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The Living Landscapes Project: landscape character and biodiversity

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The Living Landscapes Project: landscape character and biodiversity Final report

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Foreword

In December 1998 English Nature was approached by Steven Warnock, an independent consultant, to set up meeting to discuss '*a character-based approach to integrated rural decision making*'. This came not too long after the production of the **Joint Countryside Character Map** developed by the Countryside Agency, English Heritage and English Nature. At this time English Nature was developing its **Natural Area Profiles** to support its work on the **Biodiversity Action Plan** (BAP). The contact with Steve Warnock led to discussions with the **Living Landscapes Project**, a consortium of interests involving universities, consultants and participating local authorities, which was established to develop and produce **Landscape Character Assessments** (LCA).

English Nature agreed to part-fund a project to understand more about the landscape characterisation approach, specifically the relationship between landscape character and biodiversity, and to test the approach to measure ecological integrity, although in practice less progress was made on this complex aspect of the work. English Nature also wanted to explore the concept of **Landscape Description Units** and how these related to existing **Natural Areas** and **Countryside Character Areas**.

LCA was undertaken by the **Living Landscapes Project** in all the counties of the West Midlands Region, except Warwickshire. In addition, a LCA was completed for Kent and Suffolk during the period of English Nature involvement, where it was used to assist the **Lifescapes** programme (English Nature-sponsored projects seeking to re-create biodiversity at the landscape scale).

The **Living Landscapes Project** was undertaken at a time of increasing awareness of landscape issues in English Nature and a realisation that new approaches needed to be taken to deliver BAP outside designated sites and to support designated sites and their species within a less hostile landscape. The need to work on a landscape scale was clearly demonstrated in the Government's Farmland Birds Public Service Agreement target to halt the decline in common bird species. More recently an analysis of BAP species has revealed that two thirds of more widespread species are still declining, in contrast to the considerable successes, which had been achieved for the very rarest species.

A number of other initiatives emerged during this time, some of which are noted in the report, such as the joint Countryside Agency and Scottish Natural Heritage ***Guidance on Landscape Character Assessment***, and the increased availability of spatial data. The recent development as **Countryside Quality Counts** work (an indicator of countryside quality) within the ***State of Countryside Report*** (2004) shows how data from a range of organisations can be brought together to provide an indication of how the English landscape is changing. Other initiatives such as strategies for targeting new agri-environment schemes, have helped to shed more light on how information can be used at various scales in the characterisation framework.

The emergence of **Historic Landscape Characterisation**, promoted by English Heritage, as a widely available data set is also noted in the report and provides scope for further development of landscape characterisation. In particular, the report highlights the importance of both the physical and cultural dimensions of landscape diversity in England and emphasises the role of landscape character as a holistic spatial framework within which to develop policies for the countryside.

It is quite clear that the ***Living Landscapes Project Final Report*** demonstrates the utility of LCA, a landscape tool, for nature conservation purposes; something which was not readily appreciated at the start of the process.

Steve Preston
Landscape Ecologist, English Nature

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1. Introduction

1.1 Changing views of landscape

The English countryside has been shaped over millennia by a complex set of social, historical and economic factors operating against a varied physical background. Change has always been a characteristic of the countryside, but in the last 50 years the rate of change has been very rapid with adverse consequences for habitats and wildlife (Marren 2002). A major challenge for wildlife conservation today is to find new ways of accommodating such rapid change, whilst retaining the pattern and diversity of elements in the landscape. This is essential not only to maintain the aesthetic, cultural, and economic value of the landscape but also to maintain ecological function and biodiversity, the focus of this report.

However, this challenge is unlikely to be met without a more holistic approach to wildlife conservation that recognises the differences in the cultural and physical factors that have shaped and control the spatial pattern of habitats and the distribution of species at the landscape scale. The aim of this report is to demonstrate the potential of Landscape Character Assessment (LCA) as an appropriate spatial framework within which to:

- describe and record ecological variation;
- report on the conservation status of the 'wider countryside';
- develop policies for habitat restoration and wildlife protection.

The appreciation of landscape scale functions and processes within a rapidly changing countryside has resulted in a move away from site-based conservation towards a landscape scale approach. It is now recognised for example, that Sites of Special Scientific Interest (SSSIs) cannot be maintained in favourable condition if they exist as isolated sites in an inhospitable countryside (English Nature 2003). Many widespread species, for example farmland birds, inhabit mosaics of habitats across wide areas and depend upon well-connected patches of semi-natural habitat in the landscape for feeding, nesting and shelter (Baillie and others 2000). Many common birds have undergone serious population declines on farmland (Robinson & Sutherland 2002) leading recently to the establishment of a Public Service Agreement (PSA) by the Department of Environment, Farming and Rural Affairs (DEFRA 2003) to reverse the decline of farmland birds in the period 2014-2020.

The common perception of the English landscape as a patchwork implies that, once stitched – by hedgerow, wood bank or thoroughfare - the design is permanent and the patches long-lasting. Whilst it is now acknowledged that the English countryside has always been characterised by change (Rackham 1986), recent change has been especially rapid. Post 1945 in particular the imperative for the UK to produce more of its own food by intensifying traditional agricultural systems (Agriculture Act 1947), has been a significant cause of countryside change.

This transformation of the English landscape in the post-War period has been driven by national imperatives that bear little relation to the local and regional contexts in which settlements and agriculture have developed over millennia. The intensification of production methods enabled many local environmental constraints to be overcome – new rye grass varieties, machinery and inorganic fertilisers multiplied the livestock capacity of grazing land and the removal of field boundaries and small woods streamlined arable farming operations.

The result has been significant and damaging losses both to the area and quality of semi-natural habitats: 23% of hedgerow length was lost between 1984 and 1990 (Barr and others 1993); more than 85% of heathland lost since 1850 (Webb 1994) and 80% of chalk grassland since 1940 (Wells 1989). The 'coniferisation' of Ancient Woodlands, for example, has had a wildlife impact of equal importance to the eight percent loss in the area of this habitat since 1950 (Kirby 1992). The loss of semi-natural habitats and the decline in the quality of many remaining habitats (English Nature 2004) has been reflected in significant losses in associated species, especially plants (Rich & Woodruff 1996).

The Nature Conservation Review (Ratcliffe1986), commissioned by the then Nature Conservancy Council (NCC), listed for the first time a catalogue of the 735 best examples of coastlands, woodlands, lowland grasslands and heaths, peatlands and upland habitats and established a policy for nature reserve acquisition. This policy of site protection by acquisition combined with scheduling of SSSIs from 1949 onwards has dominated wildlife conservation policy until recently. However, data continue to show that despite protection afforded by the Wildlife & Countryside Act (1981), later strengthened by the Countryside and Rights of Way Act (CROW 2000), damage continues to protected sites; approximately 60 percent of SSSIs remain in unfavourable condition (English Nature 2003). A PSA target of 95% of SSSIs to achieve favourable, or unfavourable recovering, condition by 2010 has been set.

It was also realized however, that loss of wildlife interest in protected sites was not just a consequence of damage to the site itself but in many cases resulted from hostile land management practices in the surrounding landscape. The loss of habitats and the connections between them has frequently resulted in increased isolation of small remnant patches, threatening the long-term survival of viable and representative communities of plants and animals. This recognition of the importance of landscape scale processes with a theoretical foundation in island biogeography theory (McArthur & Wilson 1967) and metapopulation dynamics (Hanski & Ovaskainen 2000), has been stimulated by empirical work in the emerging discipline of landscape ecology. Research on birds (Opdam and Hustings 1985) and invertebrates in particular, demonstrates the importance of understanding the spatial pattern of habitats in the landscape as an important, although not the only, determinant of species diversity and abundance.

The increasing recognition of the multi-functional nature of the countryside outlined in the Rural White Paper (DEFRA 2000) serving the needs of sustainable agriculture, the rural economy, recreation and wildlife conservation, has also prompted a reappraisal of wildlife conservation in England. There is also an increasing awareness of the social and health benefits that can be provided by contact with nature (Pretty, Griffin & Sellens 2003). The Lifescapes initiative supported by English Nature in four pilot areas (South Downs, Suffolk Coasts & Heaths, Chilterns and Forest of Bowland) emphasised the importance of stakeholder participation in reconciling the multiple uses of land in the countryside.

These pressures have resulted in some specific policy responses with, for example, support for intensive systems of agricultural production being switched towards support for agri-environment schemes and a focus on the potential for habitat re-creation and restoration. The BAP (Biodiversity Action Plan) 'process' emerging from the UK Biodiversity Action Plan (HMSO 1995) is part of this shift of emphasis away from site-based conservation to a concern for the conservation status of the wider countryside. Progress with species recovery programmes over recent years has been largely successful with 75% of species which are rare

(occupancy of 1-5 10km squares) recovering or stable; conversely 80% of widespread species (occupancy of >100 10km squares) are still in decline.

There is a need therefore, to incorporate wildlife conservation into a wider planning framework. This has prompted the search for a common spatial framework as the foundation for integrating a variety of data from multiple sources that fulfils the needs for employment, recreation and agriculture in the rural environment without compromising wildlife interest. Such a framework is needed to:

- ∉ develop indicators of ecological quality for monitoring the conservation status of the wider countryside;
- ∉ identify priority areas that are especially rich in wildlife interest;
- ∉ develop strategies for habitat restoration and re-creation at regional and local scales that are sensitive to differences in landscape type;
- ∉ identify areas that provide the best opportunities to link, expand or buffer existing nature reserves and other protected sites;
- ∉ increase understanding of the relationship between economic, social, and cultural factors and biodiversity;
- ∉ find ways to achieve long-term sustainable change in the landscape whilst protecting wildlife.

The framework should be hierarchical, operating at different spatial scales and levels of detail, consistent and repeatable and capable of storing and retrieving ecological information. *There is currently no nationally available system at an appropriate scale that captures the variation in the range of physical, cultural and historical factors that, over millennia, have created the distinctive landscapes of England.*

The development of a consistent, national spatial framework of this type is however, challenging and requires:

- ∉ selection of the appropriate spatial scale;
- ∉ selection of appropriate attributes, both cultural and physical;
- ∉ identification of sources of data: cost, availability and quality.

The emergence of systematic techniques for mapping landscape character in the early 1990s offered great promise for providing such a framework. This report explores the potential role of LCA to fulfil these objectives within selected counties in the West Midlands.

1.2 Aims and objectives

The aim of the project was to evaluate the extent to which landscape character provides the basis for describing ecological variation and function at the landscape scale. Whilst considerable progress has been made towards the development of techniques for landscape character mapping (see review in: Swanwick & Land Use Consultants 2002) the relationship between a landscape and its ecological characteristics (type & extent of habitats; species presence & abundance) is a complex one and has not been fully investigated.

To achieve this aim a number of specific objectives were identified:

- produce maps of landscape character and associated database for five counties in the West Midlands and Oxfordshire;
- develop a technique for grouping landscape units into landscape types with shared physical and cultural attributes;
- develop a system for recording the extent and pattern of semi-natural habitats at a landscape scale.

1.3 The study area

The study area includes five counties in the Midlands and one in the South East. The selection of Midland counties reflected both the origins of the project in Warwickshire and the early participation of these counties in the Living Landscape Project. Oxfordshire was selected to serve the needs of the English Nature/Countryside Agency funded Oxfordshire Wildlife & Landscape Study (OWLS). It is acknowledged that the counties selected do not cover the full range of landscapes in England, especially the moorland and mountain landscapes of the north and west. However, the variation from the limestone of the Jurassic Cotswolds in the south to the Carboniferous limestone/gritstone of Derbyshire in the north, the Silurian slates and shales of Shropshire and the Triassic sandstones of Worcestershire, represents a wide range of Landscape Types with considerable variation in topography, soils, landform and cultural patterns.

1.4 Structure of the report

This report describes the development of a prototype spatial landscape character framework for a study area in the West Midlands and assesses its potential for describing and recording ecological variation at the landscape scale. It represents the results of a three-year project jointly funded by English Nature and five county Local Authorities (LAs) in the West Midlands (Shropshire, Worcestershire, Herefordshire, Staffordshire and Derbyshire) and Oxfordshire. English Nature was responsible for funding a part-time (0.4) Research Assistant at the University of Reading and further input from two academics at the University of Reading and Wye College, both with research interests and experience in landscape ecology.

The Local Authority partners, as members of the Living Landscapes Project, funded the Landscape Character Assessment that was undertaken by Steven Warnock, an independent consultant and member of the Living Landscapes Project (LLP) based at the University of Reading. The project was managed by a Steering Group including representatives from the Local Authority partners, The University of Reading, Wye College and English Nature (Appendix 1).

Section 2 describes, in brief, the Landscape Character Assessment method that is followed, in Section 3, with a discussion of terms and definitions. Section 4 describes the techniques used to develop a classification of Landscape Types and Section 5 describes the ecological field survey methods and data. A comparison of the LCA typology with Natural Areas and The Land Cover Map 2000 is included in Section 6 and Section 7 provides worked examples of the application of the landscape character framework for ecological analysis. The final Section, 8, summaries and discusses the results of the project with suggestions for further work.

2. Landscape character

There is a long history of landscape research in Britain, going back to William Smith's publication of the first Geological Map in 1815 and his early interest in the relationship between geological strata, landform and agricultural land use (Winchester 2001). This long tradition reflects the unusually varied physical landscapes of Britain, the strong imprint of human activity and an early interest in natural history among the land owning aristocracy from the end of the eighteenth century (Allen 1978).

Landscape character is defined as a distinct, recognisable and consistent pattern of elements in the landscape. Habitats and species are important elements of landscape character, and it is increasingly realised that the patterns of biodiversity are an integral part of our cultural heritage. By contrast, Landscape Character Assessment is a set of techniques and procedures to map differences between landscapes, based on their historical evolution and physical characteristics.

2.1 The evolution of the English landscape

The rapid changes that characterised the last half of the 20th Century and which continue into this century has occurred against a background of a long and varied history of settlement and landscape evolution. The long tradition of historical geography in Britain provides a wealth of information about the evolution of the landscape following the clearance of the wildwood by Neolithic farmers from 4000 BC. This historical tradition has provided a wealth of data on the clearance of the 'wildwood', the Anglo-Saxon settlement (Hooke 1998), the impact of the conquest and the record of Norman Britain (Darby 1973), through the expansion of medieval settlement and agriculture to the Black Death (Aston, Austin & Dyer 1989) and the emergence of the post-Medieval planned landscapes of late Parliamentary enclosure.

In lowland England a critically important distinction is between the planned countryside of the Midland belt and the 'ancient' countryside to the west and east of this Midland region. Rackham (1986) describes the critical factors that differentiate between these two types of countryside. Thus, in the ancient countryside of the west in the county of Herefordshire for example, is found a landscape of, 'hamlets, medieval farms in hollows of the hills, lonely moats and many footpaths, fords, irregularly shaped groves with thick hedges colourful with maples, dogwood and spindle – an intricate land of mystery and surprise'. By contrast in Cambridgeshire, an example of planned landscape, Rackham (1986) describes a landscape of, 'big villages, few, busy roads, thin hawthorn hedges, windswept brick farms, and ivied clumps of trees in corners of fields; a predictable land of wide views, sweeping sameness, and straight lines'.

The cultural landscapes of England are as varied as the physical characteristics of the land upon which they have evolved. The development of systems for landscape characterisation and classification, have increasingly sought to reflect this diversity of form and pattern recognising that the future landscapes of England should be based on an understanding of present and past landscapes.

2.2 Landscape Character Assessment (LCA)

The rapid changes of the 20th century and growing concern about their impact on the quality of the countryside has led to a renewed interest in, firstly, the inventory of land cover and land use and, secondly, mapping and understanding landscapes. Landscape studies in the 1970s focussed on evaluation of landscapes, with the aim of protecting the most 'valuable landscapes'. Such approaches did not gain widespread acceptance, in part due to the difficulty of reducing complex, cultural landscapes to simple formulae and numbers. There was also a growing realisation of the need to actively manage all landscapes, not just those considered valuable or beautiful. At the start of the 21st century, Landscape Character Assessment (LCA) is maturing as the primary tool for classifying, describing and evaluating landscapes to support decision making about the future direction of the countryside.

Landscape Character Assessment is the technique used to classify, describe and understand the evolution and physical and cultural characteristics of a landscape. LCA draws on data from existing published sources, field survey information and the input of stakeholders to identify and describe areas of common character. Landscape character assessment can operate at multiple scales, from broad-brush national studies, strategic county assessments and community-led parish projects.

The growing interest in character-based decision making has been made possible through the adoption of a more structured and systematic approach to landscape assessment (Warwickshire County Council 1993) that clearly separates the process of characterisation from evaluation and which gives equal weight to the natural, cultural and visual dimensions of the landscape. A characterisation approach is endorsed within the Rural White Paper (DEFRA 2000) and in *National and Regional Planning Guidance*. The publication of *Landscape Character Assessment Guidance for England & Scotland* (Swanwick and Land Use Consultants 2002) described the key principles of Landscape Character Assessment and highlighted the need to give full consideration to the interaction of natural, cultural and aesthetic dimensions of the landscape. The concurrent development of Geographical Information Systems (GIS) technology has facilitated the storage, retrieval, analysis and display of map based data that is central to Landscape Character Assessment (Porter & Ahern 2003).

Multi-disciplinary teams increasingly complete Landscape Character Assessment, including landscape architects, ecologists, archaeologists and planners. Such studies are being used as integrating planning framework for landscape management and spatially targeting resources. Perhaps the most important role for landscape character however, is the opportunity for holistic and cross-sectoral policy–making that incorporates social, economic and environmental considerations.

The need for a national landscape framework was recognised with the development of English Nature's Natural Areas: 97 land and 23 coastal areas in England. In 1996 the former Countryside Commission and English Nature, with support from English Heritage, produced The Character of England Map (Countryside Commission & English Nature 1996). This combines English Nature's Natural Areas and the former Countryside Commission's Countryside Character Areas into a map of Joint Character Areas for the whole of England to give 159 units in total. The map provides a picture of landscape character at the national scale, incorporating both the natural and cultural aspects of the landscape.

Due to the great range of landscapes that occur within each of the Joint Character Areas, there is a need to develop a finer scale character based framework that can be used to focus national and regional strategies to a more local level. Many local Landscape Character Assessments have been carried out by district and county planning authorities, by AONB management boards and by DEFRA scientists shaping Environmentally Sensitive Area (ESA) schemes. Despite most studies sharing a common approach, there has been no consistent spatial framework within which to store and analyse the data. Hence, there is a lack of consistency between Landscape Character Assessments, with even adjacent or congruent assessments showing discrepancies. There is a great need for a consistent framework, based upon nationally available data that can link national landscape studies and strategies with stakeholders and projects at a regional and local level.

2.3 Developing a spatial framework

One of the main outputs from the Living Landscapes Project is the development of a GIS based spatial framework that integrates the natural (physical and biological) and cultural aspects of the countryside at the landscape scale. The framework has been developed in partnership with national agencies, local authorities and academic institutions.

The fundamental building block of the hierarchy at the landscape level is the Landscape Description Unit (LDU). LDUs are distinct and relatively homogenous units of land each defined by a series of *definitive attributes*, so called because they define the spatial extent of each landscape unit. Level 1 is a broad scale of LDU mapping with each Level 1 LDU having four definitive attributes: Physiography, Ground Type, Land Cover and Settlement.

Each of these attributes splits / divides into two attributes at Level 2, giving a finer scale of mapping. The eight attributes at Level 2 are Landform, Geology (structure), Geology (rock type), Soils, Farm type (cover), Tree Cover, Settlement and Farm Type (structure). The definitive attributes are summarised in Table 1 and the full Level 2 definitive attributes are shown in Appendix 1.

Table 1. Living Landscape Project, definitive attributes of Landscape Description Units at Level 1 and Level 2

	Regional	County / District
	Level 1 (1:250,000)	Level 2 (1:50,000)
Natural	Physiography	Landform Geology (structure)
	Ground type	Geology (rock type) Soils
Cultural	Landcover	Farm type (cover) Tree cover
	Settlement	Settlement Farm type (structure)

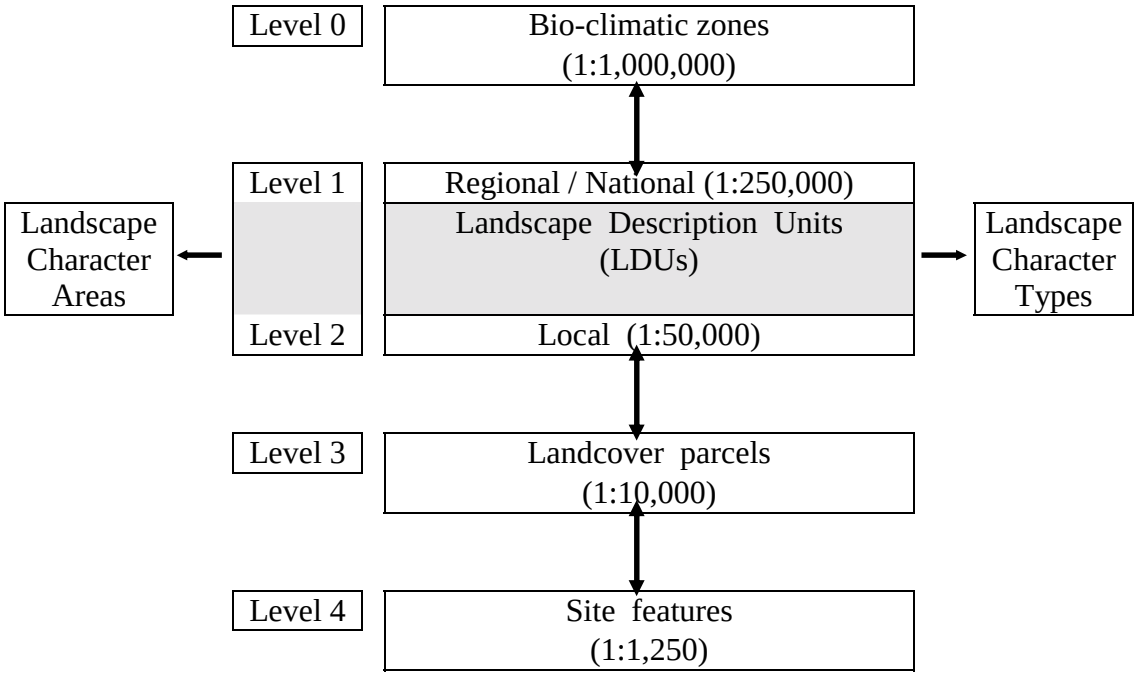

Figure 1. The Landscape Description Unit spatial framework

2.3.1 Landscape character at different scales

There are two important scales for strategic landscape planning - National and Regional Agencies generally require a regional policy perspective and Local Authorities who have county/district wide planning and land management responsibilities. The hierarchical structure of the Landscape Description Units provides a spatial framework for linking national/regional policy objectives (Level 1) to local planning and land management activities (Level 2) to farm and site-based management (Level 3). The diagram in Figure 1 illustrates the hierarchical structure of the LDU spatial framework.

2.3.2 LDU mapping

LDU mapping is essentially a desk-based exercise involving the preparation and analysis of simplified map overlays, which are used to generate the LDUs (Figure 2). The natural dimension of the landscape is mapped first, not only because it provides a context for analysing the historical evolution of the landscape, but also because the attributes of relief, geology and soils have 'real' boundaries that can be readily extracted from existing published maps. Cultural attributes do not usually have such clearly defined boundaries, but because of the constraints that have historically been imposed on land utilisation by slope, soil fertility and drainage it is often possible to map cultural patterns at the landscape scale assisted by the pre-existing physiographic mapping.

LDU mapping involves the step-by-step procedure of data acquisition, processing and synthesis to produce a series of character based overlays incorporating the key factors that contribute to landscape character. These factors are summarised in the GIS database as a series of definitive codes. The definition of discrete LDUs provides a systematic spatial framework that can be used subsequently for gathering additional descriptive information about the landscape. Descriptive attributes include both character based information (eg species associations) and qualitative information relating to the significance of particular attributes, their condition and their vulnerability to change. All of this information is held on a GIS database linked to the LDU polygons.

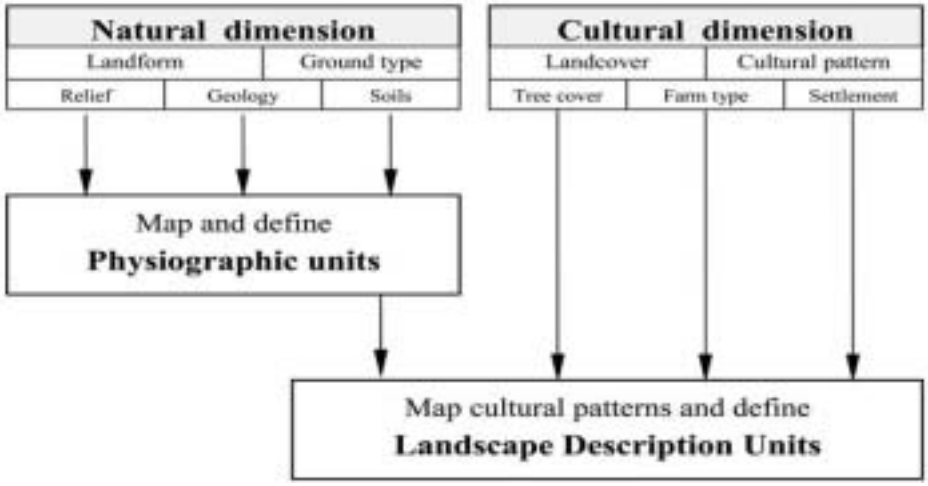

Figure 2. The LDU mapping process

2.4 Data sources

Before the process of overlay mapping can begin all of the relevant, readily available information for the study area and its immediate surroundings needs to be collated as a series of digital map layers within the GIS. These include:

Landform - the relative relief and shape of the land surface as derived from interpretation of OS Landform Profile contour data (10m vertical resolution).

Structural geology - the origin and underlying structure of the earth's surface derived from interpretation of 1:50 000 scale British Geological Survey (BGS) geology maps.

Rock type - the nature of the soil forming bedrock/drift as derived from interpretation of 1:50 000 scale geology maps.

Soils - the nature of the surficial material covering the land surface as derived from interpretation of the National Soil Resources Institute (NSRI) 1:250 000 database and older Soil Survey paper maps.

Land use - the broad pattern of primary land use at the landscape scale as derived from interpretation of parish-based DEFRA Agricultural Census data ('June Returns') and the Moorland line. Both data-sets from the DEFRA Geographical Information Unit, Leeds.

Tree cover - the nature and spatial pattern of tree and woodland cover as derived from interpretation of The Forestry Commission's National Inventory of Woodland & Trees (Forestry Commission 2003) and English Nature's Ancient Woodland Inventory (Thomas1994; Spencer & Kirby 1992).

Settlement - the historic pattern of rural settlement taken from OS 1:50 000 scale Land Ranger maps with additional information from the national settlement map (Roberts & Wrathmell 2002).

Farm type - the broad pattern and structure of land holdings (farm size and tenancy) as derived from interpretation of parish-based data from the DEFRA Agricultural Census data.

2.5 The natural dimension

2.5.1 Physiographic analysis

Physiography is an expression of the shape and structure of the land surface as influenced both by the nature of the underlying geology and the effect of subsequent geomorphological processes. Two definitive attributes are used at Level 2, one defining *geological structure* and the other the *form* of the land surface (Table 1).

Geological structure

A simplified geological base map showing Geology–structure is prepared first from Geological Maps. Geology-structure refers both to geological Period and to broad differences in lithology:

- ∉ Fluvial drift (F)
- ∉ Glacial drift (T)
- ∉ Soft (Mesozoic) rocks (M)
- ∉ Hard (Palaeozoic/Caledonian) rocks (C)
- ∉ Ancient/Igneous rocks (I)

Landform

A contour overlay colour coded to show broad altitude bands is overlain onto the geological base map to generate the Level 2 Physiographic units. Thus, the Geology structure categories are sub-divided according to landform characteristics including, vales & valleys; rolling lowland; upstanding/undulating; low plateau; sloping; high hills.

The resulting Physiographic units for an area on the Warwickshire/Worcestershire border (Evesham-Stratford) are presented in Figure 3. Referring to Table 1 it is observed that this map represents the level of detail available at the Level 1 scale of analysis based on **two** definitive attributes: Geology-structure and Landform. At Level 2 these units are sub-divided according to differences in rock type and soil type.

2.5.2 Ground type analysis

Ground type is an expression of the soil forming environment and its influence in determining the surface pattern of vegetation and land use. Two definitive attributes are used to generate the Level 2 Physiographic units, one describing the nature of the underlying bedrock/drift (Rock type), the other reflecting variations in the process of soil formation related to drainage and soil fertility (Soil type).

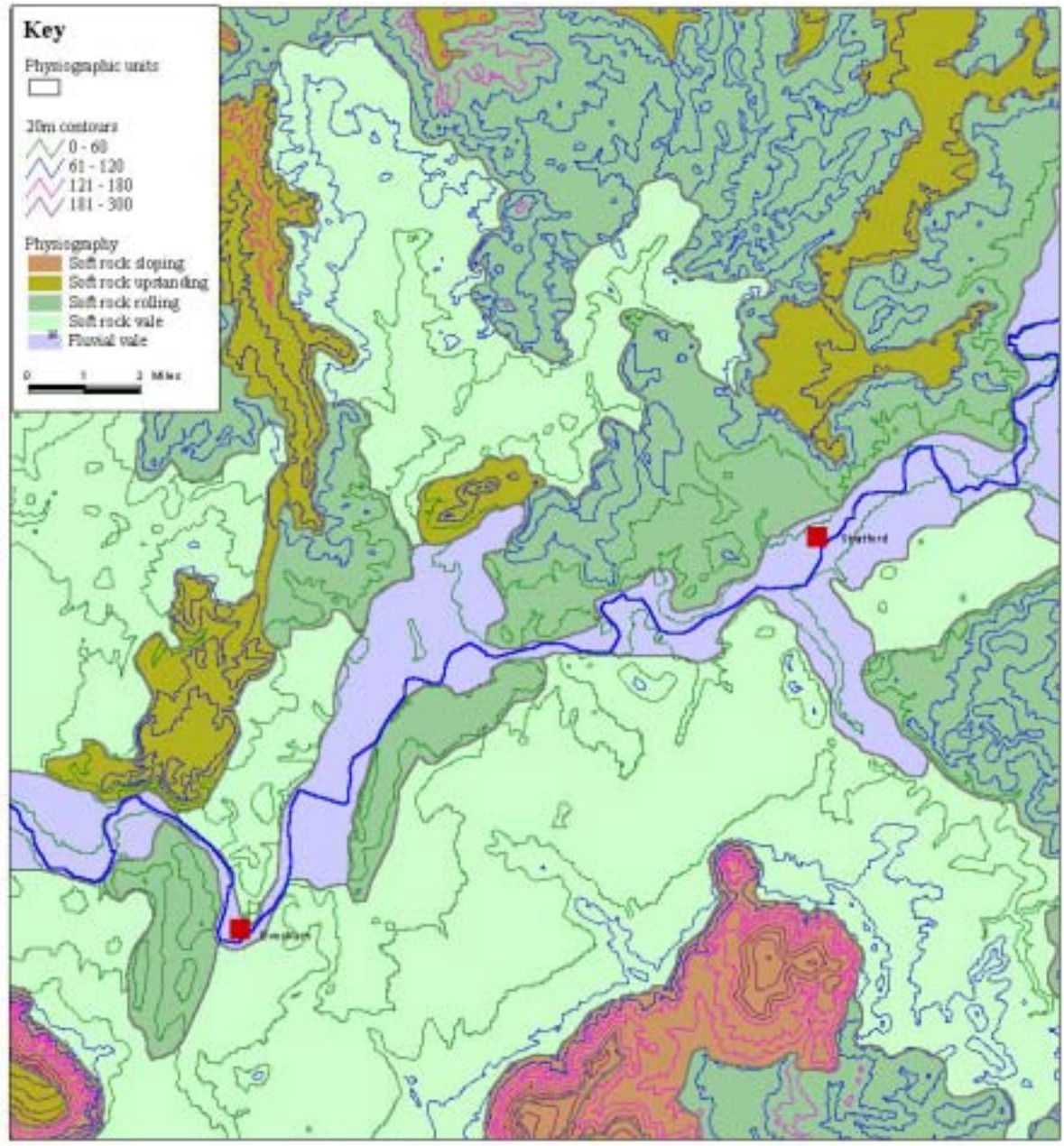

Figure 3. Physiographic units derived from structural geology and landform data. © Crown Copyright Ordnance Survey. An EDINA Digimap / JISC supplied service.

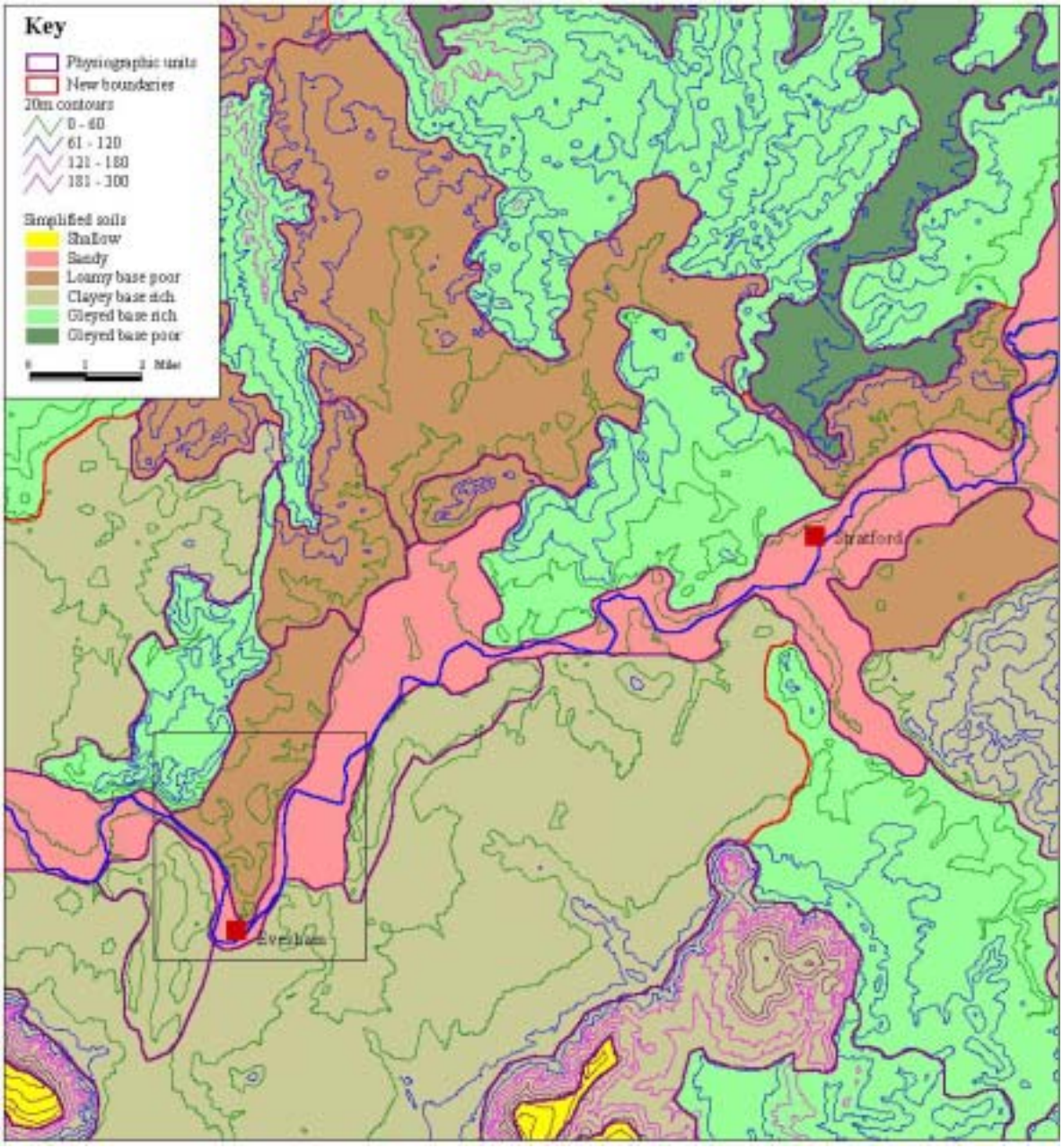

Figure 4. Physiographic units further subdivided according to differences in broad soil types (red lines). © Crown Copyright Ordnance Survey. An EDINA Digimap / JISC supplied service.

Rock type

The Level 1 Physiographic Units are, firstly, sub-divided using the Rock type categories derived from the geological base map:

- Alluvium & fen peat
- Clay & chalky till
- Other till/plateau drift
- Soft sandstone/sandy drift
- Chalk & limestone
- Mixed soft rock
- Igneous/metamorphic rocks
- Other hard rocks
- Humic drift

Soil type

Secondly, the Physiographic units are characterised, sub-dividing where necessary, according to differences in soil drainage and soil fertility derived from the simplified national soil map. Typical soil categories include, raw soils; impoverished soils; shallow soils; deep, free-draining soils; gleyed soils and bog/fen peat. Note, for example, how the Level 1 Physiographic unit 'Soft Rock Vale' has been subdivided at Level 2 into 'Clayey base rich' and 'Gleyed base rich' soils (denoted by a red line) in Figure 4.

2.6 The cultural dimension

Experience has shown that about two thirds of the LDU boundaries can be defined by physical attributes alone. Important differences in cultural patterns account for the remaining differentiation between the wide diversity of landscapes found in England. Cultural pattern is an expression of the structural component of the cultural landscape as reflected in the historic pattern of enclosure and rural settlement. The cultural analysis gives an insight into the historical evolution of the landscape and the degree to which human activity has modified/replaced the natural pattern of vegetation.

The analysis of cultural pattern is the least well developed part of the characterisation process and this area is currently the subject of further development by the Living Landscapes Project. For example, detailed historical mapping of Rockingham Forest in Northamptonshire (Foard, Hall & Britnell 2004) is being used to improve the quality and accuracy of Level 2 LDU mapping within the project area.

Two definitive attributes are used at Level 1: settlement pattern and tree cover. At the more detailed Level 2 additional information on farm type and structure is also included (Table 1).

2.6.1 Land cover analysis

Land cover is an expression of the type of vegetation (natural and man-made) covering the land surface. Two Definitive Attributes are used at Level 2 describing the predominant land

use/type of farming, the other reflecting the contribution that trees and woodlands make to the character of the landscape.

Land use/type of farming

The first stage is to define a set of land use/type layers: wooded land, arable farmland, pastoral farmland; rough/wild land; disturbed land and urban.

The provisional Physiographic LDU boundaries are overlain onto a 1:50 000 OS raster topographic base map and the boundaries of large urban areas (> 4km²) are added into the LDU framework. The land cover map is the percent of grassland (permanent & ley grass) generated from parish-based Agricultural Census data (1995):

- pastoral: >70% grassland;
- mixed pastoral: 50 – 70 % grassland;
- mixed arable: 30 – 50 % grassland;
- arable: < 30% grassland).

Areas of rough/wild land are derived from the Moorland Line (source: DEFRA GI Unit, Leeds)) and the register of Lowland Commons. *The National Inventory of Woodland & Trees* (Forestry Commission 2003) is used to define heavily wooded areas (>20% cover). The provisional Physiographic LDU boundaries are overlaid onto the combined land use/type layers and characterised according to broad land cover categories (wooded land, arable farmland, pastoral farmland; rough/wild land; disturbed land and urban).

Tree cover

The National Inventory of Woodlands & Trees (Forestry Commission 2003) in combination with the Ancient Woodland Inventory (Thomas 1994) is used to generate a woodland base map. Similarly, the provisional LDU Physiographic boundaries are overlaid onto the woodland base map and sub-divided, as appropriate, into the following Tree Cover categories: ancient woods; estate plantations; secondary/recent woodland; other trees; open/unwooded/ urban.

2.6.2 Settlement analysis

A baseline analysis of settlement pattern (Roberts & Wrathmell 2002) for the following 'dispersion' classes is established:

- low density with many nucleations;
- low density without nucleations;
- moderate-high density with many nucleations;
- moderate-high density with few nucleations.

The simplified Ground Type overlay is used to identify areas of former wetland (alluvial soils) and 'waste' (peaty/podzolic soils). The Moorland Line and Lowland Common data sets are used to show areas of existing unsettled/unenclosed land.

Finally the provisional LDU boundaries are superimposed onto the settlement base and characterised (sub-dividing where necessary) using the following broad categories:

- nucleated;
- clustered;
- settled;
- dispersed;
- meadow & marsh;
- unsettled-unenclosed wild land;
- coalfields;
- urban.

Farm type

A simplified **Farm size** overlay derived from parish based Agricultural Census Data (DEFRA) is used to show differences in farm size and a second data-set, also derived from Agricultural Census data, is used to show the following the percentage of tenanted land.

The provisional LDU boundaries are overlaid onto the Farm Type information and subdivided according to the following broad categories:

- large estates;
- large farms;
- small farms/estates;
- uUnenclosed/common land;
- urban.

The final map of Level 2 LDUs for the example region of interest is shown in Figure 5. Thus, at level 2 the unit labelled ‘NEA’ has a characteristically nucleated pattern of Settlement (N); Estateland (E) with Ancient Woodland (A). Level 2 mapping was completed for the five selected counties in the West Midlands and Oxfordshire.

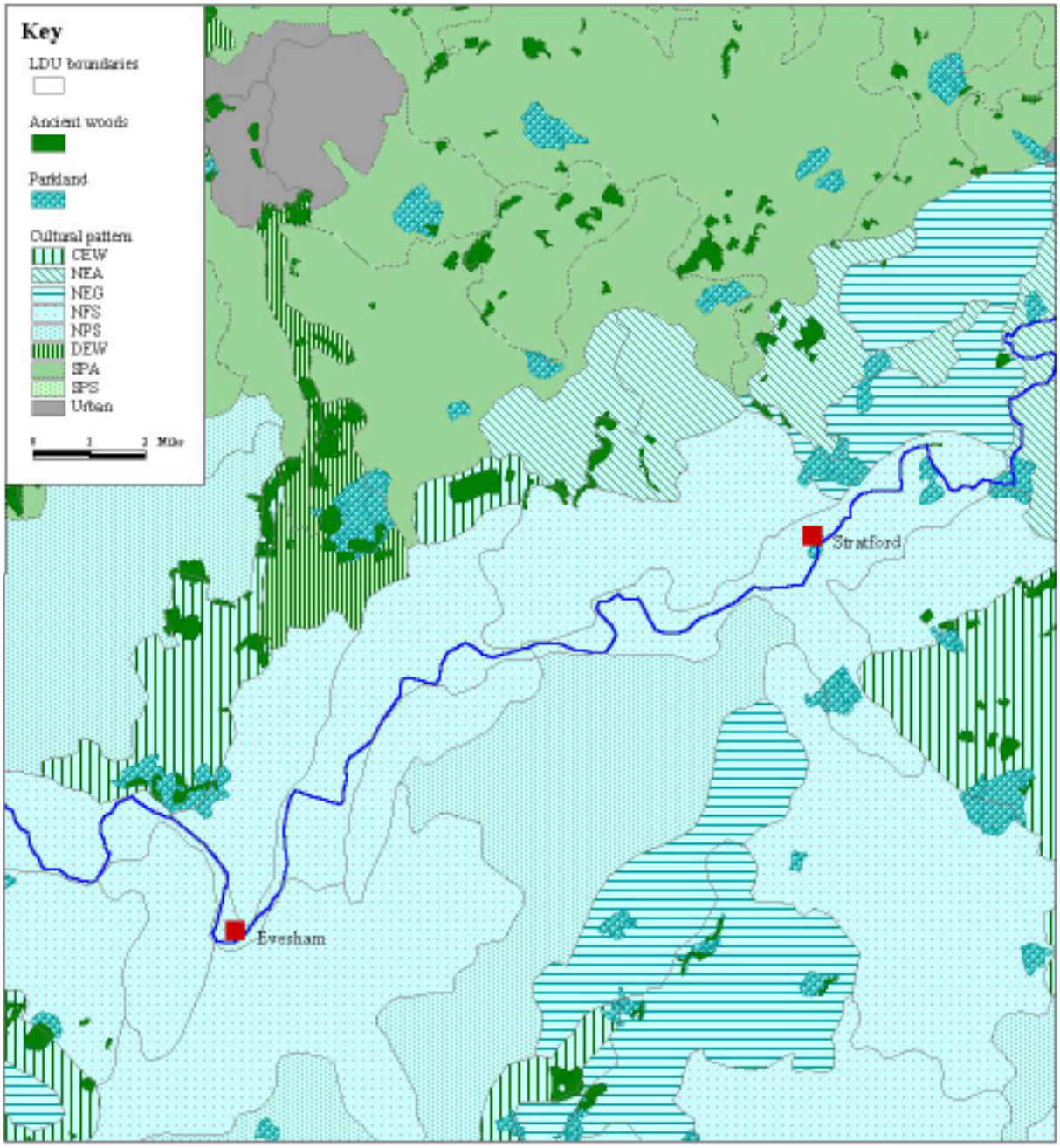

Figure 5. Landscape Description Units, shaded according to broad cultural codes

(CEW: clustered settlement, estatelands, strong pattern of ancient woodland); NEA: nucleated, estatelands, some ancient woodland; NEG: nucleated, estatelands, coverts & tree groups; NFS: nucleated, arable, scattered woodland; NPS: nucleated, pastoral, scattered woodland; DEW: dispersed, estatelands, some ancient woodland; SPA: settled, estate plantations, ancient woodland; SPS: settled, estate plantations, secondary woodland. © Crown Copyright Ordnance Survey. An EDINA Digimap / JISC supplied service.

A more detailed description of the LDU method is contained in the *Manual of Landscape Characterisation* (Warnock 2003). The final LDU map is linked to a table of attributes within the GIS containing the codes for each of the four definitive attributes at Level 1 and the eight definitive attributes at Level 2 (Appendix 1).

Improving the spatial framework

The Level 2 LDU map shows units of relatively uniform physical and cultural characteristics as interpreted from nationally available data-sets. Whilst the use of national data-sets allows for consistent mapping at national scales, it is acknowledged that at county/district scales map resolution and information may be insufficient to capture the full range of physical and cultural differences that characterise the English countryside.

There is, for example, insufficient detailed historical information available to be confident that the cultural dimension of the LDU mapping is correct. Progress towards national coverage of historic landscape character studies is well underway (Fairclough & Macinnes 2003) but there is currently no consistent national dataset to inform and assist with Level 2 LDU mapping. The Living Landscapes Project is currently working with a number of counties to determine the type of information and level of detail required to improve the LDU mapping. Key questions relate to the identifying the type of information, for example the extent of former Medieval open fields, the location of former common land, the distinction between early and late patterns of enclosure etc, that can be used to inform the mapping. A major challenge however, is to determine the extent to which former patterns persist in the present day landscape and therefore contribute to its inherent character.

There are other challenges relating the quality of the physical data-sets. The soil data in particular is only available nationally at 1:250 000 scale. This is insufficiently detailed for accurate mapping of variations in soil type at Level 2. By contrast, the broad patterns of geology structure and rock type provide important base information that, in combination with digital contour data at a 10m vertical interval, is 'fit for purpose'.

Although the mapping utilises layers of digital data within a GIS environment, the boundaries between units are interpreted visually. The lack of detail in the soil data combined with the uncertainty associated with mapping cultural features, invariably means that boundaries are estimated with varying degrees of certainty. There is a need to develop data structures, beyond the simple polygon model currently employed, that can describe this level of uncertainty, while still forming a usable spatial framework for landscape planning.

3. Relationship between LCA terms

This section describes the relationship between terms used in this report and in the Landscape Character Assessment Guidance for England and Scotland (Swanwick & Land Use Consultants 2002).

Landscape Description Units are distinct and relatively homogenous units of land each defined by a series of *definitive attributes*, so called because they define the spatial extent of each landscape unit. The definitive attributes describe key aspects of the landscape and are derived from nationally available datasets. There are four definitive attributes at **Level 1** (1:250,000) each of which is split into two to give eight definitive attributes at **Level 2**. Thus Level 2 mapping contains additional information allowing for a finer scale of mapping at 1:50,000 scale. This approach to identifying Landscape Description Units was developed by the Living Landscapes Project.

The (Draft National) **Landscape Typology** is a classification of the Level 1 Landscape Description Units. The classification was carried out by summarising the Level 1 definitive

attributes as a three letter 'LCT' code and then grouping Level 1 LDUs with a shared code. The Draft Landscape Typology was developed for The Countryside Agency by the Living Landscapes Project, in a joint contract with Entec UK Ltd and Smart Data (Countryside Agency 2001).

Landscape Character Assessment is a tool for identifying the features that give a locality its 'sense of place' and pinpointing what makes it different from its neighbouring areas. The *Landscape Character Assessment Guidance for England and Scotland* provides an outline of the stages of the LCA method which are as follows:

- defining the scope of the study;
- **desk study** to define draft areas of common character;
- **field survey** to gather further information about the landscape; and
- **classification and description** to define and communicate Landscape Character Types and Areas.

It is important to note that stakeholders should be included in the LCA process, to enrich the assessment with local and specialist knowledge and to give greater ownership and acceptance of the results. The results of a LCA can be used as a framework for developing landscape policies and as a decision support tool for development control decisions.

Landscape Character Assessment can be carried out at various scales, from national studies down to parish assessments. Many Landscape Character Assessments have been completed by local authorities at the county or district scale and the mapping of Level 2 Landscape Description Units can be considered as equivalent to the desk study stage of an assessment at this scale.

The LDUs, determined from the desk study, provide a spatial framework within which further information about the landscape can be gathered. Using the LDUs in this way allows the boundaries to be checked in the field and influenced by stakeholders. Several local authorities (particularly in the West Midlands region) have had successful results when using Landscape Description Units in this way and now share a common spatial framework.

Landscape Character Types are defined as distinct types of landscape that are relatively homogenous in character (Swanwick and Land use Consultants 2002). They are generic in nature in that they may occur in different parts of the country, but wherever they occur they share broadly similar combinations of geology, topography, drainage patterns, vegetation and historical land use and settlement pattern. Thus, the Limestone Dales are a Landscape Character Type – a representative of a specific type of landscape sharing pastoral farming on steeply sloping valley sides, over Carboniferous limestone. Landscape Description Units can be grouped into Landscape Character Types according to shared characteristics. Landscape Character Types are often defined manually based upon an analysis of the character and often the aesthetic properties of landscapes. The aesthetic properties of the landscape such as visual prominence of landscape elements are often gathered as part of the Landscape Character Assessment field survey. Importantly, Landscape Character Types should incorporate input from a wide range of stakeholders, including local communities, to ensure that they have the widest possible acceptance and utility.

Landscape Character Areas refer to a landscape with shared attributes that is culturally recognisable and confined to a particular area, eg Dovedale, The Cotswolds (Swanwick & Land Use Consultants 2002). Landscape Character Areas can be defined at various scales and can encompass a range of landscapes. The **Countryside Character Areas** (Countryside Commission & English Nature 1996) represent the broadest scale of Landscape Character Areas, for example the Dark Peak character area encompasses a variety of landscapes found on carboniferous sandstones and shales, including open moorland, rocky edges, enclosed farmland, wooded valleys and flood plains.

Many county Landscape Character Assessments have subdivided the Countryside Character Areas, thus defining Landscape Character Areas that broadly divide a county or district into culturally recognisable units. For example in the Herefordshire Landscape Character Assessment, the South Herefordshire and Over Severn CCA (Countryside Character Area) has been divided into three Landscape Character Areas: Archenfield (sandstone upland area with strong Welsh cultural associations); The Woolhope Dome (intricate landscape of wooded ridges and pastoral valleys over Silurian limestones and shales); and Leadon Vale, (low-lying farmland with many orchards over Devonian mudstone). These areas each encompass a range of Landscape Character Types.

Other Landscape Character Assessments define LCA at a much finer scale. For example, the Test Valley Community Landscape Project, identifies 40 Landscape Character Areas in the Test Valley District. Each of the Landscape Character Areas contains only one Landscape Character Type. Landscape Description Units can also be used to define the boundaries of these finer scale Landscape Character Areas, as their boundaries are often clearly recognisable in the landscape. Landscape Description Units that encompass several communities may be sub-divided into smaller, culturally recognised Landscape Character Areas.

A key benefit of the Landscape Description Unit spatial framework, is that the LDUs can be grouped using a variety of methods, each suited to a particular application. Landscape Character Types have many applications including strategic and development control planning and for landscape management. LDUs have also been classified according to their woodland pattern, agricultural value, landscape sensitivity and presence of BAP species.

The process of LDU mapping using nationally available datasets and subsequent characterisation with other descriptive data, enables patterns to be distinguished which assist with understanding the relationship between the many factors that contribute to landscape character. The iterative nature of this process greatly assists in the understanding of how a particular landscape has developed and is the key to assessing the character of that landscape. Similarly, it is much easier to evaluate the condition of a particular landscape and its sensitivity and capacity to accept change, where this is supported by an appreciation of how that landscape has evolved.

4. Classification of LDUs using TWINSPAN

There are over 1,800 Level 2 LDUs in the West Midlands/Oxfordshire study area. It would not be practical to define individual landscape strategies for each LDU. For this reason LDUs with similar characteristics were together according to shared characteristics. As described in the previous section, there are many possible techniques for classifying LDUs.

This project explored techniques for classifying LDUs based upon multivariate analysis of natural and cultural LDU Definitive Attributes.

A key aim of the project was to explore repeatable methods for classifying Landscape Description Units based upon the Definitive Attributes. This section describes the classification of the mapped LDUs using Two Way Indicator Species Analysis (TWINSPAN) into Landscape Types (Hill 1979). The method builds on work in earlier stages of the project, using a smaller set of LDUs, and alternative analysis techniques.

The groups of LDUs defined in this way will be referred to in this report as LDU Types, to distinguish them from Landscape Character Types, a product of Landscape Character Assessment. It must be emphasised that the LDU Types do not affect the validity of existing Landscape Character Types as there has been no consideration in this project, of the aesthetic properties of the landscape or the views of stakeholders.

4.1 TWINSPAN classification

TWINSPAN was initially developed for the classification of 'presence/absence' species data. It is also appropriate for landscape classification because it uses sample composition, in this case physical and cultural attributes, and the strength of affiliation of the attributes to different sample groups. TWINSPAN is also generally regarded as a robust analysis for data where there are many zeros in the data set.

Previous investigations have shown that TWINSPAN, based upon Definitive Attributes produced a meaningful classification of LDUs in Derbyshire. The addition of the cultural Definitive Attributes as input variables has a strong effect on the classification compared to a classification based solely on natural Definitive Attributes (Warnock and others 2001). Important cultural divisions between landscapes types were apparent in the division between arable and pastoral farming landscapes and the division between enclosed moorland and open moorland. Table 2 shows an example of the input variables for one LDU: the four Level 1 attributes are split into the 8 Level 2 attributes. The Level 2 codes are used as the input to TWINSPAN.

Table 2. Example of TWINSPAN input variables for one LDU

Leve1 1 Attribute	Level 2 codes	Interpretation
Physiography	PS	Hard (Palaeozoic) rocks / Sloping land
Ground Type	LR	Limestone / Raw shallow soils
Cultural Pattern	DE	Dispersed / Large Estates
Landcover	WA	Woodland / Ancient trees & woods

4.2 TWINSPAN classification of Midlands Level 2 LDUs

The following analyses were completed using PC Ord Version 4.20. TWINSPAN was run on the set of 1845 Level 2 Landscape Description Units in the Midlands (Derbyshire, Herefordshire, Oxfordshire, Shropshire, Staffordshire and Worcestershire), each described by natural and cultural Definitive Attributes. Urban LDUs were excluded from the analysis as experience earlier in the project showed that they can distort the classification because urban cultural Definitive Attributes can occur with almost any combination of natural Definitive Attributes.

Each of the attributes was entered into the analysis as a nominal variable with mutually exclusive categories. PC-Ord was designed to perform multivariate analysis of ecological data. Data is commonly used in the form of presence/absence tables with rows representing survey plots and columns representing the presence of species within the plot with the value of ‘1’ and the absence of species with the value of "0". It was necessary to convert the LDU data into a similar format with rows representing LDUs and columns representing each value of the Definitive Attribute. A simple computer program was developed to convert the categorical LDU codes into presence/ absence data in the appropriate PC-Ord input format

TWINSPAN was run for seven divisions. Samples are divided into groups by repeated dichotomization. The end groups are clusters of LDUs with similar attributes. In TWINSPAN it is important to recognise that in some instances the dichotomies may not appear to arise naturally. The attributes that are preferential to one side of the division may be a more clearly defined grouping than on the other side. TWINSPAN uses the preferential attributes to refine the initial dichotomy thus giving a refined ordination. A third ordination is also constructed, the ‘indicator’ ordination, based on a small number of the most strongly differential attributes - this allows for a succinct characterisation of each dichotomy.

The first four divisions of the TWINSPAN classification of Midlands LDUs are shown in Figure 6. Some key divisions of the classification are described below. The first dichotomy (Figure 6a) resulted in a split between landscapes on soft rock with no ancient woodlands (*0) and landscapes with hard rock and landscapes with ancient wooded character (*1). The second dichotomy (Figure 6b) divided the river landscapes (*00) from other soft rock landscapes (*01) and unenclosed moorland (*11) from other hard rock landscapes (*10). The third dichotomy (Figure 6c) divided the river meadow landscapes (*000) from the river terrace farmlands (*001) and the vale landscapes (*010) from rolling landscapes with brown soils (*011).

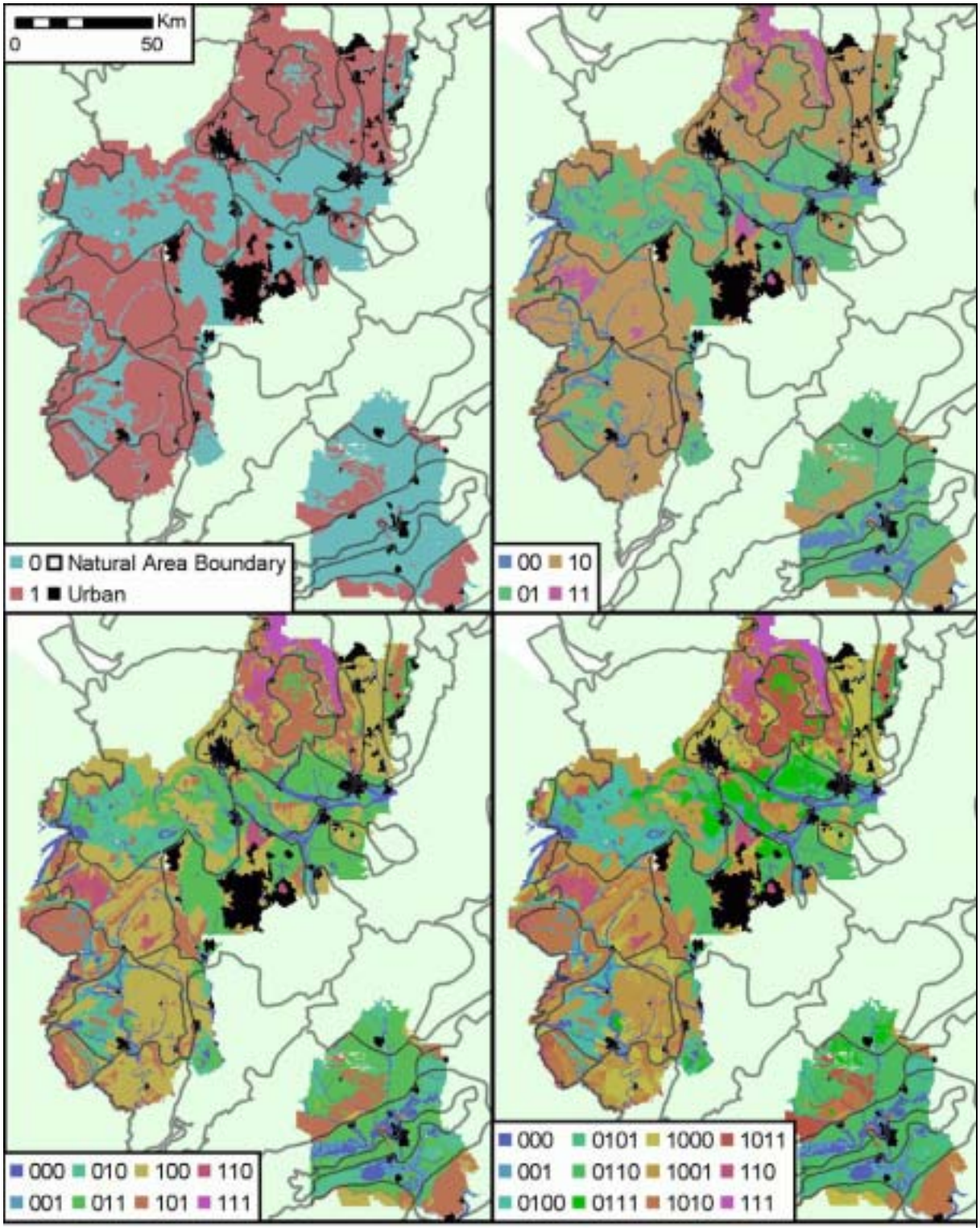

Figure 6. The first four divisions of the TWINSPAN classification of LDUs in the Midlands

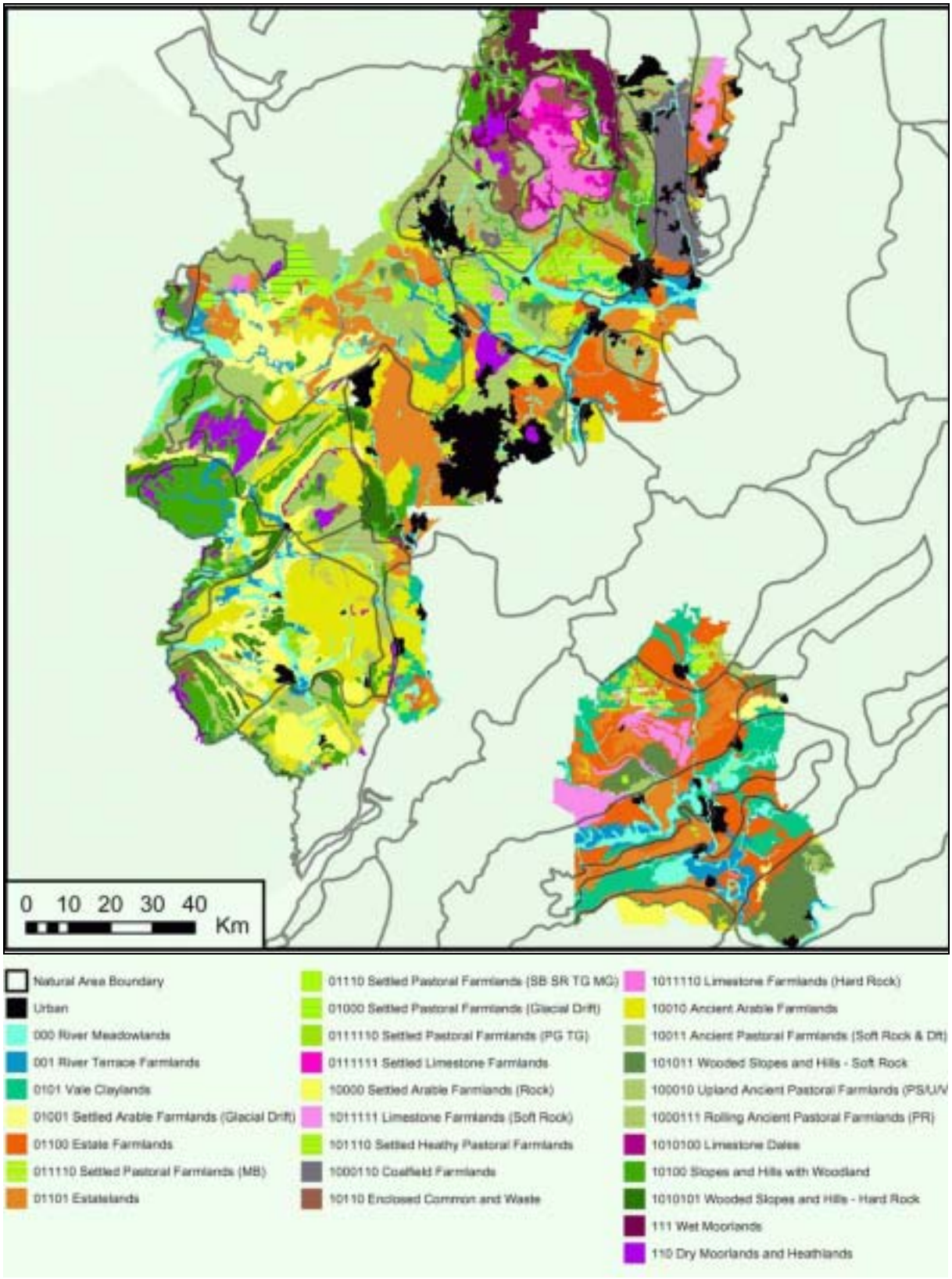

Figure 7. TWINSPAN classification of Midlands LDU showing Landscape Types

TWINSPAN will continue to divide the data in this way to give successively smaller groups. It is often the case that groups are subdivided to a level that is no longer significant given the purpose of the classification. Hence, it is necessary to examine the resultant groups at each stage of the classification and to determine appropriate end-groups. For this dataset, the end-groups were chosen from understanding of the Midlands landscape by the project team. The results were also compared with county level Landscape Character Assessments and the draft National Landscape Typology.

The final classification is shown in Figure 7. The classification shows a broad range of landscapes across the Midlands. LDU Types include those with a strong natural character such as Wet Moorlands (111), which are unenclosed upland landscapes dominated by semi-natural vegetation and extensive deposits of peat. The LDU Types also include landscapes with a strong cultural character, such as Estatelands (01101). These landscapes have been strongly influenced by the large land-owners and are associated with a regular pattern of recent plantation woodlands and game coverts. The Coalfield Farmlands (1000110) LDU Type includes those LDUs where patterns of land use and settlement have been strongly influenced by coal extraction.

4.3 Improving the classification

This analysis has demonstrated a possible technique for grouping LDUs based upon multivariate analysis of their natural and cultural LDU attributes. The classification has been applied consistently across the study area and so the resulting LDU Types can be used as a consistent dataset. The classification reflects the strong inter-relationship between natural and cultural patterns in the landscape and shows a close relationship with Landscape Character Types identified by County Landscape Character Assessments across the Midlands.

The key problems with this approach are mis-classified LDUs which arise from the TWINSPAN method. There is no means within the method to correct these errors, without manually overriding the results of the classification. This is a weakness of the LDU Type classification and shows that further work is required to develop a robust classification of the LDUs.

Unlike Landscape Character Types, defined as part of a Landscape Character Assessment, the LDU types do not incorporate any of the aesthetic properties of the landscape or the views of local stakeholders. Hence, while the LDU Types have been defined consistently across the Midlands, they are informed by a lesser degree of local knowledge and will certainly by less widely accepted by stakeholders as a valid planning tool.

There is a need to develop more rigorous and repeatable methods for classifying Landscape Character Types as part of Landscape Character Assessment, to ensure that consistency is achieved at all spatial scales and across administrative boundaries. Such methods must be capable of incorporating field survey data and stakeholder input, but should be understandable to a broad range of users of the study. A more precisely defined methodology for Landscape Character Assessment, where the desk-study stage is based upon LDU mapping will promote consistency of landscape typology across administrative boundaries.

5. Field survey

Information on the type and spatial configuration of habitats in the landscape is important for understanding ecological function and process, evaluating ecological quality and determining priorities for habitat re-creation and restoration. In general, current and detailed habitat data, for example Phase 1, is not available for large parts of the country and only available in digital form for selected counties (eg Kent, Warwickshire). An important objective of the project was to develop and test a method for collecting an overview of habitats in a landscape, as part of a Landscape Character Assessment field survey.

The process of Landscape Character Assessment requires inputs from a number of disciplines, including, landscape ecology, landscape history and archaeology, agriculture, forestry and planning. Some Landscape Character Assessments have placed too much emphasis on the visual characteristics of the landscape, and have neglected the ecological aspects. It is important, therefore to develop a method for capturing ecological information that can be applied by surveyors from many different backgrounds. This project focussed on identifying ecological parameters that capture important properties of habitats in a Landscape Description Unit, yet are simple enough to be gathered as part of a full Landscape Character Assessment.

The field mapping techniques were not developed as a replacement for detailed habitat survey. Instead they were intended to give an overview of the habitats element in a LDU that can be enriched with more detailed data at a later stage. It would be necessary to combine data gathered at the LDU level with more detailed data, such as aerial photography or satellite imagery, to build up a more complete picture of the pattern, extent and types of habitats within each LDU. Information about protected areas, such as SSSIs or Sites of Interest for Nature Conservation and National Habitat Inventories could also add further detail.

5.1 Habitat spatial properties

Landscape ecology theory is based on a model of identifiable 'patches' within a background matrix, enclosed by a distinct boundary (Forman 1995). In the Living Landscapes Project the LDU boundaries provide the framework within which the spatial arrangement of patches can be measured. The background matrix is also of great significance: land cover in the matrix can directly influence habitat quality and patch connectivity. Forman (1995) defined landscape elements as:

> "each of the relatively homogenous units, or spatial elements recognised at the scale of a landscape mosaic. (This refers to each patch, corridor, and area of matrix in the landscape.)"

Landscape elements can be area features such as woodlands or meadows or linear features such as hedgerows or streams. To record each individual landscape element is beyond the scope of a landscape level field survey. Instead, groups of landscape elements of the same habitat type are recorded, together with estimates of their spatial configuration, based upon landscape ecological properties, such as patch size.

The development of the method was guided both by the need to collect information on habitat type and pattern and, anticipating the need to develop indicators of landscape quality in the longer term, for example:

Patch survival	Survival of habitat	Intensity of land use
Continuous	Intact (linked corridors – good condition)	High
Widespread patches	Declining (linked corridors – poor condition)	Moderate
Localised patches	Fragmented	Low
Relic (only a 'ghost' remains)		

Adjacent land use has significant impact on the quality of a habitat - depending to some extent on the habitat patch size and intensity of land use. A further objective of the field survey was to record consistent and commonly occurring adjacencies, eg grassland/woodland or arable/woodland within LDUs. It is not the intention to record every spatial relationship between habitat types, which would be impossible in practical terms. Only those spatial relationships that are clearly apparent to the surveyor would be recorded. There is no single measure of distance between patches that have ecological significance for all species - the distances to be recorded are related to the size of the LDU and provide information on repeating patterns when comparing LDUs.

5.2 Habitat classification

It was important to base the field survey upon an existing habitat classification to ensure that habitat classes were clearly defined and for the results to be comparable with other survey data. An early candidate was the Baseline Classification of land use, land cover and vegetation type developed by ITE (now Centre for Ecology & Hydrology) as part of Countryside Survey 1990 (Barr and others 1993). This classification has the benefit of being exhaustive, exclusive and structured and has well defined relationships with other key classifications. The key application of the Baseline Classification has been as a tool for cross-linking between pairs of habitat classifications (see report on Land Cover Definitions, Wyatt and others 1993).

After discussion with the Project Steering Group, it was decided that the main criteria for selection of the habitat classification should be its practical utility. Consequently it was decided to use the Phase 1 Survey Habitat Classification (JNCC 1993) which is widely used and understood.

To use the full Phase 1 Survey Habitat Classification for LDU survey would be too time-consuming to be feasible. Consequently a simplified version of the Phase 1 Habitat Classification was developed at a level of detail appropriate for landscape level field survey. The simplified habitat classification is based upon the hierarchical nature of the Phase 1 Habitat Classification and is shown in Table 3. This habitat classification was developed in consultation with the project Steering Group, English Nature, and JNCC. The classification could be used to guide the development of future habitat classifications, to ensure that they contain a level of detail that is appropriate to landscape level work.

A number of typical species that are closely associated with habitats in the Midlands were selected from the literature and following a consultation exercise (Table 3). The typical species were selected to assist surveyors to identify habitat types within each LDU. For example, Ling *Calluna vulgaris* is typical of dry dwarf shrub heath.

5.3 Field survey method

The surveyor travels around the survey area, using public rights of way, to observe as much of the area as possible. Each habitat type present in the LDU is recorded on the survey form, together with descriptive information about that habitat type, including estimates of patch size, percentage cover of the LDU

The field sheets take approximately 10 minutes to complete, so collecting the ecological information does not significantly add to the time taken to complete a Landscape Character Assessment field survey. Much of the required information is gathered from public roads although the use of footpaths and bridleways may be necessary to collect sufficient detail. Due to the limitation of recording from public rights of way, some landscape elements will be under-recorded. However, the survey data gives an overall picture of the habitats present in each LDU and further information can be added by inclusion of other more detailed datasets, as described above.

Table 3. The condensed Phase 1 habitat classification, and associated 'typical species' selected for recording as part of the landscape scale field survey.

Phase 1 code	Phase 1 type	Species 1	Species 2	Species 3	Species 4
A1.1.1	Broadleaved woodland - semi-natural	*Mercurialis perennis*	*Hyacinthoides non-scripta*	*Lamiastrum galeobdolon*	*Corylus avellana*
A1.1.2	Broadleaved woodland - plantation				
A1.2.1	Coniferous woodland - semi-natural				
A1.2.2	Coniferous woodland - plantation	*Picea sitchensis*	*Larix decidua*		
A1.3.1	Mixed woodland - semi-natural	*Taxus baccata*	*Juniperus communis*		
A1.3.2	Mixed woodland - plantation				
A2.1	Scrub - dense/continuous	*Crataegus monogyna*	*Prunus spinosa*	*Salix cinerea*	*Viburnam lantana*
A2.2	Scrub - scattered	*Hippocrepis comosa*	*Ulex spp.*		
A3	Parkland and scattered trees				
A4	Recently felled woodland	*Digitalis purpurea*	*Anemone nemorosa*		
B1.1	Acid grassland - unimproved	*Galium saxatile*	*Nardus stricta*	*Molinia caerulea*	*Deschampsia flexuosa*
B1.2	Acid grassland - semi-improved				
B2.1	Neutral grassland - unimproved	*Alopecurus pratensis*	*Dactylis glomerata*	*Arrenatherum elatius*	
B2.2	Neutral grassland - semi-improved				
B3.1	Calcareous grassland - unimproved	*Helianthemum nummularium*	*Clematis vitalba*	*Briza media*	*Brachypodium pinnatum*
B3.2	Calcareous grassland - semi-improved				
B4	Improved grassland	*Lolium perenne*	*Trifolium repens*	*Rumex acetosa*	*Taraxacum officinale*
B5	Marsh/marshy grassland	*Juncus spp.*	*Carex nigra*	*Filipendula ulmaria*	*Caltha palustris*
B6	Poor semi-improved				
C1	Bracken	*Pteridium aquilinum*			
C2	Upland species-rich ledges				

Phase 1 code	Phase 1 type	Species 1	Species 2	Species 3	Species 4
C3.1	Tall ruderal	*Chamenerion angustifolium*	*Reynoutria japonica*		
C3.2	Non-ruderal	*Dryopteris spp.*			
D1	Dry dwarf shrub heath	*Calluna vulgaris*	*Vaccinium spp.*	*Empetrum spp.*	
D2	Wet dwarf shrub heath	*Molinia caerula*	*Erica tetralix*		
D3	Lichen/bryophyte heath				
D4	Montane heath/dwarf herb	*Alchemilla alpina*	*Saxifraga spp.*		
D5	Dry heath/acid grassland mosaic	*Ulex spp.*	*Deschampsia flexuosa*		
D6	Wet heath/acid grassland mosaic	*Molinia caerula*	*Erica tetralix*		
E1	Bog	*Sphagnum imbricatum*	*Eriophorum vaginatum*	*Drosera rotundifolia*	
E2	Flush and spring	*Sphagnum spp.*	*Glyceria spp.*	*Carex flacca*	
E3	Fen	*Sphagnum spp*	*Phragmites australis*		
E4	Bare peat				
F1	Swamp	*Typha spp.*	*Phalaris arundinacea*		
F2	Marginal/inundation	*Alnus glutinosa*	*Nastutium officinale*	*Polygonum spp.*	
G1	Standing water	*Nuphar lutea*	*Phragmites australis*		
G2	Running water	*Salix fragilis*			
I1.1	Inland cliff				
I1.2	Scree				
I1.3	Limestone pavement				
I1.4	Other exposure				
I1.5	Cave				
I2	Artificial inland rock and waste				
J1.1	Cultivated/disturbed land - arable	*Brassica napus ssp oleifera*	*Papaver rhoeas*		
J1.2	Cultivated/disturbed land - amenity				
J1.3	Cultivated/disturbed land - ephemeral/				
J1.4	Introduced shrub	*Rhododendron ponticum*			
J2.1.1	Hedges - intact - species-rich	*Ilex aquifolium*	*Cornus sanguinea*	*Rosa spp.*	*Euonymus europaeus*
J2.1.2	Hedges - intact - species-poor	*Crataegus monogyna*	*Sambucus nigra*		
J2.2.1	Hedges - defunct - species-rich				
J2.2.2	Hedges - defunct - species-poor				
J2.3.1	Hedges - with trees - species-rich				
J2.3.2	Hedges - with trees - species-poor				
J2.4	Fence				
J2.5	Wall				
J2.6	Dry ditch				
J2.7	Boundary removed				
J2.8	Earth bank				
J3	Built up areas				
J4	Bare ground				
J5	Other habitat				

5.4 Field survey form

The field survey form is shown in below. At least one field survey form is completed for each LDU, recording up to four area and linear habitat types. Where more habitat types are present, additional forms are completed as required. In the following description, the text in **bold type** refers to attributes recorded on the survey form. Each form is referenced with a unique code (**LDU code**) that identifies the LDU, the survey **Date** and text describing the **Location.**

The upper half of the form contains four groups of boxes for recording **Area habitats**. A code identifying the Phase 1 type of the habitat is entered in **Habitat type**, with codes drawn from the condensed Phase 1 classification (Table 3). An estimate of the range of patch sizes of the habitat is recorded in hectares (**Area / ha**). The size classes have been chosen to record a wide range of patch size and to permit their easy identification in the field. The **Extent** of the habitat is recorded using the following categories:

- **Extensive**, occurring across the entire LDU;
- **Widespread**, occurring frequently across the entire LDU;
- **Localised**, occurring in only some parts of an LDU, or associated with a physical landscape feature;
- **Occasional**, occurring only rarely.

An estimate of the percentage **Cover** of the habitat type is recorded, using broad categories that are easy to identify in the field. The **Proximity Self** attribute records the adjacency of other patches of the same habitat type, for example, the distance from one patch of woodland to an adjacent patch. This proximity is recorded using the following categories:

- **Adjacent**, occurring directly beside a patch of similar habitat, or separated only by a field boundary such as a hedgerow or dry-stone wall;
- **Near < 50m**, occurring within 50m of a patch of similar habitat;
- **Distant**, occurring more than 50m of a patch of similar habitat.

Any other habitats (area or linear) that are consistently found **Adjacent** or **Near** to patches of the currently considered habitat are recorded in **H1** and **H2**, using the condensed Phase 1 classification (Table 3). The ten empty boxes allow species that have been observed within the habitat type to be recorded, using the short text species codes from the Phase 1 habitat survey manual (JNCC 1993). The larger boxes provide space for recording free text notes that apply to all occurrences of the habitat type (**W**) and that apply only in localised parts of the habitat type (**L**).

Living Landscapes Project
Ecological Field Survey 2001

Date	Location	LDU Code

Area habitats

Habitat type	Area / ha	Extent	Cover	Proximity	H1	H2	T	I
	> 100 10 – 100 1 – 10 0.1 - 1 0 – 0.1	Extensive Widespread Localised Occasional	> 66% 33 - 66% 10-33% 0-10%	Self Adjacent Near <50m Distant	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Area / ha	Extent	Cover	Proximity	H1	H2	T	I
	> 100 10 – 100 1 – 10 0.1 - 1 0 – 0.1	Extensive Widespread Localised Occasional	> 66% 33 - 66% 10-33% 0-10%	Self Adjacent Near <50m Distant	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Area / ha	Extent	Cover	Proximity	H1	H2	T	I
	> 100 10 – 100 1 – 10 0.1 - 1 0 – 0.1	Extensive Widespread Localised Occasional	> 66% 33 - 66% 10-33% 0-10%	Self Adjacent Near <50m Distant	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Area / ha	Extent	Cover	Proximity	H1	H2	T	I
	> 100 10 – 100 1 – 10 0.1 - 1 0 – 0.1	Extensive Widespread Localised Occasional	> 66% 33 - 66% 10-33% 0-10%	Self Adjacent Near <50m Distant	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Linear habitats

Habitat type	Width / m	Height / m	Extent	Conditon	H1	H2	T	I
	>10 5 - 10 1 - 5 < 1	>5 2 – 5 1 – 2 < 1	Widespread Localised Occasional	Continuous Interrupted Scattered Relic	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Width / m	Height / m	Extent	Conditon	H1	H2	T	I
	>10 5 - 10 1 - 5 < 1	>5 2 – 5 1 – 2 < 1	Widespread Localised Occasional	Continuous Interrupted Scattered Relic	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Width / m	Height / m	Extent	Conditon	H1	H2	T	I
	>10 5 - 10 1 - 5 < 1	>5 2 – 5 1 – 2 < 1	Widespread Localised Occasional	Continuous Interrupted Scattered Relic	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

Habitat type	Width / m	Height / m	Extent	Conditon	H1	H2	T	I
	>10 5 - 10 1 - 5 < 1	>5 2 – 5 1 – 2 < 1	Widespread Localised Occasional	Continuous Interrupted Scattered Relic	Adjacent Near	Adjacent Near	C I D S N	H M L N
				W		L		

The lower half of the form contains four groups of boxes for recording **Linear features**. A code identifying the Phase 1 type of the habitat is entered in **Habitat type**, with codes drawn from the condensed Phase 1 classification (Table 3). An estimate of **Width /m** and **height /m** of the linear habitat are recorded. The **Extent** of the habitat is recorded using the following categories:

- **Widespread**, occurring frequently across the entire LDU;
- **Localised**, occurring in only some parts of an LDU, or associated with a physical landscape feature;
- **Occasional**, occurring only rarely.

An assessment of the continuity of the linear features is recorded using to the following categories:

- **Continuous**, linear features are unbroken throughout their length
- **Interrupted**, there are occasional gaps in linear features
- **Scattered**, there are frequent gaps in linear features
- **Relic**, the linear feature is marked by only occasional remnants

Area or linear habitats that are consistently found **Adjacent** or **Near** to patches of the currently considered habitat are recorded in **H1** and **H2**, using the condensed Phase 1 classification (Table 3). The ten empty boxes allow species that have been observed within the habitat type to be recorded, using the short text species codes from the Phase 1 habitat survey manual (JNCC 1993). The larger boxes provide space for recording free text notes that apply to all occurrences of the habitat type (**W**) and that apply only in localised parts of the habitat type (**L**).

5.5 Field Survey Programme

During the summer of 2000, several field visits were made to test different versions of the Field Survey Form. The Field Survey Form was evaluated in terms of the quality of data gathered and its ease of use. A field survey was planned to start in April 2001 but this was postponed due to the Foot and Mouth outbreak. Field survey work was resumed in late summer 2001, with initial field visits in uninfected areas of Oxfordshire, extending into Herefordshire and Derbyshire. LDUs covering a range of landscape types were surveyed. Figure 8 shows the percentage cover of broadleaved woodland – semi-natural (Phase 1 class A.1.1.1) in southwest Herefordshire, as derived from the field survey data.

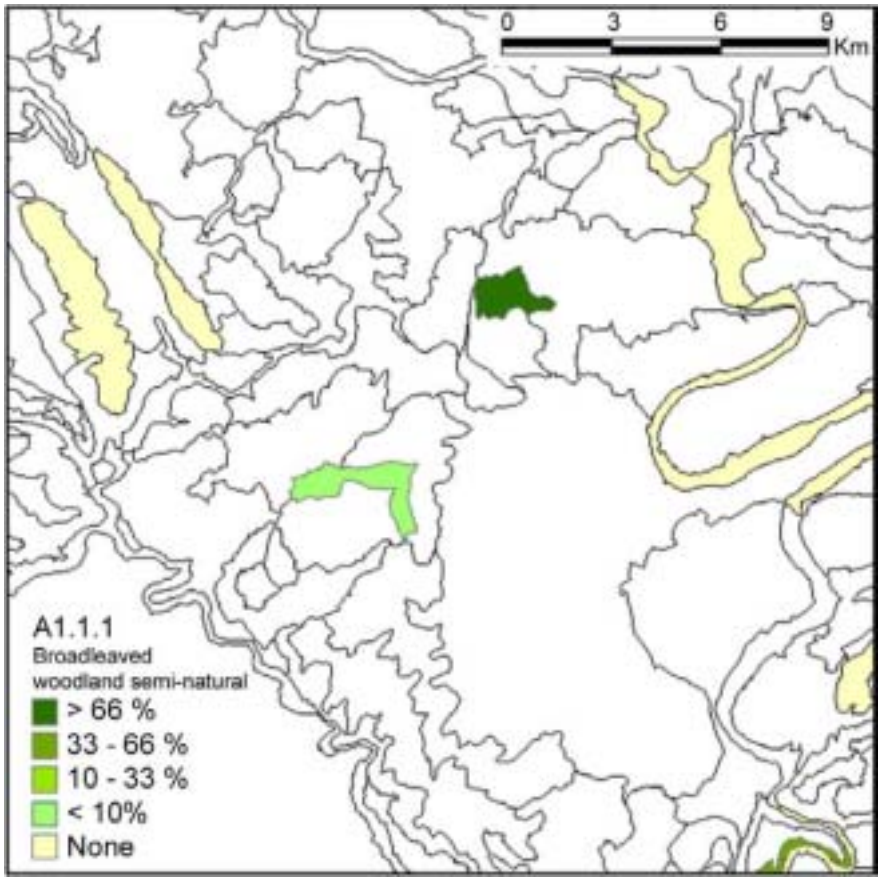

Figure 8. Map showing the estimated cover of Broadleaved woodland – semi-natural (A111) in southwest Herefordshire, derived from the landscape level field survey. White areas were not surveyed.

5.6 Improving the method

The method of landscape-level ecological survey is sufficiently flexible to be used in a wide variety of landscape types, from lowland floodplains, to wooded hills and upland moors. The level of resolution provided by the condensed Phase 1 habitat survey is manageable for recording habitats over large areas of landscape. The method can be completed by surveyors as part of a Landscape Character Assessment.

The rapid and broad scale approach to field survey will inevitably lead to the under-recording of certain landscape elements and habitat types. Landscape elements that are not visible from public rights-of-way or that are screened by trees will be under-recorded. For example, small ponds are often obscured behind hedgerows or in field corners. Habitat types that are not easy to identify also cause problems. This is particularly a problem for grassland habitats, where only detailed survey work can distinguish between different grassland habitat types at many times of the year. Additional information, such as designations and habitat inventories, can be incorporated into the analysis to provide further detail. There is also considerable potential for increasing both the efficiency and the accuracy of the field survey process, by referring to current digital aerial photography.

It is important that the area of an LDU is considered in any analysis and presentation of the field survey data. The area of LDUs can have an influence on the number of habitat types that are observed. There is not a simple relationship between LDU area and number of habitats

because the LDU mapping process identifies consistent patterns of soils, landform, land use etc. Further investigation is required to study the effect of LDU area on its composition and pattern of biodiversity.

6. Comparison of the LDU typology with other datasets

An important aspect of the project was to demonstrate the extent to which the Landscape Character framework captures spatial differences in ecological characteristics at a landscape scale. This is important because we need to know whether the resolution (information content and spatial properties) contained in the Level 2 LDU mapping is significantly better than existing datasets, for example English Nature Natural Areas; Joint Character Areas and the New Typology (a subdivision of Countryside Character Areas based on the Living Landscapes method).

6.1 Ecological characteristics

We have used the type and spatial pattern of semi-natural habitats as a proxy for defining differences in ecological characteristics. This is a limited definition, failing in particular to account for habitat quality as an equally important determinant of biodiversity. However, basic theory in landscape ecology combined with information on the habitat preferences of different species demonstrates that the type, area and connectivity of habitat patches explains a proportion of the observed differences in species presence and abundance at landscape scales.

6.2 English Nature Natural Areas

English Nature Natural Areas provide a broad scale subdivision of England designed to capture ecological variation at a national scale. National biodiversity targets have been set for each Natural Area (Natural Area Profiles) as the first stage in delivering improvements in biodiversity across the country. However, each Natural Area encompasses a range of LDUs and Landscape Types at Level 1 and a further sub-set of LDUs and Landscape Types at Level 2. Which level in this hierarchy should be adopted as the framework for capturing ecological variation and, by inference, as the basis for setting national biodiversity targets? A potentially important application is the refinement of existing national targets to assist with biodiversity targeting.

Figure 9 is a detail of the Landscape Types map for Derbyshire and Staffordshire with the Natural Area boundary superimposed. There are strong contrasts between Natural Areas, with the Natural Area boundaries frequently running close to a boundary between two Landscape Types. The boundaries are not exactly the same because of the differing scales of the datasets, with Natural Areas developed at a broad, national scale.

The Midlands Landscape Types and English Natural Areas were cross-tabulated, using ESRI ArcView Spatial Analyst. The area of each Natural Area covered by different Landscape Types was calculated and expressed as a percentage of the total area of the Natural Area that intersects with the Midlands LDU dataset. Table 4 shows the area covered by each Landscape Type expressed as a percentage of the total extent of each English Nature Natural Area in the study area.

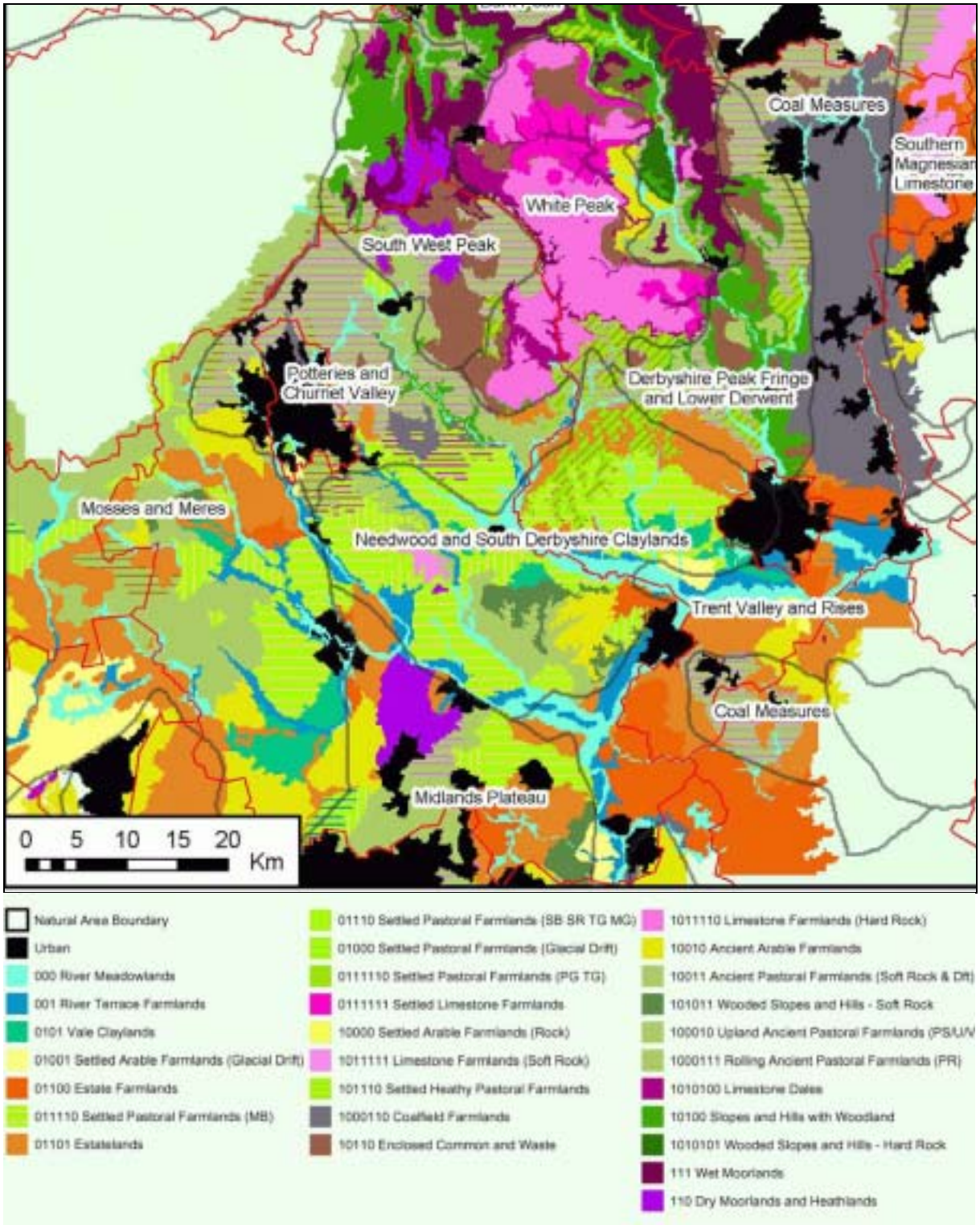

Figure 9. Landscape Types, defined by use of TWINSPAN in Derbyshire and Staffordshire, together with English Nature Natural Areas

Table 4. Percentage cover of Landscape Types within English Nature Natural Areas

	23 Southern Magnesian Limestone	24 Coal Measures	25 Dark Peak	27 Mosses and Meres	28 Potteries and Churnet Valley	29 South West Peak	30 White Peak	31 Derbyshire Peak Fringe and Lower Derwent	33 Trent Valley and Rises	40 Needwood and South Derbyshire Claylands	41 Oswestry Uplands	42 Shropshire Hills	43 Midlands Plateau	44 Midland Clay Pastures	55 Cotswolds	56 Severn and Avon Vales	57 Malvern Hills and Teme Valley	58 Clun and North West Herefordshire Hills	59 Central Herefordshire	60 Black Mountains and Golden Valley	61 Dean Plateau and Wye Valley	63 Thames and Avon Vales	64 Midvale Ridge	65 Chilterns	79 Berkshire and Marlborough Downs
000 River Meadowlands	-	3	2	6	7	1	<1	4	19	11	4	3	3	4	3	11	6	7	10	2	5	21	4	5	1
001 River Terrace Farmlands	-	<1	-	5	1	-	-	-	13	5	1	2	<1	-	-	2	1	8	4	<1	1	13	3	4	<1
0101 Vale Claylands	-	-	-	3	-	-	-	-	1	5	-	-	1	27	12	20	-	-	-	-	-	30	9	-	<1
01001 Settled Arable Farmlands (Glacial Drift)	-	-	-	17	1	-	-	-	3	1	-	3	1	-	<1	1	-	6	19	15	<1	<1	-	2	-
01100 Estate Farmlands	28	5	-	1	-	-	-	-	36	1	12	-	2	49	28	5	-	-	-	-	-	21	38	11	-
011110 Settled Pastoral Farmlands (MB)	-	-	-	4	8	-	-	-	1	32	-	-	4	13	3	-	-	-	-	-	-	<1	-	-	-
01101 Estatelands	6	9	-	16	4	-	<1	6	22	9	-	<1	37	3	18	10	6	<1	1	-	1	10	43	<1	35
01110 Settled Pastoral Farmlands (SB SR TG MG)	-	-	-	4	1	<1	-	-	<1	7	-	-	1	-	1	5	-	-	-	-	-	-	-	-	-
01000 Settled Pastoral Farmlands (Glacial Drift)	-	-	-	6	-	-	-	-	-	-	1	<1	1	-	-	3	<1	<1	1	<1	-	-	-	-	-
0111110 Settled Pastoral Farmlands (PG TG)	1	<1	3	-	1	<1	5	10	-	7	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-
0111111 Settled Limestone Farmlands	-	-	<1	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10000 Settled Arable Farmlands (Rock)	-	-	-	-	-	-	-	-	1	-	-	7	-	-	-	-	1	1	11	-	32	-	-	-	41
1011111 Limestone Farmlands (Soft Rock)	33	-	-	-	-	-	-	-	-	1	-	-	-	-	19	-	-	-	-	-	-	2	-	-	-
101110 Settled Heathy Pastoral Farmlands	-	-	-	<1	7	-	-	<1	-	1	-	-	-	-	2	<1	-	-	-	-	-	-	1	-	-
1000110 Coalfield Farmlands	16	55	-	-	5	<1	-	6	1	-	25	-	1	-	-	-	-	-	-	-	-	-	-	-	-
10110 Enclosed Common and Waste	-	1	6	1	1	18	13	13	-	-	-	1	-	-	-	<1	-	<1	-	6	-	-	-	-	-
1011110 Limestone Farmlands (Hard Rock)	-	-	1	1	<1	<1	45	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-
10010 Ancient Arable Farmlands	3	2	1	10	3	-	3	-	3	4	-	21	16	-	<1	31	32	8	42	5	19	<1	-	1	3
10011 Ancient Pastoral Farmlands (Soft Rock & Dft)	-	<1	3	24	11	6	<1	4	<1	10	-	22	8	4	2	10	8	5	1	13	16	<1	-	8	-
101011 Wooded Slopes and Hills - Soft Rock	2	-	-	1	1	-	-	-	<1	4	-	-	2	1	10	-	-	-	-	-	-	1	1	68	20
100010 Upland Ancient Pastoral Farmlands (PS/U/V)	11	23	8	<1	42	23	4	27	1	1	14	3	4	-	-	-	18	2	2	-	3	-	-	-	-
1000111 Rolling Ancient Pastoral Farmlands (PR)	-	1	-	2	5	2	-	4	-	1	<1	<1	-	-	-	-	18	-	3	2	5	-	-	-	-
1010100 Limestone Dales	-	-	1	-	-	2	13	<1	<1	-	-	1	<1	-	-	-	<1	-	-	-	<1	-	-	-	-
10100 Slopes and Hills with Woodland	-	<1	15	1	2	20	1	23	<1	-	36	20	4	-	-	1	7	51	2	47	13	-	-	-	-
1010101 Wooded Slopes and Hills - Hard Rock	-	-	7	-	-	-	-	-	-	-	-	3	8	-	-	-	1	6	3	4	3	-	-	-	-
111 Wet Moorlands	-	<1	53	-	-	15	2	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The Southern Magnesium Limestone Natural Area is mainly comprised of:

limestone farmlands – Soft rock (33%)
estate farmlands (28%)
coalfield farmlands (16%)

The Coal Measures Natural Area is dominated by:

coalfield farmlands (55%)
upland ancient pastoral farmlands (23%)

The Dark Peak Natural Area is dominated by:

wet moorlands (53%) and
slopes and hills with woodlands (15%)

The White Peak Natural Area is dominated by:

limestone farmlands (45%) and,
equal proportions (13%) of settled limestone farmlands, enclosed common and waste and limestone dales.

The Derbyshire Peak Fringe and Lower Derwent Natural Area is dominated by:

upland ancient pastoral farmland (27%) and,
slopes and hills with woodland (23%).

The Trent Valley and Rises Natural Area is dominated by:

estate farmlands (36%), estatelands (22%),
river meadowlands (19%) and
river terrace farmlands (13%).

There is clearly a very strong relationship between English Nature Natural Areas and LDUs / Landscape Types. Natural Area boundaries are often associated with a change in Landscape Type and the proportionate cover of Landscape Types is markedly different between Natural Areas. However, the different scale of data used to define Natural Areas, LDU Level 1 and LDU Level 2 maps introduces discrepancies between the boundaries and at each level.

6.3 Landscape types & the satellite land cover map of Great Britain

A similar analysis was performed to estimate the differences in land cover from the satellite Land Cover Map of Great Britain 2000 (LCM 2000) and Landscape Types. There are known to be inaccuracies in the Satellite Land Cover Map, resulting from the spectral similarity of some land classes under specific conditions. However, whilst the map may be inaccurate in detail, realistic estimates of the area and distribution of land cover can be obtained. In order to reduce the number of land cover classes and to reduce the errors associated with the grassland categories, Aggregate Classes were used. Table 5 shows the relationship between LCM2000 Target Classes, UK BAP Broad Habitats (BH) and the LCM2000 Aggregate Classes.

Table 5. Land Cover Map 2000 Aggregate Classes

Broad habitat	**LCM2000 Aggregate classes**		**LCM2000 Target class**
1. Broad-leaved woodland	Broad-leaved / mixed wood	1	Broad-leaved / mixed wood
2. Coniferous woodland	Coniferous woodland	2	Coniferous woodland
4. Arable & horticultural	Arable and horticultural	3	Arable and horticultural
5. Improved grassland	Improved grassland	4	Improved grassland
6. Neutral grass	Semi-natural / rough grass and	5	Neutral / calcareous
7. Calcareous grass	bracken		semi-natural / rough
8. Acid grass			grasslands
9. Bracken			Acid grass and bracken
11. Fen, marsh and swamp			Fen, marsh and swamp
12. Bogs	Mountain, heath and bog	6	Bogs (deep peat)
			Dwarf shrub heath
10. Dwarf shrub heath			
15. Montane habitats			Montane habitats
16. Inland rock			Inland Bare Ground
17. Built up areas, gardens	Built-up & Gardens	7	Suburban and urban
13. Standing water / canals	Standing Open Water and Canals	8	Water (inland)
20. Littoral rock	Coastal	9	Littoral rock and sediment
21. Littoral sediment			
18. Supra-littoral rock			Supra-littoral rock and
19. Supra-littoral sediment			sediment
22. Inshore sublittoral	Sea	0	Sea / Estuary
20 relevant BHs	10 Aggregate classes		16 target classes

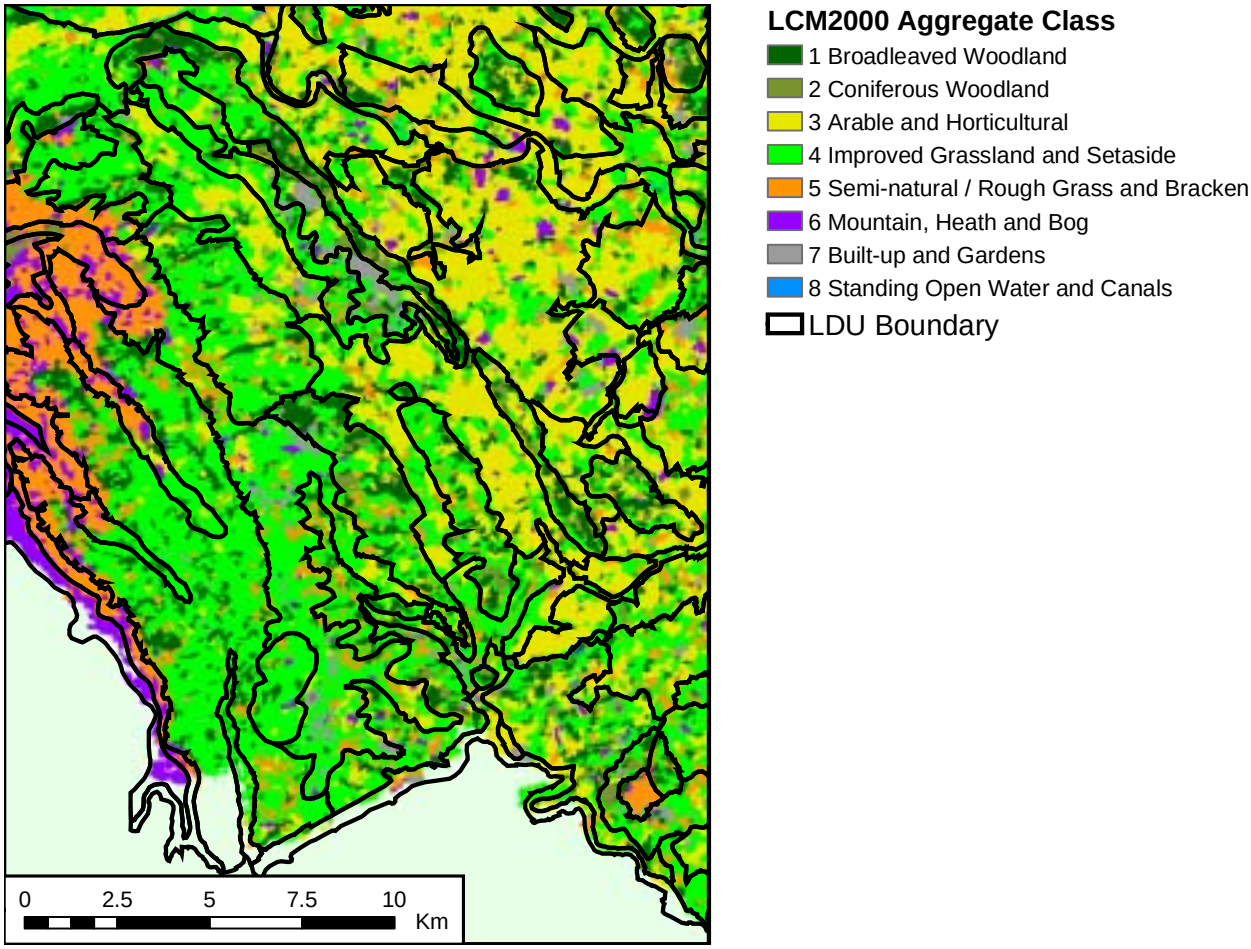

Figure 10. Superimposition of Landscape Types onto the Land Cover 2000 Map for southwest Herefordshire

The comparison is illustrated visually in Figure 10 and in tabular format in Table 6. Figure 10 shows marked differences in the area of LCM2000 Aggregate Classes mapped from the satellite classification and the Landscape Types superimposed onto the satellite map. Table 6 shows how the highest proportion of Broadleaved/Mixed Woodland cover occurs in the 'Wooded Slopes and Hills – Hard Rock' Landscape Type. Generally there is a high proportion of Broadleaved / Mixed Woodland cover in the 'ancient' landscapes that are associated with ancient woodland and a low proportion in the 'farmlands' landscapes that are associated with good agricultural soils. It can be observed that the highest proportion of the Semi-natural/Rough Grass and Bracken occurs in the 'Enclosed Common and Waste' and 'Dry Moorlands and Heathlands' Landscape Types.

Table 6. Percentage cover of LCM2000 Aggregate Classes derived from the Land Cover Map (LCM2000) of Great Britain in each Landscape Type for Herefordshire.

	LCM2000 Broad Habitats							
Landscape types	Standing Open Water and Canals	Built-up & Gardens	Mountain, heath and bog	Semi-natural / Rough Grass and Bracken	Improved Grassland	Arable and Horticultural	Coniferous Woodland	Broad-leaved / Mixed Woodland
000 River Meadowlands	3	3	1	10	34	40	1	7
001 River Terrace Farmlands	0	3	1	11	31	46	1	7
0101 Vale Claylands	0	4	0	15	42	30	0	9
01001 Settled Arable Farmlands (Glacial Drift)	0	2	1	11	28	49	1	7
01100 Estate Farmlands	0	4	0	8	32	51	0	5
01101 Estatelands	0	8	1	9	25	40	3	14
01110 Settled Pastoral Farmlands (SB SR TG MG)	0	1	0	11	40	42	1	6
01000 Settled Pastoral Farmlands (Glacial Drift)	0	4	1	16	35	35	0	9
0111110 Settled Pastoral Farmlands (PG TG)	0	3	2	14	27	46	0	8
10000 Settled Arable Farmlands (Rock)	0	4	2	9	28	48	1	6
10110 Enclosed Common and Waste	0	0	11	40	36	5	2	5
10010 Ancient Arable Farmlands	0	3	1	10	38	36	2	10
10011 Ancient Pastoral Farmlands (Soft Rock & Dft)	0	4	1	11	44	26	3	11
100010 Upland Ancient Pastoral Farmlands (PS/U/V)	1	4	1	8	45	19	5	18
1000111 Rolling Ancient Pastoral Farmlands (PR)	0	3	1	10	48	20	3	15
10100 Slopes and Hills with Woodland	0	2	3	14	43	14	6	17
1010101 Wooded Slopes and Hills - Hard Rock	1	2	1	10	29	14	16	26

The relationship between the Landscape Types and the Land Cover map provides an example of how finer grained information can be presented and analysed within the LDU framework.

7. Ecological applications

Landscape evaluation needs to do more than simply identify important or 'high quality' landscapes. It must also be capable of making judgements about the relative sensitivity of different types of landscape, their current condition and their vulnerability to change. This includes historical and aesthetic properties of a landscape as well as its ecological characteristics. Thus, Landscape Character Assessment can be used to, (i) establish appropriate targets for habitat restoration at a range of scales, (ii) undertake sensitivity analysis to determine the potential for change and, (iii) make an assessment of condition to determine needs and opportunities for change.

7.1 Biodiversity targets

Setting biodiversity targets at a range of scales from the national to the regional to the local, is a potentially important application of Landscape Character Assessment. The challenge is to determine biodiversity targets at national and regional scales that can subsequently be translated into the selection of specific sites for habitat restoration or re-creation at the local, site scale.

Priority Habitat Action Plans provide detailed descriptions for 45 specific habitat types at the national scale. They set out detailed actions that order to protect and enhance these habitats (JNCC 2001). However, the targets are national with limited reference to specific counties

and regions. Many of the targets specify the importance of targeting restoration and re-creation outside SSSIs and NNRs for which monitoring of ecological status is already in place. It is important therefore, not only to develop a system for establishing regional targets but also to monitor progress towards the achievement of those targets in the wider countryside outside designated sites.

7.1.1 Regional scale

At the regional level information on the distribution of characteristic habitats and protected sites (SSSIs, NNRs, County Wildlife Sites) and the location of 'core' biodiversity areas can be used to develop more specific BAP (Biodiversity Action Plan) targets for habitats. A good example is the Life ECONet project that used GIS techniques in Cheshire to define 'core' biodiversity areas and to establish corridor links between them. However, this approach fails to take into account the critical differences in the physical and cultural attributes between landscapes and therefore, the appropriateness or otherwise, of proposed habitat restoration or re-creation.

The following examples from Oxfordshire and, outside the study area in Wales for The Countryside Council for Wales (CCW), demonstrates how the landscape character framework can be used to determine appropriate targets for priority habitats. The targets are 'appropriate' only because they reinforce the existing character, physical and cultural, of a specific landscape. In many cases, public opinion may favour radical departures from existing character, but this is done in the full knowledge that it represents a significant change. A good example is The National Forest, where extensive woodland planting is having a major impact on the character of the landscapes.

Case Study 1: Landscape sensitivity in Oxfordshire

Aims: To derive an index of landscape sensitivity for the Oxfordshire Wildlife and Landscape Study (OWLS)

Objectives:

- Produce a map of inherent ecological character;
- derive a map of ecological sensitivity from inherent ecological character and ecological condition;
- generate a map of cultural sensitivity;
- combine ecological and cultural sensitivity to produce a map of landscape overall sensitivity.

Landscape sensitivity is a measure of a landscape's inherent vulnerability to change. Capacity by contrast, is an impact-related concept providing a measure of relative levels of acceptable change in a landscape in relation to specific development (Swanwick 2004).

Sensitivity is closely related to the nature and pattern of key elements that define the character of a particular landscape. Landscapes with 'time depth' (ie those that display a long and continuous history of evolution), together with those that are characterised by a clear and consistent pattern of key elements, tend to be more sensitive to change than landscapes of more recent origin, or those that have fewer distinguishing features. A landscape that has a clearly defined and strongly unified character will be more sensitive to change by virtue of the fact that such landscapes are less able to accommodate 'alien' features that do not conform to the existing pattern. Any analysis of sensitivity needs to look separately at the inherent character of the landscape, both ecological and cultural.

Inherent ecological character

The oldest (and by implication most sensitive) landscapes are those that still contain a high proportion of semi-natural habitat, mostly now found in moorland and upland areas. Most landscapes in the lowlands, however, have been settled and improved for agricultural production and as a result, any surviving semi-natural habitat is almost invariably associated with the cultural pattern (ie woodlands, field boundaries and other 'man made' features). Where such patches still survive they will increase overall sensitivity. Analysis of patch survival is largely a predictive exercise which looks at the current pattern of land use within the context of 'productive' and more 'marginal' ground types. The assumption is that a settled arable landscape on shallow slopes associated with good (brown/gleyed) soils is likely to have fewer patches of semi-natural habitat than a pastoral landscape associated with marginal (wetland, heathland, chalk & limestone or moorland) soils on steep slopes. This concept is summarised in Figure 11, below:

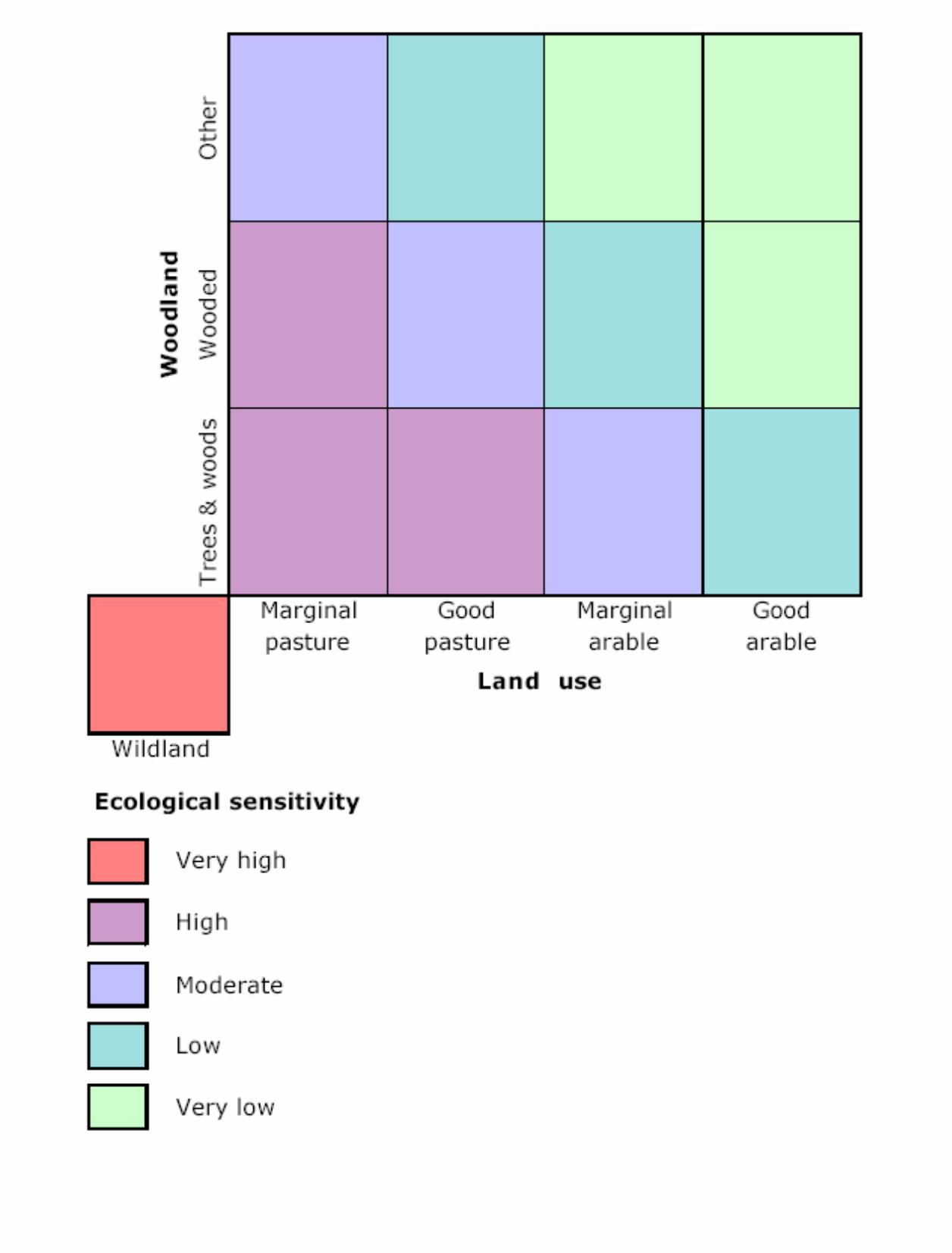

Figure 11. Matrix illustrating the concept of inherent ecological character

Ecological sensitivity

In the case of OWLS field survey data was available from recording the extent and pattern of surviving semi-natural habitats within each LDU, based on the method described in this report (Section 5.2) A weighted score was calculated for each LDU based upon the type and extent of surviving semi-natural habitat and expressed as a 'bioscore'. The numerical bioscore values were subsequently amalgamated into categorical 'bands' to give a general assessment of the ecological condition of each LDU. The availability of mapped bioscores made it possible to combine the assessment of inherent ecological character derived from the GIS-based desk-study with ecological condition as summarised in Figure 12.

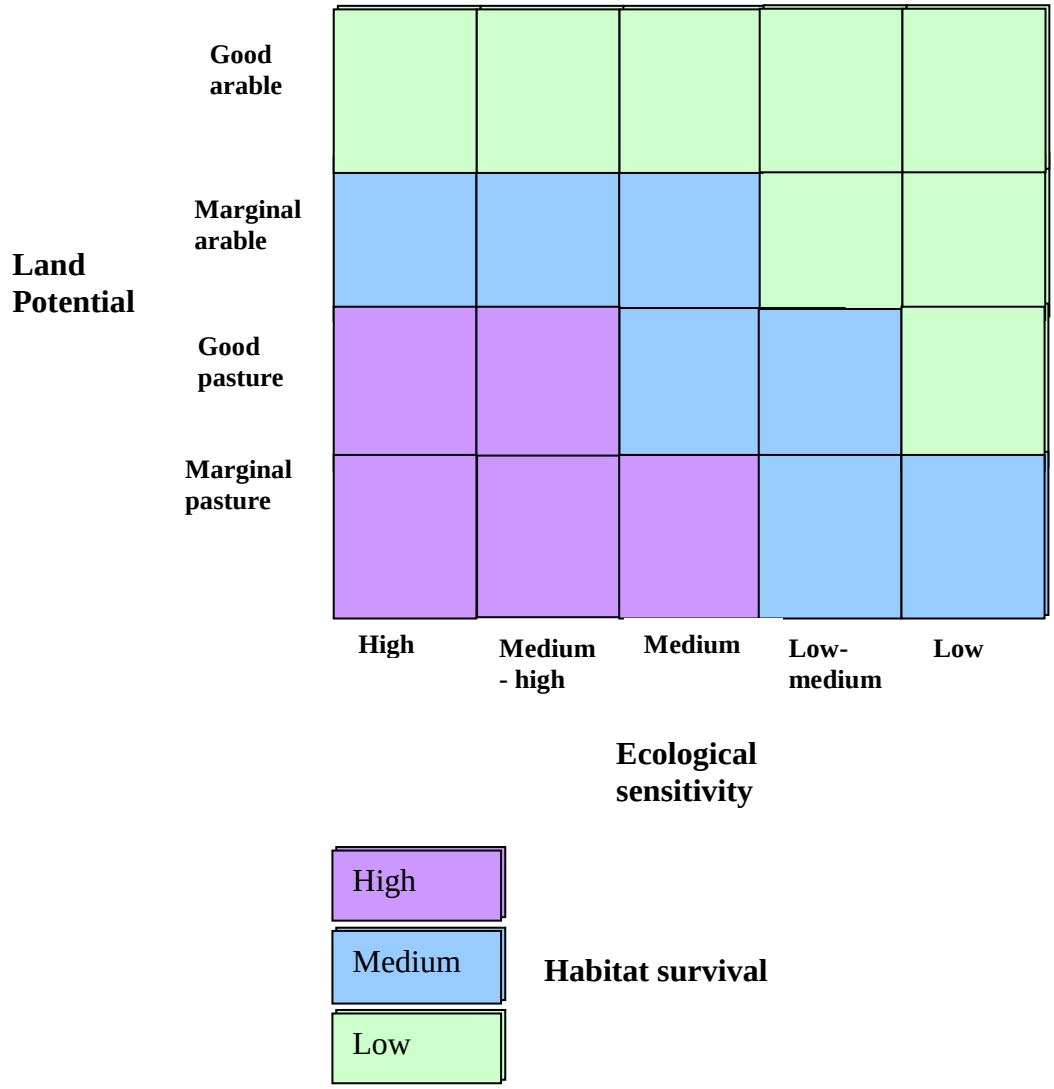

Figure 12. Matrix illustrating the concept of ecological sensitivity, based on a combination of habitat potential and habitat survival.

In this way a map of ecological sensitivity was generated for West Oxfordshire based on the combined attributes of 'habitat potential' and 'habitat survival from field survey (Figure 13). This type of mapping can extended to county and regional scales to assist with policies for biodiversity targeting and habitat restoration and re-creation.

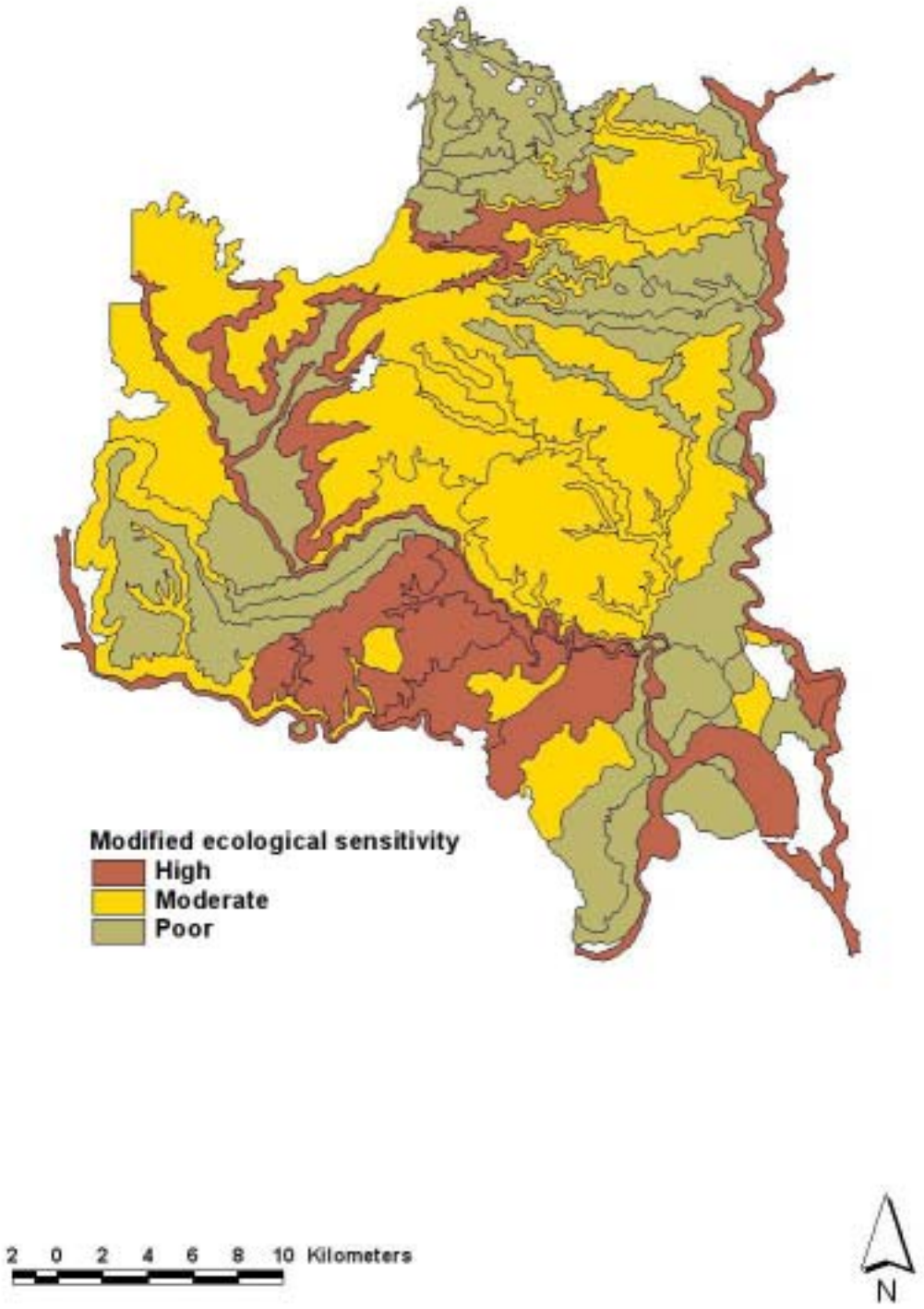

Figure 13. Ecological sensitivity for West Oxfordshire, based on a combination of inherent ecological character and habitat survival from field survey.

Case Study 2: Habitat restoration at the landscape scale in Wales

The restoration target and re-creation target for Upland oakwood in Wales is 2,200ha, distributed across all 24 Local Biodiversity Action Plan (LBAP) areas (Jones and others 2003). Similar targets have also been established for remaining priority habitats including, Lowland mixed deciduous woodland, Upland birchwood and Lowland wood-pasture and parkland. These figures are national targets and the criteria used to develop the targets and, more importantly, to select suitable sites for habitat re-creation remain ill-defined (Knightbridge 2000) with implications for effective long-term policy.

An important aim of the project is to determine the habitat potential of each LDU Landscape Type from knowledge of the environmental conditions under which it is typically found and to identify the cultural constraints. Thus, a LDU Landscape Type with a high potential to support, for example, Upland oak woodland but which only contains a few surviving and isolated fragments is deemed to be in poor condition but with the opportunity for significant habitat re-creation. Conversely, a LDU Landscape Type with a low potential to support a specific habitat type, for example, in areas where a habitat is transitional or at the edge of its range, but high actual extent may be more suitable for restoration and protection of the remaining extant habitat. These are policy decisions but it is anticipated that this type of analysis will assist with formulating policies to protect those habitats that remain and identify suitable sites for re-creation of habitats that have been lost.

Landscape Types are relatively large, covering in some cases 40 – 50 km^2 and incorporating a wide range of environmental conditions and cultural characteristics. At the next scale of analysis, the project is attempting to answer questions about 'which habitats, where and how much' within the context of updated habitat targets for each LDU Landscape Type. This is being achieved using a GIS habitat model, thus providing the link between the regional strategy for habitat targets and the local implementation for restoration and re-creation at the scale of the field-parcel.

For each target habitat the GIS-based model uses a set of spatial ecological decision rules to assign a suitability score for the creation of the target habitat within each land parcel. The ecological decision rules were informed with reference to questions about the development of a future landscape that conforms to a desirable ecological outcome at the scale of the Level 2 Landscape Description Unit:

- What is the influence of the existing habitat on the suitability for creation of a new habitat?
- What is the minimum desirable area for a new habitat patch?
- What is the optimum distance to other similar habitat patches?
- What role do adjacent land cover types play in determining the score for a target habitat type?
- What is the relationship between landscape character and habitat type?

The starting point of the model is the digitised Phase 1 Habitat Survey for Wales, a map of habitats for all field parcels.

A major component of the model is to ‘weight’ the output by Landscape Type in recognition of the critical significance of physical **and** cultural factors in determining the suitability, or otherwise, of a land parcel for re-creation of a target habitat type. The derived weights were based upon an assessment of the cultural constraints indicated by the typical pattern of woodland cover distributed across the LDUs in the study area (Figure 14a). These weights were subsequently used to transform the scores from the GIS habitat model output for each Active Land Parcel depending upon which LDU the field parcel was located. The resulting map is a score for each land parcel based upon the ecological decision rules and landscape character that can be used for targeting resources for habitat re-creation and/or restoration (Figure 14b).

The challenge is to determine the suitability of different Landscape Types for a range of habitat types to establish the correct ‘weights’ for the model. Further work is therefore required to establish the relationship between the physical and cultural attributes of a Landscape Type and its characteristic pattern of habitats.

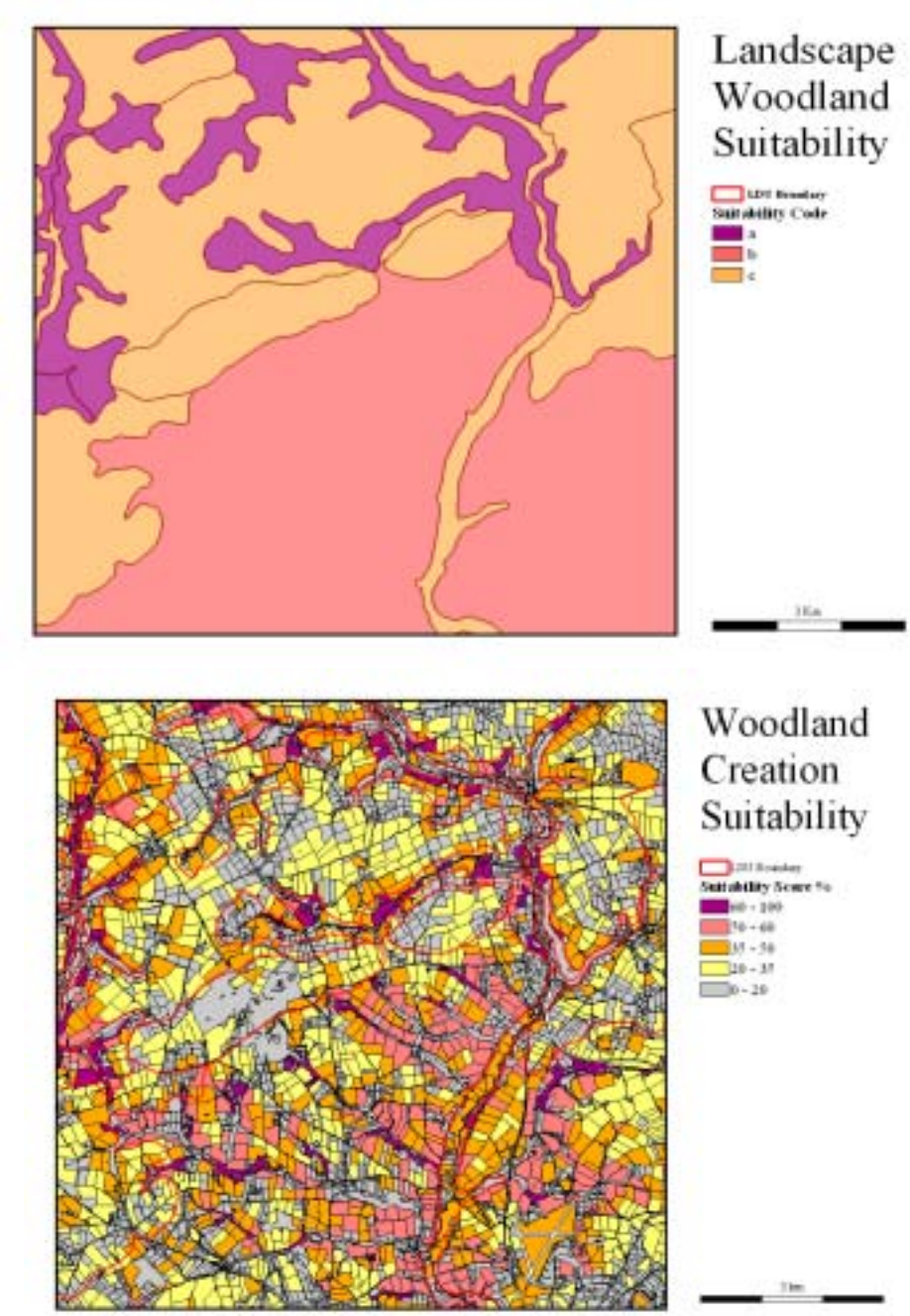

Figure 14. Two maps of the study area in Pembrokeshire showing weightings for suitability for broadleaf woodland re-creation (b) and the weighted scores by land parcel for broadleaf woodland re-creation.

8. Discussion and conclusions

Level 2 Landscape Description Units with their associated database of physical and cultural attributes, provide a robust description of variations in the character of the landscape at a regional scale. The system is robust, transparent and repeatable, based on nationally consistent data-sets with the advantages of data retrieval, analysis and display provided by GIS. The report has demonstrated a method for aggregating LDUs with similar attributes into a system of LDU Landscape Types that could be developed at the national scale. This would require the inclusion of information on climate data to account for the sharp climatic differences between the milder, wetter SW compared with an appreciably colder, drier NE.

LDUs provide an important strategic overview within which to develop policies for a multi-functional landscape in which the conflicting demands of agriculture, development, recreation and nature conservation need to be resolved. More specifically, the landscape character framework is an appropriate system within which to explore the relationship between landscape character and biodiversity. For example, further work is needed to explore the relationship between the wealth of species level data for a wide range of taxonomic groups soon to be available from the National Biodiversity Network and other sources and landscape character. Important questions about the species composition of different LDUs within the same Landscape Type will provide important insights into an assessment of ecological quality, the assumption being that units with a 'full' complement of species are in better condition compared with units that have lost species. In many cases the 'loss' of species may be diagnostic of a reduction in ecological quality, a situation that could be explored with reference to the type and extent of surviving semi-natural vegetation. Information on land use change and habitat survival from air-photography and field survey will be critical to explain observed differences. To some extent this has been achieved in West Oxfordshire, but this type of analysis needs to be expanded for a range of landscapes to begin to explore the complex relationship between landscape character and ecological condition.

The important distinction between character and condition is central to debate about the value of landscape character for rural policy. This report has concentrated upon the development of techniques for mapping Landscape Types over a relatively large area of varied countryside. However, it is recognised that for an assessment of character to be robust and acceptable it must relate to the presence of features in the contemporary landscape and not to a past landscape that can never be recovered. Character is therefore time dependent and, in highly degraded landscape where the pattern of surviving cultural features and their associated ecology are no longer strongly represented in the landscape, the inherent character of this landscape may have gone for good. Landscapes of this type have low sensitivity and, potentially, there is the opportunity, for example in some 20th Century post-industrial landscapes, to implement a new and very different vision for a future landscape. By contrast, some ancient landscapes with a strongly surviving cultural pattern are highly sensitive and many types of change would be irreversibly damaging. We need to refine methods for the objective assessment of landscape sensitivity and capacity to absorb change, based on consistent and nationally available datasets within the spatial framework of landscape character.

The issue of scale remains an important challenge. The Level 2 LDU is, given the limitations of contributing national data-sets, the optimal scale that can be achieved. The 1:50 000 scale of mapping provides the strategic overview for policy development, eg targeting resources

for agri-environment schemes, the assessment of ecological condition etc. Level 1 at the smaller scale of 1:250,000, although now available for the whole country and an improvement on Natural Areas and Countryside Character Areas, is too small for strategic planning at anything less than the national scale. However, in relation to development control, selecting sites for habitat restoration and other specific land management issues, Level 2 is also too broad scale and further division into Level 3 Land Cover Parcels is appropriate. LCPs, discrete areas of land bounded by roads, railways, water courses and parish boundaries where similar patterns of land use, field pattern and tree cover are evident, provide a finer grain of resolution at the sub-landscape scale.

The main challenge, however for the continued development of a spatial framework for landscape planning, is the integration of disciplines and data to develop an increasingly holistic view of the landscape at multiple scales. The emerging national framework needs to capable of translating policies and targets from a national down to a local level. There must also be sufficient flexibility to ensure that the national spatial framework can be shaped by the results of local studies.

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Appendix 1: Level 2 Definitive attributes

Physiography

Phys

Geology *(structure)*		***Landform***	
F	Fluvial drift	**C**	Coastal dunes/shingle
T	Glacial drift	**M**	Marine levels
M	Soft (Mesozoic) rocks	**V**	Vales & valley bottoms
P	Hard (Palaeozoic) rocks	**R**	Rolling/undulating
C	Hard (Caledonian) rocks	**P**	Low plateau
I	Ancient/Igneous rocks	**S**	Sloping (Low hills)
		U	High plateau (>300m)
		H	High hills (>600m)

Ground type

Ecol

Rock type		***Soils*** *(broad habitat)*		
W	Alluvium/fen peat	**R**	Raw soils (saltmarsh)	
S	Sand/gravel	**D**	Impoverished	- mineral (SD,PD)
C	Clay & chalky till			- humic (HD)
T	Other till/plateau drift	**R**	Shallow soils	- base poor (PR)
M	Mixed soft rock			- base rich (LR)
S	Soft sandstone	**B**	Deep soils	- sandy (SB)
L	Chalk & limestone			- loamy (PB,LB)
I	Igneous/metamorphic rocks			- wetland (WB)
P	Other hard rock	**G**	Gleyed soils	- base poor (PG)
H	Humic drift			- base rich (CG)
				- wetland (WG)
		T	Deep peat	

Cultural pattern

Cult

Pattern *(Settlement)*		***Farm type***	
N	Nucleated	**E**	Large estates
C	Clustered	**S**	Small estates
S	Settled	**R**	Large owner (>65ha)
D	Dispersed	**O**	Small owner (<65ha)
P	Planned (waste)	**U**	Unenclosed/common land
M	Unsettled - meadow		
R	Unsettled - wild land		
U	Coalfields		
Ur	Urban		

Landcover

Land

Pattern *(Farm type)*		***Tree cover***	
C	Arable farms	**W**	Wooded - ancient
F	Mixed farms	**S**	Wooded - recent
P	Pastoral farms	**A**	Trees & woods
W	Woodland	**G**	Coverts & tree groups
R	Rough/wild land	**T**	Other trees
X	Disturbed	**O**	Open/unwooded
Ur	Urban		

Appendix 2: The Project Steering Group

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