Natural England Research Report NERR051

Assessing the potential consequences of climate change for England's landscapes: the South Downs National Park

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Assessing the potential consequences of climate change for England's landscapes: the South Downs National Park

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Project details

This work was carried out in order to consider the vulnerability of the natural environment to climate change in the South Downs. It was undertaken by: Sarah Taylor, Roger Matthews, Nicholas Macgregor and Andy Neale from Natural England, and Nikki Van Dijk and Geoff Darch from Atkins.

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Summary

This study considered the vulnerability of the natural environment to climate change in the South Downs National Park. This landscape of national significance is dominated by the chalk spine which stretches from Winchester in the west to the white cliffs of Beachy Head in the east, rising gently from the South Coast Plain before ending with a north-facing scarp. To the north the older sandy rocks of the Lower Greensand and soft shales of the Wealden Clays are exposed. The Low Weald is characterised by broad, low lying and gently undulating clay vales. Rivers from the Low Weald and the Wealden Greensand cut through the chalk to form deep river valleys and broad floodplains. The area is rich in wildlife, supporting a wide range of important habitats such as chalk grassland, heathland, floodplain grazing marsh, ancient semi-natural woodland and coastal habitats.

The vulnerability of the natural environment in the South Downs National Park was assessed by considering how it is exposed to changes in climatic conditions, how sensitive it is to those changes (including its ability to adapt, which can be influenced by its current condition) and how much scope there is for conservation management to promote adaptation. This assessment of vulnerability is based on the best available scientific knowledge of how climate change might affect the natural environment and discussions with experts. The assessment considered both landscape assets (biodiversity, heritage, soils and geology) and its ecosystem service functions.

Geomorphological processes which help to shape the National Park may be altered by an increase in erosion and sedimentation. This may lead to impacts on iconic features such as the chalk cliffs. The chalk aquifer which provides many people with fresh water may be more susceptible to drying out and winter recharge may be reduced.

The assessment highlighted that habitats in the South Downs National Park are likely to be vulnerable to climate change, for example changes in habitat extents and species composition. These are also likely to alter the overall character of the National Park. For example:

- Woodland is likely to experience changes in species, possible increased pests and disease and will be vulnerable to drought. Beech trees and woodlands on well-drained, south facing slopes are likely to be most affected.
- Chalk Rivers and streams will be vulnerable to drought leading to drying out of stream heads and changes in flow. This can lead to destabilisation of banks, an increase in sedimentation, concentration of pollution, reductions in habitat area, and a reduction in the effectiveness of flood storage services.
- Coastal habitats such as inter-tidal chalk and maritime cliff and slope are potentially vulnerable to erosion, rubble, landslides and permanent inundation from sea level rise. This is particularly relevant to Seaford to Beachy Head SSSI.
- Wetlands such as floodplain grazing marsh are vulnerable to cycles of drought and flood leading to waterlogging and increased siltation, but also drying out, causing loss of habitat for wetland birds and soil erosion. Increased demand for water and changes in management, such as grazing practices, will exacerbate the vulnerability of this habitat. These impacts are particularly relevant to the Arun Valley SPA and associated SSSIs and Local Wildlife Sites.
- Lowland heath is particularly vulnerable to drought and increased summer temperatures, which may lead to changes in the composition of plant communities. Drier summers will also increase the risk of fires. These impacts are particularly relevant to the heaths of the Wealden greensand in West Sussex and extending in to Hampshire.
- Chalk grassland is vulnerable to drought and increased winter rainfall, leading to changes in species composition, parching and erosion of soils, and increased fire risk. In addition to direct impacts of climate change, chalk grassland could be vulnerable to changes in land management.

- Historic designed landscapes may be vulnerable to higher temperatures and drought leading to the loss of characteristic vegetation. Historic wetlands are likely to be impacted by seasonal changes in precipitation. The extensive archaeology, historic buildings and historic landscapes in the National Park will be vulnerable to changes in land management, increased rainfall penetration and erosion.
- Key access and recreation assets such as footpaths may be vulnerable to erosion due to drought in summer, flooding in winter and increased visitor use. Country Parks and other sites will be vulnerable to both drought and flooding, which could damage sites, alter the landscape, and potentially reduce access.

Climate change could bring opportunities for food production in the area and farmers may respond by growing more or changing to different crop types. But, changes in agriculture could have consequences for the natural environment and add to the pressure on soils, water and habitats. Changes in agriculture could also change the appearance of the landscape.

It is likely that the landscape of the National Park will change due to the direct impacts of climate change, but also society's response to changing climate. For example, the agricultural sector will respond to socio-economic changes such as increasing oil prices, food and energy security, and changes in markets and policies. These changes to the landscape may impact on the way people feel and identify with their surroundings.

The report suggests a range of possible adaptation actions to respond to these potential changes.

It is hoped that the findings of this study into climate change vulnerabilities and potential adaptation options will provide a useful starting point for adaptation in the South Downs National Park. The actions described in the study are designed to increase the adaptive capacity of the natural environment in the area to the impacts of climate change and ensure that society continues to enjoy the benefits the environment currently provides. While some of the impacts of climate change on the natural environment are uncertain, adaptation action taken now will improve the resilience of the natural environment to change whether this is from climate change or other pressures, and provide a range of other benefits.

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1 Introduction

Context

1.1 England's natural environment is important for the species and ecosystems it supports and for the benefits it provides society. We enjoy a wide range of services from our environment: food and water, clean air, storage of carbon, regulation of hazards such as flooding, opportunities for recreation; and distinctive landscapes, shaped over thousands of years by natural processes and human land use, that give both local communities and visitors a 'sense of place'. The natural environment contributes to our livelihoods as well as our health and well-being.

1.2 However, the natural environment is vulnerable to climate change (for example, Hopkins *et al*., 2007; Mitchell *et al*., 2007; IPCC 2007; Rosenzweig *et al*., 2008). Landscapes are dynamic and have responded to changes in the past, but the scale and rate of projected change, coupled with existing pressures on the natural environment, is likely to have serious implications for the wide range of benefits and services we obtain from ecosystems and landscapes and the species that they support. At the same time appropriate land management to preserve and enhance ecosystems can help buffer society from a changing climate (Morecroft & Cowan 2010). Adaptation for the natural environment will therefore be essential and form an important part of our overall adaptation effort.

1.3 We have a general idea of how the climate might change (for example, Murphy *et al*., 2009), and some information about the possible consequences for different aspects of the natural environment (for example, Hopkins *et al*., 2007; Mitchell *et al*., 2007). However, consequences of climate change are likely to vary greatly from place to place. For the same reason, adaptation is likely to be a very time - and place -specific activity. Several sets of principles have been developed for adaptation (for example, Hopkins *et al*., 2007; Smithers *et al*., 2008; Macgregor & Cowan 2011), which have an important role in guiding general approaches. However, these need to be applied and tailored to specific locations and different landscape and habitat types, to help develop detailed adaptation solutions for different areas.

1.4 A key issue therefore is the scale at which adaptation action should take place – spatially, temporally and institutionally. Spatially, large scale approaches are likely to be important. This is not a new idea in conservation (for example, Noss, 1983), but climate change and its potential to further enhance the 'fluidity' (Manning *et al.,* 2009) of landscapes in time and space makes it a particularly relevant issue to adaptation (for example, Opdam and Wascher, 2004). The recently published Lawton Review, Making Space for Nature, sets out a number of recommendations for practical action to achieve a coherent and resilient ecological network in England. The Review summarises summarises the approach which needs to be adopted to support and enhance England's nature, as 'more, bigger, better and joined' (Lawton *et al.,* 2010). Central to the delivery of this vision is a large scale approach to conservation and adaptation. It is also important that we try to take an integrated and sustainable approach to considering vulnerability and adaptation (for example, Macgregor and Cowan, 2011).

1.5 The concept of 'landscape' is particularly useful to address both scale and sustainability issues. As well as providing a spatial dimension, landscape has great potential to act as an integrating framework that can help us to consider a range of aspects of the natural environment in a holistic way, to consider how changes to physical features of the landscape will affect the things that society values and benefits from, and to focus our adaptation responses on maintaining or enhancing those things in the face of inevitable change.

1.6 National Character Areas (NCAs), which make up a well-established spatial framework across England (Fig 1), provide a suitable geographic unit to explore vulnerability and adaptation. Ranging in size from 1,122 ha[1] to 382,627 ha, they provide an opportunity to consider vulnerability and adaptation at a 'landscape scale'; but are small and distinct enough (each having a well-described and distinctive set of geological, biological and cultural characteristics) to enable us to explore the possible implications of climate change in specific different places.

Natural England's Character Area Climate Change Project

1.7 The Character Area Climate Change Project commenced in 2007. It began with a set of four pilot studies that trialled a methodology that used bioclimatic data, information from national experts, and workshops with external stakeholders. It broadly followed a 'top-down' or hazard-based approach to impact assessment and adaptation (Parry and Carter, 1998; see also Jones and Mearns, 2005). The research reports from these early studies (Natural England 2009a, b, c, d), their summaries and an overall summary were published in 2009. The NCAs studied were:

- Cumbria High Fells in the Lake District area of north west England – a mountainous landscape with many lakes and peat soils.
- Shropshire Hills in the West Midlands, bordering Wales – a farmed landscape with fragmented heathland areas and diverse geology.
- Dorset Downs and Cranborne Chase in the south west of England – a rolling chalk landscape characterised by calcareous grassland and chalk stream valleys.
- The Broads on the east coast of England – a low lying freshwater wetland landscape with large areas of open water.

1.8 A second phase of studies commenced in 2009. The second phase built on the lessons learnt in the pilot studies and a revised methodology was developed, focusing on assessing vulnerability to climate change and increasing resilience of the natural environment. This drew on 'bottom-up' methodologies associated with vulnerability assessment (see for example Kelly and Adger, 2000; Downing and Patwardhan, 2005) and the concept of resilience (see for example Handmer and Dovers, 1996). The NCAs in the second phase of studies were:

- Sherwood in the East Midlands, bordering on the Yorkshire and Humber region – rolling countryside, with well established, iconic woodlands and a strong coal mining heritage.
- South East Northumberland Coastal Plain on the north east coast of England – a flat landscape with coastline of sand dunes and rocky outcrops, scarred by a heavily industrial past.
- Humberhead Levels, inland of the Humber estuary – a broad floodplain of navigable rivers, and an important area of lowland peat.
- London – a large city, but with extensive urban green space, dominated by the influence of the river Thames.
- South Downs National Park, stretching from Eastbourne to Winchester in the south east of England – a chalk landscape of rolling arable fields and close-cropped grassland on the bold scarps, with rounded open ridges.
- North Kent – a distinctively open and atmospheric landscape dominated by industrial heritage and extensive areas of grazing marsh and intertidal habitats which support a large and varied bird population.

[1] Excluding the two smallest NCAs, Lundy and the Isles of Scilly

- Lancashire and Amounderness Plain on the Irish Sea coast in the north west of England – a flat, predominantly drained coastal marsh landscape of mostly peat soils which has seen significant coastal development of Victorian coastal resorts.
- Morecambe Bay Limestones to the north of Lancashire and Amounderness Plain – a contrasting landscape of limestone hills interspersed with flat agriculturally-reclaimed flood plains, surrounding the multiple estuaries and mudflats that make Morecambe Bay.
- Solway Basin in the far north west of England, bordering Scotland – a broad lowland coastal plain gently rising to the hills behind with large expanses of intertidal mudflats backed by salt marsh.

1.9 The 13 studies completed in the two phases of the project cover a wide range of landscape types across England (Figure 1).

Figure 1 England's 159 National Character Areas, with the 13 areas studied in the two phases of the project highlighted. The South Downs National Park is shaded in yellow

1.10 This report presents the results of the South Downs National Park study. Chapter 2 outlines the overall approach taken in this study and the other studies in the second phase of the National Park study. The results of the study are presented in Chapter 4 and discussed in Chapter 5.

2 Approach

Introduction

2.1 This study and the others in the second phase of the Natural England Character Area Climate Change project are underpinned by three main concepts: sustainable adaptation; using a vulnerability approach to assess the potential impacts of climate change; and using landscape as an integrating framework for adaptation. This chapter defines these concepts and describes how they have been used to inform the methodology used.

Sustainable adaptation

2.2 Adaptation must be sustainable. Four principles for sustainable adaptation have been proposed (Macgregor and Cowen 2011):

1) Adaptation should aim to maintain or enhance the environmental, social and economic benefits provided by a system, while accepting and accommodating inevitable changes to it.
2) Adaptation should not solve one problem while creating or worsening others. We should prioritise action that has multiple benefits and avoid creating negative effects for other people, places and sectors.
3) Adaptation should seek to increase resilience to a wide range of future risks and address all aspects of vulnerability, rather than focusing solely on specific projected climate impacts.
4) Approaches to adaptation must be flexible and not limit future action.

2.3 An important aspect of applying the first principle above is to consider, as a starting point, the benefits a system provides, in order to establish objectives for adaptation against which both the consequences of climate change and the sustainability of possible adaptation actions can be evaluated. This thus frames the question from the point of view of 'what are we adapting for?' rather than 'what impacts are we adapting to?'.

2.4 An important aspect of sustainable adaptation is to identify action that would maintain or enhance the multiple benefits an area provides to society by reducing vulnerability to a range of possible consequences of climate change (principle 3 above). Therefore, in this project we have not chosen a specific climate change scenario (for example, 2080s, high emissions) to assess the vulnerability of the natural environment or identify adaptation responses. The project aimed to develop adaptation responses which are valid for a broad range of climate changes, using the headline messages from the United Kingdom Climate Projections 2009 (UKCP09) (see '**Vulnerability assessment**' below). In the face of uncertainty about the magnitude and timing of climatic changes and the cascade of possible consequences for natural systems, we believe this approach is more appropriate than focusing solely on trying to identify and respond to detailed projections of climate impacts. This is one of the key lessons that emerged from the phase one studies (Natural England 2009a, b, c, d).

Vulnerability assessment

2.5 Following the sustainable adaptation framework, a bottom-up, vulnerability based approach to assessing the potential impacts of climate change on the natural environment of the NCAs was taken. Vulnerability has been defined by the Intergovernmental Panel on Climate Change (IPCC) as a function of a system's exposure and sensitivity to climate impacts and its capacity to adapt (IPCC 2007; Figure 2), where:

- sensitivity refers to the degree to which a system is affected by weather or climate related stimuli (Willows and Connell 2003);
- exposure refers to the extent to which the system is subject to the weather or climate variable in question; and
- capacity to adapt refers to the ability of a system to adjust to climate change, to moderate potential damage or to take advantage of opportunities (Willows and Connell 2003).

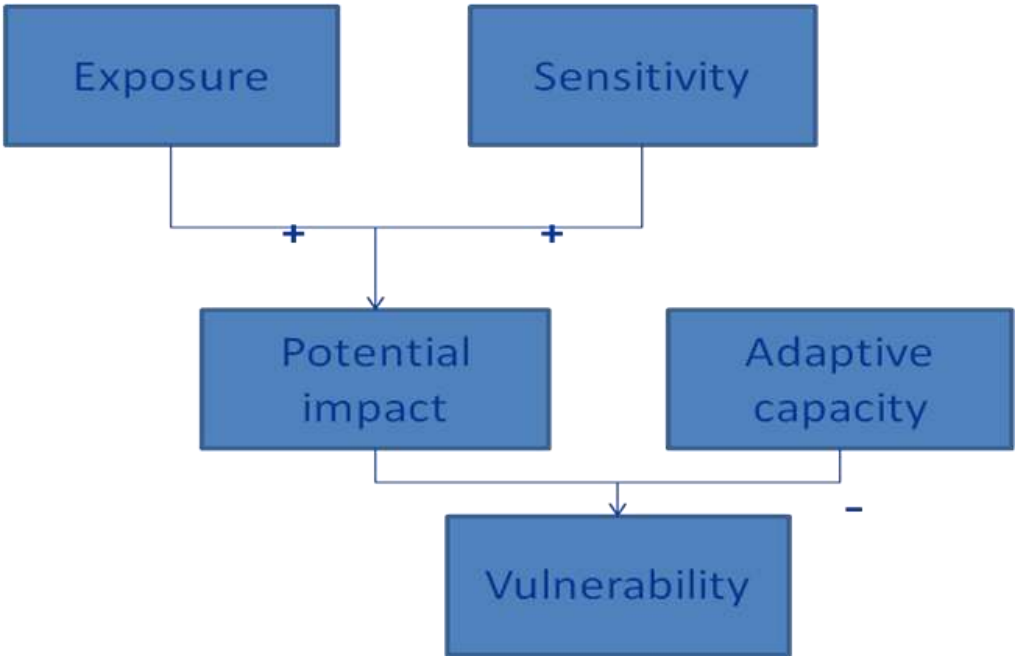

Figure 2 Components of vulnerability according to the IPCC (2007)

2.6 The IPCC vulnerability framework distinguishes between 'natural' and 'human-managed' adaptive capacity (IPCC 2007), and further studies (for example, Williams *et al.,* 2008, Steffen *et al.,* 2009) have explored in detail the factors that influence vulnerability in complex natural systems.

2.7 Exposure is determined by two factors. The first of these is the general change in climate variables that occurs in the area of interest. Information on change in climate variables can be found in the United Kingdom Climate Projections 2009 (UKCP09) (Murphy *et al.,* 2009). The UKCP09 projections provide probabilistic projections of climate change, assimilated from an ensemble of models and model runs for three emissions scenarios (Low, Medium and High). The projections are presented for 25 x 25 km grid squares across the UK and for seven over-lapping 30-year 'timeslices' (30 year averages of climate variables), moving forward in decadal steps (2010-2039, 2020-2049, until 2070-2099).

2.8 Headline messages for the UK from UKCP09 can be summarised as:

- All areas of the UK get warmer and the warming is greater in summer than in winter.
- There is little change in the amount of precipitation that falls annually but it is likely that more of it will fall in winter with drier summers for much of the UK.
- Sea levels rise and are greater in the south of the UK than the north.

2.9 Second, the exposure of a particular feature (for example, a plant or an animal, or an archaeological feature) may be moderated by the physical structure of the environment in the immediate vicinity. For example, even though an overall area might experience a certain average temperature rise, sites that are naturally cool and shaded (for example, sheltered wooded valleys) are likely to reach a lower maximum temperature than nearby sites in direct sun, such as open hilltops.

2.10 Sensitivity to a climatic change is determined by intrinsic traits of a feature, such as a species' tolerance to changes in temperature or water availability or the type of material used to build a historic property and the extent to which it is affected by flooding. Sensitivity in a particular location is also likely to be exacerbated by the presence of non-climate pressures. For example, areas of blanket bog that are already water-stressed as a result of existing drainage are likely to be more sensitive to additional water shortage in drier summers than are areas in good condition with sufficient water resources. Historic features in a poor state of repair might be more sensitive to damage from heavy rainfall than features that have been well conserved.

2.11 Capacity to adapt is determined by three sets of factors:

- For living things, it is the intrinsic traits of a species that enable it to adjust to changing conditions. This includes the ability to modify behaviour to use different microhabitats or to be active at different times of the day; phenotypic plasticity[2], such as the ability of some plants to develop leaves of a different shape to cope with hotter drier conditions; the ability of an animal, or the seeds of a plant, to disperse to other, more suitable areas; changes in phenology, that is timing of seasonal events such as egg hatching, migration and leafing; and capacity to adapt (in an evolutionary sense) *in situ* to be more adapted to the new conditions, which will be constrained by the existing level of genetic diversity in a population and the species' generation time.
- The local environment, which can either support or hamper a species' intrinsic ability to adapt. For example, a species might have the ability to modify its behaviour to use different microhabitat in its current range, or to disperse to new habitat in a different area, but will be able to successfully adapt if suitable habitat is available and accessible.
- For both living and non-living features, the ability of humans to manage the system ('adaptive management capacity'; Williams *et al.,* 2008). Factors such as the existence of management plans or policies which consider climate change, measurement and monitoring of the impacts of climate change, availability of land for people to allow translocation or migration of wildlife or to move non-living features, and the existence of partnerships to manage features, can all contribute to adaptive management capacity.

Dealing with uncertainty in vulnerability assessment

2.12 There are multiple sources of uncertainty in the vulnerability assessment that make it difficult to make an objective assessment of the vulnerability of features of the natural environment to the impacts of climate change. There are a range of projections of climate change due to natural climate variability, incomplete understanding of Earth system processes and a range of possible scenarios of future greenhouse gas emissions (Jenkins *et al.,* 2009). Another source of uncertainty is added when translating the projections into potential impacts on the natural environment: our understanding of how the complex interactions which exist in the natural environment will respond to climate change is limited.

2.13 While acknowledging these various sources of uncertainty, we understand enough about possible climate change and its potential effects on the natural environment to consider a range of plausible future changes. The aim of the vulnerability assessment in these studies was to highlight the relative vulnerability of features in the NCA to the impacts of climate change, based on the best knowledge available at present. Sources of information included expert judgement of Natural England specialists, other experts from outside the organisation, including local experts, and published literature. By setting out each feature in terms of its exposure and sensitivity to climate change and its capacity to adapt, the justification for the assessment was made as transparent as possible.

[2] Phenotypic plasticity is the ability of an organism to change its morphology, development, biochemical or physiological properties, or behaviour, in response to changes in the environment

Landscape as an integrating concept

2.14 The third central concept is the idea of landscape as an integrating framework for adaptation (and for conservation in general). Landscape in this sense is far more than just 'the view' – it is the full set of environmental features in an area and the services they provide. In these studies, landscape was considered in terms of a range of physical features that combine and interact to produce important services and benefits. Three broad categories of benefits were considered: biodiversity, landscape character and other ecosystem services.

2.15 Landscape character refers to the distinct, recognisable and consistent pattern of elements that make one landscape different from another and provide people who live there or visit with a 'sense of place'. The concept of landscape character does not imply any value judgement ie it does not make a distinction between landscapes that are better or worse, but considers the distinct, recognisable and consistent pattern of elements that make one landscape different from another. This might include physical features such as hedgerows or buildings but also physical patterns at different spatial scales. These elements come together to influence how people perceive landscapes. National Character Areas are discreet areas which, in broad terms, have a coherent landscape character that differs from that of neighbouring areas. Valued landscape character is just one of a range of ecosystem services (see below) that landscapes provide, but because it determines how a place 'looks and feels' to people, it was considered in a separate category for the purposes of this study.

2.16 Ecosystem services are the services the natural environment delivers to society. They can be described as "the processes or structures within ecosystems that give rise to a range of goods and services from which humans derive benefit" (Parliamentary Office of Science and Technology 2007).

2.17 The Millennium Ecosystem Assessment (MA 2005) identified four types of ecosystem services:

- Provisioning services such as food and forestry, energy and fresh water.
- Regulating services such as climate regulation and water purification.
- Supporting services such as soil formation and pollination.
- Cultural services such as recreation, inspiration and sense of place.

2.18 Landscape character, ecosystem services and biodiversity are the result of a combination of elements such as habitats, geology, soil types, historic features, water courses and human land use, and the interactions between them. The elements that make an important contribution to biodiversity, landscape character and ecosystem services are referred to as 'assets' in this report. Examples of assets are trees and hedgerows which combine to give a landscape a wooded character, deliver functions such as carbon sequestration or soil conservation and support wildlife.

2.19 Biodiversity (short for biological diversity) is the variety of all life forms: the different plants, animals and micro-organisms, their genes, and the communities and ecosystems of which they are part. Biodiversity is usually recognised at three levels: genetic diversity, species diversity and ecosystem diversity. As well as being valuable in its own right, it supports ecosystem services and contributes to the character of a landscape.

2.20 Landscape character, ecosystem services and biodiversity are the result of a combination of elements such as habitats, geology, soil types and land use and the interactions between them. A very simple example of this might be trees and hedgerows which combine to give a landscape a wooded character, provide habitats for wildlife and also deliver services such as carbon sequestration or soil conservation. Features such as this that make an important contribution to character, ecosystem services or biodiversity are referred to as 'assets' in this study.

2.21 This study, and the others in the second phase of the Character Area Climate Change project, brought together these three concepts (sustainable adaptation, vulnerability assessment, landscape as an integrating framework) to develop and trial a methodology for an integrated landscape and ecosystem approach to adaptation.

3 Method

3.1 The method we followed in this study (and in the parallel studies noted above) for assessing vulnerability and considering adaptation options consisted of six steps (Figure 3). The starting point was to identify the most important aspects of landscape character, ecosystem services and biodiversity, and the physical assets which make the most important contribution to them. We then assessed the vulnerability of those physical assets, and from this we inferred the possible implications for landscape character, biodiversity and ecosystem services. We then identified possible adaptation actions to address vulnerability before evaluating them to identify actions that would have multiple benefits, and any potential conflicts between actions.

3.2 For this assessment of the South Downs National Park, parts of other Character Areas surrounding the core South Downs Character Area have been brought in to the assessment to cover the majority of the area within the South Downs National Park. The NCAs included in this assessment are the South Downs, part of the Hampshire Downs, part of the Low Weald and part of the Wealden Greensand. Two NCAs that extend only very slightly into the South Downs National Park (South Coast Plain and the South Hampshire Lowlands) were not included in the study because they were not considered to be representative of the landscape character, ecosystem services and biodiversity of the South Downs.

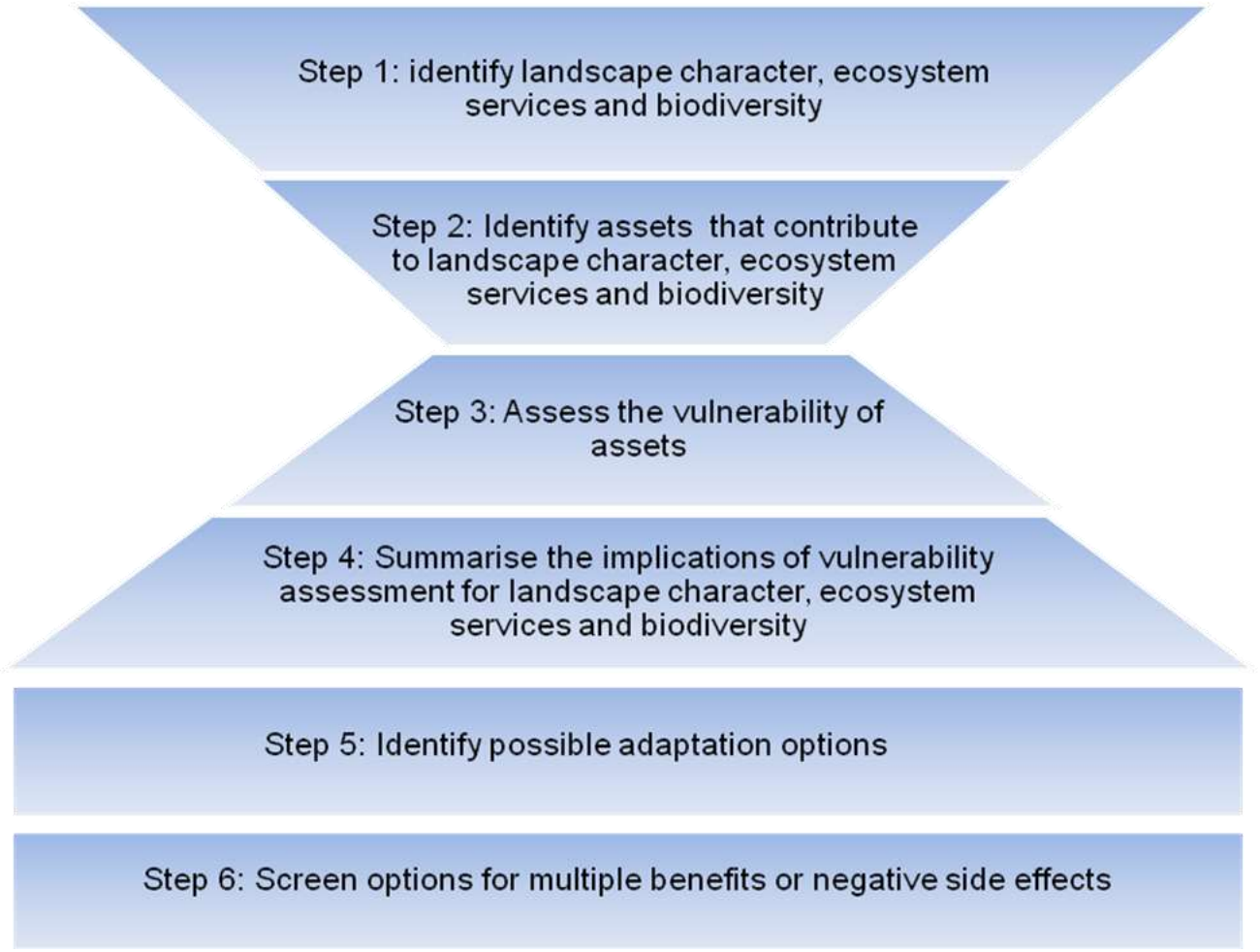

Figure 3 The main steps in the method used to assess vulnerability of the landscape area to climate change and to identify and evaluate possible adaptation options

3.3 The remainder of this chapter outlines in more detail how each of the steps in Figure 3.1 was completed for the South Downs.

Step 1 – Identification of landscape characteristics, ecosystem services and biodiversity

3.4 We identified the landscape characteristics, ecosystem services and biodiversity of the South Downs National Park through a review of: the current NCA descriptions (Countryside Agency 1999), The South Downs Integrated Landscape Character Assessment – Technical Report (Land Use Consultants 2005) and electronic consultation with Natural England regional landscape, biodiversity, access, historic environment, soils and geology specialists. The identification of landscape character, ecosystem services and biodiversity assets for the South Downs had already been carried out to a large extent through the production of, and stakeholder consultation on, landscape character assessments and management plan documents. We drew heavily on previous publications to provide information about the distinctive landscape character, ecosystem services and biodiversity of the area.

3.5 Throughout the assessment, we have assessed biodiversity at a broad habitat level rather than at a species level. This was felt appropriate for the more strategic scale of this study and aligns with the South East Regional Biodiversity Climate Change Vulnerability Assessment carried out in the region (Taylor & Knight 2011).

3.6 As urban landscapes are not considered in any detail within the NCA description, urban character and ecosystem services were largely excluded from this study. However, although the South Downs is predominantly a rural area, parts are urban in nature, with towns such as Petersfield, Midhurst and Lewes falling within its boundary and Brighton to the south having an influence.

3.7 We identified urban greenspace as a facet of urban landscapes that may be vulnerable to climate change. Urban greenspace has the potential to provide adaptation options that could contribute to wider adaptation and we considered this alongside other recreational resources in this report.

Step 2 – Identification of assets which contribute to landscape character and ecosystem services

3.8 We identified the assets which contribute to the landscape character, ecosystem services and biodiversity of the South Downs National Park under the following headings:

- Geology and soils.
- Habitats.
- Historic environment.
- Areas for access and recreation.

3.9 Again, we identified the assets through reviewing the NCA description, the South Downs Integrated Landscape Character Assessment – Technical Report (Land Use Consultants 2005), and consultation with Natural England regional specialists. Regional specialists drew on unpublished information provided by national experts to identify the South Downs assets. Having made an initial identification of the most important natural assets in the area, we carried out targeted stakeholder consultation with the South Downs Joint Committee via email, and amended our initial findings to reflect any comments we received.

3.10 In addition, we mapped many of the assets using spatial data held by Natural England. The maps presented in this report illustrate information that we hold on certain asset types and do not necessarily include every asset. There are also some types of asset which do not lend themselves to mapping (for example, some features of the landscape that contribute to aesthetic value and sense of place).

3.11 The South Downs Joint Committee agreed this approach to assessing the vulnerability of landscape character and ecosystem services in the South Downs National Park. The approval and involvement of the South Downs Joint Committee and the relationship of Natural England's South Downs Spatial Project Manager with the stakeholders in the area facilitated swift stakeholder engagement where it was sought.

Step 3 – Identification of how the assets may be vulnerable to the impacts of climate change

3.12 The aim of the vulnerability assessment was to highlight assets which are potentially more vulnerable to the impacts of climate change than others.

3.13 We assessed the exposure and sensitivity of each asset, and its capacity to adapt (see Section 2).

3.14 We considered vulnerability to both direct effects of climate change and indirect effects caused by the response of people to climate change. In determining the vulnerability of assets, we considered the following sources of information:

1) **Exposure**

To identify climatic changes to which assets might be exposed, we considered the scenarios for the South East region in the UKCP09 climate projections (UK Climate Projections, 2010). These give an indication of the 'direction of travel' we are likely to see for climate change, and enabled us to consider some of the effects that might result, such as drought. Box 1 below gives an indication of predicted climate change parameters for the South East region:

Climate Change Projections UKCP09

Key headline findings from UKCP09 for the South East (2080s medium emissions scenario):

- The central estimate of increase in winter mean temperature is 3°C; it is very unlikely to be less than 1.6°C and is very unlikely to be more than 4.7°C.
- The central estimate of increase in summer mean temperature is 3.9ºC; it is very unlikely to be less than 2ºC and is very unlikely to be more than 6.5ºC.
- The central estimate of change in winter mean precipitation is 22%; it is very unlikely to be less than 4% and is very unlikely to be more than 51%.
- The central estimate of change in summer mean precipitation is –23%; it is very unlikely to be less than –48% and is very unlikely to be more than 7%.

2) **Sensitivity**

Sensitivity was determined by considering the characteristics of the asset including its tolerance of a gradual directional change in climate, its reaction to the impacts of one off 'shock' events, and the combination of these factors. We considered sensitivity of the assets through literature review, for example, the England Biodiversity Strategy document 'Towards Adaptation to Climate change' risk of direct impact classifications (Mitchell *et al.,* 2007), and expert input.

3) **Adaptive capacity**

To determine the adaptive capacity of environmental assets in the face of a changing climate, we considered whether the asset could adapt and retain its value by moving, through changes in habitat composition, or through natural or managed processes. The current condition and extent of the asset and thoughts about our ability to manage the asset formed part of the thinking about the capacity of the asset to adapt to climate change.

3.15 Based on assessment of sensitivity and exposure of an asset to the impacts of climate change and its adaptive capacity, each asset was classified as being relatively less vulnerable, moderately vulnerable or relatively more vulnerable, with some flexibility given by providing intermediate classifications of more/moderately vulnerable and moderately/less vulnerable. The vulnerability categories used, and their descriptions, are shown in Table 1.

Table 1 Vulnerability ratings used

Vulnerability rating	Description of relative vulnerability
More vulnerable	Asset is likely to be significantly changed or destroyed as a result of climate change. Adaptation action should be implemented as a matter of priority.
More / moderately vulnerable	Somewhere between more vulnerable and moderately vulnerable.
Moderately vulnerable	Asset may be changed as a result of climate change. Careful management or monitoring is likely to be required to support adaptation.
Moderately / less vulnerable	Somewhere between moderately vulnerable and less vulnerable.
Less vulnerable	Asset is less likely to be significantly changed as a result of climate change or change may be beneficial. Adaptation action may be necessary, but other assets should be considered with greater urgency.

3.16 We carried out this classification using information from the national and regional subject experts, as well as some wider literature. These classifications represent a largely expert opinion-based assessment of the relative vulnerability of the assets.

3.17 We summarised the results of the vulnerability assessment in a series of templates - one for each of the categories of assets listed above, such as habitats, geology and soils. We then emailed these to regional specialists in Natural England and the South Downs Joint Committee for comments and verification based on their local knowledge. We asked the consultees a series of questions to guide them through the templates and to highlight the contribution required to the templates.

3.18 We conducted follow up conversations with some specialists to ensure that their expert opinion on the vulnerability of natural assets was accurately captured.

3.19 Assigning vulnerability ratings to assets was intended to provide a guide to the relative vulnerabilities of assets in the South Downs rather than an absolute assessment of vulnerability. The uncertain nature of climate change and the response of the natural environment make it difficult to make an objective assessment about the relative vulnerability of assets. We recognise that the assessment of vulnerability undertaken in this study is a subjective process, however, by setting out each asset in terms of its exposure and sensitivity to climate change and its adaptive capacity, we have made the justification for the assessment as transparent as possible.

Step 4 – Identification of potential major changes to landscape character, biodiversity and ecosystem services

3.20 Having assessed the vulnerability of the South Downs' important natural assets, we considered what the combined effects of changes to assets deemed to be 'moderately vulnerable' and above would be on landscape character, ecosystem services and biodiversity. We considered the possible effects on each of the separate elements of landscape character, ecosystem services and biodiversity that had been identified in Step 1. These conclusions

were then summarised as a set of statements about potential major changes. This evaluation was based on the results of the assessment exercise carried out in Step 3, local knowledge of the project team, examination of available literature and through consultation with Natural England regional specialists.

Steps 5 and 6 – Identification and evaluation of potential adaptation actions

3.21 We identified potential adaptation actions to address the vulnerability of the assets of South Downs National Park. We identified potential actions from a combination of published literature (for example, Hopkins *et al*., 2007, Mitchell *et al.*, 2007, Heller and Zavaleta 2009), expert opinion from Natural England specialist staff, and consultation with local experts and stakeholders in the study area.

3.22 We reviewed the full list of adaptation actions for each theme and identified priority actions using a combination of approaches. First we counted the number of times an adaptation option was identified and the number of assets for which they provided adaptation, to highlight the actions that addressed a number of assets. We then screened the full list to check for alignment of all actions to the South Downs Management plan and for appropriateness to the landscape. This refined the full list to a combination of actions that had either multiple benefits and/or aligned with the current South Downs management.

3.23 We aimed to identify responses to climate change which are valid for a broad range of climate variables suggested by the UKCP09 scenarios (for instance, increase in frequency of extreme rainfall events and extreme temperature events such as heat-wave), rather than focusing on a specific narrow scenario.

3.24 A number of principles were followed when deciding which adaptation actions were most appropriate:

- Win-win adaptation response – A ‘win-win’ adaptation response is a response to climate change that reduces the vulnerability to climate change of more than one characteristic or service of the natural environment, providing multiple benefits (UKCIP n.d).
- Low regrets adaptation response – Adaptation measure that would be relatively cheap to implement and for which benefits, although primarily realised under projected future climate change, may be relatively large (UKCIP n.d).
- No regrets adaptation response – A response to projected climate change impact that is beneficial regardless of whether climate change occurs (UKCIP n.d).
- Avoiding conflict between adaptation responses – It will be important that when implementing one adaption response, the ability to carry out other adaptation responses is not unduly compromised. This is a central tenet of the concept of sustainable adaptation, alongside the principle that adaptation responses should not increase climate change unnecessarily (Macgregor & Cowan 2011).

3.25 To ensure that adaptation actions were as consistent as possible with these principles, we used a matrix to assess whether there were any potential conflicts between adaptation actions for a specific characteristic or service, and to check that ‘win-win’, ‘no-regrets’ and ‘low regrets’ actions were, wherever possible, identified. The full matrix can be seen at Appendix 4.

3.26 The concept of ‘adaptive management’ was also considered when identifying potential adaptation actions (Holling 1978). Adaptive management has been defined as ‘*a structured process of "learning by doing" that involves much more than simply better ecological monitoring and response to unexpected management impacts. In particular, it has been repeatedly argued that adaptive management should begin with a concerted effort to integrate*

existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies.' (Walters 1997).

3.27 Once a set of priority actions had been identified, we noted which of the potential 'major changes', identified in Step 4, they would primarily address.

3.28 In addition, we identified a number of potential strategic adaptation actions that apply across many or all aspects of the South Downs landscape and provide a framework for adaptation across the whole area.

4 Results

Part 1 – Description of the landscape area

4.1 In this part of the Results chapter, the findings of Steps 1 and 2 of the method are presented. We have identified the main features of the NCAs under the headings of landscape character, ecosystem services and biodiversity. Under each heading, we outline the assets that make the most important contribution, considering the following range of different asset types (though these headings are not explicitly used in this section of the report):

- Geology and soils.
- Habitats.
- Areas for access and recreation.
- Historic environment.

4.2 The South Downs is a landscape of national significance, recognised for its distinctive and highly valued character. It is a typical chalk landscape, which has been influenced by human history and comprises some of the most visually dramatic scenery in Southern England. Its exceptional landscape qualities led to its designation as two Areas of Outstanding Natural Beauty (AONB) and, more recently, as the South Downs National Park. The National Park covers an area of 1671 km^2, and includes parts of three counties (Hampshire, West Sussex and East Sussex), plus the Unitary Authority of Brighton and Hove and eleven local authorities (Land Use Consultants 2005). The landscape comprises a chalk ridge stretching from Beachy Head in the east to Winchester in the west with a dramatic northern escarpment and gentler dipslope towards the coast. There is also great landscape diversity, including the Greensand shelf at the foot of the downland scarps and the clay hinterland of the Low Weald. This creates a very varied and complex landscape character (Land Use Consultants 2005).

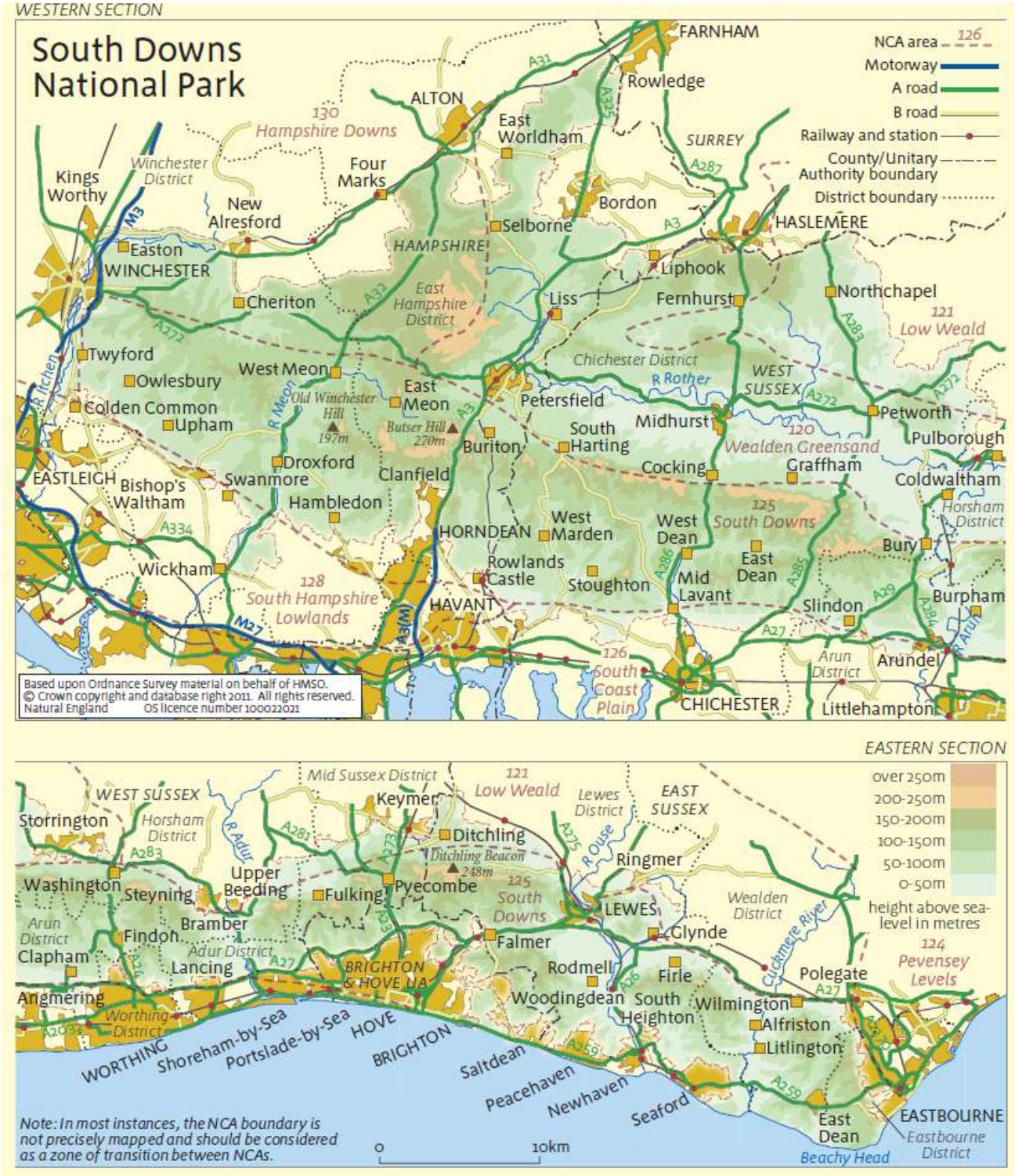

Figure 4 Map of the South Downs National Park

Landscape character

4.3 The Countryside Quality Counts project measured landscape change by assessing change in landscape character for two periods: 1990-1998 and 1999-2003. The project used England's National Character Areas (NCAs) and assessed both the magnitude and the direction of landscape change for each NCA, using four categories:

1) Maintained.

2) Enhancing.
3) Neglected.
4) Diverging (Natural England website c).

4.4 The following map shows the results for the NCAs within the South Downs National Park.

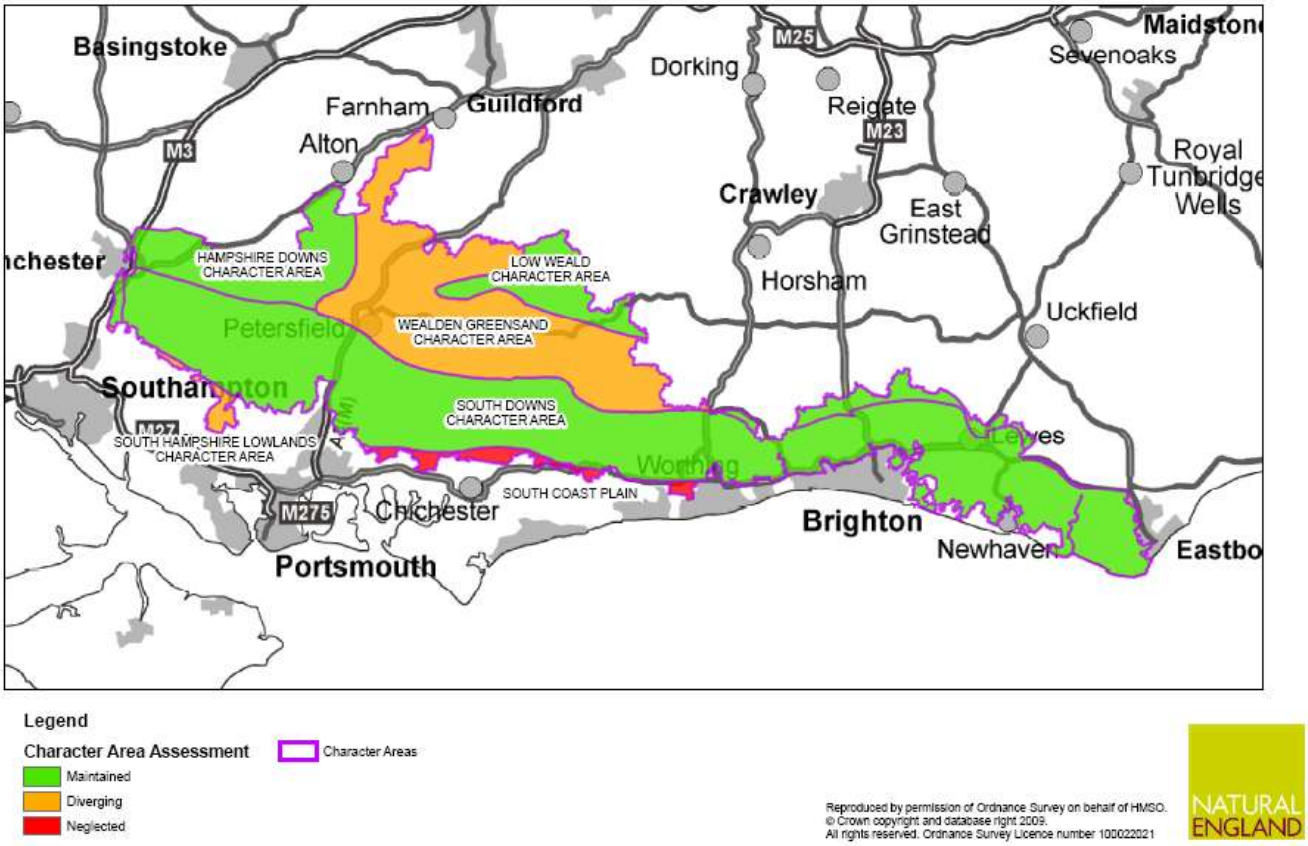

Figure 5 Map showing the NCAs in the South Downs and their landscape assessment

4.5 The following section has relied heavily on landscape character descriptions from the South Downs Integrated Landscape Character Assessment: Technical Report (Land Use Consultants 2005) and the relevant NCA descriptions (Countryside Agency, 1999). Some descriptive text has been taken from these documents.

Variety and contrast

4.6 The South Downs is an extremely diverse and complex landscape with considerable local variation, reflecting the combination of physical, historic and economic influences present both now and in the past. There are numerous contrasts in the landscape; the dramatic white chalk cliffs contrasting with the seascape and rolling downs, the perception of remoteness close to urban areas, and the feelings of both openness and enclosure that can be experienced on the Downs through the mix of open downland and woodland.

4.7 There are particularly significant contrasts between the densely wooded parts, which convey a strong sense of enclosure and remoteness, and the open hilltops. The variety of land cover provides further contrasts of colour and texture, for example the mix of crops and differing habitats - grassland, woodland and heathland. This textured and colourful mosaic is enhanced by special qualities of shadow and light, with a contrast between the light in open areas and the dappled shade of the woodland. The colours of the beech woods, cereal crops and ploughed arable fields provide seasonal change. There is a distinct land cover pattern of open downland interspersed with small woodlands.

Distinctive form

4.8 The South Downs is dominated by a spine of chalk that stretches from Winchester in the west to the cliffs of Beachy Head in the east. The **prominent chalk outcrop** rises gently from the South Coast Plain with a dramatic north-facing scarp and distinctive chalk cliffs formed where the Downs end abruptly at the sea. It is a chalk landscape of rolling arable fields and close-cropped grassland on the bold scarps, rounded open ridges indented by steep coombes and sculpted dry valleys, and incised by chalk rivers. Large areas of arable crops intermix with former commons, wood-pastures and ancient semi-natural woodland.

Plate 1 Scarp slope

4.9 The cliff between Seaford and Beachy Head lies at the eastern end of the South Downs which terminate in the famous **chalk cliffs** of the Seven Sisters. This is also designated as the Sussex Heritage Coast and Foreshore. The white chalk is exposed between Seaford and Cuckmere and then continues eastwards, forming the imposing cliffs that culminate in Beachy Head (Natural England website a).

Plate 2 The iconic view of the Seven Sisters

4.10 **Coombes and dry valleys** dissect the escarpments and dip slopes of the South Downs. Devil's Dyke, a huge dry valley that carves through ridges of rolling calcareous grassland to the north of Brighton, is the most famous and remarkable of all the chalk dry valleys. It is frequently cited as the type example and is the largest single coombe anywhere in the chalk karst of Britain. It is a National Trust site (Natural England website b).

4.11 In East and West Sussex, rivers from the Low Weald and the Wealden Greensand cut through the Downs to form **deep river valleys and broad floodplains**, including those of the rivers Arun, Adur, Ouse and Cuckmere. The pastures and wet grazing meadows of the floodplains contrast with the dry uplands. The Low Weald includes an abundance of **ponds and small stream valleys**, often with wet woodlands of alder and willow.

4.12 While the chalk ridge dominates, there are other landforms which contribute to the National Park's distinctive character. To the north of the chalk the sandstones of the Lower Greensand and soft shales of the Wealden Clays crop out. The chalk is separated from the Lower Greensand by a belt of low-lying ground marked by Gault Clay and a 'terrace' consisting of Upper Greensand that lies at the foot of the chalk scarp. To the south of the chalk, younger Tertiary rocks overlie the chalk (Land Use Consultants 2005). See Figure 6 for a map showing the geology of the area.

Plate 3 Devil's Dyke

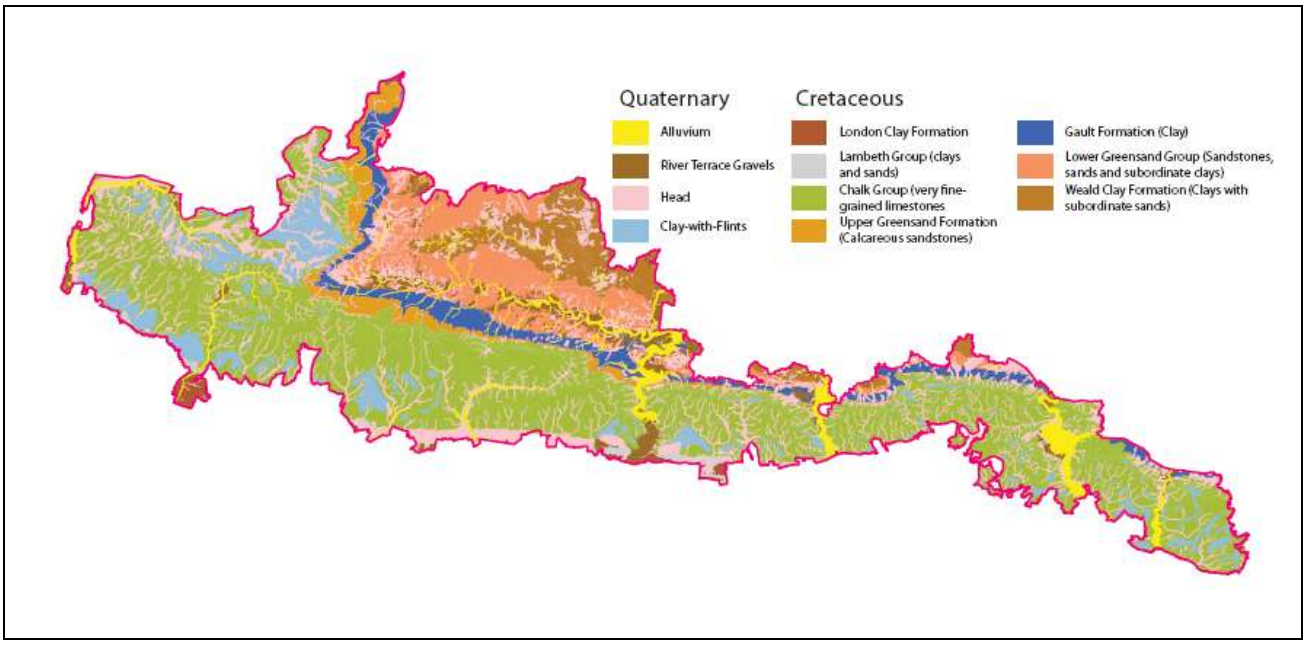

Figure 6 Map showing geodiversity in the South Downs

4.13 The **Low Weald** is characterised by **broad, low lying and gently undulating clay vales**, a small-scale, intimate landscape enclosed by an intricate mix of small woodlands and a patchwork of fields and hedgerows. The large **greensand belt** is typified by **distinctive scarp dip slope** topography.

4.14 **Geomorphological processes** underpin many elements of the National Park's landscape. For example, wave erosion and slope failure, combined with fluvial and mass wasting processes that were operating during the last glaciation, are largely responsible for the iconic Seven Sisters on the Sussex coast.

4.15 Within the National Park, there are a number of Sites of Special Scientific Interest (SSSIs) designated for their geological and geomorphological interest and regarded as nationally important. There are also a series of local sites known as Regionally Important Geological or Geomorphological Sites (RIGS), identified for their regional importance and using a broader set of criteria than SSSIs (for example, educational value). The geological SSSIs are designated mainly for the Cretaceous rocks (mainly chalk) that crop out over much of the area, as well as for the Pleistocene sediments and associated land forms such as Birling Gap and Devil's Dyke. These sites provide windows into past environments, both at a time when atmospheric CO_2 concentrations were particularly high during the late Cretaceous, and during the past 200,000 years when the climate fluctuated rapidly through a cycle of glacial advances and retreats, when the south of England was subjected to long periods of periglacial conditions. Many of these sites contain a record of these conditions, while some record the changes that took place at the end of the last glaciations. All these sites provide evidence of past climates and climate change, and form part of an extensive natural archive related to climate change. These sites are therefore valued for their contribution to our understanding of current and future climate change.

4.16 Working quarries exist within the National Park providing a mixture of chalk and aggregates. The white scars from abandoned chalk pits are a recurring prominent feature on the South Downs chalk landscape, a relic of the days when chalk was quarried to make lime for fertiliser and building mortar. About three-quarters of the SSSIs designated for their geological features and Regionally Important Geological Sites (RIGS) consist of gravel, sand or chalk pits and quarries, many of which are now remnants of past industrial or agricultural activity in the South Downs. They now provide an opportunity for research and education to improve geological understanding, for example, the boundary between the lower and upper chalk at Whitewool farm quarry. These quarries also provide, or have the potential to provide, important sites for wildlife (Currell 2005).

History

4.17 The South Downs is a strongly historic landscape, with visible links to the past including prehistoric ritual and settlement sites, flint mines, burial mounds and visually dominant hillforts. Abandoned field systems survive as earthworks on the high downland, and extensive below ground archaeology elsewhere indicates the centuries of cultivation and use by farming communities from the Neolithic to the present day (Land Use Consultants 2005). A Medieval rural character persists to this day. This complex history of human settlement in the South Downs has left behind many important sites and assets with historic importance.

4.18 These include:

- Below ground and upstanding historic assets such as round barrows, for example barrows on the Kingley Vale ridge, and historic settlements such as Bignor Roman Villa.
- Historic routeways such as reused prehistoric tracks, ancient drove roads, and trackways or trunk roads linking new settlements built by the Romans, for example, Stane Street Roman Road.
- Large scale archaeological assets, including Bronze and Iron Age Hill Forts such as Cissbury Ring, Harting Beacon and The Trundle.
- Relict boundaries still present in the landscape, including major linear earthworks that carve the landscape into territories, field systems defined by earthwork banks, ditches and cross-dykes such as those found at Rackham Banks, and hedgerows and shaws.
- Historic wetlands, for example at Arundel Wildfowl and Wetlands Trust Reserve.

- Farm buildings and walls, including the timber and brick built traditional buildings found in the Low Weald NCA, flint in the South Downs NCA, and flint and chalk cob in the Hampshire Downs NCA. Thatch also survives in many places. Prominent walls exist in the context of the large landscaped parks, for example at Petworth Park.
- Designed landscapes. These are a key historic landscape feature. In the medieval period, deer parks and wood pasture were prominent in the western area of the Downs. The 18th and 19th centuries saw further development of large landscaped parks with expanses of grassland interspersed with extensive tree planting, excellent examples of which survive today including West Dean Park, Petworth Park, Stanstead, Arundel and Goodwood. These designed landscapes often include parkland structures or follies such as the Petworth Park folly - a Doric temple, the Nore Folly near Slindon, and Tunnel House in Pyecombe.

4.19 See Figure 7 for a map showing some of the historic environment assets in the South Downs.

Plate 4 Cissbury Ring

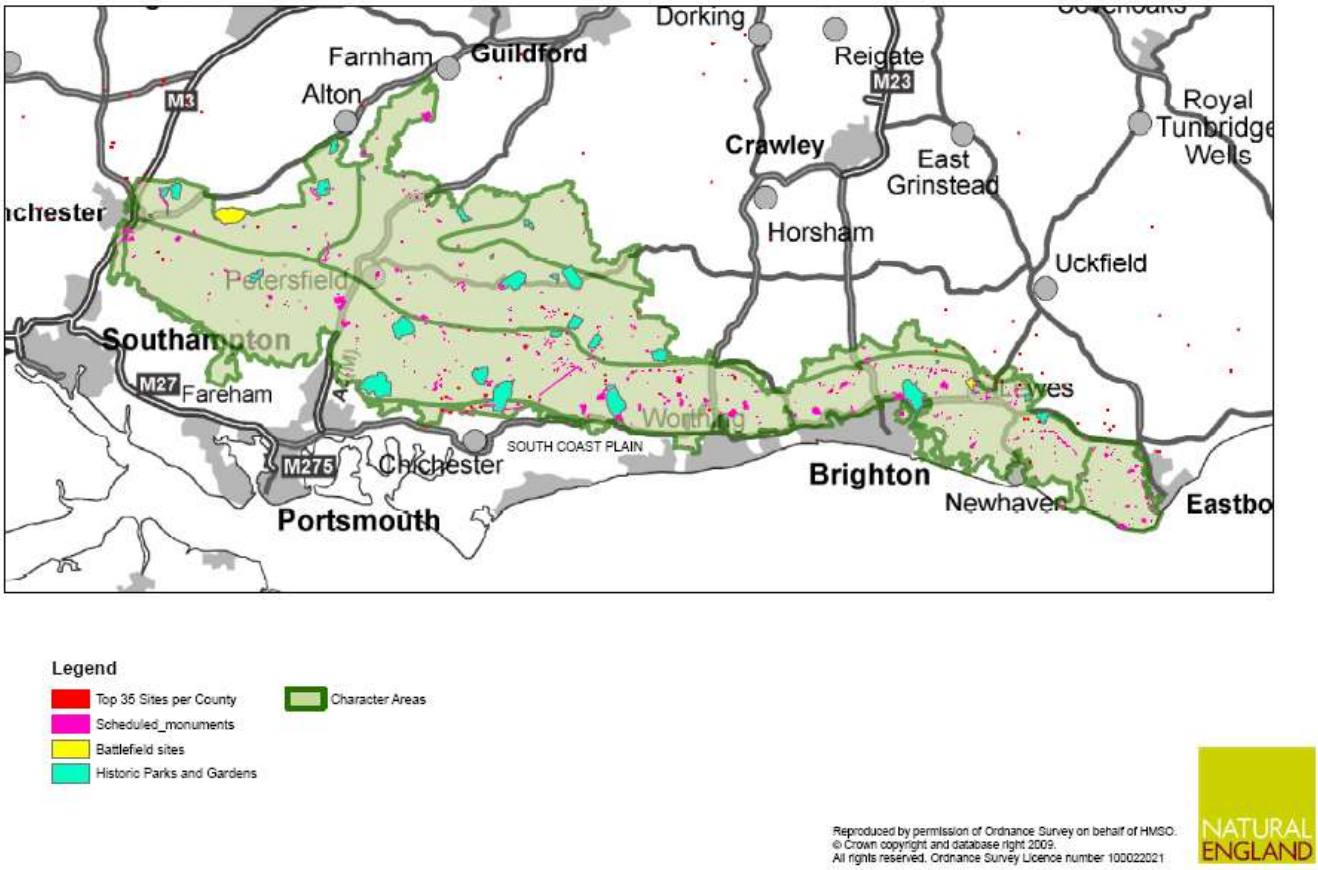

Figure 7 Map showing some historic environment assets in the South Downs

Woodland

4.20 Both coniferous and broadleaved woodlands are a distinctive feature of the western Downs. Charlton Forest, on the top of the scarp slope near Singleton in West Sussex, is the largest example and is the largest Forestry Commission managed woodland in the South East. The Wealden Greensand in Hampshire and West Sussex comprises areas of high ground supporting a mosaic of open heath and wooded hangers and rough grazing in Sussex this is pine forest. There are extensive belts of ancient mixed woodland of hazel, oak and birch, together with more recent coniferous colonisation and plantations. Large sections of the winding Upper Greensand escarpment are noted for their steep 'hanger' woodlands, the hangers at Selborne being the most well known. A large proportion of the woodlands in the South Downs are relatively small, but form an important element of the landscape. On the Hampshire Downs, within the sheltered downland valleys, the network of mixed-species hedgerows interspersed by numerous oak/ash or hazel woodland coppice gives a strong sense of enclosure. Tall hedgerows with numerous mature trees link copses, shaws and remnant woodlands, which combine to give the Low Weald a well-wooded character.

Agriculture and forestry land use

4.21 Within the **South Downs** NCA component of the National Park, the land use pattern is predominantly centred on cereals and sheep, with some woodland surviving on the steeper slopes. However, extensive plantations exist on the enclosed uplands of the dip slope in western Sussex, for example Charlton Forest. Cereals are grown predominantly on the deeper soils of the less exposed lower slopes. The vegetation of the river valleys is markedly different, including permanent semi-improved pastures providing grazing for cattle in late spring and summer (The Countryside Agency, 1999).

Plate 5 Conifer plantation on the Downs

4.22 The plateau of the **Hampshire Downs** NCA is predominantly a landscape of arable farmland with varying degrees of enclosure. Scarps and hilltops are characterised by **extensive open tracts of large arable fields** and some ley pasture, sporadically interrupted by woodlands (The Countryside Agency, 1999).

4.23 The **Low Weald** NCA is largely pastoral due to the heavy clay soils, with either forage or grazed grassland. However, where there are lighter soils on slightly higher ground a more mixed farming is found in a more open landscape. Arable cropping is often associated with larger fields, a much sparser hedge pattern and fewer trees, in contrast to the characteristic well-wooded pastoral appearance of the Low Weald (The Countryside Agency, 1999).

4.24 The **Wealden Greensand** NCA has extensive belts of woodland, both ancient mixed woods of hazel, oak and birch and more recent coniferous plantations. There are also **broad river valley plains** which support arable farming on light soils with large geometric fields (The Countryside Agency, 1999).

4.25 See Figure 8 for a map showing the landcover distribution in the South Downs.

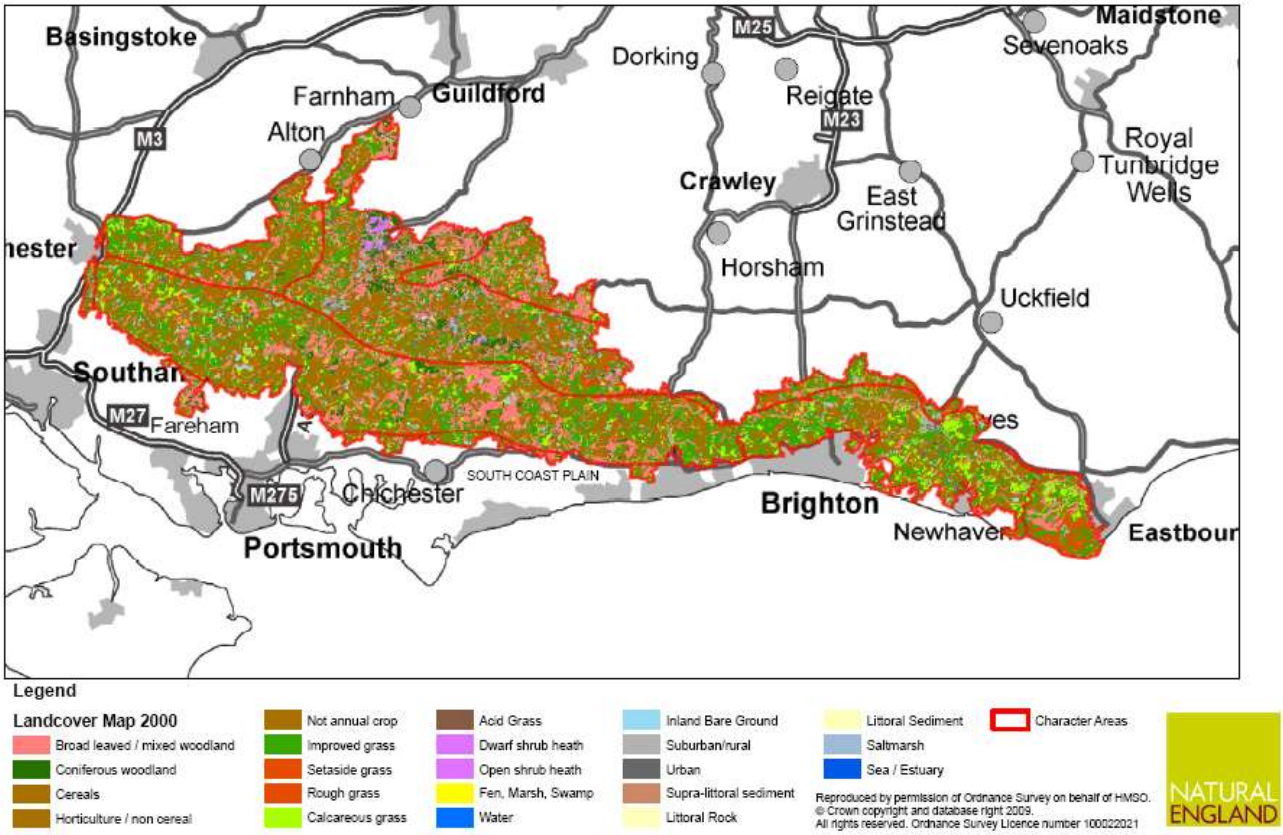

Figure 8 Map showing landcover in the South Downs

Buildings and settlements

4.26 The National Park displays a distinctive pattern of rural settlement, with isolated farmsteads set within a **medieval wooded landscape** in the Weald, medieval villages on the Greensand, spring line villages along the scarp foot, for example Fulking, and a concentration of settlement in the dip slope valleys of the Downs (Land Use Consultants 2005). Local distinctiveness exists within this general pattern, such as the distinct style of estate villages. It is a **deeply rural and secluded** landscape with large tracts devoid of roads and settlement. Overall habitation is low, with small and scattered settlements and dispersed farmsteads. Villages and shrunken hamlets of Saxon or early medieval origin are interspersed by scattered farmsteads of 18th-19th century origin. In the western South Downs and Hampshire Downs, **large estates** are numerous and important features, with formal designed parkland providing a contrast to the more typical farmland pasture, for example West Dean Estate (The Countryside Agency, 1999).

4.27 Figures 9 and 10 show the settlement pattern and density in the South Downs.

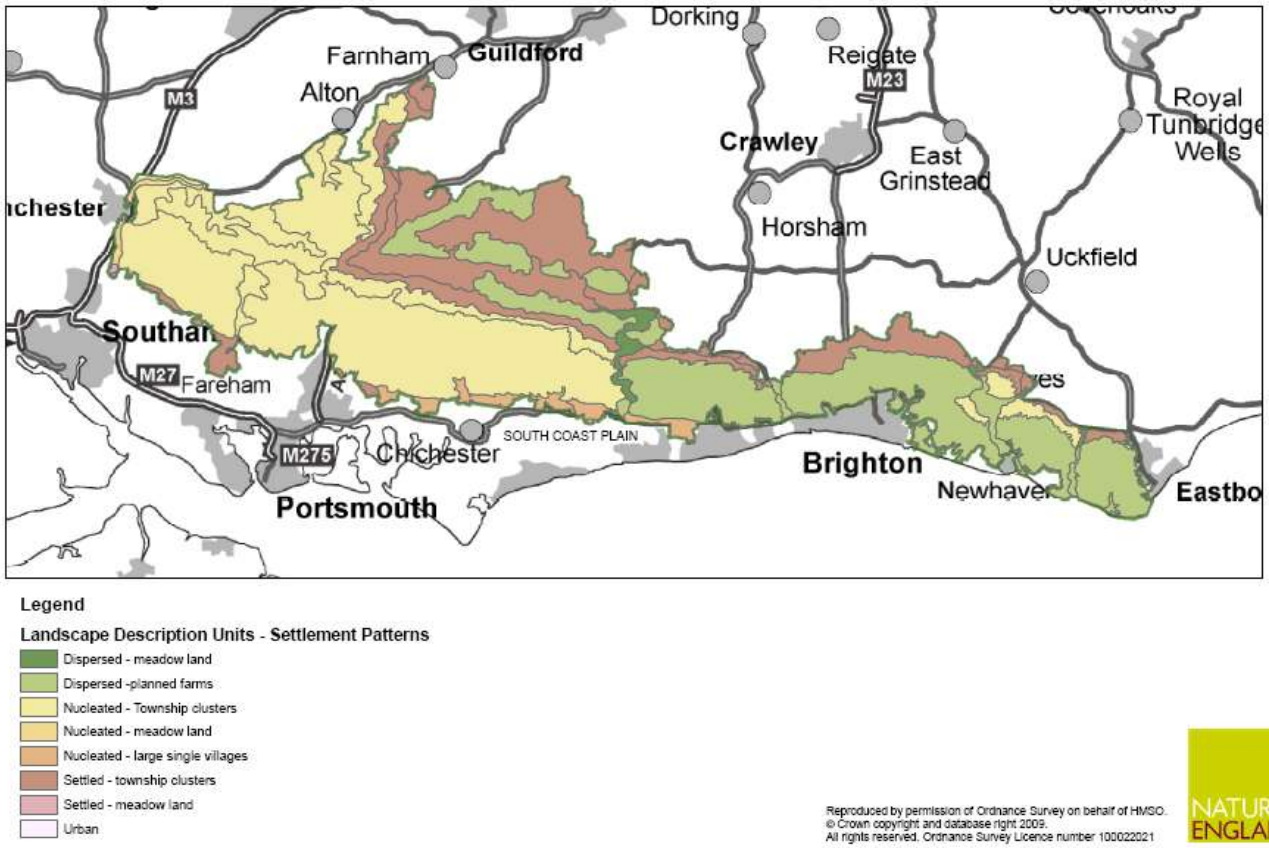

Figure 9 Map showing settlement patterns in the South Downs

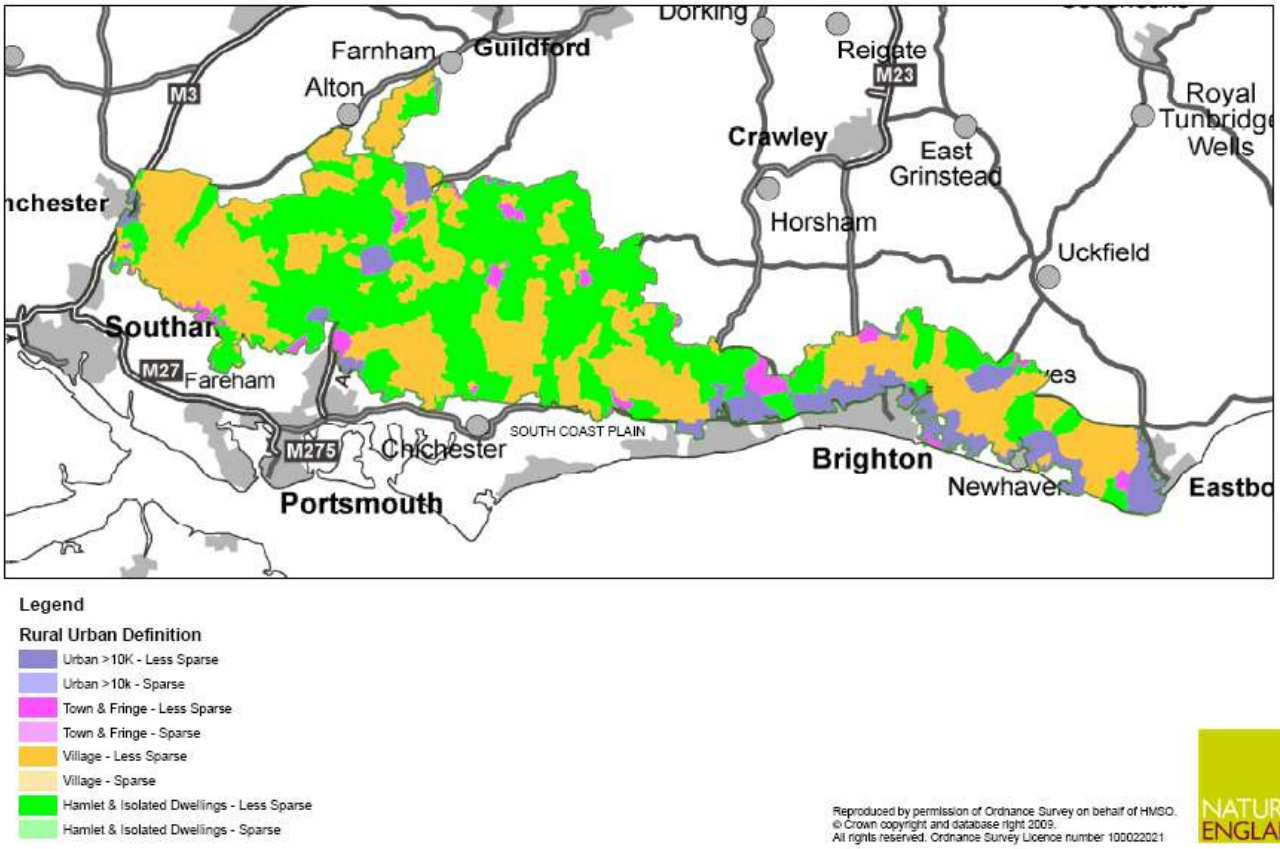

Figure 10 Map showing settlement density in the South Downs

Views

4.28 There are expansive views with **big open skies**, strong skylines and sense of elevation, with views down onto and across the surrounding landscape and seascape from the chalk ridge, contrasting with areas of enclosure, seclusion and intimacy. The dramatic northern escarpment is a dominant backdrop to views from the low lying Weald, with the sequence of ridges across the chalk creating a strong sculptural landform and dramatic skylines and skyscapes (Land Use Consultants 2005).

Ecosystem services

4.29 This section has relied heavily on the South Downs Integrated Landscape Character Assessment: Technical Report (Land Use Consultants 2005) and the relevant NCA descriptions (Countryside Agency, 1999). Some descriptive text has been taken from these documents.

Provisioning services

Agriculture and forestry

4.30 Farmland dominates the National Park area and influences the overall character of the area significantly. More than 50% of farmland is arable, the majority of which is intensively managed under modern farming systems (Land Use Consultants 2005). Free-draining soils and the porous chalk enable easy working and spring cropping for agriculture on the dip slope, and suit grazing with sheep on the steeper slopes. The alluvial soils, some of the most productive in the area, support crops and intensive dairying (see agriculture section in landscape character for a more detailed description).

Plate 6 Arable farming on the Downs

4.31 Mature broadleaved woodland comprises half of all woodland in the South Downs, with the largest proportion being in the Greensand and Weald region. Mixed broadleaf/conifer is the next most common, followed by conifer. Coppice comprises 4% of woodland across the area, with the total area being 3721 ha, of which 2002 ha is represented by stands under 2 ha in size (Land Use Consultants 2005).

4.32 Of more than 4,000 hectares of Forestry Commission woodland in the area (Forestry Commission 2006), 1,700 hectares are plantation forests (primarily conifers) on ancient woodland sites. There is an intention to restore a large proportion of these sites to native species. There is a growing focus on bringing unmanaged and undermanaged woodlands back in to management where appropriate, thereby increasing the provision of wood fuel for energy provision locally and improving management for biodiversity (Forestry Commission 2006).

Renewable Energy

4.33 The current South Downs management plan and planning guidelines support community based micro-renewable energy projects, but do not support large scale wind energy or photovoltaic energy projects within the National Park on landscape grounds (South Downs Joint Committee 2008b). The management plan is currently under review. There is a growing focus on the provision of wood fuel from the National Park woodlands.

Water resources

4.34 More than 1.2 million people living within and around the Downs, predominantly on the densely populated coastal plain, rely on the chalk aquifer for their drinking water (Currell 2005). The chalk aquifer and other permeable strata, ie the freely draining nature of most geology and soils in National Park, are extremely important as it means that winter rainfall is often readily absorbed, recharging aquifers and making an important contribution to water supplies.

Regulating services

Carbon Storage

4.35 Soils and bio-mass can perform an important role in sequestering carbon to help mitigate climate change. Although they are not found extensively in the National Park, fen peat soils and the peaty or other organic deposits within loamy and clayey floodplain soils with naturally high groundwater are important carbon stores. Fen peat soils are found in two main areas, in the Itchen valley east of Shawford along the western boundary of the National Park, and at Amberley Wild Brooks in the Arun valley. Peaty or organic deposits may also be found in back swamps and other depressions associated with the upper reaches of the main rivers (Itchen, Meon, Lavant, Rother and Ouse) where these occur within the National Park. Soils low in organic matter content may also have some potential for carbon sequestration by increasing organic matter inputs such as manures.

4.36 Vegetation within the South Downs also carries out this function; for example the extensive woodland within the National Park is a significant carbon store.

Climate regulation

4.37 The natural environment performs an important function in supporting climate change adaptation through regulating the climate. For example, trees can provide an important counter to the effects of urban heat islands (Bowler *et al.,* 2010 and Land Use Consultants 2009) (albeit at a small scale, for example, Lewes, Midhurst, Petersfield), as well contributing to flood alleviation, particularly along valley bottoms. Shade provided by woodlands provides cooling for livestock and people using the area. It is also understood that rural areas with a greater proportion of semi-natural habitats are cooler than urban areas (Forest Research

2010). The South Downs therefore, could have a cooling effect on urban areas within and beside it.

Water quality

4.38 Many of the boreholes in the National Park have increasing levels of nitrates, some periodically failing Government health standard targets. In addition, certain pesticides, such as metaldehyde, also enter the ground water in some areas. The impact of sediment in watercourses from accelerated erosion or run-off is also a water quality issue (South Downs Joint Committee 2008b). Both of these are predominantly caused by diffuse pollution from agriculture. In addition, Water Framework Directive targets for ground and surface water are not being met in many water bodies.

Flood protection

4.39 The flood plains of the main rivers and their tributaries, and other wetlands in the National Park, provide flood protection. Winter rainfall is absorbed and stored in well structured, permeable soils, which helps to avoid accelerated water run-off and flooding (South Downs Joint Committee 2008b).

Plate 7 Flood protection along the River Ouse

Cultural services

Sense of place

4.40 The South Downs is an accessible landscape retaining special qualities of space, remoteness and quietness. It is perceived as an isolated 'island' set apart from the busier surrounding landscapes of South East England. The absence of main roads, presence of narrow winding

lanes and perceived naturalness of the woodland, pasture and small stream valleys creates an ‘undiscovered’ feeling in the National Park (Land Use Consultants 2005).

4.41 These qualities are valued both by the more than 108,000 people who live in the Park (South Downs National Park Authority website a) and by the large number of people who visit from surrounding areas. The landscape has long been a source of inspiration to artists and writers including, including Kipling, Elgar, William Cobbet, WH Hudson, Richard Jeffries, Gilbert White, Edward Thomas, and Hilaire Belloc (Land Use Consultants 2005). There are many accessible cultural highlights including Jane Austen’s House and Petworth House, a 17th-century mansion set in a deer park landscaped by 'Capability' Brown.

Recreation

4.42 Recreation opportunities in the National Park provide great health benefits to a large population in the surrounding area. With 10 million people living within a 1 hour drive of the National Park and around 39 million visitor days per year (South Downs National Park Authority website b), the green spaces, woodlands and recreational resources of the South Downs have a particular value to the local and wider community. The high parts of the South Downs NCA, including the South Downs Way, are among the most important recreational assets of the Downs. The escarpment tops and the coastal headlands are particularly popular places due largely to the panoramic views, ease of access and sense of remoteness. The key recreational assets within the National Park include:

- The **South Downs Way** – The South Downs Way National Trail stretches the entire 160 km length of the Park from Winchester in Hampshire to the chalk cliffs of Beachy Head, near Eastbourne (South Downs National Park Authority website b).

Plate 8 Walkers on the South Downs Way

- **Country parks** including Queen Elizabeth Country Park in Hampshire and Seven Sisters Country Park and Beachy Head, East Sussex. Queen Elizabeth Country Park in Hampshire is the county's biggest country park and includes 32 km of trails for walkers, cyclists and horse riders, 570 ha of open access woodland and downland, Butser Hill National Nature Reserve, and the highest point on the chalk (HantsWeb, Hampshire County Council). Seven Sisters Country Park comprises chalk cliffs, meandering river valley and open calcareous grassland covering 280 hectares (South Downs Online) and is a popular place for a number of outdoor activities including walking, birdwatching, cycling and canoeing. The Country Park is named after the famous Seven Sisters that form part of the chalk cliffs on the Sussex Heritage Coast, one of Britain's finest unspoilt coastlines (South Downs Online b).

Plate 9 Butser Hill

- **Rights of Way** – The National Park contains over 3200 km of rights of way (Land Use Consultants 2005), which makes public rights of way one of the most important access and recreation assets within the Park.
- **Open access land** – Open Access land covers areas of land registered for common use. This means that anyone can enjoy and travel across this land without having to follow a footpath. It is on Access areas that we have the right to roam. On the chalk downs in the summer months many different flowers, butterflies and birds can be enjoyed. In the Wealden area of the National Park heather and reptiles can be seen. Open Access land is found at over 300 sites on the South Downs, notable locations are Deep Dean, Malling Hill, Harting Down and Butser Hill.

Hills, commons and other landscape features

- **Devil's Dyke** – To the north of Brighton, this National Trust site is a huge dry valley that carves its way through ridges of rolling calcareous grassland, provides stunning views

north to the Weald and south to the English Channel and also provides opportunities for walking and cycling (National Trust website a).

- **Ditchling Beacon** – A prominent hill fort overlooking the Weald, the third highest point in the South Downs at nearly 250 m.
- **Kingley Vale** – A 150 ha National Nature Reserve containing one of the finest yew forests in Western Europe, including a grove of ancient trees which are thought to be among the oldest living things in Britain (Natural England website d). Alongside the yew forest there are areas of chalk downland and chalk heath and a wealth of wildlife including breeding birds and 39 species of butterfly recorded.
- **Cissbury Ring** – This National Trust site is an Iron Age hill fort built in 300BC, its ditch and ramparts is the second largest in England (National Trust Website b).
- **Chanctonbury Ring** – A small Iron Age hill fort in West Sussex, with a crown of beech trees planted in the 18th century and replanted after the 1987 storm.
- **St Catherine's Hill** – An Iron Age hill fort with other historic assets, and a Hampshire Wildlife Trust reserve comprising 58 hectares of flower-rich calcareous grassland with views over Winchester, the Itchen Valley and the surrounding countryside (Hampshire Wildlife Trust website).
- **Selborne Hill and Common** – A National Trust site, SSSI and SAC. This site includes ancient wood pasture, beech hanger woodlands and remnants of calcareous grassland, and site provides a good opportunity for access to these habitats. The now famous observations of the Rev Gilbert White, pastor and naturalist, published in 'The Natural History and Antiquities of Selborne' in 1789, are an invaluable record, with descriptions and locations of many now scarce plants and animals (National Trust website c).

Designated sites, nature reserves and other green space

There are a great many SSSIs and local wildlife sites within the National Park, of which a significant number have some level of public access, in part because they are designated open access land, and provide attractive green space for people to enjoy the outdoors and see nature at first hand. Other popular sites include National Nature Reserves, such as Ebernoe Common and Kingley Vale in West Sussex, and Local Nature Reserves, including Wealden Edge Hangers and Rotherlands in Hampshire. There is also a range of other sites, including areas of coast, woodlands, allotments, formal parks and sports pitches, which offer a mosaic of locally valued green space.

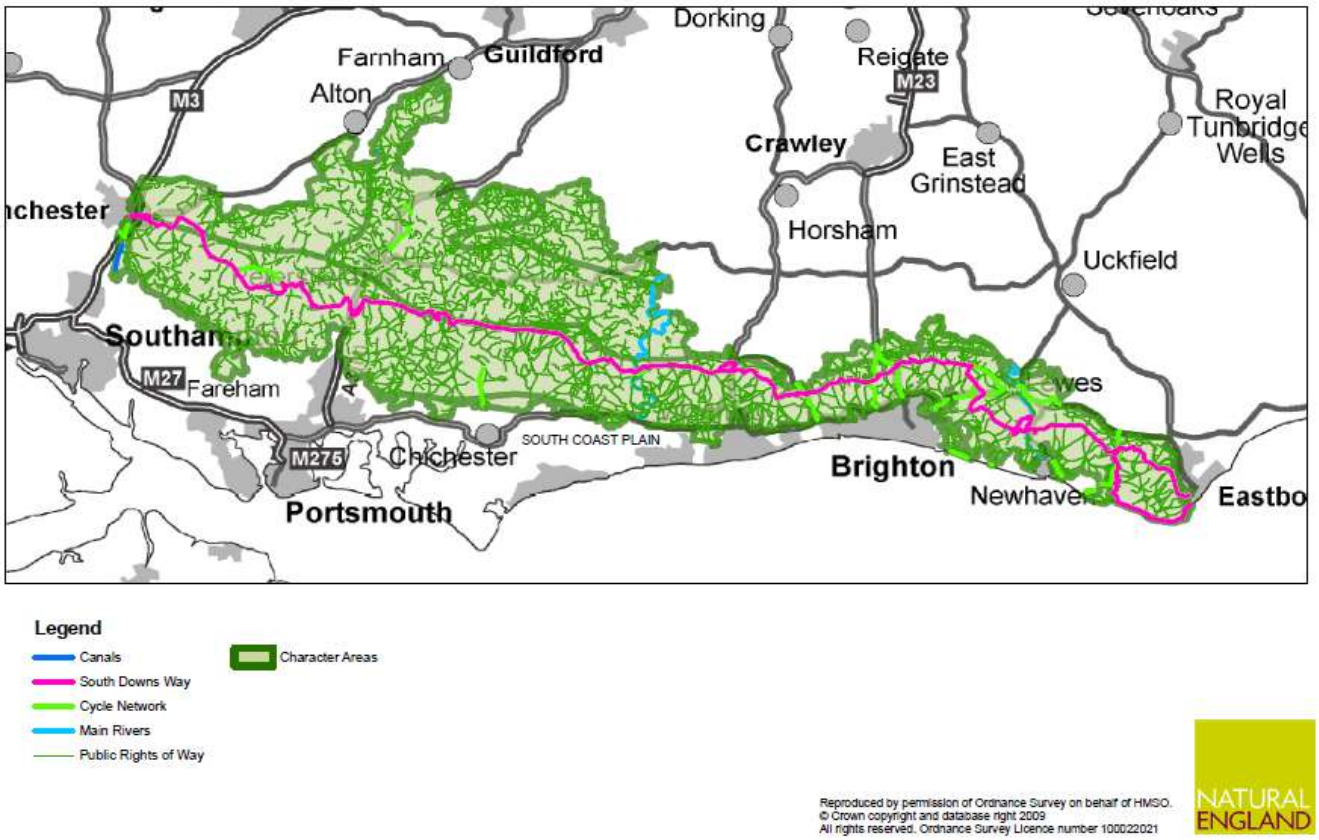

Figure 11 A map showing some linear access and recreation assets in the South Downs

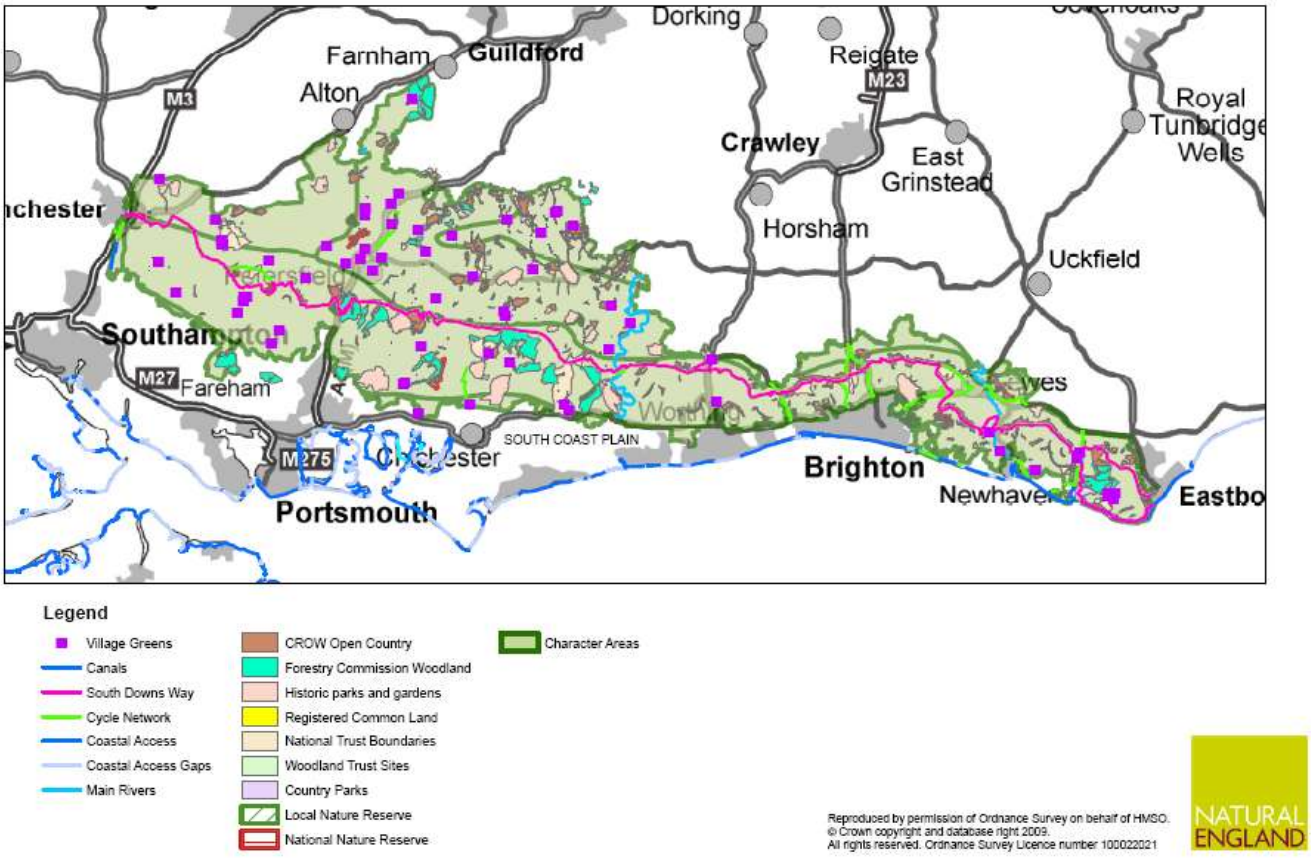

Figure 12 A map showing some site based access and recreation assets in the South Downs

Research and education

4.43 A large variety of education and research opportunities are provided by the natural environment of the South Downs National Park, for example for biodiversity, geology, ecosystems and the historic environment.

Supporting services

Nutrient cycling and soil formation

4.44 Soils process water and nutrients for the plants we eat, decompose and recycle our waste, moderate flooding, and provide raw materials and substrate for development of infrastructure. Fundamentally, soils are an integral part of any land-based ecosystem, and interact constantly with the organisms, atmosphere, climate and geology, and are one of the building blocks of landscapes. Unless carefully managed, soil erosion can be an issue, particularly in areas such as the western Rother valley, where the soils are particularly vulnerable (South Downs Joint Committee 2008b).

4.45 The soils within the National Park have been analysed used the Soilscape typology, which loosely classes soils into 27 typologies. There are 12 soil types within the National Park, the main soil types are:

- **Shallow lime-rich soils over chalk or limestone** – These are the most extensive soils in the National Park, covering approximately 40% of the area. They comprise shallow, well drained calcareous silty soils over chalk, typical of chalk downland areas of the South Downs. These chalky soils may be associated with deeper non-calcareous types in valley bottoms, or on upper slopes associated with deep clayey drift. Soils are variably flinty.
- **Freely draining lime-rich loamy soils** – In the National Park these comprise well drained calcareous fine silty soils over chalk and chalk rubble, typically at the foot of the chalk escarpment or in the broad valleys floors of the dipslope. They make up about 9% of the National Park area.
- **Freely draining very acid sandy and loamy soils** – These occur on the Lower Greensand outcrop in a rough arc from Liphook to Midhurst and east to Pulborough. Soils are sandy and loamy and are often stony and inherently infertile. Consequently, much land is uncultivated and in semi-natural vegetation - woodland, heathland and scrub. These soils cover around 8% of the National Park area.
- **Slowly permeable, seasonally wet, slightly acid but base-rich loamy and clayey soils** – These are extensive in the National Park, covering 13% of the area and occurring in two main areas: fringing the foot of the scarp face of the downs in typically low lying areas associated with Gault Clay deposits, and running across the north of the National Park from Milland to Wisborough Green in the western part of the ‘Low Weald’ associated with Wealden clays. Smaller areas are found on the southern boundaries of the National Park associated with tertiary clays of the coastal plain.

4.46 Other soils types comprising 2% coverage or below are freely draining slightly acid but base-rich soils, slightly acid loamy and clayey soils with impeded drainage, freely draining slightly acid sandy soils, loamy and clayey floodplain soils with naturally high groundwater, loamy and clayey soils of coastal flats with naturally high groundwater, loamy soils with naturally high groundwater, and fen peat soils.

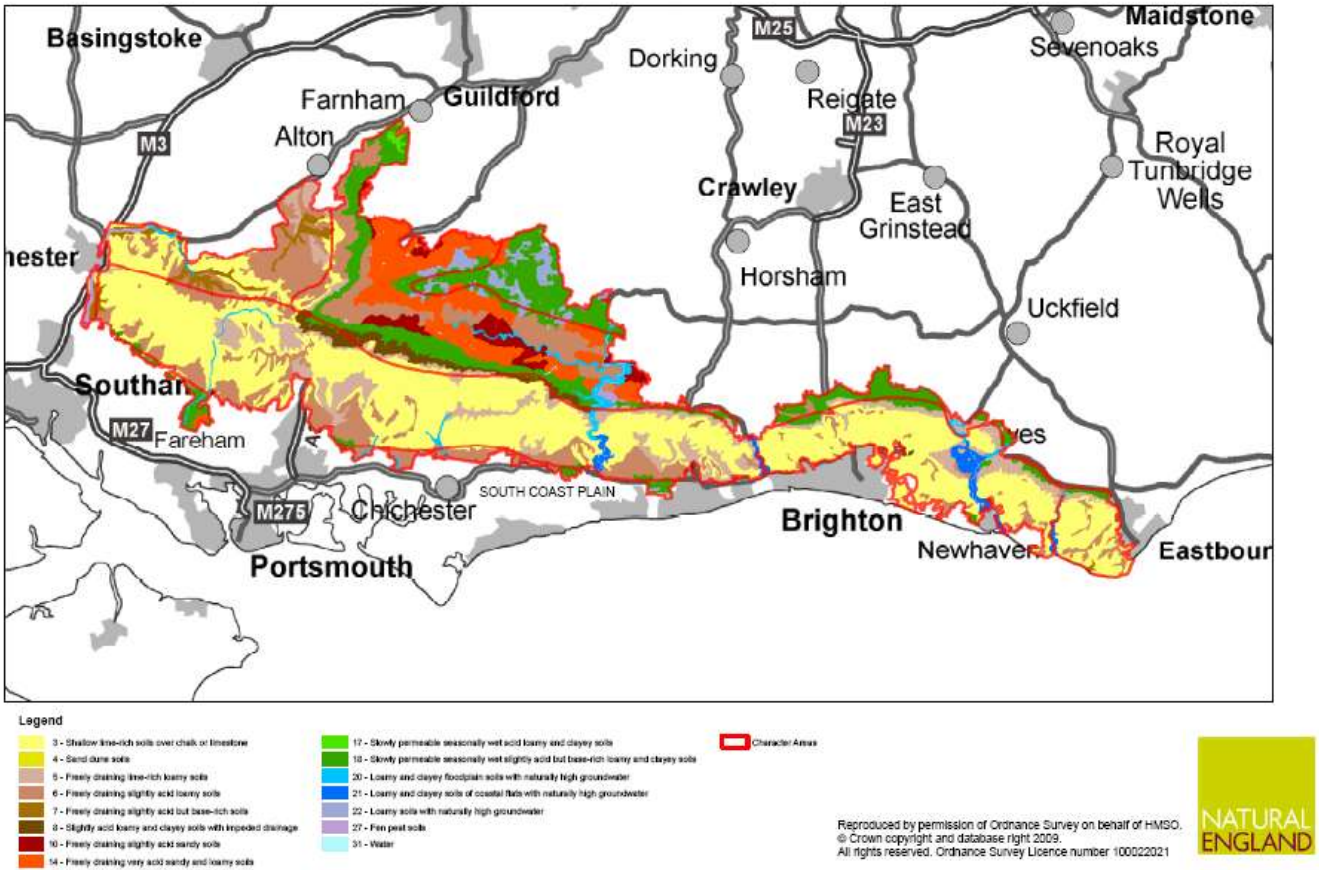

Figure 13 A Map showing the soils in the South Downs National Park

Biodiversity

4.47 The area is outstanding in its biodiversity, which reflects the varied geology and history of land use and management. The South Downs supports a wide range of habitat types, including ecologically rich **calcareous grassland** and associated downland habitats, **beech hanger woodland, floodplain grassland, ancient woodland, heathland, chalk streams and coastal habitats** (Land Use Consultants 2005).

4.48 The South Downs National Park contains a total of 84 Sites of Special Scientific Interest (SSSIs), which represent 6% of land area of the National Park. Of these nationally important sites, nine are National Nature Reserves, and internationally important sites include 13 Special Areas of Conservation (SACs), two Special Protection Areas (SPAs) and one Ramsar site. The area also contains 777 non-statutory County Wildlife Sites (Local Wildlife Sites, Sites of Nature Conservation Interest and Site of Importance for Nature Conservation), 19 Local Nature Reserves (LNRs), and 1219 woodlands of ancient origin (Land Use Consultants 2005) (Box 2).

4.49 There are more than 20 UK BAP habitats within the South Downs (the key BAP habitats are listed in Box 2). The most characteristic and valuable habitat types are calcareous grassland, rivers and floodplain habitats, ancient semi-natural woodland, heathland and farmland and arable (habitat data indicates that the South Downs supports a significant area of semi-natural broadleaved woodland at 19,879 ha or 12.1% cover and calcareous grassland at 3,966 ha or 2.4% cover) (Land Use Consultants 2005).

Designated sites, species and BAP Habitats in the South Downs

Internationally important sites:

Rook Clift SAC, Ebernoe Common SAC, Arun Valley SPA and Ramsar Site, Kingley Vale SAC, Castle Hill SAC, Lewes Downs SAC, Singleton & Cocking Tunnels SAC, Duncton to Bignor Escarpment, The Mens SAC, Woolmer Forest SAC, Hampshire Chalk Hangers SAC, The Upper Greensand Hangers SAC, River Itchen SAC.

Nationally important sites:

84 SSSIs including Cheesefoot Head, Harting Down, Ambersham Common, Amberley Wildbrooks, Beeding Hill to Newtimber Hill, Firle Escarpment and Seaford to Beachy Head.

European Protected Species, BAP species and some other species of note:

- Great Crested Newt *Triturus cristatus.*
- White Clawed Crayfish *Austropotamobius pallipes.*
- Bats, in particular Bechstein's *Myotis bechsteinii* and Barbastelle *Barbastella barbastellus.*
- Otter *Lutra lutra.*
- Dormouse *Muscardinus avellanarius.*
- Water vole *Arvicola terrestris.*
- Natterjack Toad *Epidalea calamita.*
- Adder *Vipera berus.*
- Barn owl *Tyto alba.*
- Field cricket *Gryllus campestris.*
- Adonis blue butterfly *Lysandra bellargus.*
- Duke of Burgundy butterfly *Hamearis lucina.*
- Pearl-bordered fritillary butterfly *Boloria euphrosyne.*
- Silver-studded blue butterfly *Plebeius argus.*

Key UK Biodiversity Action Plan Habitats:

- Maritime cliffs and slopes.
- Intertidal Chalk.
- Coastal and flood plain grazing marsh.
- Running water (rivers and chalk streams).
- Ponds.
- Lowland Calcareous Grassland.
- Lowland meadows.
- Cereal field margins.
- Hedgerows.
- Beech and Yew Woodland.
- Woodland pastures and parkland.
- Lowland mixed deciduous woodland.
- Wet woodland.
- Lowland Heathland.

4.50 The most important and characteristic habitat types found in the South Downs are described below. The text is taken from the South Downs Integrated Landscape Character Assessment – Technical Report (Land Use Consultants, 2005).

Plate 10 Ancient Kingley Vale yew tree

Grassland and arable land

4.51 The South Downs supports significant areas of unimproved calcareous grassland, with extensive areas occurring along the north-facing escarpment, and more widely scattered fragments on the south-facing, shallow sloping, predominantly arable dip slope. These areas support diverse plant communities, including many notable plant species, and important populations of invertebrates and breeding birds. Several internationally important calcareous grassland sites occur within the South Downs. It is the extent, variety and species composition of calcareous grassland within the South Downs that make this an internationally important resource (Land Use Consultants 2005).

4.52 A number of other habitats may be found in association with this calcareous grassland, including more mesotrophic and even acid grassland associated with the clay caps, heathland, chalk heath and transitions to coastal grassland. Where present, such habitats provide important diversity at the landscape scale, and contribute to the ecological value of the area as a whole. Chalk heath in particular, is of inherent ecological value and is thought to have developed over undulating chalk bedrock where low-lying areas were filled with windblown lime-free loess during the last ice age. This has created an intimate mosaic of basic and acidic soil conditions, resulting in a unique community comprising a mix of specialist chalk and acid plant species. The best example of chalk heath habitat within the South Downs is found at Lullington Heath NNR. Scrub and woodland frequently form an important component of the calcareous grassland system, and include communities such as yew woodland and juniper scrub that are of individual ecological value. However, continued grazing is crucial to maintaining the open, species-rich turf structure, and a lack of grazing at some sites has led to the loss of open species-rich grassland to course grassland, dense woody scrub and eventually woodland (Land Use Consultants 2005).

Plate 11 Species-rich calcareous grassland

Rivers, streams and floodplain habitat

4.53 The Rivers Arun, Adur, Ouse, Cuckmere and Western Rother run through the South Downs, with all except the Rother running in a southward direction and cutting through the chalk escarpment. These rivers provide a range of important wetland habitats, that support a diverse range of aquatic plants, invertebrates and over-wintering birds. The rivers vary in character according to underlying geology and the geology at source, with the four major rivers, forming relatively large lowland clay rivers. Large sections of these rivers have been engineered and embanked for flood protection purposes, and the majority of the floodplain has been drained for agricultural use. Nevertheless areas of high nature conservation interest still occur, such as floodplain grassland, reedbed, ditches and bankside trees. Many of these wetland habitats carry statutory nature conservation designation, and also include areas of international importance such as the Arun Valley Ramsar site (Land Use Consultants 2005).

4.54 In addition to the large rivers and their floodplains, small chalk streams and winterbournes (streams dry in the summer months) are also characteristic of the Downs, and are of high ecological value. Chalk rivers such as the Itchen contain water throughout the year, while the Lavant dries totally during late summer. These chalk streams and rivers support a diverse aquatic flora and are important habitat for a range of aquatic invertebrates and fish. The Itchen is a classic example of an ecologically rich chalk river, and is of international importance (Land Use Consultants 2005).

4.55 Ponds are also an important habitat in the Low Weald, as are the dew ponds on the chalk ridge and across the dip slope, where natural standing water for livestock is largely absent because of the porous nature of chalk. Many now constitute important refuges for wildlife, as well as being of cultural significance.

Plate 12 Chalk stream flowing through the Downs

Woodland

4.56 The South Downs has a large amount of woodland, supporting a range of woodland types that vary according to local geology, climate and management history. Woodland types include hanger woodland which is found both on the chalk and on the greensand, ghyll woodland associated with steep sided stream valleys, as well as more mixed semi-natural woodlands, including much of ancient origin together with a range of more recent woodland plantations (Land Use Consultants 2005).

4.57 The hanger woods of the South Downs include areas of international importance for their uncommon woodland communities, and include the East Hampshire Hangers SAC. These include those dominated by mixtures of beech and ash on chalk rich soils, which are extremely rich in vascular plants. Other ecologically important woodland types that occur on the chalk include yew dominated woodland, and an unusual mixed woodland of ash, maple, wych elm, beech and occasional large leaved lime (Land Use Consultants 2005).

4.58 On the Greensand, areas of small-leaved lime dominated woodland occur, which are notable for their rich bryophyte flora. Areas of woodland associated with sheltered stream side valleys (known as ghyll woodland) also occur locally and favour a range of species more typical of the northwest of England. These woodlands are also important sites for bryophytes and ferns (text from Land Use Consultants 2005). Areas of broadleaved plantation woodland occur throughout the South Downs, with areas of mixed and coniferous plantation locally abundant within the Greensand regions. Although not of such high ecological value as semi-natural woodlands, these areas do provide valuable habitat for a range of plant and animal species (Land Use Consultants 2005).

4.59 Other woodland habitat in the South Downs includes wet woodland, and wood pasture and parkland. Wet woodland is relatively limited in its distribution, largely confined to small remnants along the major river valleys. One of the most significant areas is around Burton

Pond on the Wealden greensand. There are a number of important parkland sites across the National Park, Arundel Park being one of the most significant ecologically particularly for invertebrates. Ebernoe Common, now in part owned and managed by the Sussex Wildlife Trust has had grazing re-introduced, and retains its wood pasture interest.

Plate 13 Beech hangers

Heathland

4.60 The sandy soils of the Wealden Greensand support occasional areas of heathland, including areas of dry and wet heath, acid grassland, mire and scrub. These heathland sites support an interesting flora, as well as being important for specialist invertebrates and for breeding birds such as woodlark, nightjar and Dartford warbler. Examples of important heathland sites within the area include the internationally important Wealden Heath SPA, Ambersham Common SSSI and Iping Common SSSI. Areas of dry heath are relatively plant species poor, although they do support an interesting lichen flora and are support important populations of reptiles and specialist invertebrates. Areas of wet heath and valley mire also occur locally, and are of high ecological importance. These habitats are more species rich, and support a number of locally notable plant species, for example marsh clubrush, oblong-leaved sundew and white beak sedge, and are rich in bryophytes, including Sphagnum bog mosses. Areas of scrub and woodland often form a component of these heathlands, and where managed appropriately provide valuable habitat diversity (Land Use Consultants 2005).

Plate 14 Heathland at Iping Common

Plate 15 Exposed chalk cliffs at Beachy Head

Maritime cliffs and slopes

4.61 As the name suggests, these can vary from sheer faces to gentle slopes on the coastline, which are created through slippages and coastal erosion. There is no defined minimum height or angle of slope for a cliff, but the distance that the cliff-top extends inland is determined by the limit of salt spray deposition. On the seaward side this habitat ends immediately above high water, and so includes the splash zone lichens and other species which occupy this habitat. The maritime cliffs in Sussex are soft due to their underlying geology, and occur between from Eastbourne and Seaford (constituting more than 14% of the European coastal chalk), and a shorter stretch between Newhaven and Brighton (adapted from UKBAP Action Plans Tranches 1 and 2 (1995-1999)). Characteristic species include Fulmar *Fulmarus glacialis*, Peregrine Falcon *Falco peregrinus*, Chalk Carpet *Scotopteryx bipunctaria*, Bee Wolf *Philanthus triangulum*, Sea Carrot *Daucus carota* ssp. *Gummifer*, rock sea lavender *Limonium binervosum*, sea radish *Raphanus maritimus* and rock samphire *Ceithmum maritimum*.

Sublittoral chalk

4.62 Characteristic of chalk coasts are wave-cut platforms, formed where a vertical cliff face meets an extensive foreshore, and caused by both aerial and marine erosion. These often extend several hundred metres seawards, and are one of the differences between these coastlines and many of the harder rocky coasts of western and northern Britain. Further out to sea, this habitat often includes subtidal chalk sea caves and reef habitats. Here shallow, subtidal communities are limited or absent due to the easily eroded nature of chalk and the prevailing harsh environment, characterised by extreme water temperatures, high levels of turbidity, siltation and scouring. Less robust species such as large seaweeds, which are vulnerable to wave damage are replaced by more opportunistic species. As a result the shallow subtidal zone is dominated by animals and communities that are low in species richness reflecting the hostile environment. The most extensive areas of sublittoral chalk in Britain occur in Kent and Sussex. The distribution of these chalk wave-cut platforms on the Downs mirrors that of the maritime cliffs which are located above them, namely between Eastbourne and Seaford, and a shorter stretch between Newhaven and Brighton (adapted from UKBAP Action Plans Tranches 1 and 2 (1995-1999)). The upper levels are dominated by barnacles and limpets, but a dense seaweed canopy and understorey is present from the middle shore downwards supporting several species of piddock and the worm *Polydora* spp.

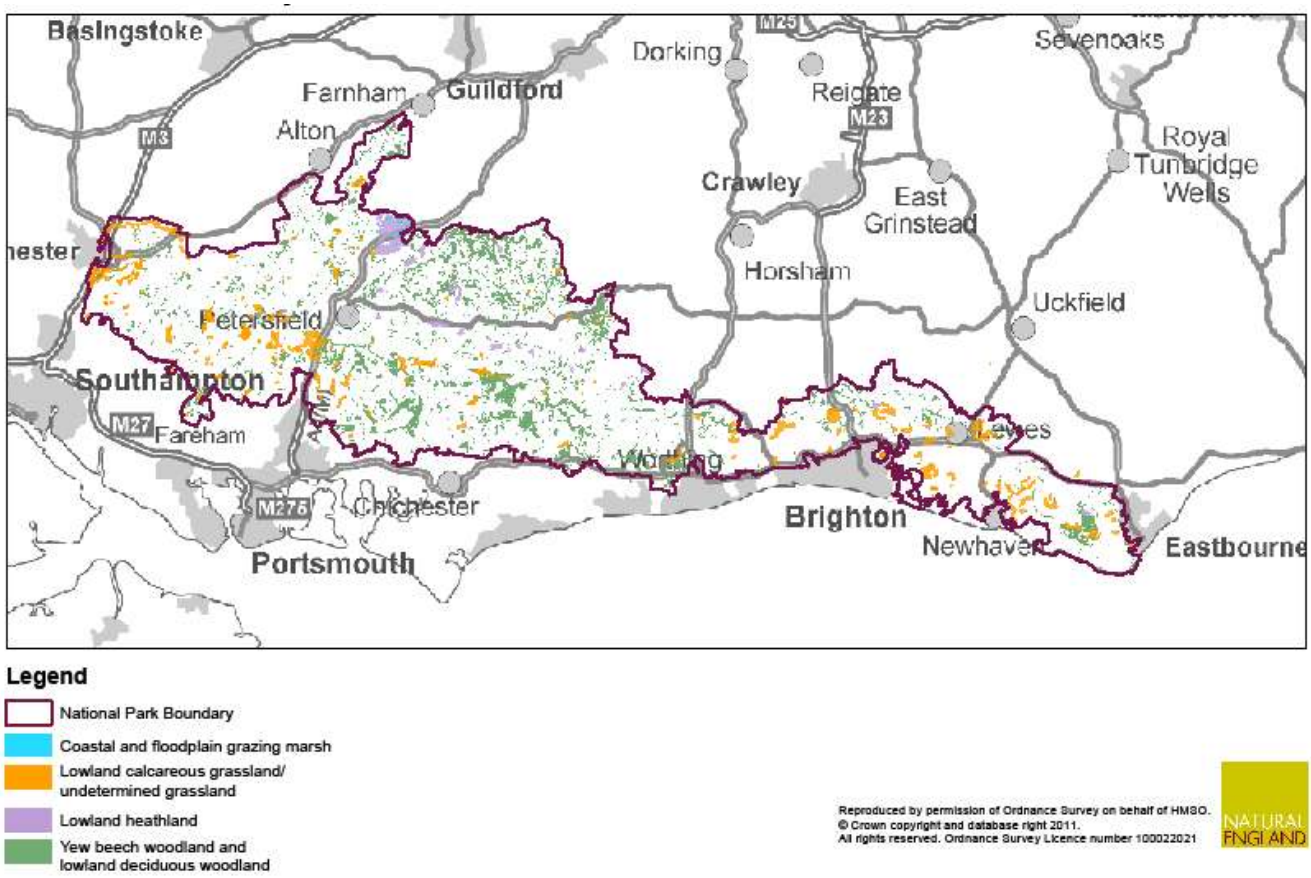

Figure 14 A map showing major BAP habitats in the South Downs

Summary of the South Downs National Park landscape character, ecosystem services and biodiversity

4.63 From the above descriptions, the following were identified by the project team as the most important aspects of landscape character and ecosystem services that we should seek to maintain and enhance:

- A landscape that can deliver clean water, food, fuel, flood protection and significant income from tourism and agriculture.
- Tranquillity, a sense of wildness, and opportunities for recreation, in an area surrounded by dense populations.
- A huge variety of flora and fauna and habitats, including characteristic open downland and woodlands.
- "The Blunt, bow-headed, whale-backed Downs", (Rudyard Kipling, 1907) - The chalk ridge, the spine of the National Park, from which many of its iconic views can be enjoyed.
- The cultural landscape, including literary and artistic connections.

4.64 The most important assets that provide these characteristics and services are:

- The distinctive geology of the area that underpins the landforms and the soils that support the land uses in the National Park.
- Over 850 statutory and non-statutory designated biodiversity sites, including calcareous grassland, heathland, ancient woodland and floodplain grassland. These are key assets for biodiversity, landscape and access, and are home to a wealth of species.
- An extensive Public Rights of Way network, and significant areas of open access, which are key recreational assets.

- Historic landscapes, including concentrations of ancient monuments and stately homes with parkland.

Part 2 – Results of vulnerability assessment

4.65 This section summarises the assets in each category – geology and soils, biodiversity, historic environment and access and recreation – that were deemed to be 'more vulnerable' or 'moderately vulnerable'. Detailed tables of results, including assets assessed as having relatively low vulnerability, can be found in Appendix 1.

Geology

4.66 In a review of the potential impacts of climate change on geological and geomorphological features Prosser *et al.,* (2010) indicated that all types of feature were likely to be affected, while the effects of human responses to climate change on such sites might be even more significant in some cases. Areas of particular concern within the South Downs from a geological perspective are the coastal cliffs and the geomorphology associated with rivers and dry coombes such as Devil's Dyke. There will also be opportunities associated with climate change, for example the creation of new exposures and the potential for increasing public awareness of the need to allow processes to operate naturally in order to allow the natural environment provide society with sustainable adaptation.

More/moderately vulnerable

4.67 **Coastal cliffs and foreshore:** This includes much of the coast, particularly to the east of Newhaven and Seaford, extending as far as Eastbourne. Between Newhaven and Brighton, a number of short segments of coast are included in the National Park. Since this coast consists almost entirely of two SSSIs, which are designated for their stratigraphical (succession of rocks) interests that extend the length of the SSSIs, any impacts will be widespread on the coast.

4.68 These features could suffer from obstruction or reduced access to the interest feature (Prosser *et al.,* 2010). A combination of foreshore lowering and sea-level rise may reduce the accessible area of foreshore exposure as well as reduce the access time to the remaining exposures.

4.69 As a consequence of sea-level rise, foreshore lowering and heightened storminess, cliff bases are likely to be subjected to heightened erosion, leading to more frequent cliff falls and accelerated cliff recession (Prosser *et al.,* 2010). One affect of this may be to increase the supply of flint, which in some circumstances, might feed back to reduce cliff recession rates. Foreshore lowering may lead to changes in sediment movement and might ultimately affect sediment regimes further along the coast and offshore.

4.70 Within coastal designated sites the site boundaries may only be offset from the cliff or foreshore by a short distance. Eroding coastlines where the crest of the cliff, and ultimately the mean low tide datum migrate landward of the site boundary, the interest being effectively lost from the site, will lead to the feature no longer being protected by the legislation under which it was designated. This is particularly important as the coast in the South Downs is heavily designated.

4.71 On the other hand, climate change is likely to result in increased pressure to defend coasts and prevent erosion. This may lead to loss of or declining condition of exposures, interest and designated features and impairment of natural or geomorphological processes, especially if this involves substantial engineering, and particularly where property or infrastructure is involved. On the coast, to the east of Seaford, with the exception of Birling Gap, there is very little development or infrastructure immediately inland of the coast. However, proposals to realign defences close to the mouth of the Cuckmere River, which would affect an area where no property is threatened and only low grade agriculture land is present, has led to protracted public debate. This highlights some the difficulties associated with implementing change and re-instating ecosystem services and naturally functioning river valleys. On the other hand, a

previous Public Inquiry in to coastal erosion at Birling Gap, concluded with the decision to allow natural processes to prevail despite the loss of property this would incur.

Plate 16 Eroding chalk cliffs at Beachy Head

Moderately vulnerable

4.72 **Static geomorphological processes:** Such sites include Devil's Dyke, within Beeding Hill to Newtimber Hill SSSI, and Cow Gap within Seaford to Beachy Head SSSI. There are proportionately few of these sites, so that the impact is likely to be sporadic and widely dispersed. These processes could suffer from obstruction or reduced access to the interest feature and increased erosion or changes to processes.

4.73 Changes in rainfall and temperature regimes may influence the distribution and nature of vegetation, potentially increasing susceptibility to soil erosion and gullying. Drought combined with sudden high flow events resulting from changes in precipitation patterns may lead to substantial changes in slope and channel morphologies over time. In terms of features, coombes such as Devil's Dyke could undergo changes in profile, and suffer the loss of some of the associated sediments on the valley floor that may provide evidence related to the formation of this landform.

4.74 Where effects of climate change promote vegetation growth - longer growing seasons associated with hotter summers and warmer winters - some interest features, such as soft sediments may be susceptible to damage or even destruction through disturbance or disruption from the growth of shrub and tree roots. Scour caused by rapid run-off of rainwater has the potential to entirely remove some features, again features like Devil's Dyke would be vulnerable to this.

4.75 **Active geomorphological processes:** Seaford to Beachy Head SSSI is designated for its coastal geomorphology, which here demonstrates the impact of the dominant wave direction on the development of a cliff-beach-shore platform system that is not strongly controlled by the structure (bedding/joint spacing) of the chalk. Impacts on this interest will be widespread

in the coastal zone. These processes could suffer from obstruction or reduced access to the interest feature and increased erosion or changes to processes as described in the coastal cliffs and foreshore section above (Prosser *et al.,* 2010). Societal responses to climate change such as the stabilisation of exposed geological faces in the form of grading or battering, placing geotextiles over the face, carrying out drainage, planting vegetation or constructing hard engineered structures, will impact the value of assets, our ability to access them and their contribution to landscape character (Prosser *et al.,* 2010). Engineering remedies will also impact or impair the ability of geomorphological processes to adapt. Increased resources to manage impacts from climate change such as increased vegetation growth would also be a requirement in response to this direct impact.

Plate 17 The lower reaches of the Cuckmere valley

4.76 **Fluvial geomorphology:** Drought has the potential to reduce flow in rivers, and in some cases lead to seasonal flow. This, combined with sudden high flow events and the influx of large quantities of sediment may lead to substantial changes in slope and channel morphologies over time. These systems are also sensitive to drying up and changes in vegetation (Prosser *et al.,* 2010).

4.77 Impacts may also arise as a consequence of societal responses to climate change impacts and are most likely to be in relation to flood prevention. Engineering flood remedies may impact or impair the ability of geomorphological processes to function naturally, adapt to climate change and to provide society with sustainable adaptation (Prosser *et al.,* 2010).

Moderately/less vulnerable

4.78 **Active and disused quarries:** Most quarries in the South Downs are disused and are located on the Chalk. They range in scale from large disused cement works such as those in Southerham, near Lewes (all of which are geological SSSIs) to small pits such as Cadburn Pit near Glynde. Any impacts on this type of site is likely to be widespread. These features could suffer from obstruction or reduced access to the interest feature, increased erosion or changes to processes, change or loss of assets or sites and damage or destruction of features (Prosser *et al.,* 2010).

4.79 Increased winter rainfall and drier summers may have several effects, in combination with and dependant in part on aspect, and the geology of the feature. Many of the effects could simply be regarded as the acceleration of processes that take place at present. Examples might include a combination of extreme summer drought and winter wetting, wherein vegetation fails to establish and the main process is talus generation. Where rock-types are mixed, have different mechanical strengths and respond differently to wetting and drying there is a potential for larger scale failures and the obscuring of features. Given that much of the area consists of chalk (with relative contrast in mechanical properties), this particular impact may not be so significant. Where higher winter rainfall acts in combination with aspect, such that moisture is retained during the summer, rampant growth of vegetation may result in the interest features being obstructed.

4.80 As with coastal sites the boundaries of many quarries designated as SSSIs may only be offset from the crest of the face by a metre or so. Erosion of the face or slope failure may cause the face to migrate beyond the site boundary, the interest being effectively lost from the site, and although the interest features may still exist, they will no longer be protected by the legislation under which they were designated.

4.81 Where effects of climate change promote increased vegetation growth, some interest features, such as soft sediments may be susceptible to damage or even destruction through disturbance or disruption from the growth of shrub and tree roots. Scour caused by rapid run-off of rainwater has the potential to entirely remove some features.

4.82 Societal responses to climate change could result in the covering/loss of access to features or the impairment of processes. For example, the stabilisation of exposed geological faces in the form of grading or battering, placing geotextiles over the face, carrying out drainage, planting vegetation or constructing hard engineered structures, will impact the value of assets, our ability to access them and their contribution to landscape character. Increased resources may be required to manage impacts such as increased vegetation growth.

4.83 **Extensive and finite buried interest:** These features, such as the underlying chalk, are vulnerable to drying out due to drought, increased erosion from drought followed by intensive rainfall events and increased vegetation encroachment due to increased growing season, which can damage assets. Changes in land use, such as agricultural changes, could also impact access to and condition of these interest features. For example increased surface demands for agriculture and energy crops can obscure or damage interest features.

Soils

4.84 Soil-climate models predict that expected changes in temperature, precipitation and evaporation will cause significant increases in organic matter turnover and increased losses of CO_2 in mineral and organic soils across the UK. Due to the region experiencing the highest rates of temperature increase, the greatest losses, relative to existing soil carbon content, are expected in south east England. Generally, this could lead to poorer soil structure, stability, topsoil water holding capacity, nutrient availability and erosion (National Soil Resources Institute 2005). The following describes the vulnerability of soil types within the National Park.

More vulnerable

4.85 **Freely draining slightly acid sandy soils:** This soil type is already drought and erosion prone. Drier summers and wetter winters are particularly important climate change variables for this soil type, along with the consequences of extreme weather events such as increased rainfall intensity and drought. The main direct impact of climate change is likely to be increased erosion. This soil type is likely to be vulnerable to drying out during hotter, drier summer months, leading to lower soil moisture content and poorer growth of crops, grass and other vegetation, this may lead to an increase in erosion due to greater precipitation in winter months and increased rainfall intensity (National Soil Resources Institute 2005). This increased erosion will lead to sediment loss and exacerbation of existing risks such as nutrient run off and flooding. Coarser sandy varieties of this soil type on sloping land where soil is cultivated or bare, for example footpaths, is likely to be most vulnerable to this impact.

4.86 Loamy and clayey soils of coastal flats with naturally high groundwater. Sea level rise will threaten these soils that already have low adaptive capacity due to their location. Increased coastal flooding leading to an increase in saline conditions will cause the loss or degradation of this soil type.

Moderately/more vulnerable

4.87 **Shallow lime-rich soils over chalk or limestone:** Drier summers and more intense rainfall may lead to increased rates of soil erosion and sediment loss (National Soil Resources Institute 2005). Shallow soil on the steeply sloping scarp face will be most at risk.

4.88 **Freely draining slightly acid loamy soils:** Drier summers and more intense rainfall may lead to increased rates of soil erosion (National Soil Resources Institute 2005). This soil is already drought prone where coarser types occur and soil on moderately or steeply sloping land where cultivated or bare soil is exposed (for example, footpaths) will be most at risk.

4.89 **Slightly acid loamy and clayey soils with impeded drainage:** Wetter winters and more intense rainfall, lead to increased soil wetness and instability, compaction, run-off and increased erosion for this soil type (National Soil Resources Institute 2005). This soil is already prone to erosion due to high silt content and wetness and soils on sloping ground or water receiving sites are least able to adapt. Changes in ground water levels, caused by changes in precipitation patterns is likely to alter the physical and chemical properties of some soils, which will in turn influence flora.

4.90 **Fen peat soils:** This soil type is sensitive to drying out due to hotter drier summers, leading to loss of peat stock and carbon stores. The current condition of soils may limit adaptive capacity.

Moderately vulnerable

4.91 **Freely draining lime-rich loamy soils:** Drier summers and more intense rainfall may lead to increased rates of soil erosion (National Soil Resources Institute 2005). This soil is already drought prone and where it occurs on moderately or steeply sloping land where cultivated or bare soil is exposed (for example, footpaths) it is most at risk.

4.92 **Freely draining slightly acid but base-rich soils:** This soil is already slightly drought prone and therefore may be impacted by drier summers. However, it may be less vulnerable than other soils due to its loamy texture and depth.

4.93 **Freely draining very acid sandy and loamy soils:** Drier summers and more intense rainfall may lead to increased rates of soil erosion (National Soil Resources Institute 2005). These soils are already marginal to agricultural use due to drought, stoniness and inherent infertility.

4.94 **Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils:** Wetter winters and more intense rainfall, lead to increased wetness and risk of soil

compaction, diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding. It is also sensitive to 'shrink swell' due to its high clay content (National Soil Resources Institute 2005). This soil type's vulnerability is increased as soils are already wet and prone to structural damage.

4.95 **Loamy and clayey floodplain soils with naturally high groundwater:** Wetter winters and more intense rainfall, lead to increased winter flooding leading to possible deposition of sediment, increased risk of soil compaction and erosion by floodwaters if soil is bare or cultivated (National Soil Resources Institute 2005). These soils are already on floodplains and therefore have low adaptive potential.

4.96 **Loamy soils with naturally high groundwater:** Wetter winters and more intense rainfall, lead to increased wetness, risk of soil compaction, diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding.

Habitats

4.97 Biodiversity will be impacted generally by changes in species' ranges, new species colonising from Europe, changes in the composition of species communities, increased pest species, and changes in synchronicity, for example bird-caterpillar-tree food chains and between pollinators and flowers (Hopkins *et al.,* 2007, ICCAF 2010). Loss of habitat condition relating to designated sites and priority habitats is also a potential impact for all habitats. Climate change is already beginning to have some observable impacts on the wildlife of the South Downs. A number of invertebrate species have expanded their range across the South Downs in recent years, with species such as silver-spotted skipper spreading westward across the Downs, as their ability to breed on more northerly facing slopes has increased with rising summer temperatures (Thomas & Jones 1993).

More vulnerable

4.98 **Beech and Yew woodland** in the South East will be particularly vulnerable to loss of its Beech component due to its drought sensitive nature and the potential impact of sun-scorch leading to bark-death (Mitchell *et al.,* 2007, Broadmeadow and Ray 2005, Wesche 2003, Hossell and Rowe 2006). Climate space modelling through the MONARCH project has also suggested a potential reduction of beech in the South East area (UKCIP 2001). Observation of beech stands in the Chilterns and on a calcareous grassland site in Kent, Wye and Crundale NNR from the 1976 drought saw 80% of trees killed by bark necrosis as well as ubiquitous early browning and leaf loss (Hearn and Gilbert 1977). Increased winter temperatures could also lead to a reduction in Beech due to reductions in bud initiation. Beech specialists, such as fungi and invertebrates, are also likely to suffer due to this loss. Changes in precipitation may also lead to an increase in more drought tolerant species such as Ash (Broadmeadow and Ray 2005). This will all lead to increased difficulties in meeting beech woodland Habitat Action Plan targets. This will be particularly relevant in the West Weald area, the most densely wooded part of the National Park, with large areas of ancient woodland, a significant proportion of which is unmanaged or under managed.

4.99 **Inter-tidal chalk wave cut platforms** are potentially vulnerable to erosion, rubble, landslides and permanent inundation from sea level rise. This is particularly relevant to Seaford to Beachy Head SSSI.

4.100 **Running water - rivers and chalk streams:** Many smaller water courses throughout the National Park will be vulnerable to droughts and may dry out completely in their upper stretches, in particular those fed from the chalk aquifer through chalk springs. This could lead to the downstream migration of stream heads and winterbourne sections.

4.101 Changes in flow are likely to be experienced, both flashier flows due to more intense rainfall in winter and lower water levels due to less rainfall in summer (Hossell and Rowe 2006, Mitchell *et al.,* 2007, Clarke 2009). Longer drought periods in combination with intense rainfall events,

leading to increased run off are known stressors of freshwater ecology (Clarke 2009). Flashier flows can lead to destabilisation of sediments and banks and a reduction in rainfall can lower water levels. Changes in water levels will lead to a change local hydrological conditions and impacts on habitat suitability and connectivity between habitats (Conlan *et al.,* 2007).

4.102 As many freshwater species have limited ability to regulate their own body temperature, changes in water temperature has the potential to impact on a range of species, for example, salmonid fish and macroinvertebrate species (Clarke 2009) especially those near or at the southern limit of their range. This is exacerbated where connectivity to upstream habitats or other catchments is inhibited (Conlan *et al.,* 2007 and Mitchell *et al.,* 2007). Potentially the most significant effect of increased summer temperatures and decreased summer precipitation for freshwater systems will be an increased risk of deoxygenation (ICCAF 2010).

4.103 Increased pollution of waterbodies resulting from increased run-off will adversely affect water freshwater habitats and species (Clarke 2009) and may lead to increased invasive species and algal growths, species mortality and reduction of water quality (Mitchell *et al.,* 2007, ICCAF 2010). This will be exacerbated by the lower flows being less able to dilute or flush contaminants.

4.104 The findings from the assessment of impacts on rivers from the 1976 drought concluded that lack of rain combined with high temperatures led to a reduction of water levels and rates of flow, extremes in oxygen content, and increased nutrient concentration, all of which led to impacts on plant life and fauna (Hearn and Gilbert 1977).

4.105 Demand for water, for household, agricultural and recreational use is likely to increase with higher summer temperatures, and increased droughts will exacerbate the vulnerability of these habitats to the impacts of climate change (Mitchell *et al.,* 2007). This is particularly relevant to the Rivers Itchen, Meon, Ems and Lavant, and a number of chalk springs emerging at the foot of the scarp-slope, together with a number of lakes on the greensand and low weald, for example Burton Pond and Shillinglee Lake.

4.106 Engineering works on rivers to stabilise channels or increase flow, barrages and sluices may also exacerbate vulnerabilities by preventing movement of species or impacting on feeding habitat (Mitchell *et al.,* 2007).

4.107 **Ponds** share many of the vulnerabilities of rivers, such as reduced habitat volume, increased drying out and greater concentration of pollution (Mitchell *et al.,* 2007). Ponds are particularly vulnerable to increases in temperature, with increased likelihood of eutrophication symptoms where nutrient loads are high, contributing to a degradation of water quality and encouraging the growth of toxic algae (Mitchell *et al.,* 2007 and Hearn and Gilbert 1977).

4.108 Changes to rainfall and temperature may result in permanent pond communities being replaced by temporary pond species. Pond taxa are capable of rapid dispersal, and if the landscape can be adapted to provide sufficient sites then the communities will be sustainable, even if individual ponds change in character. However, lack of connectivity with other freshwater habitats may impede this.

4.109 Invasive species, an alteration to breeding cycles, or the emergence of invertebrates may have knock-on effects on, for example, predator prey relationships (Mitchell *et al.,* 2007). Dew ponds on the chalk geology of the Park are likely to be particularly vulnerable to these impacts.

4.110 **Floodplain grazing marsh** is vulnerable to increased flooding, waterlogging and increased siltation, but also periods of drought, when drying out of the marsh causes loss of feeding and breeding habitat for wetland birds (Mitchell *et al.,* 2007). Increased cycles of drought and flood may also lead to increased erosion of soils. Periods of drought can lead to the spread of species such as creeping thistle and ragwort, and warmer weather may also favour the spread of invasive species and greater survival of pest species. Changes in temperature may

also lead to changes in species composition and synchronicity, for example, migratory species becoming resident and predator-prey relationships becoming out of sync (Mitchell *et al.,* 2007).

4.111 As for the water bodies mentioned above, increased demand for water, for household, agricultural and recreational use, will exacerbate the vulnerability of this habitat (Mitchell *et al.,* 2007).

4.112 Management changes have the potential to affect the vulnerability of this habitat. For example, changes in grazing practices, the need to increase flood-storage or increase drainage to avoid flood risk, and other flood protection measures such as managed realignment could lead to damage to freshwater habitats of biodiversity value in the coastal zone (Mitchell *et al.,* 2007). These impacts are particularly relevant to the Arun Valley SPA and associated SSSIs and Local Wildlife Sites.

Moderately vulnerable

4.113 **Lowland meadows:** Though not a particularly common or significant feature on the Downs, lowland meadows are vulnerable to changes in rainfall and increased drought (Mitchell *et al.,* 2007), which could encourage the spread of injurious weeds such as creeping thistle and ragwort, especially when combined with excessive grazing pressures, and could impact on important bird populations (Mitchell *et al.,* 2007). Conversely, increased winter flooding in meadow habitat could lead to increased bare ground and increased ruderal species, including docks and nettles. This habitat is also likely to be vulnerable to the impacts of climate change on phenology of when plants flower and seed, impacting on the food chain of key bird species.

4.114 Lowland meadows are also likely to be vulnerable to growing pressures to maximise agricultural productivity, increase use of drought-tolerant grass species, changes in drainage and cutting regimes, and abstraction of water in the surrounding area (Mitchell *et al.,* 2007).

Plate 18 Ancient woodland on the Downs

4.115 **Wood pasture and parkland** is likely to be most vulnerable to the loss of veteran trees and a lack of replacement of these lost trees (Mitchell *et al.,* 2007). Further impacts are likely to be the loss of specialist associated species of veteran tree habitat. Increased fire risk particular to this habitat is where bracken and tall grass or heath is present between the trees. These impacts are particularly relevant to a number of parkland sites in West Sussex such as Arundel Park and parts of Ebernoe Common.

4.116 **Wet woodland** will be vulnerable to drying out at rainfall dependent sites in summer and in severe droughts, which could lead to significant vegetation change towards mixed deciduous woodland BAP habitat type. Conversely, a potential indirect vulnerability is that future flood prevention measures and river controls in response to increased risk of flooding to communities could lead to reductions in water supply, which in turn will lead to significant changes to the woodland structure. This is not a particularly common habitat within the National Park, the most notable site being Burton Pond.

4.117 **Maritime cliff and slope** habitat is particularly vulnerable to 'coastal squeeze' as there is often nowhere for the vegetation to retreat to as coastal erosion increases as a consequence of climate change and sea level rise. Maritime cliff and slope may be increasingly vulnerable to cliff erosion and more frequent landslides (Mitchell *et al.,* 2007). This is not necessarily a negative impact as the reactivation of old landslide complexes may be beneficial to cliff habitats and species. Rapid retreat of coastal cliffs could occur through greater toe erosion and more rainfall increasing groundwater levels and seepage. Changes to this habitat may impact on the extent of cliff-top habitat and species assemblages will change, affecting bird and mammal food sources and the composition of cliff vegetation communities. These impacts are particularly relevant to the Seaford to Beachy Head SSSI and Brighton to Newhaven Cliffs SSSI.

4.118 **Lowland heath** is particularly vulnerable to drought, but also increased summer temperatures which may lead to increased competition from other types of vegetation encroaching on areas of bare ground. This could change the composition of plant communities, for example, changes in the ratios of grassland, heathland and bracken (Hearn and Gilbert 1977, Mitchell *et al.,* 2007). The BRANCH project modelled the climate space of heathland species in Hampshire and concluded that the species composition of current heathlands could change significantly (Berry *et al.,* 2007). Drought may also decrease soil microbial activity and nutrient cycling (Mitchell *et al.,* 2007) and increased survival of pest species may increase vegetation damage, for example by heather beetles. Drier summers will also increase the risk of fires (Hearn and Gilbert 1977, Mitchell *et al.,* 2007). Lowland heath occurs within the National Park in fragmented sites such as Iping Common. These impacts are particularly relevant to the heaths of the Wealden greensand in West Sussex and extending in to Hampshire. Species reliant on high quality heathland such as a number of ground nesting birds are therefore particularly vulnerable.

4.119 Increased tourism and more visits to sites may have an impact, not least by increasing the possibility of summer fires, alongside increasing erosion and disturbance. Other management changes in response to other climate change drivers, such as increased tree planting would also be of detriment to lowland heathland.

South East regional biodiversity climate change vulnerability assessment results

4.120 The South East regional biodiversity climate change vulnerability assessment (Taylor and Knight 2011)[3] is a GIS grid based model (200m^2) which uses a number of variables – value,

[3] The South East regional biodiversity climate change vulnerability assessment has now been expanded to the national scale. For the latest National Biodiversity Climate Change Vulnerability Assessment information please **click here**

sensitivity and exposure, physical adaptive capacity (topographic heterogeneity and structural habitat connectivity) and management adaptive capacity – to assess the overall vulnerability of Biodiversity Action Plan (BAP) habitats based on principles for biodiversity adaptation identified by Defra (Hopkins *et al.,* 2007). This assessment allows us to add a spatially explicit element to the biodiversity vulnerability assessment for the South Downs National Park. Figures 15 and 16 show the results for the overall vulnerability assessment (all habitats) and the vulnerability assessment for calcareous grassland, a major habitat of the South Downs National Park.

4.121 The overall vulnerability results suggest the following are particularly vulnerable in the South Downs:

- Rivers – Itchen, Meon, Arun, Adur, Ouse and Cuckmere.
- Wetlands – particularly areas of flood plain grazing marsh at Lewes Brooks and Amberley Wild Brooks.
- Coastal habitats – including the cliffs at Seaford to Beachy Head and Brighton to Newhaven.
- Heathland – Woolmer Forest SAC, the largest area of lowland heath in Hampshire outside the New Forest (Natural England SSSI description).

4.122 Woodland and calcareous grassland generally show up as moderate to low vulnerability when compared to other habitats. However, this has to be viewed in the context of the importance of these habitats for the South Downs National Park, and the knowledge that the woodland dataset used in the assessment was one that covered all woodland types under 'deciduous woodland' and does not differentiate between woodland types with differing sensitivities to climate change ie certain types of woodland may be more vulnerable than others such as Lowland Beech and Yew woodland as described above. This is reflected in the vulnerability table and should be taken in to account when planning adaptation action using these results.

4.123 The habitat map for calcareous grassland (Figure 16) gives an example of the relative vulnerability results produced for this specific habitat. Some of the smaller fragments appear particularly vulnerable due to a lack of habitat connectivity and some of the grassland along the cliff tops is also particularly vulnerable. Other variables such as low topographic heterogeneity and lack of management to address current sources of harm identified for this habitat will contribute to the relative vulnerability assessment for this habitat.

4.124 The variables within the model can be used to help identify appropriate and targeted adaptation actions for a particular location. These results should be used with local data and local partners to ground truth the results and decide on appropriate actions. We can discuss the potential approaches to be applied, for example targeting the most vulnerable habitats or areas of moderately vulnerable habitat, and once this has been decided we can target action on habitat management and connectivity in particular, in line with the Lawton review recommendations (Lawton *et al.,* 2010) and in collaboration with our partners, specifically the South Downs National Park Authority.

4.125 Due to the importance of calcareous grassland habitat to the National Park, the following information on how this habitat may be vulnerable has been produced.

4.126 **Lowland calcareous grassland** may see changes in the composition of species (Hossell and Rowe 2006, Berry *et al.,* 2007, Mitchell *et al.,* 2007). For example, drought tolerant species may expand while drought sensitive species may contract. Drought and higher temperatures will also see greater incidents of parching and erosion of the soil that supports the habitat. Furthermore, increases in fires during hot dry periods could damage plant assemblages and the secondary impact of fire fighting activity on erosion rates has also been noted as a potential impact (Hearn and Gilbert 1977).

4.127 Increased rainfall in the winter could lead to grasses becoming dominant in this habitat (Mitchell *et al.,* 2007) and could also lead to greater erosion of soils. Invertebrate, fungi and moss communities will also be affected by changes in temperature and rainfall. Hearn and Gilbert (1977), in their review of the impacts of the 1976 drought on nature conservation sites in England and Wales, noted that some species of butterfly increased while others decreased. Other noted effects on calcareous grasslands from the 1976 drought were changes in species composition, with some species seeing dramatic declines and others dramatic increases, drying out and trampling leading to erosion, increased fires, and impacts on grazing invertebrates (Hearn and Gilbert 1977). The impacts were further exacerbated by aspect and grazing levels, for example severe rabbit grazing at Aston Rowant (Chilterns) and Wye and Crundale Downs (Kent Downs) NNRs increased the impacts of the drought on the vegetation (Hearn and Gilbert 1977). Younger calcareous grasslands composed of fast-growing or short-lived species are likely to be more vulnerable than older calcareous grasslands (Grime *et al.,* 2000).

4.128 In common with some of the observations from the 1976 drought, some calcareous grassland species have been modelled as gaining climate space and other modelled as losing it (BRANCH and MONARCH projects). Some of the species projected as gaining climate space early on, for example the silver-spotted skipper *Hesperia comma* and the chalkhill blue *Lysandra coridon*, have also been projected as losing climate space in the 2080s high scenario as climate change impacts increase, making it important to monitor changes in species over time (Berry *et al.,* 2007). However, when assessing these projected changes in species composition it is important to remember the habitat is limited by the underlying geology, so adaptive capacity is constrained by the availability of suitable soils and geology (Mitchell *et al.,* 2007, Hossell and Rowe 2006). Sites across the chalk are likely to be vulnerable to these impacts, but East Sussex is likely to be particularly vulnerable as it supports the largest areas of calcareous grassland, and the largest areas of south facing grassland.

4.129 This habitat may also be vulnerable to changes in land management, for example changes in grazing and pesticide practices and increased woodland planting as a response to climate change (and other drivers) (Mitchell *et al.,* 2007). Increases in visitor numbers may also impact calcareous grassland and the species it supports through erosion and possible disturbance.

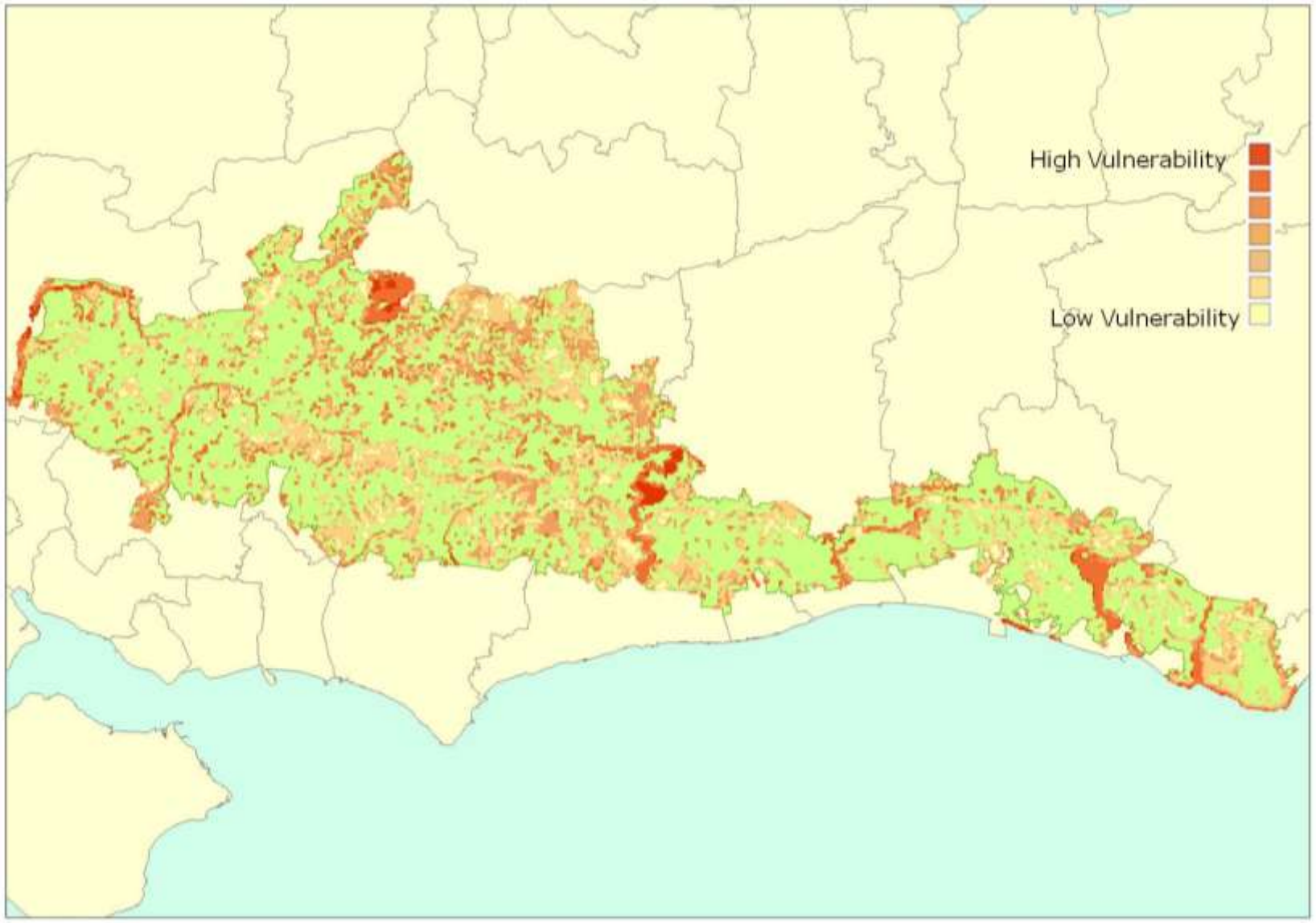

Figure 15 Map showing the vulnerability of all BAP habitats in the South Downs National Park, taken from the South East regional biodiversity climate change vulnerability assessment

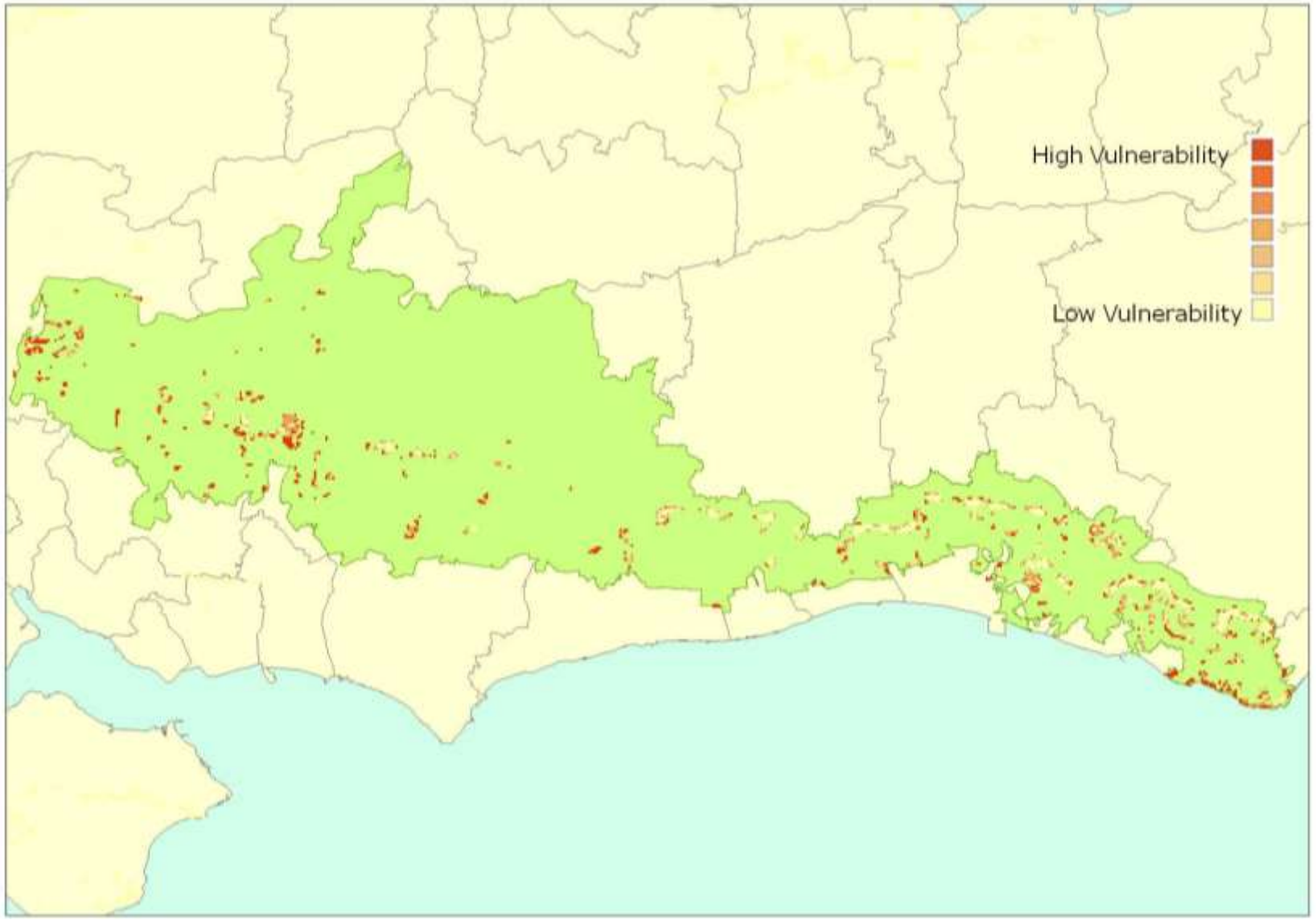

Figure 16 Map showing the vulnerability of calcareous grassland in the South Downs National Park, taken from the South East regional biodiversity climate change vulnerability assessment

Historic environment

4.130 Many of the historic sites on the South Downs may have already experienced and survived the effects of past climate change. However, the resilience of many assets may be further tested by the direct and indirect effects of future climate change. Climate change is also going to bring increased challenges to the ongoing maintenance and management of the historic environment.

More vulnerable

4.131 **Historic wetlands** will come under pressure from changes in precipitation and will suffer periods of drought.

Moderately vulnerable

4.132 Milder weather will extend the growing season in **historic gardens**, but may also limit the future of many traditional garden plants, which are less tolerant of higher summer temperatures and drought (English Heritage 2008). There may be changes in characteristic vegetation and also an increase in pests and diseases, for example, bleeding canker affecting horse chestnut (English Heritage 2008 and South East Historic Environment Forum 2008). This could lead to damage and loss of veteran trees which are important to historic parklands in the South Downs, for example, Petworth Park. Increased vegetation growth may lead to the obstruction of assets and therefore need greater management input (English Heritage 2008). Hotter drier summers may lead to increased fire risk.

4.133 **Buried archaeology** found within agricultural land, where adaptation of farming practices to climate change may bring about increased working of soils and changes in crop planting regimes, may experience greater disturbance (English Heritage 2008). Both flooding and drought may lead to changes in soil pH or moisture content which could also affect buried archaeology.

4.134 Heavy rainfall will bring increased rainfall penetration, with the potential to damage the internal fabric of buildings, including wall coverings and furnishings (South East Historic Environment Forum 2008). There may be problems retrofitting historic buildings to improve their resilience to climate change, such as by improving rainwater drainage in listed buildings, because of the restrictions on adapting existing roof coverings and rain water goods, or issues of cost or policy constraint. Increased droughts will increase the likelihood of shrink-swell in clay soils, and disturbance to building foundations. Increased soil temperature may also exacerbate chemical attack to foundations (National Soil Resources Institute 2005).

4.135 Short sharp rainfall is likely to cause greater erosion to **historic earthworks and monuments** (English Heritage 2008). Increase winter rainfall may also lead to flooding of many types of assets. Fungal infestations (such as wet and dry rot) and insect attack, including by wood boring insects, may increase in humid conditions and impact on timber structures, vulnerable decorative surfaces and organic archaeological deposits (South East Historic Environment Forum 2008).

4.136 **Areas for access and recreation:** Climate change will impact on all access and recreational assets, as warmer, drier summers may encourage people to use the outdoors much more, which will lead to increased management and maintenance needs. This could have a very positive impact of encouraging greater participation in active recreation, with many more people walking and cycling. This would not only deliver on the health objective of increasing physical activity, but will reduce the use of cars for more local short journeys which will contribute to climate change mitigation. At the same time such increased usage particular of popular sites could increase erosion and maintenance requirements. Extreme weather events associated with climate change may also have an impact on the usage patterns and management requirements of recreational assets.

More vulnerable

4.137 **Linear routes** in the South Downs National Park will be particularly vulnerability to increased winter rain, which can increase flood damage and erosion to paths, particular those on slopes or with poor drainage, due to increased run-off or puddling. The routes linking to and from the South Downs Way down to the northern scarp slope are particularly vulnerable to erosion from water run-off during storm events due to their steep and often sunken topography.

4.138 Climate change may lead to changes in the timings of use of footpaths. Hotter summers could lead to changes in peak use leading to congestion on popular routes at some times. On the other hand wetter winters could lead to a reduction in demand for access and recreation due to wetter weather. Furthermore, there could be changes in the most popular routes such as an increased use of South Downs Way during winter weather due to low weald clay routes being flooded and too muddy to use. These impacts are particularly relevant to the South Downs Way and feeder paths.

4.139 An increase in flooding events could potentially cause significant damage to walking routes along rivers, as well as damage to infrastructure such as footbridges. Increases in hazards caused by flooding, for example, unstable banks may also have an impact on user safety. For example, the South Downs Way river crossings (Cuckmere, Ouse, Adur, Arun, Meon, and Itchen) are particularly vulnerable to flooding and bank erosion due to high level of use, and unstable banks could prevent the current bridges from remaining safe and useable.

4.140 **Rivers** used for recreation are vulnerable to impacts which affect water availability and quality and any associated health impacts such as growths of nuisance algae due to change in temperature (Clarke 2009). Reductions in water levels may lead to more pressure on the remaining resource for recreation.

4.141 **Coastal recreation** areas are susceptible to increased footpath and track erosion. The South Downs Way coastal route between the Cuckmere Estuary and Eastbourne is particularly vulnerable to increased rates of cliff erosion. An increase in demand for outdoor recreation in summer may lead to congestion on popular sites, leading to erosion. These impacts are particularly relevant to Seaford to Beachy Head SSSI.

4.142 **Country Parks, NNRs, LNRs, National Trust land and other nature reserves** will be vulnerable to drought in summer, for example, the drying out of playing fields, gardens etc leading to greater irrigation requirements, and flooding in winter leading to damage to sites and landscape. These impacts are particularly relevant to Seven Sisters Country Park, Queen Elizabeth II Country Park, Stanmer Park and Kingley Vale NNR.

4.143 Periods of heat wave could also be detrimental to some sites, particularly those with mowed grass which are particularly vulnerable to drought. It has been noted that in the 1976 drought, increased visitor pressure at Wye and Crundale NNR led to increased erosion (Hearne and Gilbert 1977).

Moderately vulnerable

4.144 **Open access to heath, downland and common land** will be vulnerable to many of the impacts mentioned for linear routes, such as increased erosion and vegetation trampling due to increased access in the summer. They will also be vulnerable to an increased risk of fire and the impacts listed above for heathland and downland, potentially leading to changes in the visual and recreational assets. These impacts are particularly relevant to calcareous grassland and heathland sites across the National Park.

4.145 **Woodland** access is vulnerable to increased fire risk in drier hotter summers, increases in ticks and potential for tick borne diseases, and increased hazard from falling branches. Increased demand for woodland recreation due to the shade it provides may lead to an increased in popularity of woodland sites for recreation in future. An increase in the use of forests and woodlands for recreational purposes may result in increased disturbance and

trampling, which may be locally detrimental to biodiversity. However, the increasing interest in woodlands for their recreational value may encourage the planting and management of woodlands for wildlife to further increase their attractiveness (Mitchell *et al.,* 2007).These impacts are relevant to woodland sites across the West Weald in particular.

Part 3 – Potential major changes to landscape character, ecosystem services and biodiversity, and possible adaptation actions

4.146 This section summarises the major changes to character, ecosystem services and biodiversity in the area that could occur as a consequence of cumulative changes to assets deemed to be at least 'moderately vulnerable'. Possible adaptation options are suggested for each set of changes.

4.147 A full list of potential changes to each individual element of landscape character, ecosystem services biodiversity is included in Appendix 2 and adaptation options for each element in Appendix 3.

Geomorphology

4.148 While the underlying geology which contributes to the distinctive form of the National Park is likely to be relatively insensitive to climate change, the geomorphological processes which help to shape the National Park may be altered by climate change. The vulnerability of geomorphological processes within the National Park, may lead to their capacity to adapt becoming constrained.

4.149 Potential adaptation actions to address this vulnerability include:

- Allow natural geomorphological processes to function where possible, for example, for quarries and coombes, and if the loss of a geodiversity interest feature is inevitable, implement 'rescue' excavations to salvage as much scientific data as possible.

Changes to agricultural areas

4.150 Changes in the agricultural sector in response to climate change could have significant impacts on the character ecosystem services and biodiversity of the South Downs National Park. With longer growing seasons and scope to grow new crops such as maize, grapes, soya and energy crops there is the potential for major changes to agriculture and forestry. This may result in the conversion of valleys and floodplains to arable fields, increased field size, and the replacement of hedgerow, woodland and grassland networks with a more uniform arable landscape. Changes to grazing levels in response to climate change could affect the vulnerability of calcareous grassland, a key characteristic of the National Park. However, the effects of climate change on agriculture are uncertain: drier summers and more frequent droughts could result in withdrawal of arable land from cropping and reversion to natural grassland, particularly in areas of thin soils. It is also possible that the South Downs will be less vulnerable to agricultural intensification due to its protected status.

4.151 Changes to agricultural land use, could lead to the removal or decline in management of hedgerows, woodlands and grassland. Farmland habitats, such as hedgerows, may be vulnerable to loss of species, for example a loss of beech trees due to drought (Mitchell *et al.,* 2007), changes in wildlife composition, loss of food resources for wildlife, increases in pests and diseases, increased shading, and displacement of species through colonisation by species from Europe (Mitchell *et al.,* 2007). Impacts on the structure of hedgerows could also lead to reduction in ecological connectivity, a key function of this habitat.

4.152 Conversely, the need for greater soil erosion measures could lead to an increase in some farmland habitats. Appropriateness of species and management for local biodiversity will be a key factor in whether this is a positive impact. This may be particularly relevant to farmland in the Low Weald National Character Area.

4.153 Climate change may impact on the capacity of the land to provide the food and other products it currently does. For example, erosion leading to impacts on the ability of the soil to support certain land use types.

4.154 These changes in agriculture may also lead to impacts on biodiversity in the National Park.

Plate 19 View across a mixed farmed landscape

4.155 Potential adaptation actions to address the vulnerability of agricultural areas in the South Downs National Park include:

- Target the most beneficial Environmental Stewardship Scheme options. This will require further action to identify them for the South Downs and tailor prescriptions to suit local form and management. This should be done with the South Downs National Park Authority.
- Support farmers through information and advice on adaptation action and diversification into new crops and breeds more resilient to emerging climate conditions, as part of an overall approach to encourage mixed sustainable farming which protects the natural assets of the South Downs. Advised actions could be as follows (South Downs Joint Committee 2008a). Suggested action include the collection of rain water from buildings and creation of on farm reservoirs to supplement farm water supplies, moving to drought resistant crops or alternative livestock breeds, plant shelterbelts to provide shade and protect crops from wind and minimise soil erosion via minimum tillage and implementation of buffer strips.
- Maintain good soil structural condition and enhance soil organic matter levels, for example, using manures and green cover crops, to maximise water holding capacity. Adopt soil moisture conservation measures, particularly in areas which are likely to be

more drought prone. Furthermore, take measures to keep soil *in-situ* such as contour ploughing.

- Where risk of erosion is high and soils are currently eroding, typically on steeper or long unbroken slopes, consider changing land use, for example from arable to grass, or reducing stocking numbers. Implement measure to increase vegetative cover and avoid over grazing, trampling, damage, poaching and compaction from mechanised activities, especially on the fine, easily eroded soils of the Western River Rother.
- Adopt land management practices to maintain and improve water infiltration in to the soil to reduce the risks excessive run off and diffuse pollution caused by increased rainfall. For example, create vegetation buffer strips along water courses and around fields, and create habitat on flood storage land, to reduce diffuse pollution and run-off leading to nutrient input to water bodies. This is in part delivered through Catchment Sensitive Advice work, one of the levers being Environmental Stewardship.
- Adopt soil, habitat and land management practices to ensure continued and enhanced carbon storage and to protect existing small areas of peaty soils from drying or other degradation.

Grassland

4.156 Significant changes to grassland in the South Downs could come from the effects of changes in seasonal precipitation and hydrology. This could lead to parching and erosion of calcareous soils and changes in species composition (Hearn and Gilbert 1977, Hossell and Rowe 2006, Berry *et al.,* 2007, Mitchell *et al.,* 2007) as drought tolerant species become more dominant. Increased winter rainfall could lead to grasses becoming dominant in this habitat (Mitchell *et al.,* 2007) and could also lead to greater erosion of soils. Invertebrate, fungi and moss communities will also be affected by changes in temperature and rainfall. Younger calcareous grasslands composed of fast-growing or short-lived species are likely to be more vulnerable than older calcareous grasslands (Grime *et al.,* 2000).

4.157 In common with some of the observations from the 1976 drought, some calcareous grassland species have been modelled as gaining climate space and other modelled as losing it (BRANCH and MONARCH projects). Some of the species projected as gaining climate space early on, for example the silver-spotted skipper *Hesperia comma* and the chalkhill blue *Lysandra coridon*, have also been projected as losing climate space in the 2080s high scenario as climate change impacts increase, making it important to monitor changes in species over time (Berry *et al.,* 2007). However, when assessing these projected changes in species composition it is important to remember the habitat is limited by the underlying geology, so adaptive capacity is constrained by the availability of suitable soils and geology (Mitchell *et al.,* 2007, Hossell and Rowe 2006). Sites across the chalk are likely to be vulnerable to these impacts, but East Sussex is likely to be particularly vulnerable as it supports the largest areas of calcareous grassland, and the largest areas of south facing grassland.

4.158 The South East regional biodiversity climate change vulnerability assessment (Taylor and Knight 2011) shows that many of the smaller fragments of calcareous grassland are most vulnerable due to a lack of connectivity, and that some of the grassland along the cliff tops is particularly vulnerable. Other variables such as low topographic heterogeneity and lack of management to addresses current sources of harm to this habitat will indicate a high vulnerability for this habitat.

4.159 Changes in land management may also have an impact on grasslands, for example changes in grazing and pesticide practices and increased woodland planting as a response to climate change (and other drivers) (Mitchell *et al.,* 2007). Increases in visitor numbers may also impact grassland and the species it supports through erosion and possible disturbance. An increase in fire risk during drier summers could also have implications for recreation on Open Access land. Furthermore, increases in fires during hot dry periods could damage plant

assemblages and the secondary impact of fire fighting activity on erosion rates has also been noted as a potential impact (Hearn and Gilbert 1977).

4.160 Changes in the area of grassland habitat and community composition would not only impact on biodiversity but could significantly change the character, views and sense of place experienced in the National Park.

4.161 Potential adaptation actions to address the vulnerability of chalk grassland areas in the South Downs National Park include:

- Implement soil and habitat conservation measures that support the adaptation of calcareous grassland.
- Increase the mosaic of habitats, including grasslands, in the National Park to enhance heterogeneity, which will allow species to take advantage of local changes in microclimate within habitat types. The creation of transitional habitats between grassland and woodland will also provide increased variability of habitats and microclimates.

Woodland

4.162 All woodland types in the South Downs National Park were judged to be vulnerable to summer droughts when trees are in full leaf and transpiration losses are high, with beech trees and woodlands on well-drained, south facing slopes likely to be most vulnerable. Beech specialists, such as fungi and invertebrates, are also likely to suffer due to this loss. Changes in precipitation may also lead to an increase in more drought tolerant species such as Ash (Broadmeadow and Ray 2005). This will be particularly relevant in the West Weald area, the most densely wooded part of the National Park, with large areas of ancient woodland, a significant proportion of which is unmanaged or under managed. Lowland mixed deciduous woodland may experience a decline in woodland cover and shifts in the composition of vegetation types or balance of types, which has implications for species interactions and reasons for site designation (Mitchell *et al.,* 2007). Changes in the abundance of rare species, competition from invasive species, and shifts in the regeneration patterns of trees are also likely. This is particularly relevant to the Hampshire Hangers and some of the scarp-slope woodlands in West Sussex, for example, Duncton to Bignor Escarpment.

4.163 Loss of the beech hangers or replacement with new species arriving from Europe could significantly affect the character and appearance of woodlands in the South Downs. Loss of individual trees in woodlands, parkland or designed landscapes as a result of increased susceptibility to disease may have a noticeable impact on the appearance and historical significance of these areas.

4.164 There could be opportunities to increase the area of woodland in the National Park if the demand for woodfuel increases. An increase in woodland cover could have benefits in terms of carbon storage, however it could impact on the typically wide open spaces and the long views experienced from the chalk escarpment.

4.165 Potential adaptation actions to address the vulnerability of woodlands in the South Downs National Park include:

- Encourage woodland management to provide woodfuel and biodiversity benefits. This includes support for South Downs branded woodland products, such as the proposed South Downs accredited firewood (South East Woodfuels Ltd, 2010).
- Increase the mosaic of habitats in the National Park to enhance heterogeneity, which will allow species to take advantage of local changes in microclimate within habitat types. Responses may include planting a mixture of woodland trees. The creation of transitional habitats between grassland and woodland will also provide increased variability of habitats and microclimates.

- Ensure an adequate replacement population of hedgerow trees. There are currently too few young trees and more are needed.
- Understand which tree species may be more vulnerable and plant ahead now with more tolerant species in appropriate places (while being alert to the risks associated with introducing alien species).
- Adapt current best practice woodland management to include climate change adaptation, for example, ride management may no longer be appropriate on south facing drought prone slopes.
- Encourage an increase in urban trees to provide summer shade and as a flood alleviation measure.
- Promote the value of in-field and boundary trees, parks and wood pasture as potential shade.
- Improve connectivity of woodland in line with the Lawton review and where connectivity is low. The biodiversity climate change vulnerability model (Taylor and Knight 2011) could contribute to identifying areas to target this action.
- Limit the introduction of non-native plant and animal species and monitor occurrence and abundance of new pests and diseases. Be alert to potential new pests and diseases and plan for their management. Also, continue to monitor native species to assess changes in numbers and distribution and undertake monitoring to identify new species appearing within the National Park.

Plate 20 Woodland management including coppicing should be encouraged where appropriate

Changes to rivers and streams

4.166 The vulnerability of chalk streams and rivers to reduction in flow or drying out completely during drought, and consequent impacts on water quality, could have a significant effect on the shape and character of the landscape in the National Park as well as on biodiversity and the services rivers and streams provide. For example, droughts leading to a reduction in available water, intense rainfall events in winter leading to increased erosion and increased pollution from runoff leading to a reduction in water quality will contribute to changes in biodiversity and fluvial geomorphology. Society's response to climate change, such as engineering works on rivers to stabilise channels or provide flood protection measures may also lead to impacts on biodiversity, ecosystem services and the character of the National Park. Drying out of water bodies could also affect their capacity to support recreational activities such as fishing, and the South Downs Way river crossings are vulnerable to flooding.

4.167 The chalk aquifer, which provides water for drinking and irrigation, may be more susceptible to drying out during hotter, drier summers, and winter recharge may be reduced as rain falls in heavy bursts. A reduction in ground water could also have negative impacts on wetland habitats and may result in them becoming drier. Demand for water, for household, agricultural and recreational use is likely to increase with higher summer temperatures, and increased droughts will exacerbate the vulnerability of freshwater habitats to the impacts of climate change (Mitchell *et al.,* 2007). This is particularly relevant to the Rivers Itchen, Meon, Ems and Lavant, and a number of chalk springs and lakes on the greensand and low weald.

4.168 The floodplains of the major rivers and areas of wetland habitats also play an important role in protecting land from flooding. Climate change is likely to increase the risk of flooding and this service is therefore likely to become more important.

4.169 Potential adaptation actions to address the vulnerability of rivers and streams to the impacts of climate change, and to increase opportunities for natural flood alleviation, include:

- Reinstate naturally functioning floodplains and implement Catchment Flood Management Plans, that take into account the potential changes in flooding from climate change. Support sustainable flood risk management schemes, such as bank naturalisation, re-profiling, re-meandering, river-edge planting, reedbed creation, floodplain restoration and storm water attenuation. In river valleys and coastlines, avoid 'hard engineering' solutions where a solution supporting more natural processes would be successful. The largest example of this is the Shopham Loop restoration near Petworth.
- Maintain flow levels in rivers and streams – this is work led by the Environment Agency and water companies in the South Downs.
- Restore hydrological connectivity between open waters and wetlands. Identify areas with the river catchments in the National Park where there are opportunity to create additional wet woodland along streams and rivers, which will enhance habitat connectivity and help reduce run-off and pollution in agricultural landscapes and land identified for flood storage. For example, the 'Wriggle Room' Project (Environment Agency 2009) identified areas that could be enhanced through minor habitat creation through Environmental Stewardship scheme agreements in the Ouse and Adur catchments, and pilot work by the Environment Agency to produce catchment factsheets.
- Create habitats on flood storage land and along streams and rivers in agricultural landscapes to reduce diffuse pollution and run-off.
- Increase the ability of river catchments to retain rainfall and reduce artificially enhanced surface run-off through increasing soil organic matter, reducing soil compaction, re-creating semi-natural habitats, and introducing Sustainable Drainage Systems (SUDS). The Sussex Wetland Partnership will deliver this, as will a specific push for Green Infrastructure delivery of SUDS.

- Adopt integrated water management within catchments and promote naturally functioning floodplains to respond to water availability issues and to better manage extreme weather events, for example, drought. Work in partnership to develop pilot catchment factsheets will help to deliver this adaptation action.
- Discourage floodplain developments and raise awareness of the implications of these in a changing climate.
- Limit the introduction of non-native plant and animal species and monitor occurrence and abundance of new pests and diseases. Be alert to potential new pests and diseases and plan for management. Freshwater ecosystems seem particularly susceptible to invasions from problem species and climate change may exacerbate this (Clarke 2009). For example, experiments simulating warmer water temperatures have shown exotic invasive plant species *Lagarosiphon major* (curly waterweed, sold by garden centres and aquarists as an oxygenating plant) have shown that it favours warmer conditions (McKee *et al.,* 2002). Therefore, continue to monitor invasive and native species to assess changes in numbers and distribution and undertake monitoring to identify new species appearing within the National Park.

Coastal areas

4.170 The vulnerability of the short stretch of coast in the National Park to sea level rise and increasing rates of erosion could lead to the capacity of coastal ecosystems to adapt becoming constrained as they become squeezed between flood defences or other hard infrastructure and rising sea levels, and ultimately to the loss of these areas. Loss of coastal habitats could reduce the degree of flood protection they provide, and loss of geologic features could result in the loss of knowledge resources. Coastal areas are also significant for recreation and changes in the character of these areas could affect how people perceive and enjoy them.

4.171 Potential adaptation actions to address the vulnerability of coastal areas to the impacts of climate change include:

- Review the boundaries of coastal geological SSSIs in order to identify where boundary changes are necessary for the management of their geological interest features in the future due to the impact of coastal erosion. Specifically, review Seaford to Beachy Head, and Brighton to Newhaven SSSIs.
- Ensure the Beachy Head to Selsey Bill Shoreline Management Plan supports the development of naturally evolving coastlines and allow for realignment of shorelines and adequate space and sediment for shoreline adjustment.
- In river valleys and coastlines, avoid ‘hard engineering’ solutions where a solution supporting more natural processes would be successful. The largest example of this is the Shopham Loop restoration near Petworth.

Historic environment

4.172 Large scale landscape features such as parklands may be affected by changes in community composition and the loss of veteran trees, and the historical significance of designed landscapes may be lost. Traditional buildings, which are significant features of the South Downs landscape, may become more vulnerable to decay. In some cases, responses to the impacts of climate change on historic buildings may alter landscape character.

4.173 As well as direct impacts, changes in land use as a result of climate change could affect the historic character of the landscape as new crops and practices replace more traditional ones. Historic landscape character contributes to sense of place, and loss or changes to historic environment assets could alter how people perceive and enjoy the National Park.

4.174 Potential adaptation actions to address the vulnerability of the historic environment to the impacts of climate change include:

- To protect historic environment assets amend current environmental management, where appropriate, and prepare emergency plans or install emergency measures in response to threats from extreme events such as flooding. All known buried and unburied archaeology and all known routeways should be recorded. It is particularly important to record assets where losses are unavoidable.
- Provide advice to landowners to manage scheduled sites (archaeological & historic parks and gardens) appropriately and encourage them to enter into the Environmental Stewardship, Higher Level Scheme (South Downs Joint Committee 2008a).
- Manage soil and vegetation, where appropriate through agri-environmental schemes, to protect buried sites likely to be damaged through changes in land use influenced by climate change, for example, a move towards arable.
- Manage wood pasture and parklands habitat, a significant element of the historic landscape character, for example by planning for the succession of veteran trees.
- Seek opportunities to enhance the flood resilience of historic buildings using techniques such as flood guards and flood resilient materials appropriate to the age and structure of the building.
- Install sympathetic higher capacity rainwater disposal systems in historic buildings and explore how Green Infrastructure could improve building resilience to climate change, such as natural buffers against strong winds, for example hedgerows and tree planting.
- Adapt the structural integrity of buildings to withstand damage and consider the removal of trees from sensitive archaeological sites to avoid damage from wind throw in extreme weather events (South Downs Joint Committee, 2008a).

Recreation

4.175 Warmer summers may encourage people to use the outdoors more for recreation. This could benefit people's quality of life but may put pressure on existing recreation facilities such as footpaths and country parks. An increase in visitor numbers could also reduce the feeling of tranquillity people experience in the National Park.

4.176 Recreation facilities could also be directly affected by changes in climate, such as footpath erosion and drying out of grassed areas. Routes linking the South Downs Way down to the northern scarp slope are particularly vulnerable to erosion during storm events due to their steep and often sunken topography. Despite potential impacts on recreation facilities, the South Downs National Park is likely to continue to provide people with opportunities to recreate and enjoy the natural environment.

4.177 Potential adaptation actions to address the vulnerability of recreation assets to the impacts of climate change and maximise opportunities for enjoyment include:

- Develop large scale habitat re-creation as part of enhancing the green infrastructure within the National Park, to provide greater recreation resource and allow the spread of potentially increased visitors across numerous sites.
- Manage visitor pressure by, where necessary, directing people away from the most vulnerable areas at sensitive times. Where appropriate, develop new recreational routes to take pressure of those routes at risk from erosion.
- Replant green space with drought tolerant species. This could lead to possible conflicts with biodiversity goals so ensure appropriate species are planted.
- Promote responsible recreation behaviour. This is particularly important during periods of heat wave, where there is increased risk to health as well as risks of fire in areas of open grassland or woodland.

- Increase maintenance of the rights of way network and areas of public green space. Improvements to path surfaces, drainage and replacement of footbridges and realignment of routes, especially on popular routes close to main centres of population, are likely to be required, placing additional pressure on local authority right of way budgets. These improvements should be incorporated as part of a green infrastructure strategy and should utilise an adaptive management approach, for example, proposed floating footpath through yew grove at Kingley Vale NNR (Personal communication, Roger Matthews, Natural England South Downs Spatial Project Manager, 2010).

Strategic adaptation actions

4.178 A number of strategic actions were identified that would provide an overarching framework to delivering adaptation within the National Park and support the specific actions above.

- Cross boundary and cross sector linkages outside National Park need to be planned and opportunities taken to enhance climate change adaptation responses. There needs to be a focus on **large scale adaptation** beyond the boundary of the National Park to ensure adaptation actions do not create islands in the wider landscape.
- **Build climate change into spatial planning agenda.** There are real opportunities to build climate change adaptation into the local planning framework. Green infrastructure has a particularly important role to play in supporting community resilience while delivering wider biodiversity and landscape benefits and needs to be central to proposed development, for example around Shoreham Growth Area.
- **Development of multi-functional wetlands through re-connecting rivers with their floodplains.** There are opportunities to develop the network of ponds and wetlands to provide water storage and restore flood plain function, as well as enhance biodiversity and amenity value. Rising sea level could push the saline wedge further up rivers, which is likely to lead to existing freshwater wetlands becoming increasingly brackish. Planning to create new wetlands through defence re-alignment needs to be taken forward now, for example through a joint approach with the Environment Agency.
- **Planning and delivering landscape-scale restoration.** Much of the remaining semi-natural habitat within the South Downs is small in size and highly fragmented within a sea of intensively managed agricultural land. In addition, ecosystem services are failing in many areas. Restoring the landscape to ensure that a functioning ecological network of semi-natural habitat exists, delivering clean water and flood storage, requires careful planning and delivery. The planning side of this requires development through 'landscape-scale delivery plans', setting out principles to bring partner activities together, and avoiding conflicts between objectives. Following on from this, projects to restore and reconnect the landscape need to be developed and taken forward.
- **Understanding and responding to land use change.** Farming in the South Downs could undergo radical change in the coming decades. It will be important to work with land managers and farmers to anticipate changes and develop appropriate responses. The next round of Higher Level Stewardship agreements have the potential to assist in the delivery of climate change adaptation, focusing on the value of wetlands, flood storage, carbon sequestration and green infrastructure, as well as supporting farmers seeking to improve the resilience of their businesses. We need to provide advice to assist farmers and landowners to put in place appropriate and sustainable land management practices that ensure the resilience of natural and cultural assets to climate change is maximised. Work within Natural England on embedding climate change in to land management should inform this. In addition, other mechanisms which provide support for specific types of desirable land management, such as grazing or coppicing, also need to be developed. Examples of this include lamb branding and firewood accreditation.
- Promote **Environmental Stewardship scheme options** that enhance landscape character, ecosystem services and biodiversity. Work with landowners and land managers to maintain landscape assets including hedgerows, field patterns, wet ditches and

traditional buildings. Again, work within Natural England on embedding climate change in to land management should help inform this.

- **Increase the resilience of existing habitats**, by increasing their size and by buffering them against external threats. An example of research around this is a study carried out by Brighton University which looked at plant species diversity in calcareous grassland fragments of different sizes across the Downs. This indicates, unsurprisingly, that bigger is better, even up to 100 ha, but also suggests that the rate of increase begins to decrease significantly after 20 ha in size is reached (Holm *et al.,* 2005). This is supported by the 'Making Space for Nature' review of England's ecological networks, in which the key words relating to the suggested actions for wildlife sites are 'more, bigger, better and joined' (Lawton *et al.,* 2010).

Plate 21 Species richness in chalk grassland is linked to patch size, the most extensive areas being confined to the steep scarp slope

- Use the results of the **South East regional biodiversity climate change vulnerability assessment** (Taylor and Knight 2011) to target adaptation action for habitats, most importantly:
  - Ensure **best practice management** of existing habitat to confer greater resilience to climatic impacts.
  - Maintain and **increase area of existing habitat** through targeted re-creation and restoration effort around existing patches. Adopt a landscape scale approach to extend calcareous grassland and woodlands and buffering to increase the core area to help support wildlife creating larger more viable and interconnected semi-natural areas, for example, wetlands along entire river valleys and contiguous grassland along the Downs. Mixed planting should be adopted and management should be improved around existing veteran trees.
  - Maintain and increase ecological **network connectivity.** Such networks need to be created with an understanding of their potential permeability to particular species and

based around habitat typologies such as woodland, grasslands, and wetlands. Proactive development of large scale habitat recreation as part of enhancing the green infrastructure within the National Park should be implemented. Opportunities for increasing our understanding and focusing effort exist through the South Downs Nature Improvement Area (NIA), and the Biodiversity Opportunity Areas (BOAs).

- **Reflect potential for changes in species composition** in conservation objectives, condition assessment and guidance for habitat management, for example by accepting a greater mix of native trees and a greater component of ash, oak etc in canopy of 'beech' woods. Changing conservation objectives may require a radical shift in attitudes towards alien and invasive species, and species not currently considered native to the region may have to be favoured.
- **Learn and apply lessons from previous extreme weather events** such as flooding or heat wave and their impacts on particular habitats or species in helping to develop future contingency plans for key conservation sites, for example the drought of 1976 (Hearn and Gilbert 1977). We can also look to other locations with similar climates to that which England may experience in future to identify potential threats and opportunities.
- There is a need to increase **public awareness and understanding** of the potential impacts of climate change. Decision makers, landowners and farmers have a key role in developing appropriate policies and taking action, and a greater understanding of the changes we are likely to face, will be required in order to respond effectively.
- **Monitoring** change and the effectiveness of adaptation measures is critical to an adaptive management approach. Further work is needed to continue to map and research the vulnerability of natural assets to climate change as knowledge is still incomplete. Long term data sets and studies assessing environmental change will also be very important to inform adaptive management.
- Undertake a more detailed **ecosystem services assessment** for the South Downs to better understand the functionality of natural assets, existing green space and green infrastructure.
- **Work in partnership** across the area to design and implement win-win landscape scale adaptation.

5 Discussion

Climate change and the vulnerability of landscape character, ecosystem services and biodiversity

5.1 The results of this study highlight that climate change poses a number of risks to the valued aspects of landscape character, ecosystem services and biodiversity in the South Downs National Park. Some of the most vulnerable elements of landscape character and ecosystem services identified in this study are as follows:

- Geomorphological processes which help to shape the National Park may be altered by an increase in erosion and sedimentation. This may lead to impacts on iconic features such as the chalk cliffs.
- Habitats in the South Downs National Park are likely to be vulnerable to climate change, for example changes in habitat extents and species composition. These are also likely to alter the overall character of the National Park. Habitats such as Beech and Yew woodland, intertidal chalk, rivers, ponds and floodplain grazing marsh have been highlighted as relatively more vulnerable.
- The South East biodiversity climate change vulnerability assessment (Taylor and Knight 2011) overall results suggest the following are particularly vulnerable in the South Downs:
  - Rivers – Itchen, Meon, Arun, Adur, Ouse and Cuckmere.
  - Wetlands – particularly areas of flood plain grazing marsh at Lewes Brooks and Amberley Wild Brooks.
  - Coastal habitats – including the cliffs at Seaford to Beachy head and Brighton to Newhaven.
  - A large area of heathland, designated as Woolmer Forest SAC.
- Historic designed landscapes may be vulnerable to higher temperatures and drought leading to the loss of characteristic vegetation. Historic wetlands are likely to be impacted by seasonal changes in precipitation. The extensive archaeology, historic buildings and historic landscapes in the National Park will be vulnerable to changes in land management, increased rainfall penetration and erosion.
- Key access and recreation assets vulnerabilities include greater erosion of footpaths due to drought in summer, flooding in winter and increased visitor use. Country Parks and other sites will be vulnerable to both drought and flooding leading to damage to sites and landscape and potentially reducing access.
- It is likely that the landscape of the National Park will change due to the direct impacts of climate change but also the society's responses. For example, changes in the agricultural sector will respond to socio-economic changes such as increasing oil prices, food and energy security and changes in markets and policies. These changes to the landscape may impact on the way people feel and identify with their surroundings.

5.2 It is important to note to that although the word 'vulnerability', which has negative connotations, is used throughout this report, climate change may also present some opportunities for the natural environment, such as the creation of new habitats and the introduction of new species.

Major findings of adaptation assessment

5.3 In the course of gathering and refining the proposed climate change adaptation actions, it became clear that many options provide low regret responses, which are beneficial to the natural environment regardless of whether the projected climate change impact occurs, and win-win responses, that provide a wide range of benefits to numerous valued assets within

the National Park. For example, some of the proposed actions to address biodiversity adaptation to climate change will also provide benefits to access and recreation provision, landscape character, the ecosystem services provided, and soil conservation necessary to support agriculture. Some of the major findings of the adaptation assessment with regard to no regrets, 'win-win' and conflicting adaptation actions are discussed below.

No regret adaptation actions

5.4 The promotion of best practice management of existing habitats or sites (including geological sites) will ensure the asset is in good condition now and that existing sources of pressure not related to climate are minimised. This will generally lead to greater resilience to climate change (Hopkins *et al.,* 2007).This can include maintaining and increasing the area an asset covers (for example, habitat or access assets), increasing connectivity (for example, habitats or hydrological systems), and ensuring that plans and objectives are site based and appropriate.

5.5 The continued promotion of Environmental Stewardship scheme options that maintain and enhance landscape character, biodiversity and ecosystem services will address current issues and will ensure better a quality natural environment that is more resilient to changes in climate in the future.

5.6 Potential changes that a site, system or service may experience due to climate change should be reflected in site objectives, condition assessments and management plans. Boundaries of designated sites also need to be assessed and changed to reflect potential changes in interest features. This means objectives to conserve the natural environment need to have greater flexibility in order to accommodate the changes that will result from climate change.

5.7 Measures to protect, enhance and raise awareness of ecosystem services, the benefits they provide and their economic value is essential as these services will become more important and potentially more degraded as the climate changes. For example, soil degradation currently costs the economy at least £150 million – £250 million per year (HM Government, 2011), and the increased precipitation projected for future winters will exacerbate this impact. Much of our work now delivers better soil conservation and management and strives to reinstate more naturally functioning river and coastal systems that can provide better water quality and management services in a more natural way.

5.8 The practise of adaptive management is also no regrets. This is when existing management practices are monitored for their effectiveness, experimental changes to this management are made in line with a theory or evidence that will make the management more effective under a changing climate, the results are again monitored for their effectiveness, and further changes made if necessary. In short this is the process of learning by doing and due to its experimental and incremental nature is perhaps a less daunting and more subtle way of making management changes than the more dramatic changes that we may need to make. Adaptive management can include more flexible and experimental approaches to site and asset management, for example, varying the timing of vegetation cutting or perhaps encouraging calcareous grassland species on north facing slopes as opposed to the more traditional south facing slopes.

5.9 Finally, monitoring the condition of assets and the actual impacts of climate change is crucial. This will help to inform adaptive management along with any more fundamental changes in management or conservation policy (for example, changes to species and provenance planting or translocation).

Adaptation actions with multiple benefits

5.10 Numerous climate change adaptation options identified in this assessment will provide multiple benefits. For example, there are many actions focussed on conserving and enhancing habitat within the National Park. These include increasing the mosaic and extent of

habitats through large scale habitat creation, increasing habitat connectivity, ensuring best practice management of habitats, and reducing existing pressures such as pollution and land use change. These actions will have a positive impact, not just on biodiversity but also on landscape character and ecosystem services. For instance, woodland enhancement and management will provide benefits to landscape character by maintaining and enhancing the valuable contribution of woodland and trees to the South Downs landscape. It would also increase biodiversity and make it more resilient in the face of climate change. Management could also help water infiltration, prevent soil erosion, provide a renewable energy resource, enhance catchment functions (ie slow the flow of water through the system and protect drinking water in the aquifers), create greater recreation opportunities, and provide shade for people and livestock.

5.11 Measures which promote naturally functioning systems, such as rivers and coasts, will also provide multiple benefits both now and under a changing climate. A move away from hard engineering solutions and towards natural environment solutions will generally provide better adaptation and improved ecosystem services, as well as benefitting biodiversity and landscape character. Adaptation actions identified as having multiple benefits include:

- targeting environmental stewardship to increase the resilience of assets;
- supporting land managers with information and advice;
- managing soils to improve water infiltration, storage, reduce run off and erosion;
- making the landscape more 'permeable' to wildlife;
- reducing pest and disease threats and slowing the spread of invasive non-native species;
- undertaking adaptive management;
- increasing the habitat diversity of wildlife sites;
- managing visitors to the countryside and raising awareness of climate change impacts; and
- monitoring key assets.

5.12 The proposed adaptation responses start to provide an overall integrated strategic approach to increasing the resilience to climate change of the natural environment in the South Downs National Park. It is intended that these responses will influence the policy and work of key partners within the region. Demonstration projects to look at how responses to climate change might work on the ground should be undertaken at a smaller spatial resolution than National Park or NCA level.

Conflicts

5.13 The response screening template used in this assessment helped to identify the no regret and win-win adaptation options, but it also helped to identify circumstances where adaptation for one asset could impact negatively on another asset. This helped us to identify changes that could be made to reduce unintended impacts of adaptation responses. Many of the suggested changes will need greater investigation and specific proposals at a local or site level, but there are some general points to be made at this scale. Some examples of conflicts are described below.

5.14 A number of adaptation measures support the reinstatement of naturally functioning systems such as rivers and coasts. These provide many benefits but may impact negatively on existing agricultural, recreational and historic environment assets through realignment of coasts and flood plains. It may be that the recreational assets can be replaced or substituted but the agricultural land and historic assets may be lost. If it is possible to protect historic assets *in situ* without constraining the natural function this should be carried out, but where this is not possible the asset should be recovered any losses should be recorded.

5.15 Any measures that deter people from accessing an area or remove access opportunities are likely to conflict with the desire to connect people with their natural surroundings. We must

ensure that there is a positive impact on access opportunities while managing the impact of access on the natural environment through very careful management.

5.16 For biodiversity adaptation, while we must accept some changes to biodiversity assets we must also acknowledge some potential conflicts, for example, changing species through planting and suggested increases in tree and woodland cover. For example, the suggestion that beech should be planted on north facing slopes and in valleys to allow it a greater chance of persevering in the South East, may also lead to conflict through impacts on existing habitat. In the South Downs, it is likely that many areas where Beech could exist on north facing slopes or valleys would already be occupied by calcareous grassland, a BAP priority habitat and a particularly important habitat for landscape character in the South Downs. An answer for this situation is to ensure that there is no net loss of woodland, supporting the South Downs management plan aspiration, and that new planting occurs in targeted locations, potentially in urban or agricultural locations.

5.17 Management for biodiversity assets could of course impact on other sectors, for example, where nature conservation interests are favoured over geological conservation. Managing geodiversity for its own sake can create biodiversity gain, for example, early successional vegetation, habitat mosaics and nest sites. Management schemes should be designed to benefit both.

5.18 It is inevitable that there will be conflicts when deciding on adaptation action as there are already conflicts when carrying out landscape and biodiversity conservation under current pressures. The overall conclusion is that it will have to be a balance and solutions will have to be applied at a local level using appropriate principles and guidelines. Major conflicts must be avoided where possible. When climate change adaptation actions are implemented, we recommend that current good practice continues with the additional inclusion of climate change adaptation principles and the need for adaptive management.

Difficult choices

5.19 As some of the above conflicts point out, there will be hard choices to be made in future years. Some of these conflicts, despite steps to mitigate their impacts, may still impact negatively on other assets. We are also very unlikely to ever have all the desired information before a decision is made on an adaptation response, particularly a pre-emptive one. Win-win and no regret actions and adaptive management are therefore more desirable and will allow us to address many adaptation needs. However, at some point more difficult choices regarding adaptation will have to be made. These must be based on all currently available evidence and data and must be thoroughly investigated, but we need to acknowledge this inevitability and be ready to take these decisions. We will also need to consider the potential reversibility of options, as it is a more serious decision if the results cannot be undone. We must also appreciate knock-on effects of adaptation actions. For example, loss of good agricultural land could lead to pressures for intensification elsewhere, either within or beyond the National Park boundary.

Accepting change

5.20 Related to the above section on difficult choices, we need to be ready to accept change in the landscape. The assets that currently contribute to the character and ecosystem services of the South Downs National Park have changed greatly over many years and they will continue to change, this time with anthropogenic climate change as an added factor. Wider society is not always good at accepting change in our landscape. This can be for many reasons. Sometimes change occurs over such a long time scale that we believe the landscape we see looks the way it always has; or if a landscape is designated as special, as with the South Downs, we may want to preserve it in its current state, despite the fact that the landscape we see has been heavily shaped by natural processes and human intervention. Climate change, and our responses to it, has the potential to change the landscape dramatically and over a relatively short timeframe. These changes could be related to the species that make up the

habitats associated with the South Downs, or the crops, livestock and processes that farmers use. This report has suggested a wide range of adaptation responses to conserve and enhance the landscape character and ecosystem services of the South Downs, but in order for the South Downs to be resilient to climate change we must accept that the overall quality and value of the landscape and ecosystem services may remain but some of the assets that make contribute to these may change. Education and awareness raising will need to be carried out to ensure the population that use and value the South Downs National Park are aware of this and can help provide and support adaptation measures.

Options for enhancing character and ecosystem services through adaptation

5.21 With the designation of the National Park, there are many opportunities to enhance landscape character and ecosystem services alongside climate change adaptation. This will largely be through modifications to the vision and associated targets in the National Park management plan, which this climate change assessment will inform. Many of the adaptation actions identified above, for example, that address landscape restoration, creation of habitat networks, and provision of access and recreation opportunities, will also enhance landscape character and ecosystem services.

5.22 Many of the adaptation options for biodiversity, for example large scale habitat recreation, creating buffer zones, increasing management of existing habitats, and some of the more urban-focussed options such as urban tree planting and urban greenspace, would also enhance landscape character and ecosystem services. The proposed strategic adaptation response - planning and delivery of landscape-scale restoration - would provide a considered, landscape scale approach to the enhancement of biodiversity, landscape character and ecosystem services, especially if it includes partnership working across local boundaries.

5.23 Much of the discussion in this document points to the probable changes in land management, including techniques, policies and crops. If managed and supported effectively, these changes could be used to sustainably adapt to climate change and enhance the landscape of the South Downs.

5.24 Existing work, such as the evidence on patch size distance criteria for calcareous grassland habitat patches (Holm *et al.,* 2005, University of Brighton 2003), the woodland targets agreed with the Forestry Commission for no net loss of woodland within the National Park, and the West Weald Project (Scott Wilson 2010) will assist in the provision of the above enhancements. The South East Regional Biodiversity Climate Change Vulnerability Assessment has also identified the vulnerability of habitats in the South Downs National Park, this will also help target the habitat enhancement options.

Scale

5.25 The aim of this project was to carry out a climate change assessment at a landscape scale using the integrating concepts of landscape character and ecosystem services. This has produced wide-ranging results that provide a broad assessment of the likely vulnerability of the natural environment in the South Downs National Park and potential adaptation options. However, given the scope of the study and the size of the South Downs National Park, the assessment was necessarily quite general in nature. Further work at a more local level, perhaps on a site by site basis, will be required in order to implement adaptation action.

5.26 Detailed assessments and investigations at a much smaller scale will be necessary to consider issues for individual species. Some species have particular traits, such as low dispersal distance, or specific requirements, such as micro climate, range of habitats, or a particular food plant or nesting place. Much greater levels of detail are required to assess the impacts of climate change at smaller scales. This assessment provides landscape specific responses that provide more general actions that have the best chance of increasing resilience for a wide range of assets but, as mentioned above, accepts that these assets may not remain exactly as they are today. For example, an increase in drought tolerant species in

grassland will lead to changes in species composition but will allow the overall function and character of a grassland landscape to be retained.

5.27 The high-level suggestions for adaptation action, such as soil conservation or water management, are important to address at a landscape scale as they are applicable across the entire area and large areas of land contribute to these services. However, the application of specific measures must be tailored to individual sites and smaller areas. For example, appropriate measures to reduce soil erosion may be different in different parts of the South Downs depending on soil type, land use and landscape character, and the creation of habitats has to take into account local conditions, such as soil type and ground water levels.

5.28 Adaptation actions can be implemented at a range of scales. Figure 17 provides a representation of where some of the adaptation options fit on the scale from large scale to small scale.

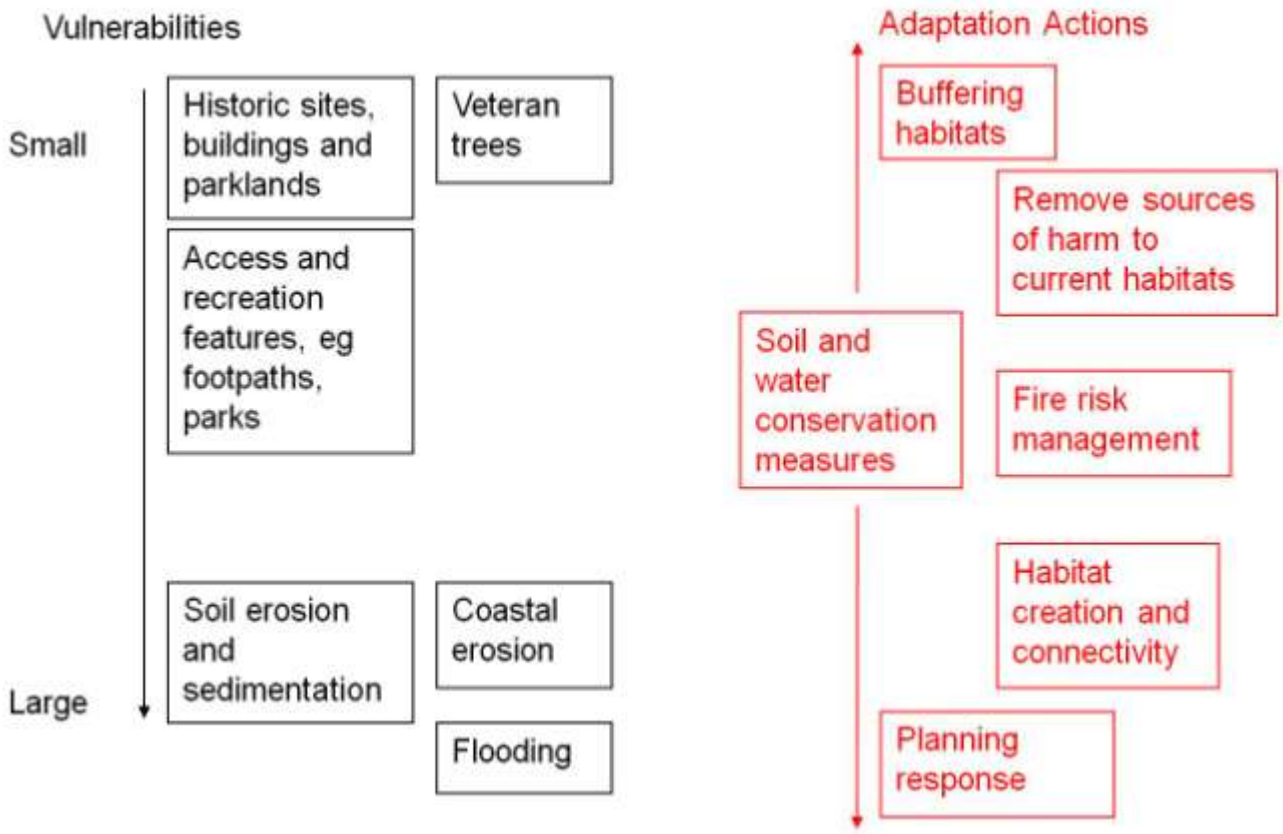

Figure 17 Range of scales for adaptation options

5.29 The integrated adaptation options focussing on repairing habitat and system connectivity and reinstating naturally functioning systems are large scale adaptation responses and action for individual assets such as historic buildings of veteran trees are small scale options. Identifying the scale of action gives an indication of the type of partner engagement needed to instate them. For example, flooding and coastal erosion scale responses will need to be delivered in an integrated way with a wide range of partners, while the site or asset based actions, which need to be widespread across the landscape, may need specific partnership work on a smaller scale.

5.30 Overall, the NCA assessment methodology provides a framework for climate change assessments at a variety of scales, including NCA, National Park and smaller, sub-NCA scale, and can be used to focus in on areas with very particular characters or services, such as river catchments.

Limitations of the study

5.31 While this study serves as a useful starting point to pursuing adaptive responses to climate change in the South Downs, a number of limitations should be recognised:

1) The study aimed to produce an overall assessment of the relative vulnerability of natural assets and from this to infer the vulnerability of major aspects of landscape character, ecosystem services and overall biodiversity. It was based on the best information available, but it is important to note that in many cases this information was limited. The assessment also relied to a great extent on the opinions of experts, and this expertise was not necessarily evenly spread across all subject areas. While the study tried to supplement professional opinion with external references wherever possible, there are assets in the National Park whose vulnerability to climate change is simply less understood than that of more extensively studied assets. Furthermore, some elements covered within the report are quite subjective. Good examples of this are cultural and aesthetic aspects of the South Downs landscape. Fully understanding the impacts on these would require some thorough additional targeted social studies. Therefore, while we believe relative vulnerability and potential adaptation actions have been identified, assessed and evaluated as accurately as possible, the results should be viewed as an initial rather than a definitive assessment. As more information becomes available the conclusions of this report can be updated.
2) An issue of scale occurs when proposing adaptive responses to climate impacts on river systems. While many actions such as buffering watercourses and re-naturalising catchments can occur within the National Park, there is often a need to deliver at a catchment scale to get the best results. Stress placed on freshwater ecosystems due to poor water quality from a combination of diffuse and point source pollution is an example of this. The challenge is for this report to be recognised by agencies working at that catchment scale. Further work on a similar methodological basis may be required in other parts of key catchments in order to provide a comprehensive evidence base for action at this scale.
3) Due to resource constraints and the large amount of existing information about the impacts of climate change on the South Downs, stakeholder engagement was limited to electronic consultation with internal specialists and key external partners at various stages in the development of this report. While a good range of people have contributed to the study, a potential subsequent stage would be a more comprehensive consultation on the report's assumptions and conclusions.
4) The framework used in the assessment is good for highlighting the valued assets in the area and identifying their vulnerability. However, as mentioned above, it is still quite generic and requires local level expertise and interpretation to ensure it is specific to the study area (be it an NCA, National Park, catchment, or some other geographic unit). Other work in the area, for example the woodland connectivity options assessment in the West Weald project (Scott Wilson 2010) and the larger scale South East Regional Biodiversity Climate Change Vulnerability Assessment (Taylor and Knight 2011), complement this study by considering adaptation at smaller and larger scales respectively. The findings of these other projects help us to further target adaptation responses identified in this study, which would have been more difficult if we had been doing the work in isolation.

5.32 Aside from these limitations, the findings presented should provide a useful starting point to focus the work being undertaken throughout the National Park to adapt to climate change. They also serve to confirm the relevance of some widely acknowledged adaptation principles, such as those described by Hopkins *et al.,* (2007), and how these can be applied more specifically in the South Downs National Park.

Comparison with other work done in the area

5.33 The South Downs is fortunate as, having been a clearly defined and recognised environmentally important area for many years, it has been subject to concentrated thinking

and writing. This includes investigating the impacts of climate change, as well as discussion about restoration and resilience at a landscape scale.

5.34 A key issue for the Downs is that the remaining semi-natural habitat, particularly calcareous grassland and lowland heath is generally small and fragmented, and often surrounded by intensive agriculture. This makes these habitat fragments and their associated biodiversity vulnerable to extinctions at the best of times, and even more so in the face of climate change. A question for conservation biologists working on the Downs is what change on the ground is required to ensure that these key habitats can function ecologically at a landscape scale ie what is required in terms of expanding, buffering, linking, creating stepping stones and creating a more permeable wider countryside. Following on from this is the question of cost.

5.35 A study by Brighton University examined plant species diversity in relation to patch size of calcareous grassland at a large number of sites across the Downs (Holm *et al.,* 2005). This produced a species-area curve, clearly illustrating that 'bigger is better', but this growth in species diversity slows the larger the patch size. At 20 ha, 60% of calcareous grassland species are present, while doubling the size (and cost) to 40 ha only increases the percentage to 80%. Studies such as this help us to arrive at targets for minimum patch size, inform the expenditure of agri-environment schemes ensuring value for money, and can help prioritise the efforts of advisers and rangers.

5.36 The impacts of climate change are already being felt on the South Downs and the species that live there. One good example of this is in the change in distribution of silver-spotted skipper butterflies over the last twenty years or so. In the 1970s and 80s this species was relatively rare, confined to hot south-facing calcareous grassland slopes with around 10+% bare ground (something that was thought to be a key habitat requirement) at the far eastern end of the Downs. During the 1990s and 2000s, this species has undergone a rapid range expansion across the Downs in East Sussex and into West Sussex, where it continues to increase its range. It is now found on flat and north-facing calcareous grassland slopes. The key to this dramatic change in fortune appears to be an increase in summer temperatures allowing the butterfly to successfully lay eggs and raise caterpillars on sites that previously had not reached the required temperatures (ie flat and north-facing slopes) (Davies *et al.,* 2005).

Other pressures and constraints in addition to climate change

5.37 There are many other pressures and constraints besides climate change that are having an impact on the South Downs now, and will continue to do in the future, such as development, agricultural change, habitat destruction and pollution. Climate change will exacerbate these existing pressures and exert additional ones. The following sections detail some of the 'forces for change' in the National Park, as identified by the South Downs Integrated Landscape Character Assessment: Technical Report (Land Use Consultants 2005). Any management for the South Downs National Park must continue mitigation of current pressures alongside adaptation to climate change.

Existing threats to valued assets

5.38 There are a vast number of existing threats to the valued assets of the South Downs. For example, impacts on biodiversity include habitat loss and fragmentation, decline of woodland management, invasive non-native species, disturbance, pollution, erosion, water abstraction, drainage or inappropriate river management, harvesting and collection of species, changes in native species dynamics, and natural disasters such as droughts, floods and storms (Defra, 2006 and Lost Life report, 2010). Climate change will exacerbate these and put further pressure on already degraded assets, which in turn will impact the landscape character and ecosystem services provided by the area. Similar existing threats apply to geology, soils and historic environment such as lack of space given for natural geological processes, soil erosion and destruction or degradation of historic environment assets.

Changing agriculture

5.39 The National Park is a managed landscape with grazing integral to its landscape character. Environmental sustainability is an increasingly important driver of agricultural change. However, changes in global markets the Common Agricultural Policy (CAP) will be primary influences and will impact on the landscape character and ecosystem services of the South Downs over both the short and long term. There are likely to be changes to the types of agriculture and land management that occur, for example, grazing is already in decline and may continue to be vulnerable. Other changes include opportunities for production of novel crops, for example, vineyards, and policy drivers encouraging production of certain crops, for example, energy crops. Higher energy costs could also affect agriculture, in that farming systems that are heavily dependent on large inputs of fertilisers, pesticides and machinery could become less viable (Foresight Land Use Futures Project, 2010).

Plate 22 Livestock grazing, in particular sheep, are vital management tool to many of the South Downs important habitats

Development (inside the National Park)

5.40 A key concern within the National Park is the gradual and incremental small scale changes that impact the local rural character and the valued assets identified in this assessment. In some areas, particularly remote downland areas, the conversion of farm buildings to dwellings or other uses is an issue for character as it can change a building's appearance and add to traffic (Land Use Consultants 2005). Potential change to buildings, both new and old, or new types of development to adapt to and mitigate climate change could also have an impact on the landscape character of the South Downs, for example the production of renewable energy both on micro and macro scales that may be required from landscapes such as the South Downs may have a greater impact in the future. Any land take involved in development or associated infrastructure may also impact the valued assets of the South Downs, and its character and the ecosystem services it provides, for example destroying and fragmenting habitats and damaging soils.

Plate 23 The lower River Adur valley where the National Park is only 4.5 km wide, with urban developments on each side, and the former Shoreham cement works site, the largest brownfield site in South East England outside of London, in the centre

Development squeeze (development outside the National Park)

5.41 The effect of development outside the designated area and associated landscape changes could have a considerable impact on the South Downs. The expanding coastal plain development to the south and more developed landscapes of the Low Weald to the north have the potential to impact on the character and ecosystem services of the National Park. This surrounding development affects the perception of remoteness and tranquillity through changes such as the glow of urban development at night (Land Use Consultants 2005). Increased water abstraction to supply the surrounding urban areas will also impact on the character and ecosystem services of the South Downs National Park. The South East of England is already heavily developed and further development is expected (Foresight Land Use Futures Project, 2010). Development outside the national park may also impact upon ecosystem services provided by the landscape, however there may also be some positive impacts including the use of Sustainable Drainage Systems and inclusion of Green Infrastructure in developments.

Traffic

5.42 This is a particular issue on the roads that run north-south across the National Park (Land Use Consultants 2005). These pressures arise from population growth, increasing recreational use, plus greater flows of through traffic between the coast and the rest of the South East and London (Land Use Consultants 2005). These increases in traffic in the National Park have an impact on the experience of the landscape character and the perception of remoteness and tranquillity gained from the National Park. They also add to air pollution.

Recreation pressures

5.43 The South Downs National Park is an accessible landscape which still has a sense of wildness, remoteness and tranquillity. These qualities lead to a desire to visit and experience them. However, increasing recreational and sports use, a very large surrounding population and expanding urban areas threaten to impact upon the recreational enjoyment of these special qualities within the South Downs landscape. The demand for access infrastructure and facilities and the increasing car traffic associated with recreational use adds to this pressure, along with overcrowding and erosion leading to negative impacts upon the special qualities and assets the Downs are so valued for.

Possible implementation of adaptation actions

5.44 This project was designed to stimulate debate and inform future adaptation action, rather than set out any sort of plan for how action might be implemented. Nevertheless, we hope that the results of the study provide a starting point for people and organisations engaged in conservation and planning in the National Park.

5.45 When identifying adaptation actions, existing strategies, policies, tools and initiatives need to be considered. Some actions defined as climate change adaptation are already occurring under a different name and it may be possible to identify existing programmes to provide a mechanism for delivering adaptation. For example, climate change adaptation is increasingly been incorporated into Environmental Stewardship Schemes and partners such as the Environment Agency, Hampshire and Sussex Wildlife Trusts, and the South Downs National Park Authority are actively working on delivery and projects that address climate change adaptation. Delivery will be more efficient and effective if these and other partners can co-ordinate their delivery in this area and work in partnership. Other tools, such as the South East regional biodiversity climate change vulnerability assessment (Taylor & Knight 2011) should be used to further target appropriate win-win adaptation action in the South Downs National Park area with partners.

5.46 In this study, we decided at the outset not to simply focus on a single NCA, but to include the NCAs that overlap with the Park boundary and make up the majority of the area within the National Park. While this increased the volume of work for the authors, it meant that the final product covered a recognised administrative boundary with an over-arching authority capable of leading delivery. However, while the study of climate change vulnerabilities can give helpful guidance on the way in which future work should progress within the National Park, in a number of cases the boundaries of the Park do not align with the boundaries of agencies most able to take action. For example, the National Park boundary straddles 3 counties, 1 city and 11 District and Borough Councils. This may create issues when developing strategic responses to climate change within an administrative area, though should not detract from the fact that at a local scale the actions identified in this report will be relevant.

5.47 Economic and social solutions will need to proceed in tandem with those of the environment. Local authorities and other organisations will need to find approaches that deliver successful long-term sustainable adaptation to climate change for the benefit of people and their environment.

5.48 Building resilience and adapting to climate change will not take place in a single burst of action or event – it will require a lengthy process of research, consultation and capacity-building. Similarly, actions are unlikely to provide ‘once-and-for-all’ solutions – detailed monitoring and frequent review of plans will be required to ensure that management of assets and the landscape as a whole is truly adaptive.

5.49 This study should therefore be considered as a step in this process. It will be necessary for local experts and stakeholders to prioritise actions to ensure that effort is focused on the most vulnerable assets and on initiatives with the potential to add most value. Bringing forward, and effectively marketing, demonstration projects could have an important role in building public

understanding and support for adaptation, in addition to acting as ‘proof of concept’ for innovative habitat creation schemes. Similarly, involving community groups, voluntary conservation organisations and schools in such projects could promote valuable ‘buy-in’ and foster a sense of ownership of both the natural environment and of responsibility for its protection.

5.50 The future of the South Downs depends on the actions we take today to reduce our greenhouse gas emissions and the decisions we make about managing our landscape to adapt to unavoidable climate change. These will determine whether we can continue to protect the National Park’s high quality landscape assets that are a key part of the region’s natural and cultural heritage and identity.

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Appendix 1 Vulnerability tables of key landscape assets

Table A Results of vulnerability assessment for geodiversity

Asset	Potential exposure	Sensitivity	Management capacity	Vulnerability rating
Active and disused quarries	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to increased vegetation growth and increased seasonality in cycles of wetting and drying, leading to slumping. Also sensitive to land use change and responses to climate change in other sectors.	Environmental: asset would be able to change and adapt naturally if permitted and space was available Management: use of hard engineered structures can reduce adaptive capacity.	**Moderate / less vulnerable**
Coastal cliffs and foreshore	Drier summers Wetter winters Intense rainfall Sea level rise	Sensitive to increased erosion rates.	Environmental: short term ability to move Management: possible pressure to defend such coasts leading to impairment of natural processes in the longer term. Use of hard engineered structures can reduce adaptive capacity.	**Moderately / more vulnerable**
Fluvial geomorphology	Intense rainfall Wetter winters Higher annual average temperatures Drier summers	Sensitive to increased rates of erosion and flooding, impacts in channel system. Also sensitive to changes in vegetation and drying up.	Management: pressure from flood defences leading to impairment of natural processes. Use of hard engineered structures can reduce adaptive capacity.	**Moderately vulnerable**
Extensive and finite buried interest	Drier summers Wetter winters Intense rainfall	Sensitive to drying out and increased vegetation encroachment which can damage assets. Also sensitive to increased rates of erosion.	Environmental: protected from some impacts due to buried situation.	**Moderately / less vulnerable**
Geomorphological processes	Hotter summers Drier summers Wetter winters Intense rainfall Sea level rise	Sensitive to increased mass movements and slumping. Also sensitive to impacts of flooding including erosion and weathering. Also sensitive to increased disturbance by vegetation.	Management: pressure from engineering leading to impairment of natural processes reduces adaptive capacity.	**Moderately vulnerable**

Table B Results of vulnerability assessment for soils

	Soilscape typology	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
3	Shallow lime-rich soils over chalk or limestone	Drier summers Intense rainfall	Sensitive to increased rates of soil erosion and sediment loss. Sensitive to increased summer drought.	Environmental: adaptive capacity reduced by existing droughtiness of soil. Shallow soil on the steeply sloping scarp face has lowest adaptive capacity. Management: maintain or enhance adaptive capacity by use of buffer strips, contour ploughing to keep soil in-situ; consider change from arable to grass in high risk erosion situations; maintain good soil structural condition and enhance soil organic matter levels to maximise water holding and infiltration capacity; ensure good vegetative cover.	**Moderately / more vulnerable**
5	Freely draining lime-rich loamy soils	Drier summers Intense rainfall	Sensitive to increased rate of erosion. Sensitive to increased summer drought.	Environmental: this soil is already drought prone. Soil on moderately or steeply sloping land where cultivated or bare soil is exposed (for example, footpaths) has lowest adaptive capacity. Management: where at risk, maintain or enhance adaptive capacity using buffer strips, contour ploughing to keep soil *in-situ;* consider change from arable to grass in high risk situations; maintain good soil structural condition and enhance soil organic matter levels to maximise water holding and infiltration capacity; ensure good vegetative cover.	**Moderately vulnerable**
6	Freely draining slightly acid loamy soils	Drier summers Intense rainfall	Sensitive to increased rate of erosion. Sensitive to increased summer drought.	Environmental: this soil is already drought prone where coarser types occur. Soil on moderately or steeply sloping land where cultivated or bare soil is exposed (for example, footpaths) has lowest adaptive capacity. Management: where at risk, maintain or enhance adaptive capacity using buffer strips, contour ploughing to keep soil in-situ; consider change from arable to grass in high risk situations; maintain good soil structural condition and enhance soil organic matter levels to maximise water holding and infiltration capacity; ensure good vegetative cover.	**Moderately / more vulnerable**
7	Freely draining slightly acid but base-rich soils	Drier summers	Sensitive to increased summer drought.	Environmental: this soil is already slightly drought prone but adaptive capacity enhanced by loamy texture and depth. Management: maintain or enhance adaptive capacity by adopting soil moisture conservation measures – maintain good soil structural condition and enhance soil organic matter levels to maximise water holding and infiltration capacity.	**Moderately vulnerable**

Table continued…

	Soilscape typology	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
8	Slightly acid loamy and clayey soils with impeded drainage	Wetter winters Intense rainfall	Sensitive to increased wetness and instability, compaction, run-off and increased erosion.	Environmental: soil is already prone to erosion due to high silt content and wetness. Soils on sloping ground or water receiving sites are least able to adapt. Management: maintain or enhance adaptive capacity by employing land management techniques to minimise soil structural deterioration and improve water infiltration and drainage.	**Moderately / more vulnerable**
10	Freely draining slightly acid sandy soils	Drier summers Intense rainfall	Sensitive to increased summer drought. Sensitive to increased rate of erosion.	Environmental: this soil is already drought and erosion prone. Coarser sandy soil on sloping land where cultivated or bare soil is exposed (for example, footpaths) has lowest adaptive capacity. Management: maintain or enhance adaptive capacity by maintaining good soil structural condition and enhancing soil organic matter levels to maximise water holding capacity; use buffer strips, contour ploughing to keep soil *in-situ*; consider change from arable to grass in high risk erosion situations; ensure good vegetative cover.	**More vulnerable**
14	Freely draining very acid sandy and loamy soils	Drier summers Intense rainfall	Sensitive to increased summer drought. Sensitive to increased rate of erosion.	Environmental: these soils are already marginal to agricultural use due to drought, stoniness and inherent infertility; in general have a low adaptive capacity especially where landscape is more dissected. Management: much land in semi-natural vegetation or forestry so important to adopt sensitive heathland and forestry management, avoiding overgrazing, trampling and fire to maintain vegetative cover to maintain or enhance adaptive capacity.	**Moderately vulnerable**
18	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	Wetter winters Intense rainfall	Sensitive to increased wetness and risk of soil compaction, diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding. Sensitive to 'shrink swell' due to high clay content.	Environmental: adaptive capacity reduced as soils are already wet and prone to structural damage. Management: maintain or enhance adaptive capacity by employing land management techniques to minimise soil structural deterioration and improve water infiltration and drainage; consider possible disturbance to the foundations of buildings (due to shrink swell potential).	**Moderately vulnerable**

Table continued…

	Soilscape typology	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
20	Loamy and clayey floodplain soils with naturally high groundwater	Wetter winters Intense rainfall	Sensitive to increased winter flooding leading to possible deposition of sediment, increased risk of soil compaction and erosion by floodwaters if soil is bare or cultivated.	Environmental: soils already on floodplains and have low adaptive potential. Management: maintain or enhance adaptive capacity by employing land management techniques to minimise soil structural deterioration and improve water infiltration and drainage; avoid bare soil in period of high flood risk; a change from arable to grass may be needed in high flood risk locations.	**Moderately vulnerable**
21	Loamy and clayey soils of coastal flats with naturally high groundwater	Sea level rise	Sensitive to increased flooding (by sea) and increase in saline conditions leading to loss or degradation of asset.	Environmental: low adaptive capacity as already in an at risk coastal location. Management: it may be difficult to manage, may have to accept loss or change in places.	**More vulnerable**
22	Loamy soils with naturally high groundwater	Wetter winters Intense rainfall	Sensitive to increased wetness, as a source of diffuse pollution or increased local flooding. Increased risk of compaction.	Environmental: some adaptive capacity if groundwater levels and drainage can be controlled. Management: maintain or enhance adaptive capacity by employing land management techniques to minimise soil structural damage and improve water infiltration and drainage.	**Moderately vulnerable**
27	Fen peat soils	Hotter summers Drier summers	Sensitive to drying out leading to loss of peat stock/carbon stores.	Environmental: current condition of soils may limit adaptive capacity. Management: consider if water levels can be maintained or enhanced to increase adaptive capacity.	**Moderately / more vulnerable**

Table C Results of vulnerability assessment for habitats

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating[4]
Beech and Yew woodland	Hotter summers Drier summers Warmer winters Increased rainfall intensity	Sensitive to loss of Beech and associated specialists. The Beech component is most sensitive.		**More vulnerable**
Wood pasture and parkland	Drier summers	Sensitive to transpiration losses, disease.	Environmental: woodland on south facing slopes has lower adaptive capacity as it is exposed to higher temperatures. Woodland on sheltered valley sides has higher adaptive capacity. Mature or ancient trees likely to have low adaptive capacity.	**Moderately vulnerable**
Wet woodland	Drier summers	Sensitive to severe drought when reservoir of seepage water runs dry.	Environmental: flood prevention measures can reduce adaptive capacity. Key factor is availability of water for maintenance of habitat, the more water the higher the adaptive capacity.	**Moderately vulnerable**
Lowland mixed deciduous woodland	Hotter summers Drier summers Warmer winters Intense rainfall	Sensitive to shifts in the composition of vegetation types and species, competition from invasive species, and changes in regeneration patterns.	Environmental: relatively high degree of adaptive capacity due to variety and size of resource.	**Less vulnerable**
Hedgerows	Drier summers Warmer average temperatures	Sensitive to drought and indirectly to intensification of farming leading to removal.	Management: responses in other sectors (for example, agriculture) may have significant effect on habitat, potentially reducing adaptive capacity.	**Less vulnerable**

Table continued…

[4] Vulnerability ratings based on regional biodiversity climate change vulnerability model (Taylor and Knight 2010)

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating[4]
Maritime cliff and slope	Sea level rise	Sensitive to increased erosion and higher wave energy.	Environmental: this habitat has the capacity to rollback naturally if there is sufficient room. Management: coastal squeeze against flood defences or other hard infrastructure can reduce management capacity as there is no room for habitat creation. exacerbate vulnerability.	**Moderately vulnerable**
Intertidal chalk	Sea level rise	Sensitive to erosion and flooding. Also sensitive to higher wave energy.	Environmental: this habitat has the capacity to rollback naturally if there is sufficient room. Management: coastal squeeze against flood defences or other hard infrastructure can reduce management capacity as there is no room for habitat creation. exacerbate vulnerability.	**More vulnerable**
Running water (rivers and chalk streams)	Hotter summers Drier summers	Sensitive to drought and thermal stress.	Management: increased water demand in extreme dry periods may reduce ability to manage this habitat Increased pressure for flood defences may also lead to less dynamic river systems.	**More vulnerable**
Ponds <1ha and ditch systems	Hotter summers Drier summers	Sensitive to increase temperatures and changes in rainfall.	Environmental: adaptive capacity dependent on ability to retain water and the degree of hydrological connectivity between open waters and wetlands. Management: increased capacity to mange this habitat if it is possible to increase water retention.	**More vulnerable**
Coastal and floodplain grazing marsh	Sea level rise Drier summers	Sensitive to flooding and inundation by the sea and periods of drought.	Management: this habitat has an important role in flood management and opportunities for habitat creation could compensate for habitat losses.	**More vulnerable**
Lowland calcareous grassland	Hotter summers Drier summers Warmer winters Wetter winters	Sensitive to changes in composition of species, increase in fires, drought and parching, erosion. Younger grasslands more vulnerable than older grasslands.	Environmental: younger grasslands have lower adaptive capacity than older grasslands. Management: adaptive capacity can be reduced by the response of other sectors to climate change, for example, changes in management, increased woodland planting and increases in visitor numbers. Sites are often in management already so capacity to manage for climate change is high.	**Less vulnerable**

Table continued…

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating[4]
Lowland meadows	Drier summers Warmer average temperatures	Sensitive to drought and indirect impact of changes in plant phenology. Also sensitive to indirect impact of increased intensification of farming.	Environmental: wet meadows are reliant on water availability, meadows with available water have higher adaptive capacity. Management: a flexible approach to management could increase adaptive capacity.	**Moderately / more vulnerable**
Cereal field margins and stubble	Hotter summers Drier summers Warmer winters Wetter winters	Sensitive to changes in species composition. Also sensitive to indirect impacts, for example, potential re-intensification of agriculture, increased use of pesticides and changes in seasonal farm practices.	Management: changes in land use are most likely to affect adaptive capacity.	**Less vulnerable**
Lowland heath	Hotter summers Drier summers	Sensitive to drying out in dry periods and competition from other vegetation and fire.	Environmental: adaptive capacity of wet heath is dependent on water availability. If water is available, adaptive capacity is higher but there is already considerable pressure on water resources in the region.	**Dry heath, moderately vulnerable** **Wet heath, more vulnerable**

Table D Results of vulnerability assessment for historic environments

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
Below ground and upstanding historic assets	Hotter summers Drier summers Wetter winters	Sensitive to change in soil pH change, erosion, hydrological change, vegetation growth, crystallisation and dissolution of salts. Also sensitive to indirect impacts such as cropping changes and intensification, increase in site visitor numbers; over-abstraction of water for changing land use practices; root damage (for example, energy crops).	Changes in agricultural land practices will affect adaptive capacity, for example, overgrazing.	**Moderately vulnerable**
Historic routeways	Drier summers Wetter winters	Sensitive to erosion, drying out and cracking.	Environmental: routeways on slopes have a lower adaptive capacity and are more likely to suffer erosion. Adaptive capacity differs between historic routeways composed of built material and natural routeways formed by historic tree avenues/hedgerows.	**Moderately / less vulnerable**
Large scale archaeological assets	Hotter summers Drier summers Wetter winters	Sensitive to erosion, drying out and cracking, flooding, increased vegetation growth leading to obstruction. Also sensitive to indirect impacts such as cropping changes and intensification, increase in site visitors.		**Moderately vulnerable**
Relict boundaries	Hotter summers	Sensitive to vegetation growth. Intensification of agriculture may be more significant than direct impacts of climate change.		**Less vulnerable**
Historic Wetlands	Hotter summers Drier summers Wetter winters	Sensitive to drying out, vegetation succession, cycles of flood and drought, increase in nutrient loading, intensification of agriculture, increases in visitor numbers.	Environmental: adaptive capacity depends on water resources and ability to function naturally, the management of surrounding hydrology is essential for increased adaptive capacity.	**More vulnerable**
Non domestic buildings (farm buildings)	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to damage from drying out, moisture related damage, flooding, structural pest infestations and vegetation growth.		**Moderately / less vulnerable**

Table continued…

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
Walls	Hotter summers Drier summers	Sensitive to drying out and cracking. Also sensitive to indirect impacts such as intensification of agriculture.		**Less vulnerable**
Designed landscape	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to water logging, increased vegetation growth, increase in pests and diseases, damage and loss of veteran trees, historic tree-lined avenues and historic species composition of landscapes areas.	Environmental: mature or ancient trees are likely to have lower adaptive capacity. Adaptive capacity dependant on level of site maintenance and a flexible management policy.	**Moderately / more vulnerable**
Parkland structure/ Follies	Hotter summers Drier summers Intense rainfall	Sensitive to drying out and cracking, increased vegetation growth, damage from flooding.		**Less vulnerable**

Table E Results of the vulnerability assessment for access and recreation assets

Asset	Potential exposure	Sensitivity	Adaptive capacity	Vulnerability rating
Informal greenspace	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to drying out of plants in drought. Also sensitive to increased visitors and changes in use patterns, for example, greater evening use, different activities, greater requirement for water and shade.	Management: already managed so potential for further management to increase adaptive capacity.	**Moderately vulnerable**
Linear routes	Drier summers Wetter winters Intense rainfall	Sensitive to erosion caused by soil desiccation and loss of flooding.	Environmental: routes at the bottom of slopes have a lower adaptive capacity to flooding. Paths on slopes or with poor drainage have lower adaptive capacity.	**More vulnerable**
Open Access to heath, downland and common land	Drier summers Wetter winters Intense rainfall	Sensitive to increased erosion and flooding. Also sensitive to trampling caused by increased visitor numbers.		**Moderately vulnerable**
Rivers	Drier summers Hotter summers Wetter winters Intense rainfall	Sensitive to reduction in water quality leading to potential health impacts. Also sensitive to reduction in water levels, increased demand for water based recreation, and flooding impacts.	Management: conflicts between natural processes and hard engineering can reduce adaptive capacity. Response of other sectors can affect water quality and quantity, affecting adaptive capacity.	**More vulnerable**
Woodlands	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to fire and increase in ticks and other hazards. Also sensitive to changes in demand for woodland recreation.		**Moderately vulnerable**
Coastline	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to changes in demand for outdoor recreation.	Environmental: coastlines will naturally evolve in response to climate change if the space is available to do so. Management: ability to allow natural coastal processes is impaired in some areas due to coastal squeeze or lack of space.	**More vulnerable**
Country Parks, NNRs, LNRs, National Trust land and other nature reserves	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to changes in demand for outdoor recreation. Also sensitive to drying out and flooding.	Management: already managed so potential for further management to increase adaptive capacity.	**More vulnerable**

Appendix 2 Implications of vulnerability assessment for landscape character, ecosystem services and biodiversity

In this section the implications of the vulnerability of specific assets on landscape character, ecosystem services and biodiversity is identified. Having considered the sensitivity and vulnerability of individual assets that help create the distinctive character and ecosystem services of the NCA, it is useful to consider the extent that the impacts of climate change on assets in turn impacts on this character and ecosystem services.

Implications for landscape character

Variety and contrast

The greatest impacts to the variety and contrast of landscape character within the South Downs National Park are likely to be due to the indirect changes to agriculture and land use patterns that climate change will bring. There is the potential for an intensification of agriculture and increased woodland planting for woodfuels which could change the field pattern and woodland cover across the Downs. The need to supply greater amounts of renewable energy may also result in increasing demand for growth of biomass crops alongside woodfuel. This could contribute to the intensification of agriculture in some areas and increases in certain crops, such as Miscanthus, will have an impact on the appearance of the landscape (Land Use Consultants 2005).

An increase in the area under cultivation and an expansion of arable farming may occur. This would be in response to longer growing seasons, new viable crops and the potential demand for food security in a changing climate. This may result in the conversion of valleys and floodplains to arable fields and potentially increased field size and a monoculture landscape at the expense of woodland and grassland networks, changing the appearance of the landscape. Patterns of crops in the arable areas are likely to continue to change due to changing temperatures and water availability affecting the length of the growing season and favouring more drought tolerant crops or novel crops, such as maize, soya and sunflower (Hossell and Rowe 2006). This would result in a change to the visual character of the landscape. In contrast, an increase in droughtiness could result in withdrawal of arable land from cropping and reversion to natural grassland, particularly in areas of thin soils. The potential to increase vineyards across the South Downs could also introduce new patterns into the landscape (Hossell and Rowe 2006).

The above impacts will also largely be driven by socio-economic changes, for example, increasing oil prices, food and energy security and changes in markets and policies. These are inextricably linked to climate change in many ways and it is difficult to disentangle what impacts result from socio-economic changes and which will result from climate change. It is also possible that the South Downs will be less vulnerable to agricultural intensification due to its protected status.

Seasonal change and variation in colour and texture has come from beech trees and seasonal changes in crops and agricultural practises, for example, ploughed fields. The potential loss of drought sensitive beech from the area and the above mentioned changes in agriculture will alter the seasonal colours and patterns in the Downs, for example the early browning and leaf loss experienced during the 1976 drought (Hearn and Gilbert 1976).

Distinctive form

The elements of landscape character that make up the distinctive form of the South Downs National Park, the chalk outcrop and cliffs, coombes and dry valleys, deep river valleys and the low weald and

greensand ridge, will be impacted by climate change for the most part through the impacts on geomorphological processes. The change to this key character of the National Park is likely to be quite subtle and emerge gradually over time.

The impacts on water provision and distribution in the area from climate change, ie drier summers and wetter winters, will impact fluvial geomorphology and erosion rates, for example, drying of rivers and streams, increased deposition of silt and flash flooding and storms.

History

The historic assets of the South Downs may be greatly changed through impacts on the built environment alongside impacts on historic landforms and land uses. For example, changes in land use practice and patterns will affect the current historic landscape character as new crops and practices out-compete more traditional ones. Larger scale landscape features such as parklands, which contribute greatly to the landscape character and historic experience of the South Downs, will be affected by the loss of veteran trees due to drought and wind blow and changes in woodland and grassland vegetation and species composition. Historic wetlands come under pressure from changes in precipitation and will suffer periods of drought. These impacts may lead to the loss of historic character. New technology in the landscape may also have an impact on the historic feel of this landscape, whether inside or outside of the National Park. Policies on the impact of new technology and buildings on the designated landscape exist and steer the types of development that are currently acceptable in the area, for example there is support for small scale micro-generation of renewable energy. However, many small scale projects inside the National Park and larger scale projects outside the National Park will undoubtedly impact the landscape of the National Park over time.

Biodiversity

Whilst the biodiversity section discusses in greater detail the likely changes in habitat and species composition that will be experienced through climate change, these changes will have an overall impact on landscape character. For example, beech trees are vulnerable to loss caused by drought which could significantly affect the character of woodlands in the South Downs. Loss of trees may also have a noticeable impact on the appearance of historic parkland areas which are currently characterised by veteran trees. Climate change could also result in an increase in woodland in the NCA as the demand for woodfuel increases.

In more subtle way, the changes in phenology, will have a visual and character impact, for example, ‘greening’ or ‘browning’ earlier in the year. Changes in extent or condition of habitats and the processes they carry out could have great impacts in landscape character. For example, changes to the iconic chalk cliff habitat have the potential to have a large impact on landscape character.

Changes in land use and management will undoubtedly have an impact on the composition of habitats which will impact landscape character. For example, hedgerows may be impacted by climate change in terms of species composition and impact on hedgerow trees from storm events and drought but potentially socio-economic changes, for example, agricultural changes, may impact these assets more than climate change.

Agriculture

An indirect consequence of climate change within the South Downs is likely to be the intensification of agriculture, due to pressure on land and food security, with new crops and changes in agricultural production, due to changing demand and climate change, likely to result in changes in appearance of the landscape (see variety and contrast above). Soil erosion in some areas will also impact agricultural areas. Intensification of agriculture in floodplains could also occur. Potential increased demands for woodfuel and carbon sequestration opportunities may see the woodland resource expand, changing the composition of land use in the area. Changes to levels of grazing driven by indirect climate change impacts and socio-economic drivers could have impacts on the character of the South Downs as the calcareous grassland is such a key characteristic of the National Park. As

mentioned previously the drive for renewable fuel sources and greater fuel and food security could have significant impacts on the landscape character of the Downs. A growing consumer demand for locally produced and organic produce may have benefits for landscape character and biodiversity however, this depends on its interplay with larger global markets and economic drivers and the influence of societies mitigation and adaptation to climate change.

Buildings and settlements

Traditional buildings may become more vulnerable to decay due to frequent, heavy rainfall and damp conditions, though a decline in frost events may compensate. Responses to these impacts and the loss of the assets themselves in some cases may alter the landscape character.

Settlement patterns inside the National Park are likely remain the same in the short term but with potential longer term changes in the location and style of settlements in response to temperature changes and exposure to extreme weather. The landscape designation that the area is under will have significant influence over the type, pattern and style of development in the National Park, however necessary demands for adaptation to and mitigation of climate change may influence this in the longer term. There may also be an impact on landscape character from renewable energy technology infrastructure in the future and any changes or adaptation responses required for other major infrastructure such as road, rail, power transmission and industry. The inclusion of sustainable drainage systems and Green Infrastructure with land specifically allocated for this purpose may positively impact on settlements both inside and outside the National Park boundary.

Views

Development on the fringes of the National Park has the potential to affect landscape character. An indirect consequence of climate change will be the increasing need to protect the area's key social and economic assets from the effects of climate change, for example increasing flood defences. Demand for wind energy development, inside or outside the National Park, could also affect the expansive views the area provides through their impact on the open skylines.

Drying out of grasslands in periods of drought has the potential to impact the characteristic views of the calcareous grasslands in the South Downs National Park. During the 1976 drought grasslands all over the county experienced drying out and browning of the vegetation (Hearn and Gilbert 1977). As drought events are expected to increase in the summer this browning of vegetation could also be an increasing impact on the visual nature of the South Downs landscape.

The changes in land use and management mentioned above will also have an impact on the view currently enjoyed from the National Park. Longer growing seasons, changes in land use patterns, for example, greater woodland area as a result of woodfuel demand, and changes in management may lead to increased scrub and woodland cover which would impact the typically wide open spaces and the long views experienced from the chalk escarpment.

Implications for ecosystem services

Some of the implications for the National Park's key ecosystem services are discussed below:

Provisioning services

Food

Climate change impacts will directly affect the types of crops which can be grown within the South Downs. Warmer temperatures, with reduced rainfall may lead to initial loss of crop and livestock production then an increasing move towards more drought tolerant arable crops, root crops or fruit and vegetable crops, which may increase the need for water, leading to greater use of irrigation systems. There may also be increased novel crops, which require higher temperatures and a longer growing season, such as vineyards and olive trees (Hossell and Rowe 2006). Higher winter temperatures may lead to increased pest survival and an increased use of pesticides (Hossell and

Rowe 2006). Damage from extreme events such as drought, flooding and storms may also impact the provision of food. Indirectly, climate change impacts globally on food production may make this area more important for agricultural production leading to greater intensification, responding to demands for greater food security.

Forestry

Drought sensitive species such as beech will be particularly vulnerable but other trees requiring higher temperatures, milder winters and longer growing seasons may be grown, although impacts on native woodlands should be avoided. Forestry plantations may suffer particular damage due to higher temperatures, drought, strong winds and storm events. There are also a number of potential impacts that may affect how we manage our woodland as a resource. For example, reduced timber supply from overseas could lead to increased demand for UK production which leads to more intensive management and reduces scope for conservation management (Foresight Land Use Futures Project, 2010). Production of timber from the UK could increase as demand for timber grows and the importance of woodlands in sequestering carbon and providing renewable energy is increasingly recognised (Mitchell *et al.,* 2007). The impact of this on biodiversity depends on the species of trees planted, the management of the woodland and the location of the woodlands. Changes in species planted for timber and the management practices will also be needed as will responses to pests and diseases (Broadmeadow and Ray 2005). The above changes to woodland management may lead to positive or negative impacts on woodlands in the South Downs. However, the increase in the use of wood fuel as a carbon neutral form of heating in the local area could result in increased beneficial management of woodland as a renewable resource.

Renewable energy

Increasing demand for renewable energy will see the South Downs National Park increase its provision of this service, particularly community based micro-renewable energy projects and the provision of woodfuel from the National Park woodlands. However, large scale projects such as macro wind turbines/farms within the South Downs National Park are not supported on landscape grounds.

Water resources

Reduced summer rainfall and increased demand could reduce aquifer recharge and deplete supply, with potential impacts on wetland sites. An increased demand for water from surrounding settlements and agriculture may also have an impact on supply and water quality.

Minerals

Working quarries within the National Park (chalk and aggregates) may be vulnerable to events such as flooding leading to the need for greater management or ‘hard engineering’ input to stabilise faces and other assets.

Regulating services

Carbon storage and sequestration

Drought, flooding and potential changes in agricultural practices could increase soil disturbance, reducing carbon stores. Increased temperatures and reduced rainfall is also likely to cause drying out and losses of carbon. However, increases in woodland cover and management may contribute to carbon sequestration but impacts on other valuable habitats, themselves good carbon stores, must be avoided.

Water quality

Reduced summer flows within river catchments due to reduced rainfall and drought could lead to further deterioration in water quality, with diffuse pollution becoming a greater issue and reduced flows leading to impaired dilution and flushing abilities. An increased demand for water from agriculture and for development may also have an impact on supply and water quality.

Flood protection

Climate change is likely to increase the risk of flooding of properties and agricultural land and this service is therefore likely to become more important. Taking up strategic opportunities for reconnecting rivers with their floodplains, delivering Catchment Floodplain Management Plan (CFMP) targets and enhancing water infiltration within the catchment by promoting good soil management will deliver flood storage save significant sums of money on maintaining potentially unsustainable flood defences and offer new opportunities for both biodiversity and access. Such rivers include the Arun, Adur, Ouse and Cuckmere.

There are existing proposals within the Shoreline Management Plan to realign defences close to the mouth of the Cuckmere River. The difficulties in achieving a consensus in this area highlights the difficulties associated with implementing change and re-instating ecosystem services and naturally functioning river valleys.

As authorities become aware of the risks presented to critical infrastructure by climate change, the area is also likely to see an increase use of sustainable drainage systems and land specifically allocated for this purpose. A greater understanding of the role that green infrastructure may play in supporting the resilience of communities to the effects of climate change may also see changes around the edges of communities with new areas of woodland or wetlands, which may well enhance the intrinsic aesthetic of local landscapes to the community and provide new opportunities for recreation.

Supporting services

Nutrient cycling and soil formation

Warmer temperatures, wetter winters, drought and flooding leading to increased erosion, changes in soil microbial activity, organic matter turnover and changes in agriculture will have an impact on this service. This will lead to knock on effects on the ability of soils to process water and nutrients for the plants we eat and the habitats we value, decompose and recycle our waste, moderate flooding, provide essential agricultural needs and raw materials and impact on soil as a platform for buildings and infrastructure.

Photo-synthesis and pollination

These services, which underpins much of our agriculture, will be affected by the impact climate change has on biodiversity. This will be through changes to the distribution, abundance and effectiveness of pollinators.

Cultural services

Recreation

Warmer temperatures and reduced rainfall in summer may make the area increasingly attractive to local residents for recreation. High quality local green networks also provide attractive alternatives to the use of the car, and further support carbon reduction aspirations, particularly if easily linked in with public transport networks. This increased use of the natural environment, if carefully targeted could also deliver improved health and wellbeing, with corresponding potential savings to the NHS. However, negative impacts on this ecosystem service include increased erosion of key assets, for example, footpaths through increased footfall, damage to resources and potential need for diversions due to flooding and demands for changes in provision of shade and water due to higher temperatures. Although these assets maybe negatively affected, the National Park will continue to perform a valuable recreation service.

Research and education

Access to research and education resources provided by the natural environment, for example, biodiversity, geology, ecosystems, and the historic environment, for example, archaeology, land use

patterns and other historic assets, may be affected by climate change impacts on physical processes such as erosion, landslips and vegetation growth, or indeed the loss of an asset.

Sense of place

It is likely that the landscape of the NCA may change very radically over coming decades, both through the responses of society to climate change, but also because of direct impacts of climate change on the valued assets of this landscape. These profound changes in the physical landscape and on its natural and historical assets may well impact on the way local people feel and identify with their surroundings. The perception of remoteness enjoyed by many in the South Downs many be affected by changing patterns of land use and changes in recreational use, for example, potential increases in people visiting the downs due to increased annual temperatures.

Appendix 3 Adaptation actions - adapting landscape character and ecosystem services

The results of this study have shown that the services delivered by the landscape are vulnerable to impacts resulting from climate change. It is, therefore, important that appropriate responses are put in place to minimise vulnerability. In this section we present potential adaptation responses to the vulnerabilities identified above. The adaptation actions proposed have been grouped according to whether they address vulnerabilities in landscape character, biodiversity or ecosystem services. In some cases actions are repeated against several aspects of character and ecosystem services. This serves to indicate that they are low regrets or win-win actions.

The adaptation responses proposed have been identified using the expertise of Natural England technical specialists.

Landscape character

Variety and contrast

- Increase the mosaic of habitats in the National Park to enhance heterogeneity which will allow species to take advantage of local changes in microclimate within habitat types. Responses may include planting a mixture of woodland trees and increasing riparian shade through flood plain planting where appropriate. The creation of transitional habitats between grassland and woodland will also provide increased variability of habitats and microclimates.
- Target the most beneficial Environmental Stewardship Scheme options (requiring further action to identify them for the South Downs and tailor prescriptions to suit local form and management. This will be done with the South Downs National Park Authority). These actions could involve maintaining the range of hedgerow structures through appropriate management, hedgerows on floristically rich banks, hedgerows with and without trees and range in sizes. Ensure adequate replacement population of hedgerow trees, already there are too few young trees and more are needed.
- Support farmers through information and advice on diversification into new crops and breeds more resilient to emerging climate conditions, as part of an overall approach to encourage mixed sustainable farming which protect the natural assets of the South Downs.
- Advocate land use practices that provide win-win responses to climate change, for example, encouraging agricultural adaptation alongside management of the landscape for biodiversity.
- Encourage woodland management to provide woodfuel and biodiversity benefits. This includes support for South Downs branded woodland products, south as South Downs accredited firewood, a proposal for which is outlined in SEWF 2010.
- Implement soil and habitat conservation measures (see more below) that support the adaptation of land uses that contribute to the South Downs National Park landscape character, for example, calcareous grassland.

Distinctive form

- Reinstate naturally functioning floodplains and implement Catchment Flood Management Plans, avoid 'hard engineering' solutions where a solution supporting more natural processes would be successful.
- Maintain environmental flows in rivers and streams – this is work led by the Environment Agency and water companies in the South Downs.
- Review of site boundaries in order to identify where boundary changes are appropriate for the management of the geological interest features in the future due to the impact of coastal erosion. Specifically review Seaford to Beachy Head, and Brighton to Newhaven SSSI site boundaries, existing coastal geological SSSIs in the National Park.
- Beachy Head to Selsey Bill Shoreline Management Plan should be influenced and implemented so that it supports the development of naturally evolving coastlines. Allow for realignment of shorelines and adequate space and sediment for shoreline adjustment through strategic coastal planning.
- Allow natural geomorphological processes to function where possible, for example, for quarries and coombes, if the loss of a geodiversity interest feature is inevitable, implement 'rescue' excavations to salvage as much scientific data as possible.

History

- Possible loss of historic environment assets should be mitigated for by ensuring assets are protected by amending current environmental management (if appropriate) or losses are recorded.
- Record all known buried and unburied archaeology, at risk archaeological sites and all known routeways.
- Prepare emergency plans or install emergency measures to negate threats to historic assets, particularly to extreme events, for example, flooding.
- Provide advice to landowners to manage scheduled sites (archaeological & historic parks and gardens) appropriately and encourage them to enter into the Environmental Stewardship, Higher Level Scheme (South Downs Joint Committee Climate change paper, April 2008).
- Manage soil and vegetation through agri-environmental schemes to protect buried sites likely to be damaged through changes in land use influenced by climate change, for example, a move towards arable.
- Appropriate management of wood pasture and parklands habitat, a significant element of the historic landscape character, for example planning for the succession of veteran trees.
- Target the most beneficial Environmental Stewardship Scheme options, (requiring further action to identify them for the South Downs and tailor prescriptions to suit local form and management. This will be done with the South Downs National Park Authority) for example, retaining and managing hedgerows, and support farmers through on appropriate diversification as part of an overall approach to encourage mixed sustainable farming which protect the natural assets of the South Downs.
- Manage recreational pressure to take pressure off sites at risk from erosion, especially during extreme events such as flooding or drought.
- Develop natural shield buffers against strong winds, for example hedgerows and tree planting.
- On-going maintenance and adaptation of historic properties as storm damage and increased water penetration will have detrimental impact on the fabric of the building, will need to be increased.
- Opportunities should be sought to enhance the flood resilience of the built environment and in particular historic assets, using techniques such as flood guards and flood resilient materials appropriate to the age and structure of the building.

- Improve landscape connectivity and develop natural buffering defences to mitigate and adapt the historic environment against fluctuating water levels.
- Support sustainable flood risk management schemes, such as bank naturalisation, re-profiling, re-meandering, river-edge planting, reedbed creation, floodplain restoration and storm water attenuation.

Biodiversity

- Use the results of the South East regional biodiversity climate change vulnerability assessment to target adaptation action for specific habitats, particularly where elements of adaptive capacity can be increased, for example, connectivity and management of habitats. This is particularly relevant to the priority habitats within the National Park, for example, calcareous grassland, woodland, rivers and heathland.
- Increase the mosaic of habitats in the National Park to enhance heterogeneity which will allow species to take advantage of local changes in microclimate within habitat types. Responses may include planting a mixture of woodland trees. The creation of transitional habitats between grassland and woodland will also provide increased variability of habitats and microclimates.
- Target the most beneficial Environmental Stewardship Scheme options (requiring further action to identify them for the South Downs and tailor prescriptions to suit local form and management. This will be done with the South Downs National Park Authority).
- Support farmers through information and advice on diversification into new crops and breeds more resilient to emerging climate conditions, as part of an overall approach to encourage mixed sustainable farming which protect the natural assets of the South Downs, including biodiversity.
- Advocate land use practices that provide win-win responses to climate change, for example, encouraging agricultural adaptation alongside management of the landscape for biodiversity and soil conservation.
- Encourage woodland management to provide woodfuel and biodiversity benefits. This includes support for South Downs branded woodland products, such as South Downs accredited firewood (outlined in South East Woodfuel Ltd 2010).
- Implement soil and habitat conservation measures (see more below) to support adaptation of land uses that contribute to the landscape character, for example, calcareous grassland.
- In river valleys and coast lines avoid ‘hard engineering’ solutions where a solution supporting more natural processes would be successful. The largest example of this is the Shopham Loop restoration near Petworth.

Agriculture

- See *Variety and contrast* section above and *Agriculture* in the ecosystem service section below.

Buildings and settlements

- Erection of sympathetic higher capacity rainwater disposal systems for listed historic buildings and explore how Green Infrastructure could improve building resilience to climate change.
- On-going maintenance of historic properties as storm damage and increased water penetration will have detrimental impact on the fabric of the building, will need to be increased.
- Opportunities should be sought to enhance the flood resilience of the built environment and in particular historic assets, using techniques such as flood guards and flood resilient materials appropriate to the age and structure of the building.

- Adapt the structural integrity of buildings to withstand damage and consider the removal of trees from sensitive archaeological sites (South Downs Joint Committee, Climate change paper April 2008).
- Further investigate the long term needs with regard to renewable energy infrastructure, settlement pattern and building design to allow adaptation whilst retaining and enhancing landscape character.

Views

- Encourage land management and land use climate change adaptation options that retain the long open views characteristic of the South Downs.
- Further investigate the provision of renewable energy and development within and outside the National Park, raising awareness of the need for change with the public may be required to facilitate acceptance of change in the landscape.

Ecosystem services

Provisioning services

Agriculture

- Maintain good soil structural condition and enhance soil organic matter levels to maximise water holding capacity. Adopt soil moisture conservation measures, particularly in areas which are likely to be more drought prone.
- Where risk is high and soils are eroding, typically steeper or long unbroken slopes, land use change may be necessary, for example from arable to grass or reduction in stocking numbers.
- Take measures to keep soil *in-situ,* for example, contour ploughing, improve soil structural condition for example by the addition of soil organic matter where low, for example, manures and green cover crops.
- Ensure good vegetative cover and avoid over grazing, trampling, damage, poaching and compaction from mechanised activities.
- Adopt land management practices to maintain and improve water infiltration in to the soil to reduce the risks excessive run off and diffuse pollution caused by increased rainfall.
- Encourage adoption of measures to reduce soil erosion caused by both water and wind, for example, buffer strips, increase in organic matter, increase vegetative cover, especially along with regard to the fine, easily eroded soils of the Western River Rother.
- Restore hydrological connectivity between open waters and wetlands. Identify areas with the river catchments in the National Park where there are opportunity to create additional wet woodland along streams and rivers which will enhance habitat connectivity but also help reduce run-off and pollution such in agricultural landscapes and land identified for flood storage. For example, the 'Wriggle Room' Project is identifying areas that can be enhanced through minor habitat creation through Environmental Stewardship scheme agreements in the Ouse and Adur catchments and pilot work with the Environment Agency on catchment factsheets.
- Investigate and action potential opportunities for habitat creation on flood storage land and along streams and rivers in agricultural landscapes to reduce diffuse pollution and run-off.
- Target the most beneficial Environmental Stewardship Scheme options. (This will require further action to identify them and tailor prescriptions to suit local form and management. This will be done with the South Downs National Park Authority).
- Manage soil and vegetation through agri-environmental schemes to protect buried sites likely to be damaged through changes in land use, for example, a move towards arable.
- Support farmers through information and advice on diversification into new crops and breeds more resilient to emerging climate conditions, as part of an overall approach to

encourage mixed sustainable farming which protect the natural assets of the South Downs. Advised actions could be as follows (identified as a Summary of South Downs Management Plan main features against potential Adaptation and Mitigation Measures in South Downs Joint Committee climate change paper April 2008):

- collect rain water from buildings;
- grow drought resistant crops or alternative livestock breeds;
- plant shelterbelts to shade / protect crops from wind;
- create on farm reservoirs;
- enhance building maintenance against storms; and
- minimise soil erosion via minimum tillage, buffer strips, good practice, irrigate at night.

Forestry

- Understand which tree species may be more vulnerable and plant ahead now with more tolerant species in appropriate places. Whilst this is a low regret, there is clear potential for conflict with biodiversity if more resilient but alien species were selected.
- Encourage woodland management that provides woodfuel and biodiversity benefits. This includes support for South Downs branded woodland products, south as South Downs accredited firewood, a proposal for which is outlined in SEWF 2010.
- Adapt current best practice woodland management to include climate change adaptation, for example, ride management may no longer be appropriate on south facing drought prone slopes.

Renewable energy

- Identify opportunities to support renewable energy production including better management of woodlands for wood fuel and growth of bio-fuel crops on poor quality land where appropriate. The South Downs Management Plan promotes renewable energy that is of a scale and type appropriate to the South Downs. The Committee has said it could go further in developing an Alternative Energy Strategy that identifies what technologies it would and would not consider appropriate and where (South Downs Joint Committee, Climate change paper April 2008).
- Awareness raising of the potential need for change with the public may be required to facilitate acceptance of change in the landscape.

Water resources

- Increase the ability of river catchments to retain rainfall and reduce artificially enhanced surface run-off through increased soil organic matter, reduce soil compaction, re-creation of semi-natural habitats and Sustainable Drainage Systems (SUDS). The Sussex Wetland Partnership will deliver this, as will a specific push for Green Infrastructure delivery of SUDS.
- Integrated water management of the catchment and promotion of naturally functioning floodplains to respond to water availability and to better manage extreme weather events (flooding and heat waves). Joint work with the Environment Agency (pilot catchment factsheets) will deliver this adaptation action.

Minerals

- Ensure that the maintenance of interest features form part of regular management and is taken account of in development plans, mineral planning including restoration plans as well as development plans that address the afteruse of the site (for example, as a disused quarry).
- If there is a possibility of loss of the interest feature, implement ‘rescue’ excavations to salvage as much scientific data as possible.

Regulating services

Carbon storage

- Adopt soil, habitat and land management practices to ensure continued and enhanced carbon storage and protect existing small areas of peaty soils from drying or other degradation.
- Identify the best carbon storage options for the National Park with the South Downs National Park Authority and agree actions to conserve and enhance the resource.
- Take measures to keep soil *in-situ,* for example, contour ploughing, improve soil structural condition for example by the addition of soil organic matter where low, for example, manures and green cover crops.
- Increase the habitat resource, particularly woodland, that plays a role in carbon sequestration.

Climate regulation

- Encourage an increase in urban trees to provide summer shade but also as part of flood alleviation measures.
- Maintain and enhance habitat and 'greenspace' which provides a cooling service for the area.
- Promote value of in-field and boundary trees, parks and wood pasture as potential shade.

Water quality

- Investigate and action potential opportunities for habitat creation on flood storage land and along streams and rivers in agricultural landscapes to reduce pollution run-off exacerbated by more frequent heavy rain events.
- Maintain environmental flows in rivers and streams – this is work led by the Environment Agency and water companies in the South Downs.
- Create vegetation buffer strips along water courses and around fields, where appropriate, to reduce nutrient input to water bodies. This is in part delivered through Catchment Sensitive Advice work, one of the levers being Environmental Stewardship.
- Encourage good soil management to increase water infiltration and minimise run-off to avoid diffuse pollution.

Flood protection

- Discourage floodplain developments and raise awareness of the implications of these in a changing climate.
- Implement naturally functioning floodplains and Catchment Flood Management Plans that take in to account the potential changes in flooding from climate change.
- Increase the development of sustainable drainage systems able to intercept and store water, including retro-fitting in urban areas with existing surface water flooding problems as flooding will increase as the climate changes.
- Carry out catchment scale management thorough improving permeability of surfaces using planting, creation of wet woodland, SUDS, good soil management etc. The Sussex Wetland Partnership will deliver this, as will a specific push for Green Infrastructure delivery of SUDS, integrated water management of the catchment and promotion of naturally functioning floodplains to respond to water availability and to better manage extreme weather events (flooding and heat waves). Joint work with the Environment Agency (pilot catchment factsheets) will also deliver this adaptation action.
- Influence flood defence schemes to facilitate natural river processes, in particular the function of river channels and flood plains to relieve peak flows in suitable areas of the catchment.

Cultural services

Recreation

- Proactive development of large scale habitat recreation as part of enhancing the green infrastructure within the National Park to provide greater recreation resource and allow the spread of the potentially increased visitors across numerous sites.
- Reduce recreation pressures on habitat to increase resilience to climate change impacts, and especially to interactions between climate change and other pressures, to enable continued recreational resource in to the future.
- Spread the load of visitors. Direct people away from most sensitive areas at most sensitive times, and only when necessary, and provide alternative routes. Possible development of new recreational routes to take pressure of those routes at risk from erosion.
- Replant green space with drought tolerant species. This could lead to possible conflicts with biodiversity so ensure appropriate species are planted.
- Promote responsible recreation. This is particularly important during periods of heat wave, where there is increased risk to health as well as risks of fire in areas of open grassland or woodland.
- Increase awareness that a combination of extreme weather events and heavy rainfall will increase maintenance on the rights of way network within the National Park. Improvements to path surfaces, replacement of footbridges and realignment of routes are likely to be required, placing additional pressure on local authority right of way budgets.
- Opportunities should be sought to improve drainage on existing rights of way, especially popular routes and routes close to main centres of population, as well as to incorporate appropriate drainage and robust surfacing on new routes developed as part of a green infrastructure strategy. Utilise an adaptive management approach, for example, proposed floating footpath through yew grove at Kingley Vale NNR.
- Protecting and enhancing the means to enjoy the National Park through continuing maintenance and development of the rights of way network and creation of new green infrastructure to better link communities with their surroundings needs to be integral to the spatial planning agenda for the National Park.
- Longer growing seasons will also increase maintenance requirements on rights of way, and areas of pubic greenspace. However, risks of drought may require greater use of drought resistance grass mixes for amenity areas.

Research and education

- Ensure access to research and education resources continue to be provided for the natural and historic environment in the face of potential losses.
- Awareness raising, of the potential need for change with the public, may be required to facilitate acceptance of change in the landscape.

Sense of place

- Education to inform people of potential landscape change in the South Downs and to encourage them to think about visions of what they would like the area to look and feel like in future incorporating the impacts of a changing climate and the adaptation options required.

Supporting services

Nutrient cycling and soil formation

- Maintain good soil structural condition and enhance soil organic matter levels to maximise water holding capacity. Adopt soil moisture conservation measures, particularly in areas which are likely to be more drought prone.
- Where risk is high and soils are eroding (typically steeper or long unbroken slopes, land use change may be necessary as erosion risk increases (for example, from arable to grass or reduction in stocking numbers).
- Take measures to keep soil *in-situ,* for example, contour ploughing, improve soil structural condition for example by the addition of soil organic matter where low, for example, manures and green cover crops.
- Ensure good vegetative cover and avoid over grazing, trampling, damage, poaching and compaction from mechanised activities.
- Encourage adoption of measures to reduce soil erosion caused by both water and wind, for example, buffer strips, increase in organic matter, increase vegetative cover, especially along with regard to the fine, easily eroded soils of the Western River Rother.
- Protect existing small areas of peaty soils from drying or other degradation.

Biodiversity

- Use the results of the South East regional biodiversity climate change vulnerability assessment to target adaptation action for specific habitats, particularly where elements of adaptive capacity can be increased, for example connectivity and management of habitats. This is particularly relevant to the priority habitats within the National Park, for example calcareous grassland, woodland, rivers and heathland. These results should be used in conjunction with local data and the South East England Biodiversity Forum (SEEBF) Biodiversity Opportunity Areas mapping (South East England Biodiversity Forum 2008).
- Ensure best practise management of existing resource using the management adaptive capacity results from the South East regional biodiversity climate change vulnerability assessment alongside other local data. Conserve protected areas and other high quality habitats, particularly those in poor or degraded condition to enhance their resilience to climate change impacts. Adopting adaptive management will be key to this approach; requiring modifying existing management practices and monitoring the results to ensure the response is effective, for example, altering hay cutting dates to respond to phenological changes or developing buffer zones next to areas of more intensive land use. This approach is supported by the ‘Hopkins Principles’ for biodiversity adaptation to climate change (Hopkins *et al.,* 2007).
- Increase the mosaic of habitats in the National Park to enhance heterogeneity which will allow species to take advantage of local changes in microclimate within habitat types. Responses may include planting a mixture of woodland trees and increasing riparian shade through flood plain planting where appropriate. The creation of transitional habitats between grassland and woodland will also provide increased variability of habitats and microclimates.
- Increase resilience of existing habitats, through increasing their size and buffering. An example of research around this is a study carried out by Brighton University (species-area curve work) which looked at plant species diversity in calcareous grassland fragments of different sizes across the Downs. This indicates unsurprisingly that bigger is better, even up to 100 ha, but also suggests that the rate of increase begins to decrease significantly after 20 ha in size is reached (Holm *et al.,* 2005). This is supported by the ‘Making Space for Nature’ review of England’s ecological networks, in which the key words relating to the suggested actions for wildlife sites are ‘more, bigger, better and joined’ (Lawton *et al.,* 2010).

- Maintain and increase ecological network connectivity using the structural habitat connectivity results from the South East regional biodiversity climate change vulnerability assessment. Such networks need to be created with an understanding of their potential permeability to particular species and based around habitat typologies such as woodland, grasslands, and wetlands. Proactive development of large scale habitat recreation as part of enhancing the green infrastructure within the National Park should be implemented. Opportunities for increasing our understanding and focusing effort exist through the South Downs Integrated Biodiversity Delivery Area (IBDA), and the Biodiversity Opportunity Areas (BOAs).
- Reduce existing pressures on habitat to increase resilience to climate change impacts, and especially to interactions between climate change and other pressures. A key adaptation action from the 'Hopkins Principles' for biodiversity adaptation to climate change (Hopkins *et al.,* 2007) and the England Biodiversity Strategy climate change adaptation principles (Smithers *et al.,* 2008).
- Limit the introduction of non-native plant and animal species and monitor occurrence and abundance of new pests and diseases.
- Restore hydrological connectivity between open waters and wetlands. Identify areas with the river catchments in the National Park where there are opportunity to create additional wet woodland along streams and rivers which will enhance habitat connectivity but also help reduce run-off and pollution such in agricultural landscapes and land identified for flood storage. For example, the 'Wriggle Room' Project is identifying areas that can be enhanced through minor habitat creation through Environmental Stewardship scheme agreements in the Ouse and Adur catchments and pilot work with the Environment Agency on catchment factsheets.
- Investigate and action potential opportunities for habitat creation on flood storage land and along streams and rivers in agricultural landscapes to reduce pollution run-off.
- Target the most beneficial Environmental Stewardship Scheme options (this will require further action to identify them and tailor prescriptions to suit local form and management. This will be done with the South Downs National Park Authority). These actions could involve maintaining the range of hedgerow structures through appropriate management, buffer strips, targeted habitat recreation and the many options that create a more permeable habitat.
- Allow for realignment of shorelines and adequate space and sediment for shoreline adjustment through strategic coastal planning.
- Reflect potential for changes in species composition in conservation objectives, condition assessment and guidance for habitat management for example accept greater mix of native trees and greater component of ash, oak etc in canopy of 'beech woods'.
- Be alert to potential new pests and diseases and plan for management. Also, continue to monitor native species to assess changes in numbers and distribution and undertake monitoring to identify new species appearing within the National Park. Changing conservation objectives may require a radical shift in current thinking; species not currently considered native to the region may have to be favoured and the attitude towards alien and invasive species may have to change.
- Begin to reappraise the boundaries of protected sites, particularly in the case of SSSIs to protect their functionality. Create buffer zones around sites and linkages between them (South Downs Joint Committee Climate change paper April 2008).
- Learn and apply lessons from other extreme weather events such as flooding or heat wave on the impact to particular habitats or species in helping to develop future contingency plans for key conservation sites, for example the drought of 1976 (Hearn and Gilbert 1977). We can also look to other locations with similar climates to that which England may experience in future to identify potential threats.
- Habitat specific adaptation suggestions (South Downs Joint Committee Climate Change Paper April 2008):

- Beech and Ancient woodland – Management of woodland to improve structure & health. Plant species better suited to new conditions and manage woods to provide diversity of habitat, improve connectivity of woodland.
- Heath – Controlled burns and landscape scale restoration.
- Calcareous grassland – Landscape scale restoration.
- River floodplains and grazing marsh – Naturally functioning floodplains and implementing Catchment Flood Management Plans.
- Coast – Managed retreat and facilitate space for inland migration of coastal habitats.

Appendix 4 Integrated response screening and identification of win-win, 'low regret' and no regret opportunities

Table F Integrated response screening and identification of win-win and low regret opportunities

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Strategic									
Catchment scale adaptation.		+	+	+	+	+	+	+	
CC in spatial planning agenda.	+	+	+	+	+	+	+	+	
Multi-functional wetlands.	+		+	+	+	+	-	+	
Understanding land – use change.	+		+	+	+	+	+	+	
Public awareness.	+			+					
Monitoring.		+	+	+	+	+	+	+	
Landscape									
Fully assess suitability of area for renewable energy to ensure a site by site decision is made.	+			+	+	+	+	+	
Promote Environmental Stewardship scheme options that enhance and retain landscape character.	+			+	+	+	+		
Adopt soil moisture conservation measures.	+			+	+	+			

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Increased introduction of landscape screening (for example, hedgerows, buffer zones) to retain soil. Existing defunct hedges should be brought in to positive management.	+		+/-	+	+	+	+		
Retain open character of field boundaries or wooded and hedgerow enclosure where appropriate and characteristic for each landscape type.	+			+	+	+	+		
Use AONB/National Park designation to influence land use changes.	+			+	+	+	+	+	
Use appropriate landscaping and green infrastructure to mitigate any negative effects of development and ensure new development is accompanied by green infrastructure linked to existing green space and habitat networks for multiple benefits.	+			+	+	+		+	
Ensure best practice management of existing habitat to confer greater resilience to climatic impacts. Maintain and increase area of existing habitat through targeted re-creation and restoration effort around existing patches.	+			+	+	+			
Manage recreational pressure to ensure enhancement to both health, access and the natural environment (see access template for more detail).	+			+	+	+		+/-	Ensure positive impact on access opportunities whilst managing the impact of this access on the natural environment.
Increased use of natural systems to reduce vulnerability.	+			+	+	+			

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Greater number of water reservoirs to store water in the winter for summer use - possible conflict with landscape and sustainable adaptation measures.	+		-	+/-		-		+	Ensure water storage options do not impact the landscape character, for example, underground or temporary etc storage solutions are used on a small scale rather than large open reservoirs/lakes. Ensure opportunities for storage fully investigate and avoid negative impacts on biodiversity.
Ensure the site and style of settlements complement the landscape character. All spatial planning should ensure that areas remain balanced at a landscape scale.		+		+	+	+	+	+	Ensure planning uses opportunities to enhance all themes.
Low weald									
Ensure best practice management of existing habitat to confer greater resilience to climatic impacts. Maintain and increase area of existing habitat through targeted re-creation and restoration effort around existing patches. Increase connectivity.	+			+		+			
Promote Environmental Stewardship scheme options that enhance and retain landscape character. Retain patchwork and irregular character of field boundaries or wooded and historic hedgerow network. Existing defunct hedges should be brought in to positive management. Greater use of organic matter in agricultural soils.	+			+	+	+	+		
Use AONB/National Park designation to influence land use changes. Use the South Downs Management Plan to manage change and ensuring a positive future for the area.	+			+	+	+	+	+	

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Use appropriate landscaping and green infrastructure to mitigate any negative effects of development. Ensure new development is accompanied by green infrastructure linked to existing green space and habitat networks. Manage recreational pressure to ensure enhancement to both health, access and the natural environment (see access template for more detail). Increased introduction of landscape screening (for example, hedgerows, buffer zones) to retain soil.	+			+		+		+	
Greater number of water reservoirs to store water in the winter for summer use - possible conflict with landscape and sustainable adaptation measures.	+		+/-	+		-		+	See above.
Increased use of natural systems to reduce vulnerability.	+			+	+	+			
Reflect potential for changes in species composition in conservation objectives and condition assessment. Build in flexibility in conservation objectives to accommodate vegetation shifts.		+				+/-?			Allowing change in biodiversity is crucial but be aware of invasive species/pests/diseases etc impact.
All spatial planning should ensure that areas remain balanced at a landscape scale. Ensure the site and style of settlements complement the landscape character.		+		+	+	+	+	+	Ensure planning uses opportunities to enhance all themes.
Ecosystem services									
Integrated water management of catchment.	+		+						
Work with land managers to get wider adoption of sensitive farming methods.	+		+		+	+	+	+	
Support farmer with info and advice on diversification, new crops and breeds more resilient to climate change.	+						-		

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Identify new opp. for renewable energy, for example, management of woodland for wood fuels and appropriate sitting wind turbines.	+		+			+			
Increase development of sustainable urban drainage systems.	+				+	+			
Increase in woodland tree cover, esp. In urban areas.	+		+		+	+		+	
Undertake detailed ecosystem services assessment for the South Downs.	+		+		+	+		+	
Geology									
Review site boundaries and identify potential changes.	+			+		+			
Beachy Head to Selsey Bill Shoreline Management Plan should be influenced/implemented so that it supports the development of naturally evolving coastlines.	+		+	+		+	+	+	
Manage development proposals to minimise impacts on interest features or otherwise oppose them.	+		+	+		+			
Influence and modify flood defence schemes that deleteriously interfere with natural river/stream processes.	+		+	+		+	-		This could mean historic environment features are exposed to floodplain functions.
Discourage floodplain development and educate about flood plain issues.	+		+	+		+	+	+	
Promote Ecosystem Service value of fluvial geomorphology and carry out further research on this.	+		+	+		+			

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Influence management agreements and the planning system to ensure that land use changes do not impact on ability to access features and do not damage access features.	+							+	
Ensure that the maintenance of interest features form part of regular management.		+	+	+		+			
Management agreements with the extractive industry to clear exposures and pump water from key areas.		+	+	-		-			May be positive for Biodiversity and Ecosystem services. Assess individual site circumstances before carrying out drainage.
Ensure that conservation objectives and management plans are appropriate to interest.		+	+	-		-			Ensure management options take in to account other assets at the site, for example, biodiversity.
If there is a possibility of loss of the interest feature, implement 'rescue' excavations or record losses.		+							
Manage engineering schemes to minimise negative impacts.		+	+	+		+/-			Ensure reduction of negative impacts for geology doesn't affect other assets.
Soils									
Employ land management practices which minimise/reduce negative impacts of soil structural deterioration.	+		+/-	+		+			Ensure land management practices for soil conservation are conducive to landscape character.

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Where risk is high and soils are eroding (typically steeper or long unbroken slopes, land use change may be necessary.	+		+/-	+		+		+	Ensure land use choices for soil conservation doesn't affect other assets.
Where cultivated consider use of buffer strips to prevent sediment polluting watercourses or impacting on adjoining land.	+		+	+		+			
Take measures to keep soil in-situ, for example, contour ploughing, improve soil structural condition, for example, by addition of soil organic matter where low, for example, manures, green cover crops.	+		+/-	+		-		+	Ensure land management practices for soil conservation doesn't affect other assets.
For any arable areas in high flood risk situations consider change to grass in high risk situations.	+		+	+		+			
Avoid soil compaction/ poaching caused by inappropriate land management.	+	+	+	+		+		+	
Ensure good vegetative cover – avoid over grazing/ trampling or damage from mechanised activities.	+	+	+	+		+		+	
Consider whether mitigation is likely /or desirable when facing loss of asset of increased saline conditions for coastal features.		+		+		+	-	-	Allowing inundation may mean negative impacts on access and historic environment assets – ensure access asset is replaced and historic environment asset is protected (if appropriate) or losses recorded.
Biodiversity									
Maintain existing habitat extent.	+		+	+	+		+	+	

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Ensure best practise management of existing habitat.	+		+	+	+		+	+	
Increase size of habitat patches – habitat creation.	+		+	+	+		+	+	
Maintain and increase ecological connectivity.	+		+	+				+	
Address existing pressures not related to climate change.	+		+	+	+			+	
Create fire risk reduction and response strategies.	+		+	+			+	+	
Replace trees with species more able to cope with the future climate.	+		+	+	+			+	
Habitat creation on flood storage land.	+		+	+	+		-	+/-	Possible loss of access and historic environment assets – ensure access asset is replaced and historic environment asset is protected (if appropriate) or losses recorded.
Target the most beneficial Environmental Stewardship Scheme options.	+		+	+			+		
Allow for realignment of shorelines.	+		+	+	+		-	+/-	Possible loss of access and historic environment assets – ensure access asset is replaced and historic environment asset is protected (if appropriate) or losses recorded.

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Increase ability of river catchments to function naturally.	+		+	+	+		-	+/-	Possible loss of access and historic environment assets – ensure access asset is replaced and historic environment asset is protected (if appropriate) or losses recorded.
Practice adaptive management.		+	+	+	+				
Reflect potential for changes in species composition in management plans etc and accept greater mix/change in species.		+	+	+					
Be alert to potential new species/pests/diseases.		+	+	+					
Maintain a proportion of deadwood *in situ.*		+		+					
Favour beech in sites in native range on north-facing slopes or in valleys.		+	+/-	+	+				Don't plant beech on chalk grassland – look for urban planting – aspiration for no net loss of woodland but planting needs to be in targeted locations.
Manage 'wildlife strips' and 'conservation headlands' under Environmental Stewardship scheme.		+	+	+	+				
Manage non-natural run-off, for example, from roads and buildings/hard surfaces.		+	+	+	+		+	+	
Reduce nutrient and sediment delivery.		+	+	+	+		+	+	

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Better storage of winter rainfall - Water resources policies and engineering works to improve the capture of peak river flows in floodplains in a way that can be stored and used for water supply at times of peak demand (periods of low rainfall).		+	-	+/-					Ensure water storage options do not impact other assets, for example, underground or temporary etc storage solutions are used on a small scale rather than large open reservoirs/lakes. Ensure opportunities for storage fully investigate and avoid negative impacts on Biodiversity and ecosystem services.
Historic Environment									
Monitor and record sites threatened with loss.		+							
Management of soil and vegetation through agri-env to reduce potential damage to buried sites.		+	+	+	+	+			
Installation of higher capacity rainwater disposal systems for historic buildings.		+		+					
Enhance flood resilience of historic assets.		+		?		?			Might restrict opportunities for naturally functioning natural environment.
Access and Recreation									
Encourage the use of drought tolerant green roofs on urban and urban fringe buildings to help the cooling effect of green space in urban/semi urban areas.	+		+	+		+			
Promote water efficiency in green space management.	+			+		+			

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Direct people away from most sensitive areas at most sensitive times, only when necessary and provide alternative routes.	+		+	+	+	+	+		
Maintain a network of well maintained routes off the Chalk Downs to spread the pressure. Promote outdoor recreation close to home, for example, green space in towns & cities, country parks close to settlements.	+		+	+	+	+	+		
Fire prevention strategy.	+		+	+	+	+	+		
Develop innovative path design and construction techniques to better cope with flooding events – possible conflict with landscape depending on design/aesthetics. Higher standards/specification of path maintenance.	+		+/-	+	+	+			Ensure path design is conducive to landscape character.
Increased maintenance requirements in face of increased hazard from falling branches.	+					+/-	-		For B in terms of deadwood provision, for H in terms of damage. Win/Win (A,B) if managed correctly.
Provide shady areas, increase deliberate planting, replant green space with drought tolerant species – possible conflicts with biodiversity.	+	+		+/-	+	+/-			Possible conflicts – ensure appropriate species planted.
Provide easily accessible and up to date information about local recreation opportunities. Promotion and information to disperse visitors to more places.		+	+		+	+			
Promote circular walks and cycle rides from settlements to reduce need for car travel. Promote responsible recreation. Raise awareness of health impacts through interpretive signing and other means. Promote use of public transport to visit inspiring landscapes and long distance cycling to reduce need for car travel.		+			+	+			

Table continued…

Action	Win-win	Low regrets	Landscape	Eco system services	Geology & soils	Biodiversity	Historic environment	Access & recreation	Recommended change to response (if – or +/-)
Increase the availability of 'spreading room' and the use of rolling path agreements – possible conflict with Biodiversity and ecosystem services.		+		+/-	+/-	+/-	-		Must ensure appropriate measures taken to avoid negative impacts, for example, trampling, erosion and disturbance.
Linear route maintenance – for example, Adaptive management approach – footpath maintenance around Kingley Vale.		+	+	+	+	+	+		

Natural England works for people, places and nature to conserve and enhance biodiversity, landscapes and wildlife in rural, urban, coastal and marine areas.

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