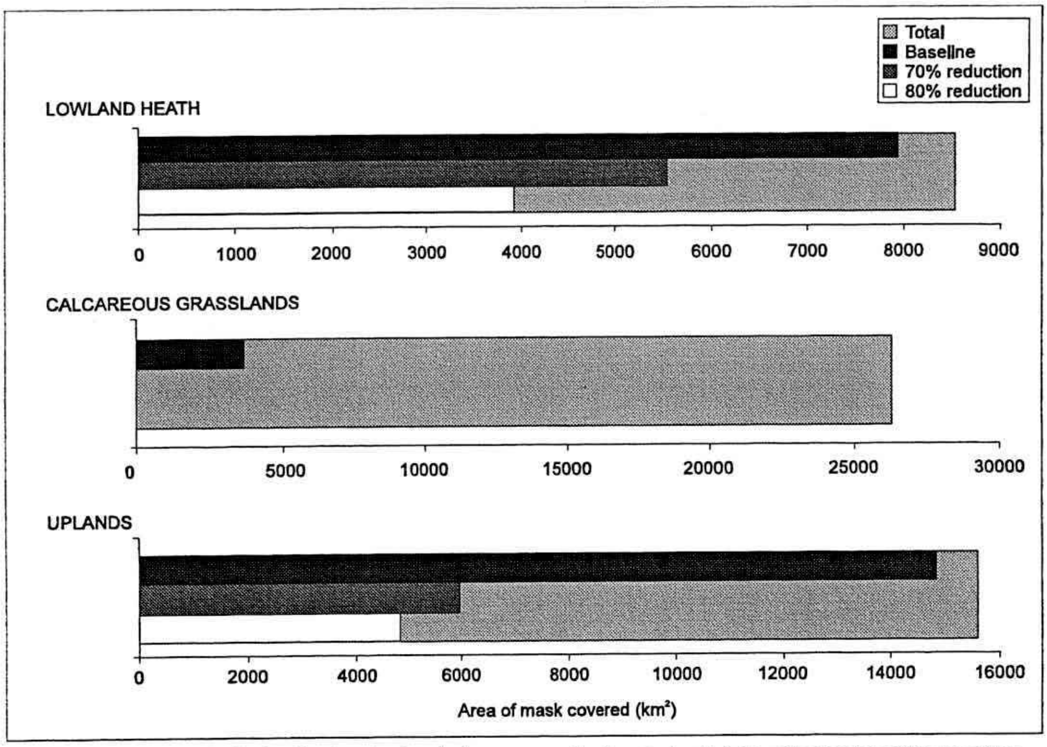

Figure 7.1 Proportions of the lowland heath, upland, and calcareous grassland masks in which the critical load of acidity for soils is exceeded by current deposition (baseline, a 70% reduction and an 80% reduction)

7.2.4 Under the planned 70% reduction in emissions, the forecast is that non of the calcareous grassland landscape will receive acidic deposition in excess of the critical load. In contrast, although the planned reductions in emissions would greatly reduce the area of the lowland heath and upland landscapes over which the critical load is exceeded, large areas of these landscapes would still be at risk. Thus, some 65% of the lowland heath landscape and 38% of the upland landscape would still be at risk. The modelling exercise also indicates that following an 80% reduction in emissions the critical load would still be exceeded in 65% of the lowland heathland areas and 31% of the uplands.

7.3 Eutrophication

7.3.1 Lowland heaths, calcareous grassland and many of the threatened upland habitats are characterised by low nutrient-demanding species, particularly with respect to N and P. They are therefore sensitive to changes in nutrient supply and the input of additional nutrients are major threats to these habitats; eutrophication leading to a change in the competitive interactions between species and a loss of the species of conservation interest.

7.3.2 As noted above, the modelling studies recognised eutrophication as a major stress; it was included in the various scenarios explored and increased atmospheric pollution was recognised as one possible cause of increased eutrophication (Table 6.2). The outputs from the modelling suggested that the lowland heath and calcareous grassland landscapes were vulnerable to increases in eutrophication in combination with

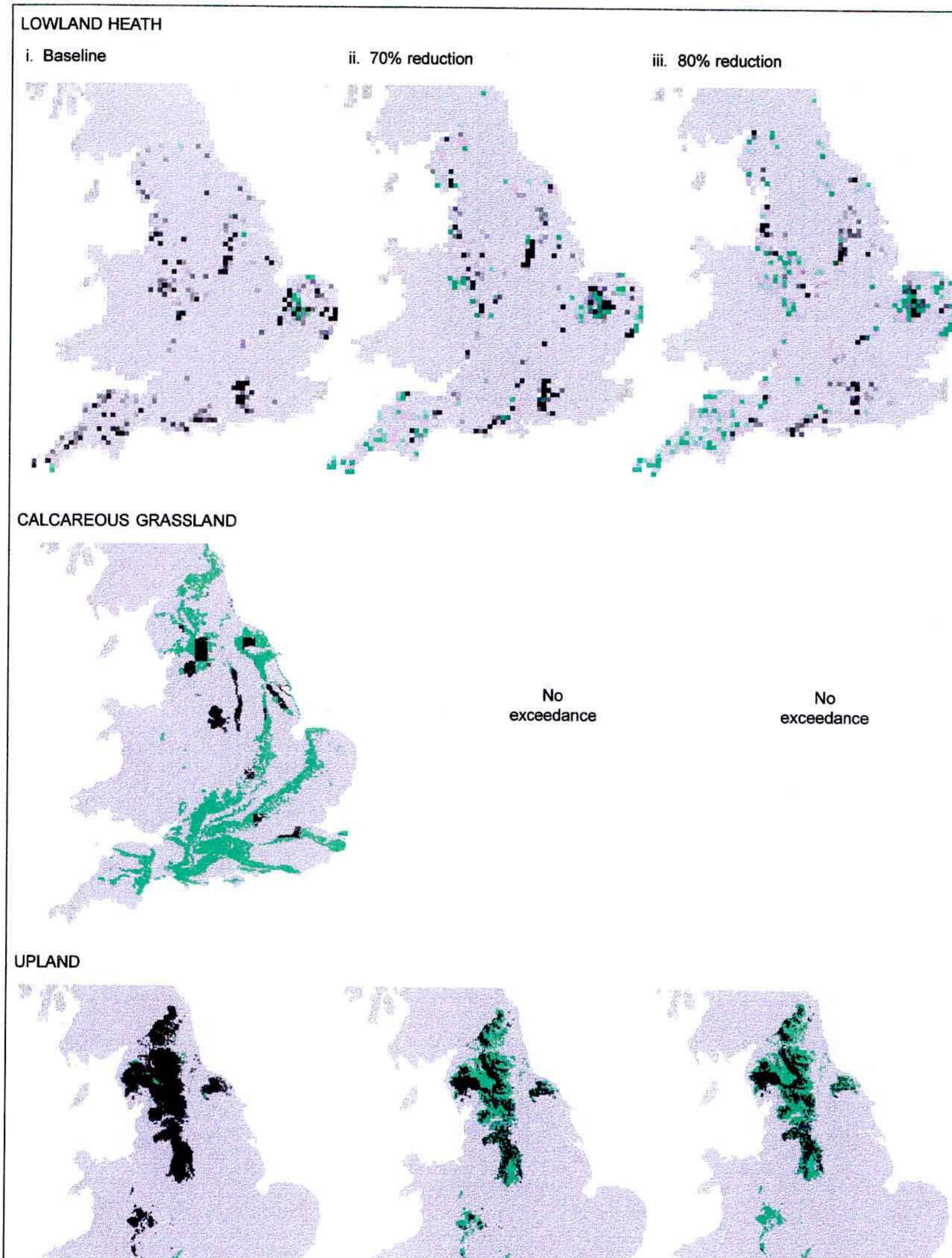

Figure 7.2 Areas within the lowland heath, upland and calcareous grassland masks where acid deposition exceeds the soils' critical load under (i) 1989–91 baseline, (ii) 70% reduction by 2005 scenario and (iii) 80% reduction by 2010. Black = exceeded areas, green = unexceeded areas (source: CLAG Soils Sub-Group)

increased disturbance and the upland vegetation had relatively high vulnerability scores for all the scenarios which included increased eutrophication.

7.3.3 Interpretation of the modelling results indicated that increased deposition of nitrogen to the lowland heathlands would result in a move away from heathlands to vegetation types dominated by tall competitive herbs and grasses, or in some situations to bracken; the dry heaths were considered to be the most sensitive. In the calcareous grasslands, there would be a decline in stress tolerant species with an increases in coarse grasses and weeds at the expense of fine grasses and forbs. There would be a decrease in diversity and a deterioration in the conservation value. The impacts would vary between habitat types in the uplands. Thus, tall competitive herbs, grasses or bracken could invade acidic moorland and fast growing perrenials and annuals could expand in the improved grasslands and wetlands.

7.3.4 In contrast the waterside habitats and coastal habitats are often naturally eutrophic; maritime habitats of the soft coasts and estuaries receiving nutrient inputs from tidal inundation and the waterside habitats from periodic flooding. They are therefore less sensitive to eutrophication. In the modelling studies, the waterside vegetation had negative vulnerability scores for the scenarios involving increased eutrophication without increased. disturbance, confirming the low sensitivity. The waterside vegetation had relatively high vulnerability scores where increased eutrophication is accompanied by a change in disturbance, either an increase or decrease.

7.3.5 In general, in both the coastal and waterside landscape, disturbance is considered to be a more important stress or threat than eutrophication. However, detailed interpretation of the modelling results indicate that there could be an increase in competitive species in the grassland and wetland habitats which would reduce the nature conservation value. Similarly, it is likely that there would be an increase in dominance of tall competitive herbs and grasses in some of the grasslands and scrub communities in the coastal landscape. The saltmarsh and other maritime habitats are confirmed as being less likely to be vulnerable.

Eutrophication by atmospheric deposition of nitrogen

7.3.6 Enhanced nutrient inputs can result from fertilizer enriched runoff or fertilizer drift from adjacent intensively managed agricultural land or from atmospheric inputs of nitrogen. As part of the project, the critical loads approach has been used to provide an indication of the areas where atmospheric inputs of nitrogen are large enough to produce a threat of eutrophication leading to changes in species composition of threatened habitats. Based on the rationale set out above, the study focused on the possible impacts on lowland heathland, calcareous grassland and upland landscapes. The critical loads for the effects of nitrogen have been defined using empirical and mass balance models; the empirically defined values have been used here.

7.3.7 The results indicate that the critical loads as currently set for characteristic habitats of the three landscapes considered are exceeded over almost the entire lowland heath and upland landscape masks, and over a smaller but significant area of the calcareous

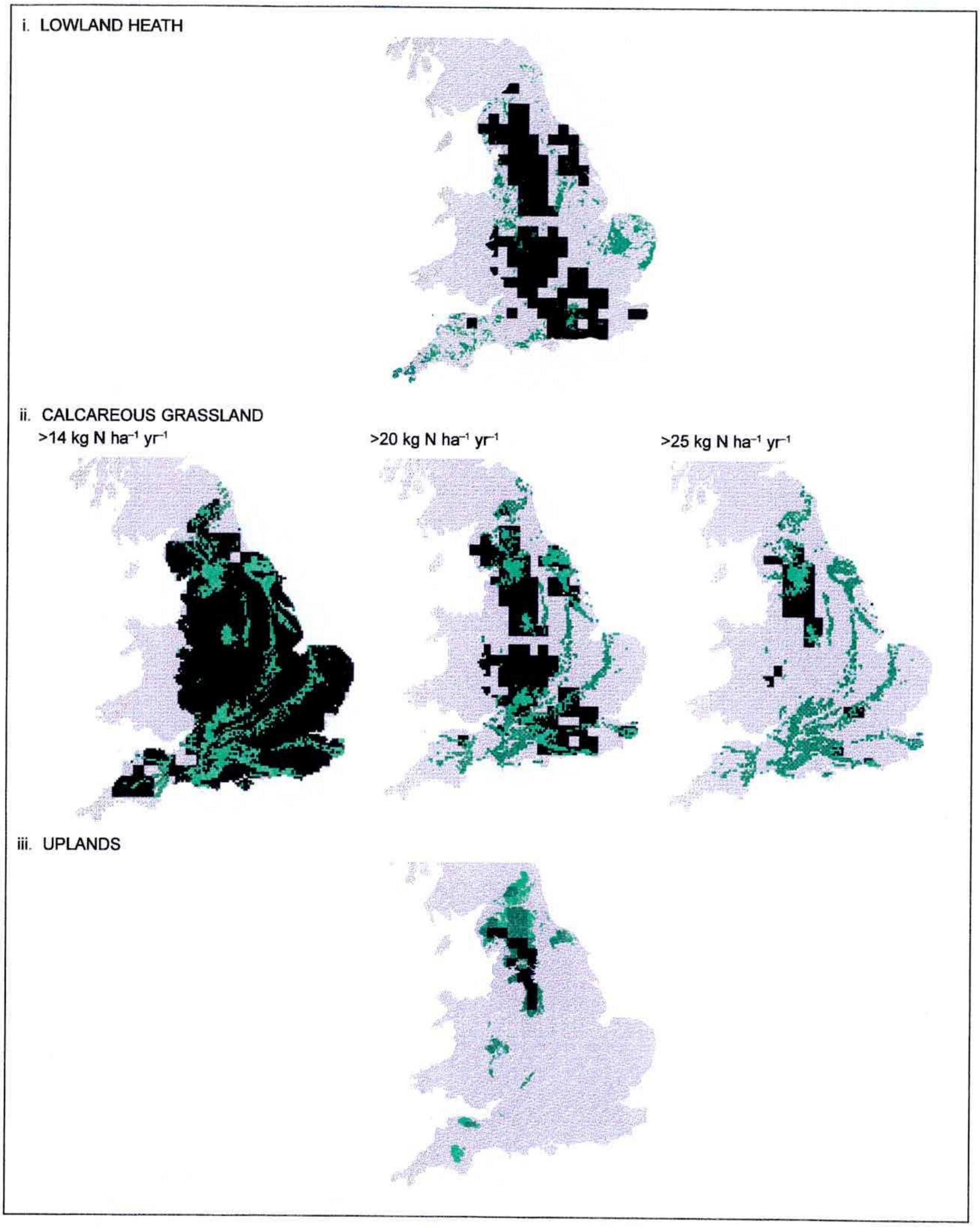

Figure 7.3

i. Areas of England receiving >20 kg atmospheric N ha^{-1} yr^{-1} (black) in relation to the lowland heath mask (green)
ii. Areas of England receiving >14, >20 and >25 kg atmospheric N ha^{-1} yr^{-1} (black) in relation to the lowland heath mask (green)
iii. Areas of the upland mask receiving > 20 kg atmospheric N ha^{-1} yr^{-1} (light green), 20–30 kg N ha^{-1} yr^{-1} (dark green), or > 30 kg N ha^{-1} yr^{-1} (black)
(Data source: CLAG Soil Subgroup)

grassland mask (Figure 7.3). It is also striking that the critical loads are generally exceeded over a larger proportion of the designated than the non-designated strata.

The critical load for lowland *Calluna* heaths has been set at 15-20 kg ha^{-1} $annum^{-1}$; exceedance of the critical load is said to be associated with a transition from heather to grass. These limits are currently exceeded by atmospheric inputs of nitrogen in 20% of the 1km squares in the lowland heath landscape mask; 26% of the squares in the 1km squares in the designated and 14% in the non-designated strata.

7.3.8 The average rates of nitrogen deposition in the area of the calcareous grassland mask for the period 1989-91 was 21kg ha^{-1}. The critical load for calcareous-species rich grassland has been set at 14-25 kg ha^{-1} $annum^{-1}$. Exceedance of this limit is expected to result in an increase in tall grass and a reduction in diversity. The higher values in the critical load range apply to calcareous grasslands with a strong phosphorus limitation and some researchers consider the critical load could be even higher in these systems. The current nitrogen deposition is greater than 14 kg ha^{-1} $annum^{-1}$ in 93% of the 1km squares in the calcareous grassland mask, 95% in the soft limestone and 87% in the hard limestone strata. Fifty percent of the mask receives more than 20 kg ha^{-1} $annum^{-1}$ and 14% more than 25kg ha^{-1} $annum^{-1}$. The hard limestone areas of northern England are most at risk with 42% of squares receiving more than 25kg ha^{-1} $annum^{-1}$.

7.3.9 The modelling outputs also suggest a deterioration in the nature conservation interest of all the plot classes in the calcareous grassland landscape, but especially the chalk and limestone grasslands, as a result of an increase in nitrogen inputs. The chalk and limestone grassland plots are predicted to show a large fall in stress tolerators, the species most likely to be of interest. There is and increase in ruderality and competitiveness where such species are already present in the sward. There would be an increase in grasses at the expense of broad-leaved herbs in the highest quality chalk grassland.In more degraded chalk grassland the situation would be worse with coarse grasses and weeds increasing as well. The neutral grasslands would see an increase in coarse grasses and a deterioration in nature conservation interest.

7.3.10 A number of habitats characteristic of the uplands have critical loads less than 15kg ha^{-1} $annum^{-1}$: ombrotrophic bogs, arctic and alpine heaths and montane-subalpine grassland. This is calculated to be exceeded by current nitrogen deposition in 96% of the 1km squares in the upland mask. There is no difference in the proportion of the mask for which this level of deposition is exceeded in the marginal or true uplands but it is exceeded for a larger proportion of the designated than for the non-designated strata, 97% compared to 85% in the marginal upland and true upland non-designated strata respectively. Exceedance of the critical load is expected to lead to an increase in grasses with a decrease in lichens, mosses and evergreen dwarf shrubs.

7.4 Land management: grazing and burning

7.4.1 The lowland heath, calcareous grassland and upland landscapes and their characteristic habitats have been largely created by human activity and are maintained by particular patterns of land management. The major current and future threats to the characteristic habitats in these landscapes are therefore related to land management and the modelling study reported in section 5 indicates that, in the short term, the impacts of exogenous threats are insignificant compared to management related threats. The land management related effects include grazing, frequency of fires, fertilizer inwash and drainage. Of these, the single most important threat in these landscapes is variations in grazing pressure. However, in some of these landscapes overgrazing forms the greatest threat while in others undergrazing is potentially more important. In the modelling studies, changes in grazing pressures or in burning were treated as changes in disturbance while changes in fertilizer in were considered under eutrophication.

7.4.2 In contrast to the uplands, calcareous grassland and lowland heath habitats, grazing is only a major threat to a small proportion of the characteristic habitats of the waterside and coastal landscapes. Changes in other forms of disturbance, such as flooding or tidal activity were considered more important in these landscapes.

7.4.3 The greatest threats to the characteristic lowland heathland habitats come from reduced grazing and burning regimes. As noted above, the modelling predicts that reduced grazing pressures and/or fire incidence would result in large increases in competitive strategists, which are generally species of lower nature conservation interest, eg bracken, and a loss of the characteristic species of interest. The reduction in these pressures eventually leads to the development of scrub and woodland. Amongst the characteristic heath plot classes recorded in the field survey, the dry heath and ultra-basic wet heath show the greatest response and are at most risk of degradation.

7.4.4 Under-grazing of the chalk grassland leads to invasion by shrubs and, where there are woodlands close by, trees; the modelling studies also indicate a decrease in stress tolerant strategists and ruderalists and a dramatic, 200% increase in competitive functional types. In the calcareous plot classes, the model implies a move to grass dominance. In the other types of grassland plots within the landscape the move is from unmanaged grassland to species poor tall herb communities. This implies a marked fall in the nature conservation interest.

7.4.5 Although a reduction in grazing would eventually lead to the development of scrub and woodland, increases in grazing pressures in some of the heathlands, calcareous grasslands and in the upland moorland habitats can lead to more subtle changes in the species composition of the characteristic habitats with the loss of characteristic species. The modelling suggest that in the calcareous grasslands, increased grazing pressure could initially be beneficial with an increase in diversity as tress tolerators and ruderals increase at the expense of competitors. Eventually, however continued heavy stocking, and the associated eutrophication would lead to an increase in weed species, although grasses would remain dominant, with a loss of many characteristic species. Thus, overgrazing is a major threat to the calcareous grasslands of the hard limestone, resulting in a loss of semi-natural grasses.

7.4.6 Similarly, overgrazing leading to the loss of dwarf shrubs in favour of species-poor grassland is a major threat to the shrub heathland habitats in the uplands and increased stock numbers, particularly sheep are thought to have lead to a reduction in *Calluna* heath. In contrast, undergrazing on some of the drier soils in the uplands can result in scrub encroachment.

7.4.7 It is therefore the balance of grazing levels and pressures, and other forms of disturbance such as fires which is crucial in the maintenance of the characteristic habitats in these landscapes.

7.5 Physical disturbance

7.5.1 The characteristic maritime habitats of the coastal landscape, which are mainly concentrated on the soft coasts and estuaries, are amongst the most natural of the habitats examined during the current study and some of these habitats are characterised by early successional vegetation stages, dependant upon disturbance by tides and coastal currents. In the case of these latter habitats, a reduction in disturbance would lead to stabilisation and the loss of early successional stages. These habitats are therefore sensitive to and under threat from any coastal developments which result in stabilisation and a reduction in disturbance.

7.5.2 The modelling studies have underlined the importance of disturbance in the maritime habitats and scenarios with decreased disturbance are interpreted as likely to threaten the core maritime habitats. the impact will clearly vary between habitats but , for example in saltmarshes reduced disturbance is likely to lead to an increase in competitor species, especially if combined with some increase in nutrient inputs, with a reduction in species of conservation interest. the saltmarshes would change to resemble less disturbed grassland habitats. In contrast, the saltmarshes are seen as less vulnerable to, or benefit from scenarios which include increases in disturbance.

7.5.3 Some of the characteristic wetland habitats of the waterside landscape are also characterised by disturbance by erosion and/or flooding with sediment deposition. The modelling studies indicate that the conservation interest of these habitats is likely to be reduced by a decrease in disturbance, as a result of an increase in competitive species at the expense of competitive ruderals.

7.5.4 Recreational use of the landscapes can result in disturbance with adverse effects on the characteristic habitats. All the various landscapes are used for recreation but the fragility of the habitats to the associated disturbance, and the threat this poses to their maintenance varies considerably. Calcareous grassland is on the whole relatively tolerant to trampling and as noted above, from the modelling studies some disturbance can be beneficial leading to the maintenance or increase in diversity. However, in heavily used sites, such as popular view points the heavy use leads to compaction, and eventually disruption of the turf and erosion. The impacts can be particularly important in the smaller of the remaining fragments of the calcareous grasslands in the south of England. Lowland heath and upland habitats on peat and shallow soils are more sensitive to trampling than calcareous grassland and major erosional problems have developed on the more heavily used routes in the uplands. Locally, such erosion is a major threat to upland habitats but the scale of the upland moorlands still leaves large areas little affected by recreation.

7.5.5 Although disturbance is characteristic of some maritime habitats. a number of the threatened coastal habitats are highly sensitive to trampling and the sheer weight of public pressure has had profound effects in many coastal areas. These range from trampling of botanically important cliff-top vegetation to destabilisation of vegetation in early successional plant communities (especially sand-dunes where trampling may cause blowouts). These pressures remain a major threat to these habitats.

7.6 Modifications to moisture regimes, flow regimes and water quality

7.6.1 The wetland habitats in all the landscapes are clearly sensitive to changes in soil water status, and hence to drainage, but especially the wet heaths and bogs of the lowland heath and upland landscapes and the wetland habitats in the waterside landscape. Drainage in the upland landscape is generally associated with land improvement, afforestation and the management of grouse moors and in the lowland heath landscape with land reclamation or afforestation. Drying out was not considered in the modelling studies but was included in the assessment of fragility, using the field plot data, for lowland heathland, uplands, coastal waterside habitats. The results from the lowland heathlands suggest that drying out has affected the vegetation more than succession, grazing or eutrophication as species sensitive to drying out occurred less frequently to those sensitive to the other stresses. This probably refers mainly to the wet heaths. In the uplands, the distribution of fragile species indicates that grazing and succession indicated have had more effect than drying out on the vegetation of the uplands as a whole. The waterside plots have been influenced more canalisation/dredging and aquatic herbicides than by drainage.

7.6.2 The major threats in the waterside landscape result from the management of the watercourses themselves, land uses on river banks and most importantly the management of the wider catchment area. Canalisation, dredging, weed control and verge management all affecting water margins and aquatic biota and, as noted above the distribution of species fragile to these threats suggests that these stresses have had an important effect on species distribution in the waterside landscape in the recent past. Water abstraction associated with high and increasing demands for water result in lowered water tables in some areas and low flows in stream and river channels. The NRA has identified 40 low flow rivers. Industrial and residential development has an impact on water quality and can give rise to increased pressures for flood control. Changes in land management in the water catchment can result in changes in the quality and quantity of runoff, increased use of fertilizers leading to eutrophication and afforestation resulting in changes in runoff and sedimentation. The expert group discussions considered agricultural management of watersides and the wider catchments as the major continuing threat to the core wetland habitats.

7.6.3 The major long term threats affecting the extent and quality of the characteristic habitats in the coastal landscape are erosion of the sinking coasts and advance of rising coasts. In the shorter term the key continuing threats are coastal protection and flood defences using hard engineering solutions, expansion and intensification of agriculture within the coastal landscape, dredging for aggregates and channel clearance in estuaries, and recreational use of the coast. These changes could, in terms of the modelling studies within this project be considered as changes in the level of disturbance. Sea walls in retreating areas lead to build up of sediment and land levels on the seaward side of the defences and relative lowering of levels on the landward side. Hard defences at the bottom of eroding cliffs starve other areas of sediment and lead to erosion of beaches and loss of saltmarshes in estuaries. the modelling studies have highlighted the potential impact of changes in the level of disturbance arising from coastal developments, particularly for the core maritime vegetation types. Reductions in tidal activity leading to invasion of saltmarshes with competitor species and the change of the habitat to resemble more stable systems. The field survey results show that agricultural land use predominates in all the coastal types, with upto 50% of the total land area under crops or improved grazing. Drainage of marshes to intensify grazing or for arable use had led to loss of diversity; reclamation of land behind sea defences to loss of saltmarshes and improvement of cliff top grasslands to increased runoff, reduced cliff stability and accelerated erosion.

7.7 Climate change

7.7.1 The characteristic habitats of all the landscapes would be affected by large changes in climate. However, species in some of the characteristic habitats in the upland landscape are sensitive to relatively small changes in mean annual temperature of only 1° C. Such changes would lead to alterations in the vertical distribution of vegetation and individual species in the uplands and increases in temperature could lead to losses of some of the more arctic species.

7.7.2 Changes in rainfall patterns and amounts could have major impacts on a wide range of the characteristic habitats in all the landscapes. The wetland and bog habitats are particularly vulnerable to reductions in rainfall which could result in drying out. The characteristic species of the calcareous grasslands require warm dry summers and might therefore be favoured by global warming; however, wetter summers would not favour these plants.

7.7.3 Changes in sea level as a result of climate change could have large impacts on the habitats of the soft coasts and estuaries. An increase in sea level would lead to erosion and loss of characteristic saltmarsh habitats.

7.8 Combinations of threats

7.8.1 The threats discussed above will only rarely operate in isolation. More commonly, the characteristic habitats will be exposed to a combination of threats, for example increased grazing pressures plus increased atmospheric inputs of nitrogen or land drainage plus inwash of fertilizers from adjacent areas. Over the longer term, most of England could be affected by changing climate in combination with continued elevated inputs of atmospheric nitrogen. The modelling studies indicated that many of the threatened habitats were particularly vulnerable to the combination of increased disturbance and increased eutrophication. It was also recognised that this combination of threats is currently the most common situation affecting the threatened habitats in England. The vegetation plots from four of the landscapes, lowland heath, calcareous grassland, upland and coastal had the highest vulnerability score for the scenario which included this combination of changes. In most cases this combination of threats would lead to an increase in tall competitive herbs and grasses and a loss of the stress tolerators which are often the species of greatest conservation interest.

7.9 Landtake

7.9.1 Landtake leads both to complete loss of the habitats and fragmentation, which in turn affects the quality of the remaining, fragmented areas and the viability of the areas of the characteristic habitats within the smaller fragments. It is the most dramatic threat to which the various characteristic habitats are exposed and has been a major factor in the reduction of the area of some of these habitats over historic and recent time.

7.9.2 Landtake to development, plantation forestry and intensive agriculture has variously affected the characteristic habitats of the different landscapes. Historically, the most dramatic effect has been landtake to arable agriculture of lowland heathland and calcareous grassland, particularly the calcareous grassland on the soft limestones. However, in the present century, urban development has been the major factor responsible for the loss of lowland heath, reflecting the occurrence of areas of heathland adjacent to large urban areas in the south, and continues to from a major threat. Ploughing up or agricultural improvement remains the most significant threat accounting for the loss of calcareous grassland.

7.9.10 Calcareous grasslands, particularly those on the hard limestones have also been lost, and small amounts continue to be lost to mineral extraction. Old, abandoned quarries can however, provide valuable habitats for calcareous species and a number are now SSSI's.

7.9.21 Since the 1920's landtake to plantation forestry has been the single most important factor resulting in loss of upland habitats but it had also been a significant influence in the lowland heath landscape. The rate of afforestation has declined over the past 10 years but it remains a threat, particularly to upland habitats. The major impact is on wetland and bog habitats, which are generally lost whereas other habitats can remain along rides or fire breaks.

7.9.22 The soft coasts have been and are affected by both urban and industrial development, and in the past by reclamation of tidal marshes for agriculture. The building of estuarine barrages would lead to major losses of key maritime habitats. Landtake to create golf courses has also lead to a significant loss of sand-dune habitats but the rate of development of new courses has greatly declined.

7.10 The key threats

7.10.1 The results from the component studies of this project indicate that the most rapid and widespread effects on the characteristic habitats of the calcareous grassland, lowland heath and upland landscapes arise from land management activities. The maintenance of the species rich chalk grassland habitats, lowland heath and of the heather moorland in the uplands depends crucially on the level of grazing and, to a lesser extent burning. Both increased and decreased levels of grazing and/or burning can have adverse effects.

7.10.2 The characteristic habitats in the above landscapes are also sensitive to eutrophication, be it from fertilizer runoff or atmospheric deposition; large areas are currently affected by enhanced levels of atmospheric deposition of nitrogen. Large areas of the uplands and lowland heath landscape are also currently thought to threatened by the effects of acidification by atmospheric deposition. These threats impact over longer time scales than the management activities and reversal requires nationally, and often internationally co-ordinated control measures.

7.10.3 The characteristic coastal habitats are particularly vulnerable to changes in the amount of disturbance and therefore, in the short to medium term, to coastal developments that affect tidal flows and currents. In the longer term, changes in sea level associated with continuing isostatic adjustments of the British landmass and with climate change are major threats to the current distribution of the core coastal habitats. Climate change effects on temperature and rainfall regimes could also have important long term effects on habitats in a number of the landscapes but particularly in the uplands.

7.10.4 The key threats to the characteristic habitats of the waterside landscape are associated with the agricultural management of the land adjacent to the waterbody and the wider catchment, and the management of the water channels themselves and of the water flows in these channel.

7.10.5 The characteristic habitats in all the landscapes are vulnerable to combinations of threats. Simultaneous increases in disturbance and eutrophication are potentially very damaging and such combinations are likely to continue to be widespread in England. The vulnerability of different habitats within the landscapes can also vary, thus changes in hydrology are perhaps the major threat to wet heaths within the lowland heath landscape while such changes would not pose a threat to the dry heaths.

7.10.6 Landtake is still a threat to all the landscapes but particularly landtake to agriculture in the calcareous grassland, waterside and coastal landscape, to development in the lowland heath and coastal landscape and to forestry in the uplands.

8. Policy implications

8.1 The types and scales of the relevant policies

8.1.1 The various threats to which the characteristic habitats are exposed differ both in nature and in the geographical scale at which they operate. Landtake operates at the site level and any one development affects a relatively small area, although the aggregate effect can be large. Controls on development are largely through planning policies and legislation which are operated locally but within national frameworks. Land management decisions are taken at the individual farm, land parcel or field level but again the aggregate effect can be large. Land use and management decisions are influenced by countryside, forestry and agriculturally-related policies; some of these policies are supranational, for example EU agreements. Impacts connected with atmospheric pollution, increased deposition of nitrogen, acidification arising from atmospheric deposition and climate change operate simultaneously, at the regional and national scale. However, the emissions leading to the pollution largely originate from a large number of point sources and control has to operate at the level of the individual source.

8.2 Designations and related types of policy instruments

8.2.1 There are a range of designations which aim to protect whole landscapes and/or specific sites and the present study has shown that large proportions of the Landscapes are covered by one of the seven designations considered (Table 8.1). A large proportion of the characteristic habitats in these landscapes are also usually covered by a designation. For example, within the calcareous grassland landscape 90% of the unimproved chalk and limestone grassland is designated. However, significant areas of the key habitats in the lowland heath are not covered by a designation.

Table 8.1 Proportion (%) of the 1 km squares in each landscape mask containing one of the seven designations covered in the current study

	Lowland heath	Calcareous grassland	Uplands	Coastal	Waterside	Area influenced by the designation - landscape (L) or site (S)
SSSI	19	23	15	39	10	S
NNR	2	2	1	6	1	S
ESA	16	10	7	33	15	L
NP	6	20	49	3	10	L
AONB	17	39	1	4	3	L
HC	3	2	0	19	0	L
G BELT	15	4	<1	6	13	L

Smaller proportions of the waterside landscape are designated, some 57% of the mask as defined in this study. Few areas have been designated specifically for river corridors and but areas of the waterside landscape are included within larger areas designated to protect other landscapes or habitats.

8.2.2 Of the designations considered in the study, five are aimed at protection at the landscape level and two at the site level (Table 8.1). The level and type of protection afforded by these designations varies considerably. The National Park, Green Belt, AONB and Heritage Coast mainly provide protection against development (Figure 8.1). The NNR and SSSI's aim to protect and enhance specific ecosystems or habitats.

8.2.3 Although a number of the designations considered in the present study are not targeted at the protection of the characteristic habitats, the results of the field survey show that the quality of the key habitats is higher, by a number of different criteria in the designated than the non-designated strata. This could be due to the protection afforded to the habitats by the designation or because many high quality sites have been designated, either specifically or because of their association with areas of natural beauty and/or recreational opportunities. In some cases the designations are too recent to have influenced the extent or quality of the threatened habitats. Any designation which does not enable land management to be influenced will not necessarily provide long term protection for the key habitats.

8.2.4 The most relevant policy instruments to the maintenance and/or enhancement of the remaining areas of the threatened habitats or to the recreation of areas of the habitats in the calcareous grassland, lowland heath and upland landscapes are those which influence land management, particularly grazing and to a lesser extent burning regimes, and the use of fertilizers. The Environmentally Sensitive Areas (Sponsored by MAFF), Countryside Stewardship Schemes (Initially Countryside Commission and now MAFF)

Figure 8.1 The threats influenced by policies, policy instruments and designations

	Landtake: Intensive agriculture	Landtake: Forestry	Landtake: Development	Grazing	Burning	Fertilizers	N deposition	Acidification	Climate change	Sea level change	Recreation	Canalisation	Drainage
Planning		●	●								●		
S protocol								●					
N protocol*							●						
CO_2 targets									●[1]	●[1]			
CAP	●			●[3]	●[3]	●[3]							
NNR	●	●	●	●	●	●					●		●
SSSI	●	●	●	●	●	●					●		●
National Park	●	●	●	●[2]	●[2]	●[2]							
ESA				●	●	●							●
WHS				●	●	●							
GB			●										
Heritage Coast	●	●	●										
AONB			●										

* To be negotiated 1996–97
[1] Will impact in the longer term
[2] Local schemes in some National Parks
[3] Policies could lead to increases or decreases

and the Wildlife Enhancement Scheme (English Nature) are each directed towards influencing management of the landscapes to maintain and/or restore their constituent threatened habitats (Figure 8.1). The WES is targeted at designated areas.

8.2.5. In the case of the coastal landscape, the studies have shown that the most important threats are land take and factors which influence disturbance, principally development on the coast which influences tidal flows and currents. In the longer term sea level change forms a major threat.

8.2.6 Waterside landscapes are under threat from landtake for agriculture but the major widespread threats are from management of the water courses, of the land adjacent to the waterbodies and in the wider catchments.

8.3 Designations and policies operating at the site level

8.3.1 Two of the designations considered in the study aim to provide protection at the site level: National Nature Reserve and Sites of Special Scientific Interest. The National Nature Reserves are managed specifically to protect and enhance, and in some cases restore specific ecosystems or habitats. The SSSI legislation provides protection against agricultural intensification and either agricultural or non-agricultural development; agreements are commonly made with landowners for management which will protect semi-natural habitats. Parts of all the landscape masks were within SSSI's, with the proportion varying from 10% in the waterside to 39% in the coastal mask (Table 8.1). Smaller proportions of the masks were within NNR's with again the largest proportion being within the coastal mask, 5.5%.

8.3.2 The Wildlife Enhancement Scheme, administered by English Nature is targeted at SSSI's in particular areas. The scheme is directed towards influencing management of the particular site type to maintain or restore the constituent characteristic habitats and it provides grants for positive management to landowners and tenants of land containing the habitats. Within the calcareous grassland landscape, the scheme applies to areas of the Craven limestone in the Yorkshire Dales and to the magnesian limestone areas of the north and east of England. In the former it aims to reduce overgrazing while in the latter it aims to reintroduce grazing on the very fragmented patches of the magnesian limestone. In the Dorset and Thames/Wealden areas, the scheme is being targeted directly at lowland heath management and restoration.

8.4 Designations which operate at the landscape level

8.4.1 Five of the designations considered in the present study aim to provide protection at the landscape level: National Parks, AONB's, Green Belt, Heritage Coast and ESA's. The relative coverage of these schemes varies between the landscapes studied here (Table 8.1) and the level and type of protection varies between the schemes. The ESA scheme is directly linked to agricultural policy and although it operates at the landscape level it is considered below with other agricultural policy influences (8.11).

8.4.2 The National Parks legislation aims to provides protection for outstanding areas of countryside and to provide opportunities for access and outdoor recreation. The legislation provides controls on development and the park authorities can enter into land management agreements and encourage farmers to manage their land in traditional ways. Some authorities also have schemes which, for example provide grants for management of landscape features such as hedgerows. A proportion of all the landscape masks is within National Parks. The largest proportion (49%) is in the uplands (Table 8.1), in the Lake District, Dartmoor, Exmoor, North York Moors, Yorkshire Dales and Northumbria National Parks. Only small proportions of the lowland heath, coastal and waterside landscape masks were within National Parks, reflecting the upland nature of most of the parks.

8.4.3 The Green Belt designation covers land adjacent to urban areas and provides protection against development to restrict the spread of large built up areas into adjacent countryside and to prevent neighbouring towns merging. It includes no specific provision for habitat protection or enhancement. Significant proportions of the lowland heath and waterside masks are within green belts (Table 8.1). The former reflecting the proximity of areas of the lowland heath to urban areas in the south of the country.

8.4.4 The Heritage Coast scheme, operated by the Countryside Commission has the objective of focusing management attention on the finest stretches of undeveloped coast in order to conserve them and promote enjoyment of the countryside. Heritage Coasts have no statutory designation status but now cover over 5,500 ha along some 1,000km of coastline covering all maritime habitats, particularly saltmarsh and sand dunes. Some 19% of the coastal landscape is covered by the Heritage Coast designation and smaller proportions of the lowland heath and calcareous grassland landscapes.

8.4.5 Development within the coastal landscape is also covered by a wide range of planning regulations, a number of which have a specific focus on the coastal zone: Shoreline Management Plans, Coastal Management Plans, and Estuary and Harbour Management Plans.

8.4.6 AONB'c include a significant proportion of the calcareous grassland (39%) and lowland heath (17%) landscapes and very small proportions of the other landscapes. The designation is designed to provide protection for outstanding areas of countryside but which lack the large areas of open country found in National Parks and which were originally promoted for recreation. The legislation affords protection against development (Figure 8.1).

8.4.7 The most important policy instruments in the context of the waterside landscape are those which influence management of the water course itself, water levels (as affected by water abstraction) and the catchment area. All these areas of management fall within the remit of the National Rivers Authority (now the Environment Agency). Catchment Management Plans aim to produce integrated management of the catchment area while Water Level Management Plans cover all aspects of water use and abstraction. The NRA also has a number of specific initiatives to enhance riverside habitats through inclusion in capital works, allocations from the operation and maintenance budgets and stand alone enhancement schemes.

8.5 Agricultural policy

8.5.1 Land management is clearly influenced by agricultural policies and associated incentives, and by market forces (moderated by the CAP). In some cases these policies can result in inappropriate management in the context of the protection and maintenance of threatened habitats. Thus, the Headage Payments available in regions covered by Less Favoured Area status has led to an increase in sheep numbers and hence grazing pressures. Overgrazing in parts of the uplands is associated with deterioration in the quality of the characteristic habitats. Grants for pasture improvement also led to drainage, liming, fertilization and reseeding of pastures, mainly in the marginal uplands, with a loss of diversity in the traditional hay meadows.

8.5.2 In contrast, the Setaside Scheme has led to the removal of land from arable production. This instrument has had the largest impact in the calcareous grassland and lowland heath landscape. The Habitat Scheme associated with setaside provides incentives for habitat creation. The ESA schemes discussed above also effectively provide a counterbalance to the grants available to increase production in the Less Favoured Areas.

8.5.3 The ESA scheme is designed to encourage farmers to maintain or adopt environmentally beneficial practices in parts of the country where the landscape, wildlife or historic features are of national importance. Restrictions are placed on the use of fertilizers and pesticides, the number of stock grazed and the timing of operations such as cultivation or cutting. Management agreements, with associated payments are made with farmers to manage and enhance the semi-natural habitats within the area and/or to recreate semi-natural habitats. Proportions of all the landscape masks are within ESA's, ranging from 7% in the uplands to 33% of the coastal mask.

8.5.4 In the calcareous grasslands landscape, The South Downs, South Wessex Downs and Cotswold Hills are covered by ESA schemes and a significant part of each of these areas has been brought into that part of the scheme which covers management and enhancement of existing habitats. Take up under the part of the scheme which covers recreation of chalk grasslands has been much smaller. The 8 upland EAS's cover parts of the upland landscape mask. These include management regimes which cover stocking rates for the moorland areas, with the general aim of enhancing the shrub heath, and traditional management of hay meadows. The ESA scheme is also providing support for the maintenance and improvement of lowland heath in West Penwith and the Breckland.

8.5.5 Although not targeted at the waterside landscape, ESA's cover a number of areas which include important waterside habitats covered by the Waterside Landscape mask used in this study: the Upper Thames Tributaries, Test Valley, Avon Valley, Somerset Levels and Moors, and Suffolk River Valleys. The Somerset Levels and Moors and Broads ESA's also include tiers for water level management. The MAFF have also introduced the Habitats scheme as a pilot project. This scheme includes two options for watersides: taking watersides out of production and creating buffer strips, and management of watersides but extensive grazing.

8.5.6 In addition to the designations covered in this study, the Countryside Stewardship Scheme covers all of the landscapes. As with the ESA's the scheme operates though agreements with landowners/tenants, and associated grants, for the application of management prescriptions to maintain and enhance existing threatened habitats, to restore degraded examples of the habitats and to recreate them from arable and intensive pasture. The Countryside Stewardship Scheme provides incentives for the positive management of existing waterside areas and restoration of wetlands and water meadows.

8.6 Atmospheric pollution control

8.6.1 The planned reduction in sulphur emissions, to meet agreed UN-ECE targets will ensure that the critical load for acidity is not exceeded over any of the calcareous landscape and will greatly reduce the area of the lowland heath and upland landscapes over which the critical load is exceeded. However, a significant area of the latter two landscapes will still be at risk, particularly the lowland heath landscape, with the critical still exceeded. The full biological impacts of exceedance of the critical load is still being assessed but damage to significant areas of these key habitats cannot be ruled out. A reduction in the 1989-91 level of emission of some 90% would be required to ensure protection of the whole of the lowland heath landscape from acidic deposition.

8.6.2 Assessment of the possible impacts of atmospheric inputs of nitrogen to the calcareous grassland, lowland heath and upland landscapes shows that the critical load for the characteristic habitats of each of the landscapes is exceeded over large areas. The impacts of changes in land use and/or management in these landscapes may have larger and quicker impacts than the nitrogen inputs but there are likely to be complex interactions between these two potential stresses. For example, the impacts of reduced grazing pressures could be confounded over the longer term by the effects of continued large atmospheric inputs of nitrogen. There are no planned UK or UN-ECE targets for reductions of nitrogen emissions. Discussion on a nitrogen protocol will begin under the auspices of the UN-ECE during 1996 but the discussions are currently planned to cover NO_x emissions alone. The protocol will certainly include targets for emission reductions but it is not possible to gauge the impacts without information n the magnitude of the reductions. Also, exploratory studies suggest that the critical load of nitrogen for the key habitats of parts of these landscapes is exceeded by atmospheric inputs of NH_y alone. Protection of the key habitats requires controls on all forms of nitrogen emissions.

8.6.3 Targets have been agreed for the reduction of emissions of carbon dioxide to limit the impact of global warming. While these measures are important their ultimate impact will depend on the implementation of related policy instruments globally. Current evaluations regard some changes in climate and in sea levels as inevitable over the next 20 to 40 years despite currently agreed measure to limit carbon dioxide emissions.

8.7 The potential impact of the policy measures

8.7.1 The policy measures outlined above provide a wide range of instruments which could influence or control most of the major threats to the characteristic habitats which have been identified. The broad suite of planning policies and regulations could in principle control the loss of the characteristic habitats through landtake to development and to some extent forestry but controls on land take to agriculture, or development in connection with agricultural activities are still not adequate to prevent the loss of important areas of the core habitats. None of the planning instruments give complete and automatic protection to the various threatened habitats against landtake.

8.7.2 There is now an impressive list of initiatives and policy instruments to influence land management, for example the ESA scheme, the Wildlife Enhancement Scheme and the Countryside Stewardship Scheme and they are having an important impact in some areas. However, the scale of the impact of these various schemes will always be limited while they remain voluntary and there is, inevitably a limited budget, and unless the level of grants available is attractive to all types of landowner. Deterioration and loss of threatened habitats will continue in areas of the lowland heath, calcareous grassland and upland landscapes outside these schemes while other areas of the habitats within the schemes are maintained or improved. The schemes as currently structured do not allow them to be targeted at key, specific sites of a given threatened habitat. A habitat as a whole can be targeted, eg heathland within the West Penwith ESA but not a specific site within the ESA because of the voluntary nature of this and the other schemes. It is also clear that it is vital that the impacts are assessed of proposed agricultural policies, or changes in policies on valued, threatened habitats.

8.7.3 The results of the project have also highlighted the need for integrated management and for policies or combinations of policies which allow for integrated control and management. As noted in section 6, the threatened habitats are rarely exposed to one threat in isolation. Effective protection and enhancement of the habitats therefore requires integrated management and control, an integrated application of policy instruments. Thus, for example coastal habitats have been fragmented by a series of pressures including urban and industrial development, coastal defences, agricultural landtake and management, and marine pollution. Similarly, protection of the threatened habitats in the waterside landscapes requires integrated control of management of the waterside zone, the wider catchment and the water channel itself. Integrated catchment management plans are being developed but need to be applied more widely. Similarly coastal zone management covers many potential threats but still does not provide a fully comprehensive approach.

8.7.4 Policies and the associated instruments in operation at the same time can also have opposite impacts. Thus, agricultural support payments may lead to increased grazing pressures while ESA schemes may be involve reductions in grazing. However, cross-compliance clauses are now being introduced whereby less favoured Area premium payments can be tied to compliance with improvements to management practices. Thus, subsidy payments can be reduced or withheld where significant over-grazing is occurring. Unless policies are developed in parallel, or with the recognition of the respective impacts the effectiveness of one or the other may be confounded. For example, the effects of ESA, WEF or CSS schemes which aim to enhance shrub heathland or calcareous grassland could be confounded if the affected area is receiving large amounts of nitrogen from the atmosphere; the latter is thought to result in the invasion of heathland by grasses and the loss of diversity from calcareous grasslands.

9. Discussion

9.1 The need for baseline information and for monitoring

9.1.1 During the last 20 years there has been growing concern over the loss of a number of valued landscapes and their associated characteristic habitats. As noted in the above section, a number of policy instruments have been introduced to protect and enhance the remaining areas of these characteristic habitats. The Biodiversity Action Plan has also set targets for the protect of threatened species and habitats. However, there is inadequate information with which to (i) judge the status and quality of these threatened habitats, (ii) assess the success or otherwise of the policy instruments designed to protect them, (iii) provide a baseline against which to judge the achievement of the targets, and (iv) interpret and predict the impact of land management on these habitats. This study has provided baseline information, evaluated current threats to the landscapes and characteristic habitats and reviewed the relevant policy issues.

9.2 The distribution and characteristics of the landscapes and threatened habitats

9.2.1 The study has broadly defined the distribution in England of the five landscapes of interest including the characteristic habitats of the landscapes and also areas with potential for these habitats. It has provided an objective characterisation and quantification of the land cover and vegetation within the defined areas of these landscape by field survey of a stratified random sample of 1km squares within each landscape. The sample squares were selected to represent a number of strata within each landscape, including designated and non-designated areas. Analysis of the data has determined the area of each landscape as defined, the proportion of different land cover types in each landscape and the proportion of the landscapes occupied by characteristic habitats. They have also provided data on the extent of the seven major types of designation within the landscapes. These data form valuable contextual information for more specific surveys and monitoring.

9.2.2 Within each of the 1km sample squares, vegetation plots were recorded to provide detailed information on species composition of the semi-natural habitats within the landscapes. The resultant data have been used to assess the distribution of species representative of the characteristic habitats, and the quality of these habitats in each landscape and in the different sampling strata of the landscapes. This is the first time that a rigorous assessment of ecological quality has been attempted across a wide range of habitats using similar methods and data collected using standardised protocols.

9.2.3 The assessment of quality has shown that, in general the areas of the characteristic habitats within the areas covered by designations are of higher ecological quality than the areas in non-designated areas. This may suggest that the designations are providing "protection" for the threatened habitats but it may equally reflect the fact that the many areas of high quality habitats were designated either because of the habitat, or because of the association with areas of natural beauty.

9.2.4 Together the land cover and vegetation data provide an important baseline which can be used to assess the impacts of current and future policy instruments and designations. It is important that the sites are included in any future surveys of the status of the British countryside. The location of the vegetation plots have been permanently marked to facilitate future resurvey.

9.2.5 The field survey data has identified the vegetation types of areas in each landscape which would be most readily restored to increase the area of the characteristic habitats. This is valuable information in the targeting of initiatives and funding designed to restore the given habitats.

9.3 Threats to the habitats

9.3.1 The literature surveys, field studies, modelling and experts groups associated with the study have identified the vulnerability of the various characteristic habitats to a range of threats. The results have underlined the role of management related factors, such as grazing, burning, drainage and fertilizer pollution (direct application, runoff or drift of liquid sprays) the survival of some of the characteristic habitats, specifically those in the lowland heath, calcareous grassland and uplands. The balance of disturbance, in the form of grazing or burning is a key factor in the maintenance of the characteristic habitats in these three latter landscapes; both overgrazing and undergrazing can lead to a decline in quality with a loss of the characteristic species.

9.3.2 The characteristic habitats in the calcareous grasslands, lowland heath and uplands are naturally adapted to low nutrient conditions and therefore any increased input of nutrients poses a threat to their maintenance. Fertilizer inwash from adjacent land is a major localised effect. However, the study has shown, using the current methodologies for the calculation and mapping of critical loads that large areas of the characteristic habitats in these landscapes are affected by enhanced atmospheric deposition of nitrogen. Although affecting a smaller area of the characteristic habitats than the enhance nitrogen deposition, atmospheric inputs of acidity are a potential threat to the characteristic habitats of the uplands and lowland heath.

9.3.3 Grazing and fire are less significant as threats to the characteristic habitats of the waterside and coastal landscapes than in the other three landscapes examined. Management of watercourses, water extraction and wider catchment management are identified as key factors in the maintenance of characteristic waterside habitats. In the coastal landscape, natural disturbance, by tidal currents is essential to the maintenance of some of the characteristic maritime habitats and therefore developments which alter flows and currents, such as coastal defences are a major factor. Over the longer term, changes in sea level constitutes a major threat to the existing threatened habitats.

9.4 Policy implications

9.4.1 The results from the study confirm that it is essential that policy instruments which aim to protect, maintain, enhance or restore the characteristic habitats in the lowland heath, calcareous grassland and upland landscape include mechanisms for influencing land management, in particularly setting appropriate grazing levels and frequency of burning, limiting the use of fertilizers and herbicides, and setting appropriate cutting times. The ESA, Countryside Stewardship and Wildlife Enhancement schemes include appropriate provisions and suitable measures are possible under the National Parks management agreements. The Countryside Stewardship Scheme also covers waterside habitats and agreements for appropriate management and measures to recreate wetland habitats. Appropriate management of watercourses and catchments are also being explored by the Environment Agency. Restoration of characteristic habitats under the various schemes could profitably be targeted at those vegetation types which would be most readily restored (cf 4.6.43).

9.4.2 The voluntary nature of the various schemes and the limits on the amount of funding available for some of them, limits their uptake and the geographical extent of the areas which come into them. It also means that the schemes cannot be effectively targeted at key areas of the threatened habitats. Important areas remain outside the schemes and are still at risk of damage and deterioration. The long-term prospects for the schemes is also uncertain; many of the measures will have to be implemented over many years, if not indefinitely to achieve the desired results.

9.4.3 Protection of the threatened habitats in the coastal landscape requires a combination of policy measures which control development, especially those which could influence the level of disturbance by affecting tidal flows and currents, and land use/management. The planning regulations and Heritage Coast scheme provide for control of development but have limited scope to influence land management. There is therefore a need for enhanced planning controls and for the further development and implementation of integrated coastal zone management.

9.4.4 Agreed and planned controls on sulphur emissions will reduce acidic deposition sufficiently to protect most of the Upland landscape mask from enhanced acidification. However, a large proportion of the Lowland Heath landscape will still be at risk. There are no agreed emission reduction targets for nitrogen but these are essential if the naturally nutrient poor threatened habitats of the lowland heath, calcareous grassland and uplands are to protected. The agreed targets for reduction in emissions of carbon dioxide are unlikely to prevent changes in climate and in sea level over the next 20 to 40 years.

9.4.5 There is a need for an integrated assessment of the impacts of the various policies which affect a given landscape and its threatened habitats. Individual policies currently tend to be developed independently with no consideration of their combined impacts. Individual policies, or even individual instruments under one policy framework can have opposite and apparently confounding effects. Thus, pollution effects could confound and limit the effectiveness of ESA schemes while headage payments and ESA schemes may have opposite impacts on some stresses, such as grazing. There is an urgent need for integration of policies which affect the rural landscape and the threatened habitats within them, particularly the wildlife, countryside and agricultural policies.

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