Natural England Research Report NERR052

Assessing the potential consequences of climate change for England's landscapes: North Kent

www.naturalengland.org.uk

NATURAL ENGLAND

Natural England Research Report NERR052

Assessing the potential consequences of climate change for England's landscapes: North Kent

Sarah Taylor[1], Paul Hyde[1], Nicholas Macgregor[1], Nikki Van Dijk[2], Geoff Darch[2] and Andy Neale[1]

[1] Natural England

[2] Atkins

Published on 05 November 2013

ISBN 978-1-78354-030-3

Project details

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

This report should be cited as:

TAYLOR, S., HYDE, P., MACGREGOR, N., VAN DIJK, N., DARCH. G. & NEALE, A. 2013. Assessing the potential consequences of climate change for England's landscapes: North Kent. *Natural England Research Reports, Number 052*.

Project manager

Andy Neale
Block B Government Buildings,
Whittington Road,
Worcester,
WR5 2LQ
Tel: 0300 060 0403
andy.neale@naturalengland.org.uk

Acknowledgements

Natural England would like to acknowledge the support of the North Kent Environmental Planning Group and the Medway and Swale Green Grid Partnerships.

Summary

This study considered the vulnerability of the natural environment to climate change in North Kent. The North Kent study area is comprised of two National Character Areas (NCAs). These are the Greater Thames Estuary and the North Kent Plain NCAs where they fall in to the boundaries of the Medway Unitary Authority and Swale Borough Council. North Kent has a distinctively open and atmospheric character dominated by the extensive areas of grazing marsh on the Hoo peninsula, Chetney marshes, the Swale and the Isle of Sheppey. The Medway estuary is dominated by the urban conurbation of the Medway Towns (Rochester, Chatham and Gillingham) and has a strong historic military association. North Kent is typified by extensive open spaces within a predominantly flat, low-lying landscape. The pervasive presence of water and numerous coastal estuaries extend the maritime influence far inland. A strong feeling of remoteness and wilderness persists on the open beaches and salt marshes, on the reclaimed farmed marshland and also on the mudflats populated by a large and varied bird population. The open, low and gently undulating landscape is characterised by high-quality, fertile, loamy soils which are dominated by agricultural land uses. The area is rich in wildlife, supporting a wide range of important habitats such as floodplain grazing marsh, rivers, and coastal habitats such as mudflats and salt marsh.

The vulnerability of the natural environment in North Kent 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.

The distinctive form of North Kent, the open, low and undulating landscape, the extensive open spaces and the pervasive presence of water, will be impacted by climate change for the most part through the impacts on geomorphological processes, changes in erosion and sedimentation, and from sea level rise. The impacts on water provision and distribution in the area from climate change, ie drier summers and wetter winters, will, in turn, impact fluvial geomorphology and erosion rates, for example, drying of rivers and streams, increased deposition of silt, and flash flooding and storms.

The assessment highlighted that habitats in North Kent are likely to be vulnerable to climate change, for example, changes in habitat extents and species composition. Coastal and wetland habitats such as coastal and floodplain grazing marsh, salt marshes, mudflats, rivers, ponds and maritime cliffs, are particularly vulnerable. The national biodiversity climate change vulnerability assessment (Taylor and Knight 2011) overall results also suggest rivers, wetlands and coastal habitats are particularly vulnerable in North Kent.

Coastal habitats are potentially vulnerable to changes in erosion rates and inundation from sea level rise. Wetlands such as floodplain grazing marsh are vulnerable to increased cycles of drought and flood leading to water logging and increased siltation, but also drying out of the marsh causes loss of habitat for wetland birds and erosion of soils. Increased demand for water and changes in management, such as grazing practices, will exacerbate the vulnerability of this habitat.

Historic wetlands are likely to be vulnerable to seasonal changes in precipitation. The extensive coastal historic buildings and historic landscapes will be vulnerable to sea level rise, increased rainfall penetration and erosion.

The vulnerabilities of key access and recreation assets include greater flooding and erosion of footpaths due to drought in summer, flooding in winter, sea level rise 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. Recreation assets at coastal and river locations are likely to be most vulnerable.

Climate change could bring opportunities for food production in the area and farmers may respond by growing more or changing to different crop types. However, 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.

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

It is hoped that the findings of this study of climate change vulnerabilities and potential adaptation options will provide a useful starting point for adaptation in North Kent. 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.

Contents

Appendices

List of tables

List of figures

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 action 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' 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 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 (Figure 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.
- 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.
- 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.

[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).

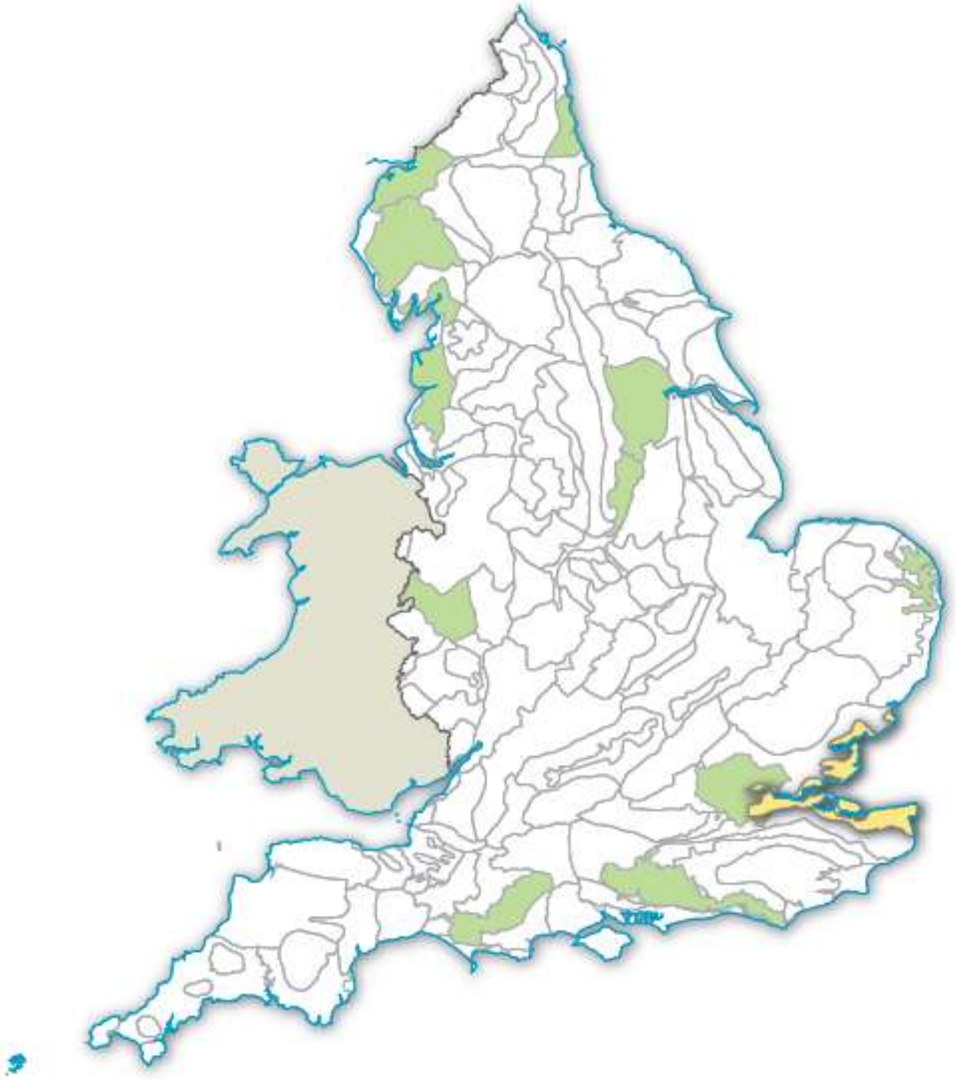


Figure 1 England's 159 National Character Areas, with the 13 areas studied in the two phases of the project highlighted. North Kent is shaded in yellow

1.10 This report presents the results of the North Kent pilot study. Chapter 2 outlines the overall approach taken in this study and the other studies in the second phase of the project while Chapter 3 describes the specific methodology used in the North Kent pilot 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).

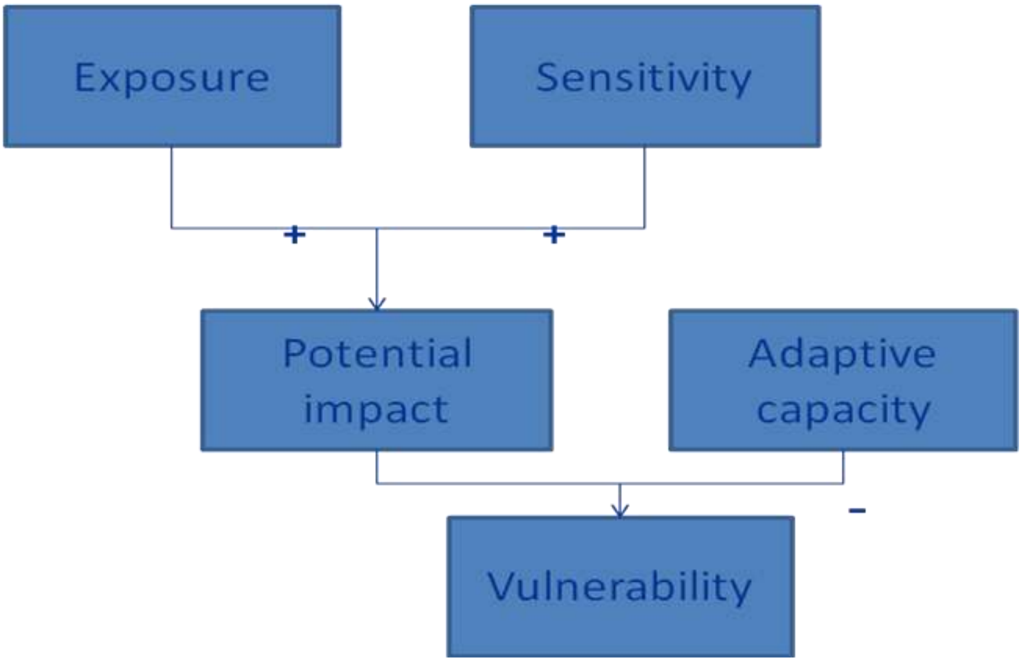


Figure 2 Components of vulnerability according to the IPCC (2007)

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) 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 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 This assessment has considered these elements within the areas of the Greater Thames Estuary and North Kent Plain NCAs that fall within the Medway Unitary Authority and Swale Borough Council boundaries as a pilot area to inform work by the North Kent Environmental Planning Group.

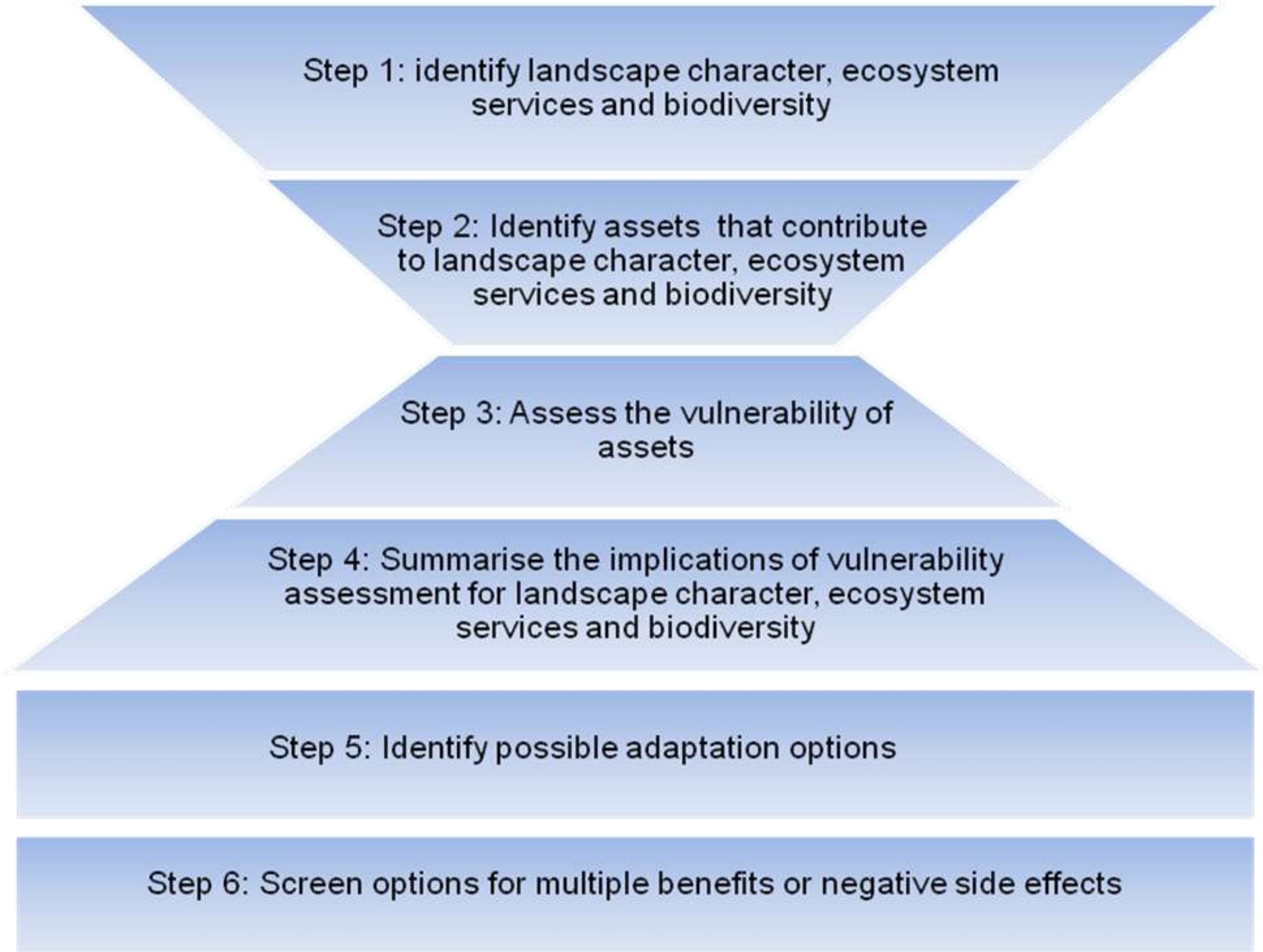


Figure 3 The main steps in the method used to assess vulnerability of the area to climate change and to identify and evaluate possible adaptation options

3.3 The remainder of this chapter outlines in more detail how each of the steps in Figure 3 was completed for North Kent.

Step 1 – Identification of important elements of landscape character, ecosystem services and biodiversity

3.4 We identified the landscape characteristics, ecosystem services and biodiversity in North Kent through a review of the current NCA descriptions (Countryside Agency 1999). The Landscape Assessment of Kent (Jacobs Babtie, 2004), and consultation with Natural England regional and local specialists. We drew heavily on existing documents and the local knowledge of the project team to provide description of the distinctive landscape character, ecosystem services and biodiversity.

3.5 We used the Millennium Ecosystem Assessment groupings to classify the ecosystem services identified as being provided by the North Kent landscape. The classifications are supporting, provisioning, regulating and cultural services (Millennium Ecosystem Assessment 2005).

3.6 Throughout the assessment we have assessed biodiversity at a broad habitat level. This was felt appropriate for the more strategic scale of this study and aligns with the National Biodiversity Climate Change Vulnerability Assessment also carried out in the region (Taylor & Knight 2011).

3.7 Urban character and ecosystem services were largely excluded from this study, however, 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 would 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, ecosystem services and biodiversity

3.8 We identified the assets which contribute to the landscape character, ecosystem services and biodiversity of North Kent under the following headings:

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

3.9 We identified the assets through reviewing the NCA descriptions, The Landscape Assessment of Kent (Jacobs Babtie, 2004) as well as consultation with Natural England regional and local specialists. Regional specialists drew on unpublished information provided by Natural England national experts to identify North Kent assets. Having made an initial identification of the most important natural assets in the area, we carried out targeted stakeholder consultation with the Medway and Swale Green Grid Partnerships via email, and amended our initial findings to reflect any comments we received. The draft report was sent to the North Kent Environmental Planning Group and the Medway and Swale Green Grid Partnerships for comments which were incorporated to ensure the assessment and adaptation suggestions are acceptable to partners.

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 assets which do not lend themselves to mapping (for example, some features of the landscape that contribute to aesthetic value and sense of place).

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

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

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

3.13 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. The example 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) (UKCIP 2010):

- 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.

3.14 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 in this report

Vulnerability rating	Definition
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.

3.15 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.

3.16 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, geodiversity and soils). We then emailed these to regional specialists in Natural England and the Swale and Medway Green Grid Partnerships 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.

3.17 Assigning vulnerability ratings to assets was intended to provide a guide to the relative vulnerabilities of assets in the area 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, ecosystem services and biodiversity

3.18 Having assessed the vulnerability of North Kent's important assets, we considered what the combined effects of changes to assets deemed to be 'moderately vulnerable' and above would be on 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

3.19 We identified potential adaptation actions to address the vulnerability of the assets. We identified potential actions from a combination of published literature (for example, Hopkins *et al*., 2007, Mitchell *et al*., 2007, Heller and Zavaleta 2009) and expert opinion from Natural England specialist and local staff.

3.20 The concept of adaptive management was considered when identifying potential adaptation actions; (Holling, 1978). Adaptive management is a way of managing resources, such as natural environment resources, through testing different approaches, monitoring the results of management activity and then adapting management decisions in line with the information gathered.

3.21 We reviewed the full list of adaptation actions for each theme and identified priority actions using a combination of approaches. Firstly we identified actions that had multiple benefits and were mentioned numerous times. We then screened the list of adaptation suggestions to check for alignment to North Kent priorities 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 priorities.

3.22 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.

3.23 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).

3.24 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).

3.25 Once a set of priority actions had been identified, we grouped them under the potential changes that had been identified in Step 4.

3.26 In addition, we identified a number of potential strategic adaptation actions that apply across many or all aspects of the North Kent 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.

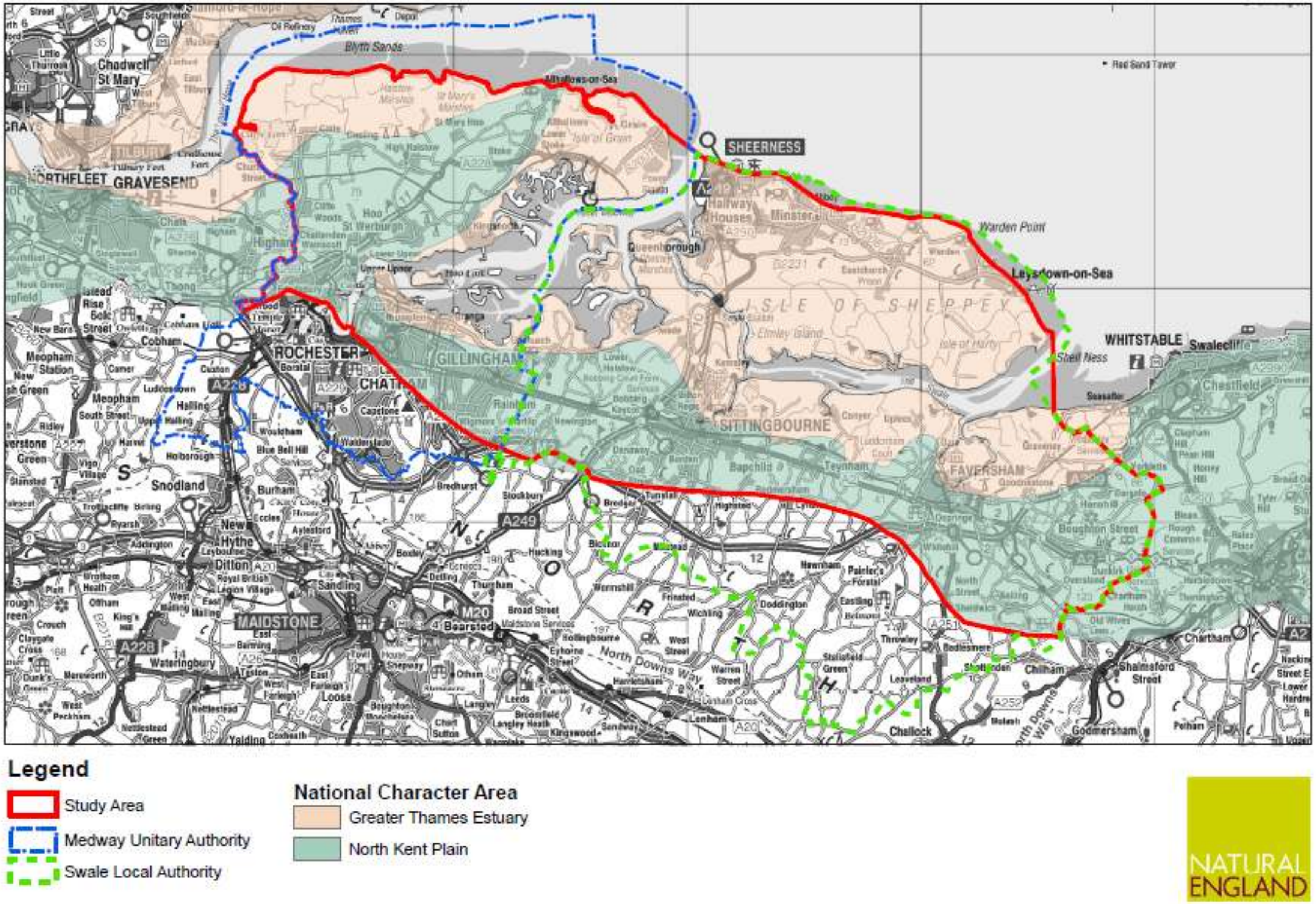


Figure 4 Map showing the North Kent study area

Landscape character

4.2 North Kent has a distinctively open and atmospheric character dominated by the extensive areas of grazing marsh on the Hoo peninsula, Chetney marshes, the Swale and the Isle of Sheppey. The Medway estuary is dominated by the urban conurbation of the Medway Towns (Rochester, Chatham and Gillingham) and has a strong historic military association. The following text describes the landscape character, landscape functions and biodiversity of North Kent.

4.3 The North Kent study area is comprised of two National Character Areas (NCAs). These are the Greater Thames Estuary and the North Kent Plain NCAs.

Variety and contrast

4.4 The greatest contrasts are evident between the maze of winding, shallow creeks, drowned estuaries, mudflats and broad tracts of tidal salt-marsh with sand and shingle beaches along the coast edge of the Greater Thames Estuary, the high proportion of arable land, characterised by a lack of hedgerows, of the North Kent Plain and the highly urban conurbation of the Medway towns. The landform is generally flat but undulates and rolls giving local variations in topography, with the Isle of Sheppey being a particularly elevated area. The intensity of agricultural production in general and conversion from pasture to arable and from one crop type to another, results in a diverse range of colours, textures and patterns in the landscape.

Distinctive form

4.5 The landform and geology are responsible for the very distinctive low-lying and flat character of the landscape which has developed on marine alluvium. Localised outcrops of chalk or London Clay produce distinctive landform features of ridges and hills (for example, Isle of Harty, Norman's, Cleve, Graveney and Horse Hills) which have a prominence out of proportion to their modest relief. A small outcrop of valley brick earth and gravel forms the higher ground of the Isle of Grain. Geology has a significant influence on the character of North Sheppey, which is underlain by a belt of London Clay giving it a distinctive, elevated relief above the surrounding alluvial marshes. The ground rises and forms an area of complex topography before dropping steeply to the sea on its northern side. These slumped, clay cliffs are of significant geological and landscape interest (Jacobs Babtie, 2004).

4.6 North Kent is typified by extensive open spaces dominated by the sky within a predominantly flat, low-lying landscape. The pervasive presence of water and numerous coastal estuaries extend the maritime influence far inland. A strong feeling of remoteness and wilderness persists on the open beaches and salt marshes, on the reclaimed farmed marshland and also on the mudflats populated by a large and varied bird population.

4.7 **Geomorphological processes** such as solifluction, land slips, cliff falls, wave cut platforms and the fluvial geomorphology associated with rivers are crucial to the landform of North Kent. These processes are mainly in relation to the coast, and the dominant estuaries of the Thames, Medway and Swale.

4.8 **Geology** - The Greater Thames Estuary is a geological formation of Tertiary sand and clay sediments deposited between 65 and 23 million years ago. Surface deposits are recent estuarine sediments, from the fine silts of the saltmarsh, grazing marsh and much of the foreshore, to coarser sands and gravels on the exposed parts of the coast (English Nature 1997a).

4.9 The physical development of the Greater Thames Estuary has been dominated by the relative levels of land and sea. The sea has risen from 60 m below its present level since the end of the last ice age, and is currently rising at an estimated 2 millemetres per year (the Environment Agency 2008), increasing sea level rise due to climate change will have a considerable impact in this low lying area. This soft coast is a continually changing shoreline due to the action of the waves and tides on the mobile sediments. The marshes have been created and are sustained from material carried by the sea from the north, a natural process of accretion that has added tens of thousands of acres to the marshes of Kent since Anglo-Saxon times, it is now reduced by man-made sea-defences (Countryside Agency 1999). Overall, the coastline has generally been accreting over the last 100 years with some local areas of erosion. This balance is likely to change with erosion and coastal squeeze becoming more of an issue due to rising sea levels over the next 100 years (Environment Agency 2008).

4.10 Sea-banks were built to protect farmland from the rising sea in the early Middle Ages and sea defences continue to be a feature impacting natural geomorphological processes to this day (Countryside Agency 1999).

4.11 The Greater Thames Estuary NCA part of the study area comprises geological exposures of Tertiary and Quaternary deposits in soft eroding cliffs and foreshores and in quarries and pits, plus the geomorphological interest of the estuary itself. This includes the following geological features:

- A dynamic ‘soft’ coastline continually influenced by the action of waves and tides on the mobile sediments results in the ongoing erosion and creation of coastal landscapes.
- Saltmarsh morphology.
- The coastline of the Isle of Sheppey provides some of the best examples of recent mass movement in Britain. Warden Point on the Isle of Sheppey provides an excellent example of mass movement in the form of coastal landslips, where average annual losses are known to reach three metres. It is also an important site for its rich fossil fauna (with the remains of subtropical fish, sharks teeth and plants), as well as for Palaeogene stratigraphy (English Nature 1997a).
- The Francis Chalk Quarry RIGS site at Cliffe, designated for its chalk exposure and the former clay pits that now form the Cliffe Pools RSPB reserve, reminders of the area’s cement making history.
- The Isle of Sheppey provides contrast with the surrounding flat land as is rises from a stretch of very flat marsh along the Swale estuary in Kent, with low, steep, clay cliffs facing north towards Essex.
- Occasional shell banks are a scarce but characteristic feature of the coast, for example, Shellness, Isle of Sheppey.
  (Text taken from the English Nature 1997a).

4.12 The North Kent Plain geology is dominated and characterised by the clays and sands deposited during the Tertiary era, principally the Thanet sands, the Woolwich, Reading and Blackheath Beds, and the London Clay. The chalk underlies the area and outcrops near the Medway towns and it is exposed in sea cliffs and inland quarries. The North Kent Plain lies upon the fine loam soils found between the London Clay of the Greater Thames Estuary to the north and the North Downs chalk to the south (English Nature 1997b). Other sites of interest include:

- Fort Amherst RIGS site, a chalk and flint exposure in the urban area of Chatham. (**Kent RIGS Group**).

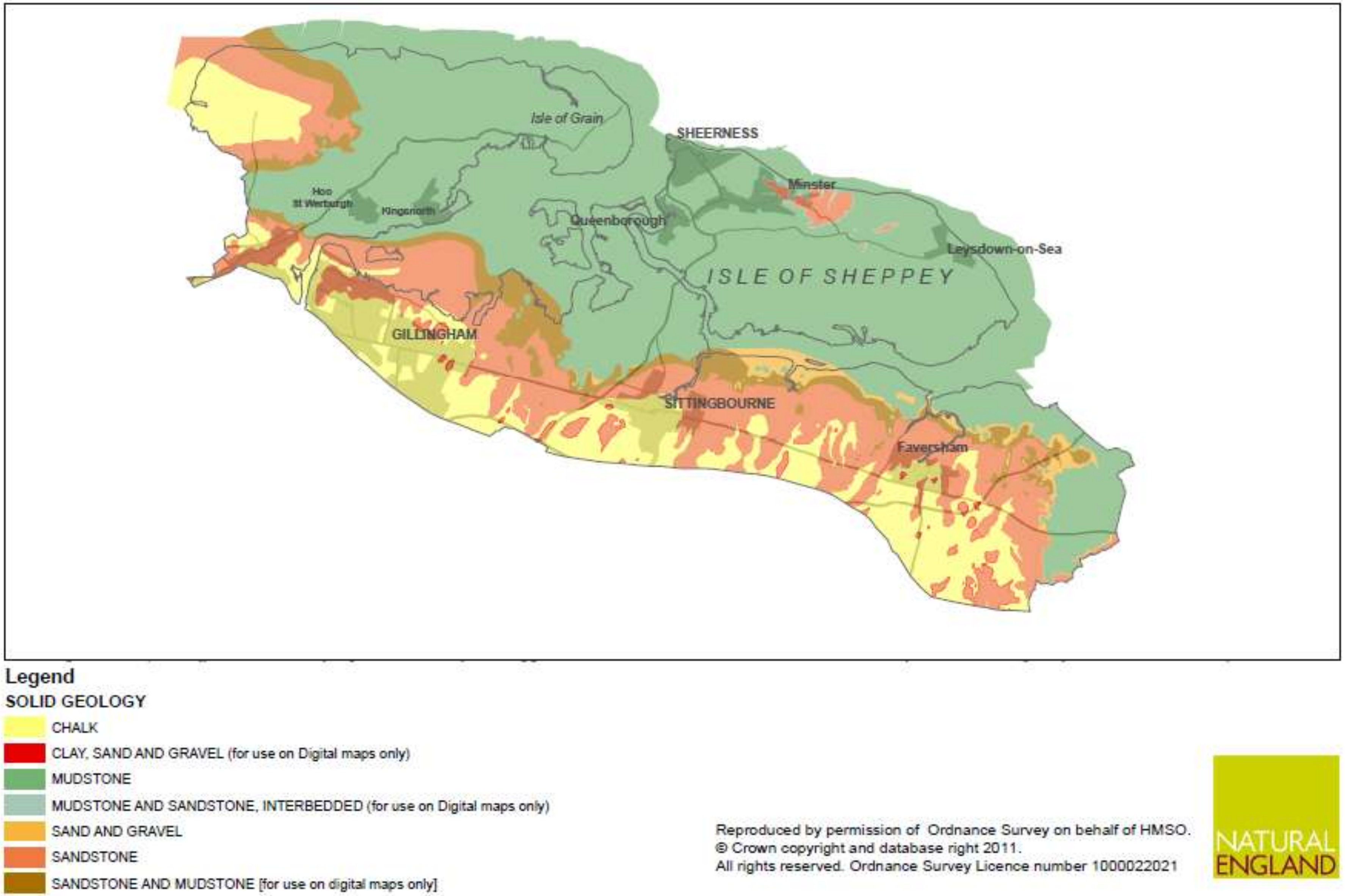


Figure 5 Map showing geodiversity in North Kent

History

4.13 The history of North Kent has centred on the use of the three major rivers in the area. The Thames, the Medway and the Swale have a long history as trade routes and as possible access routes for military invasion. This has led to constant development of military defences and local industries. These combine to form the major historic site at Chatham's Historic Dockyards.

4.14 The historic environment of the Greater Thames Estuary is heavily influenced by the defence of the land from the sea and from military invaders. Sea-banks were built to protect farmland from the sea by the early Middle Ages and defences exist to this day for the same purpose. Marshland was progressively reclaimed resulting in wet, sheep-grazed marsh within the sea walls and saltmarsh on the seaward side. Extensive drainage and fertilisation of the marshes has been carried out over many years for arable cropping, improved pasture and industry. This has led to an alteration of many of the characteristic features of the marsh landscape, for example, where the previously meandering creeks of the grazing marsh have become straight dykes and ditches in arable areas (Countryside Agency 1999). As sea level rises, saltmarsh will be lost to coastal squeeze against flood defences, although in places where managed retreat and foreshore recharge are deemed an alternative to total sea exclusion there may be the potential to retain this habitat (Environment Agency 2008). Military establishments, notably numerous forts of the 1860s and the anti-invasion works from the two World Wars, are a distinctive feature (Countryside Agency 1999). The Medway marshes were of strategic military importance as illustrated by the blockhouses of Darnet Fort and Grain Tower (Jacobs Babtie, 2004). The landscape of the Medway Marshes has also long been associated with industrial use. The Romans established extensive salt and pottery workings around Upchurch and the shore was later used for the winning of estuarine clay (Jacobs Babtie, 2004).

4.15 Other historic features include:

- Small villages and hamlets located on higher ground reflecting medieval patterns.
- Prominent military associations, including the historic naval dockyards surviving at Sheerness and Chatham.
- Large scale historic features illustrate the military history of the area ranging from the medieval at Queenborough castle through the Napoleonic forts at Shornemead, Cliffe, Hoo and Darnet Fort to the WWII batteries at Grain and Chetney.
- Abundant remains of local salt-industries, with medieval salt mounds on the edge of the Kent marshes.
- Rare Neolithic causewayed enclosures at Kingsborough Farm on the Isle of Sheppey.
- Evidence for Bronze Age settlement on the Hoo peninsula.
- Reed-fringed drainage ditches and dykes form the main field boundaries of the open grazing pastures, with hedgerows largely absent.
- Medieval or earlier irregular drained fields are characteristic of Sheppey and the Cliffe marshes.
- A network of Minster churches founded by the Saxons, such as at Minster on Sheppey.
- Historic wetlands, the grazing marshes at Elmley and the Swale NNR.

(Sources: Countryside Quality Counts Draft Historic Profile, Countryside Character Area descriptions)

4.16 In the North Kent Plain, large settlements and urban infrastructure are dominant within the landscape, notably the Medway Towns. The rural settlement pattern predominantly consists of nucleated villages with low densities of dispersed settlement. Important Roman remains are found across the area including remains of roman villas, mausoleums and cemeteries, and the walled city at Rochester, and traditional buildings such as Oast houses survive in the landscape. However, much of the area's archaeology has been lost due to tillage of arable land.

(Source: Countryside Quality Counts Draft Historic Profile, Countryside Character Area descriptions)

4.17 Other historic features include:

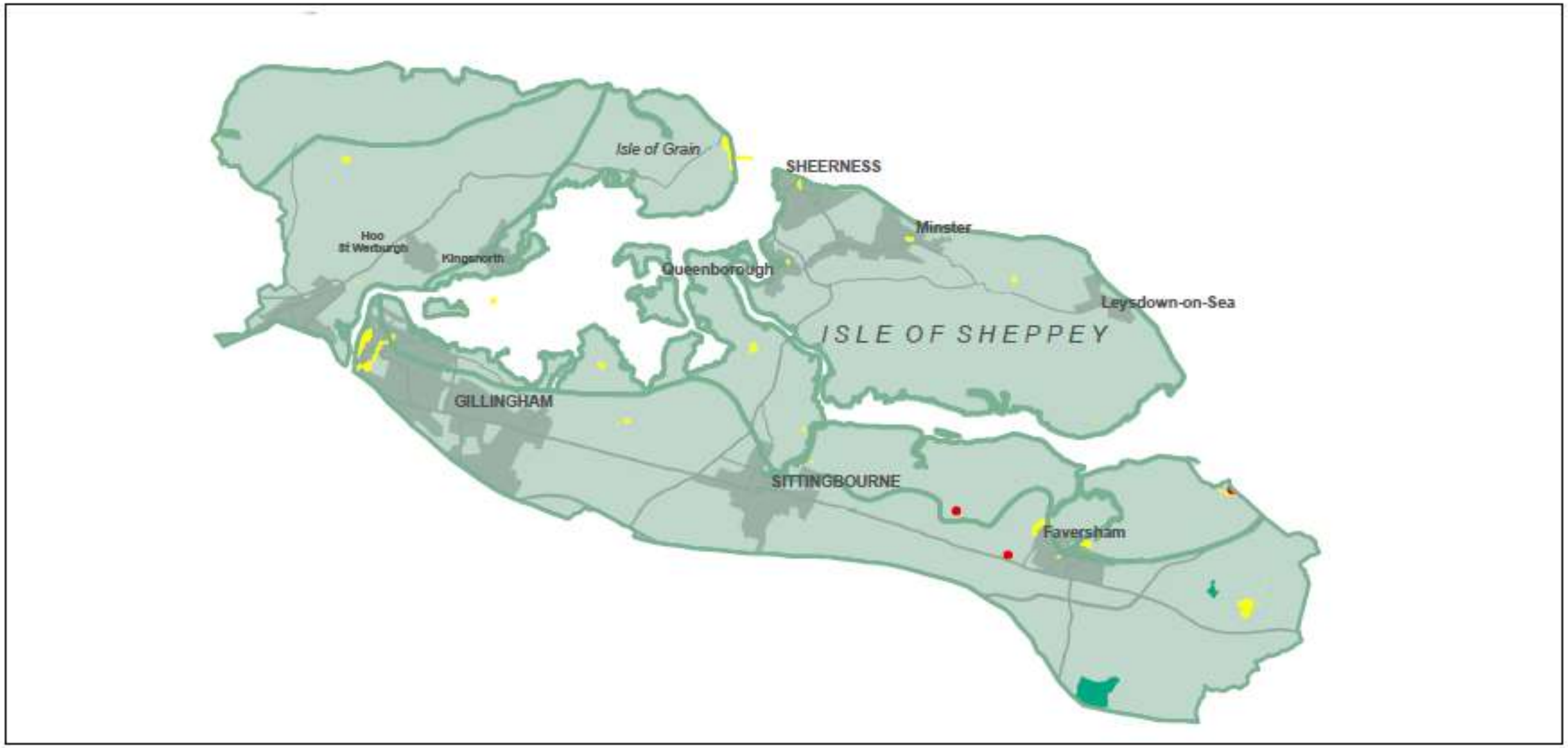
- Below ground and upstanding features such as historic settlements and Roman remains.
- Historic routeways, including reused prehistoric tracks, ancient drove roads and trackways or trunk roads linking new settlements built by the Romans, for example, Watling Street Roman Road.
- Large scale historic features which illustrate the military history of the area, for example, the medieval castle at Cooling.
- Relict boundaries still present in the landscape, including the road layout between Cliffe and All Hallows on the Hoo Peninsula, which still follows the original Saxon Field layout.
- Farm buildings include the traditional Oast houses found in the North Kent Plain.
- Mount Ephraim house and garden. Designed landscapes are not a distinctive part of the historic character of the area but Mount Ephraim is an exception.

Wildlife

4.18 Biodiversity within the area, although not exceptionally diverse, consists of significantly large areas of increasingly rare floodplain grassland. This reflects the dominance of the three major estuaries and the extensive and varied agriculture in the area. North Kent supports a range of habitat types, including coastal grazing marsh, ancient woodland, and coastal habitats (see biodiversity section for further information).

Coastal habitats

4.19 Dominated as it is by three major river estuaries the coastline is the most distinctive feature of the North Kent study area. The grazing marshes extend throughout the region from the Hoo Peninsula, through Chetney Marshes and across the Isle of Sheppey to the Swale. These combined with extensive salt marsh in the Medway and mud flats throughout the Thames Estuary provide wintering habitats for wildfowl and waders numbering in the tens of thousands (Jacobs Babtie, 2004).



Legend

- Top 35 Sites per County
- Scheduled Monuments
- Historic Parks and Gardens
- National Character Areas

NATURAL ENGLAND

Figure 6 Map showing some historic environment assets in North Kent

Woodlands

4.20 Woodland does not form part of the distinctive character of the North Kent area; however there are a number of important woodlands in the area :

- Chattenden woods near Rochester. Chattenden woods is representative of coppice-with-standards woodland on the London Clay, and constitutes the one of the examples in Kent of this scarce habitat away from the Blean Woods. The site is also importance for its breeding birds.
- Church Woods at Blean. The Church Woods site is one of the most extensive areas of broadleaved woodland remaining in the Forest of Blean and is representative of these woodlands which are situated on London Clay. The traditional coppice with standards management of the woods has, together with climatic, soil and other factors, given rise to the great biological interest currently present.
- Northward Hill on the Hoo Peninsula. The most important feature of the site is the heronry which, with over 200 pairs, is the largest in Britain. There is a diverse breeding bird community and the insect fauna is also of interest, particularly moths and butterflies. The site consists of mixed deciduous woodland and scrub with some open areas of grassland and bracken (Jacobs Babtie, 2004).

Agriculture

4.21 In the Thames Estuary NCA the land use pattern is predominantly traditional unimproved wet pasture grazed with sheep and cattle. Within this essentially marshland character contrast is provided by the extensive areas, usually lying between coastal edge and rising ground, of former marshland, where draining, levelling and improvement of the soil structure has allowed wheat and barley to be cultivated. This ‘improvement’ process has altered many of the characteristic features of the marsh landscape such as where the numerous meandering creeks of the grazing marsh have become straight dykes and ditches in arable areas. There are also some areas of more mixed agriculture including a few orchards on the higher ground. The orchards enclosed by hedgerows, tree lines and windbreaks provide a contrast to the surrounding open marsh landscape.

4.22 Lying upon the fine loam soils found between the London Clay underlying the Greater Thames Estuary, to the north and the North Downs chalk to the south, the North Kent Plain NCA is one of the most productive agricultural areas in Kent. The exposed arable and horticultural fields have a sparse hedgerow pattern and only limited shelter belt planting around settlements and farmsteads. Gently undulating, the large intensively cropped fields to the west are mainly devoid of trees and hedges. Orchards and horticultural crops to the east predominate and are enclosed by poplar or alder shelter belts and scattered small woodlands (Jacobs Babtie, 2004).

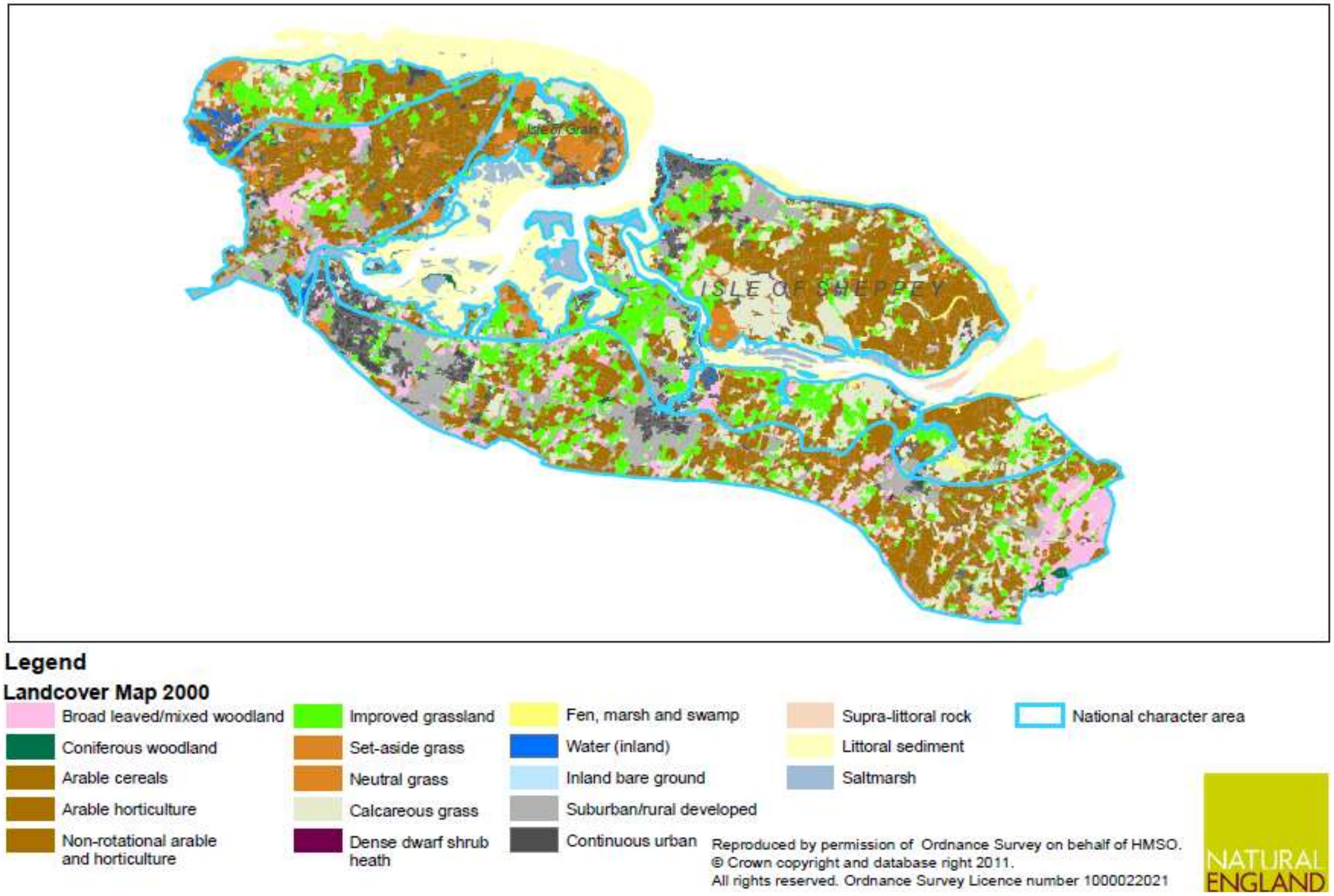


Figure 7 Map showing landcover in North Kent

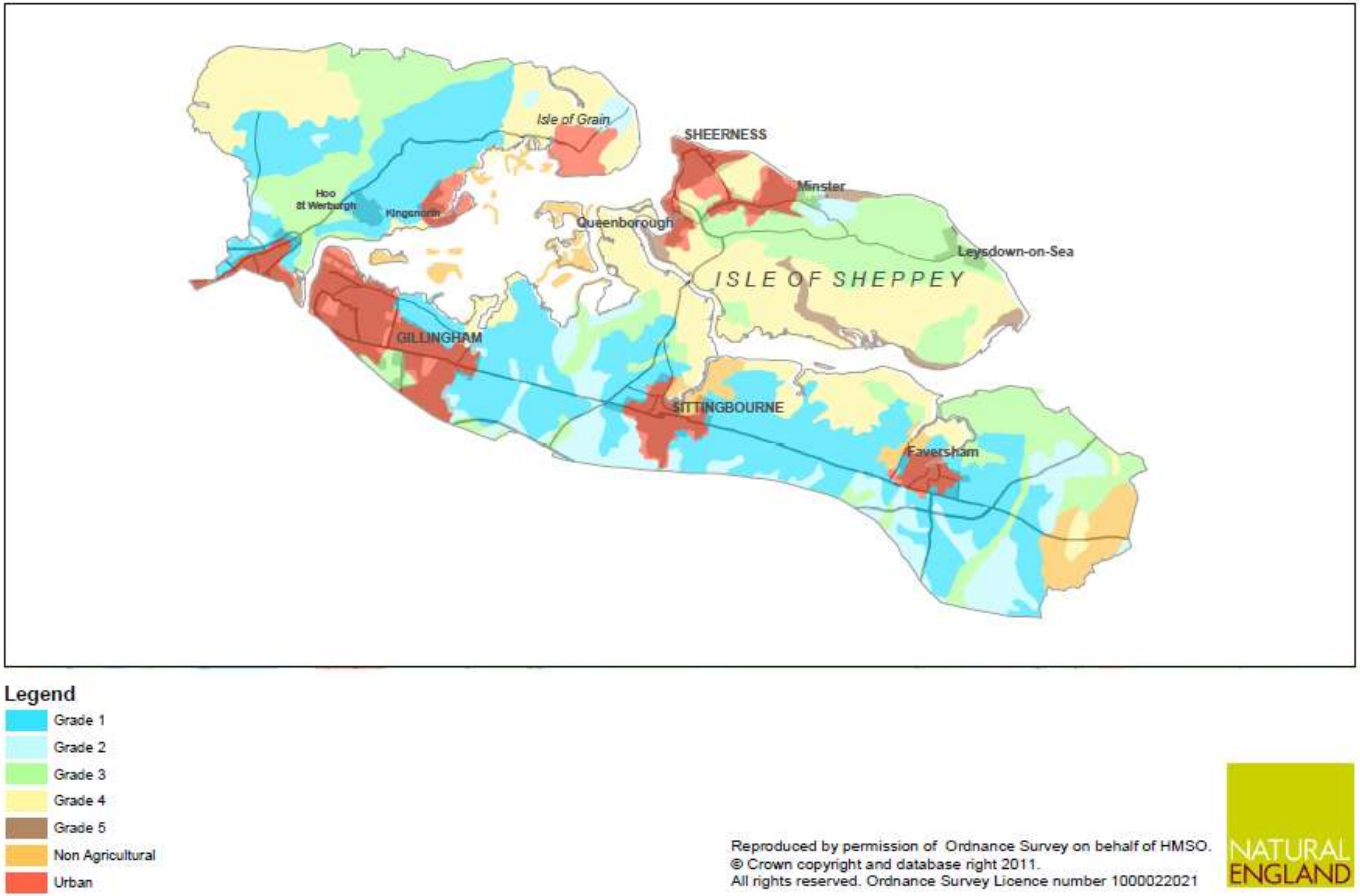


Figure 8 Map showing Agricultural Land Classification of North Kent

Buildings and settlements

4.23 Modern day pattern of local parishes reflects the historical layout of settlements, surrounded by farmland on the higher ground inland, giving way to marsh down to the waterfront. **The Thames Estuary NCA** suffers pressure on edges, particularly around major estuaries, from urban, industrial and recreational developments together with the associated infrastructure requirements often on highly visible sites against which the marshes are often viewed. The Thames edge marshes are themselves subject to the chaotic activity of various major developments including ports, waste disposal, marine dredging, urbanisation, mineral extraction and prominent power stations plus numerous other industry-related activities such as petrochemical complexes.

4.24 Tourism and formal recreation-related uses of the Estuary such as boating, water and jet skiing, new marinas and increasing visitor pressure have acted to reduce the general feeling of remoteness and wilderness.

4.25 Significant pressures on the landscape have resulted from new roads and the development of industrial complexes and their ancillary structures. The Thames Gateway and associated developments including transport are likely to further increase these pressures in the future. Such developments are particularly visible within the flat landscape of the Estuary.

4.26 Within the North Kent Plain, the rural population is largely scattered in small farmsteads across the area, and there are very few strongly nucleated settlements. This dispersed settlement pattern with surrounding fields defined by a dense network of narrow lanes is typical of the area.

4.27 Settlement growth and urbanisation have been primary influences which have markedly changed the local landscape character. The development of Faversham and Sittingbourne, plus the sprawl around Dartford and the Medway Towns in particular, have all impinged on the character of the area (Countryside Agency 1999 and Jacobs Babtie, 2004).

Views

4.28 The area is characterised by extensive open spaces dominated by the sky, within a predominantly flat, low-lying landscape. The pervasive presence of water and numerous coastal estuaries extend the maritime influence far inland. A strong feeling of remoteness and wilderness persists on the open beaches and salt marshes, on the reclaimed farmed marshland, and also on the mudflats, which are populated by a large and varied bird population. Open grazing pastures patterned by a network of ancient and modern reed-fringed drainage ditches and dykes, numerous creeks and few vertical boundaries such as hedges or fences (Jacobs Babtie, 2004).

Sense of place

4.29 The North Kent coast contains stunning shorelines, tranquil marshland wilderness and a fascinating maritime heritage. The marshes are a distinctive, exposed, flat landscape of pasture and arable land. Agricultural land predominates, with grassland dominating. The estuarial and coastal landscapes are also very rich in wildlife. The North Kent marshes convey a strong sense of space, remoteness and quietness, a special quality in the South East of England. The wide open spaces and big skies convey a special character. The landscape of the Medway Marshes has also long been associated with industrial use, in contrast to the Swale Marshes that have a predominantly agricultural and particularly tranquil, unspoilt character. The landscape of the Isle of Sheppey has a particularly distinctive character as a result of its coastal island situation. A sense of remoteness is accentuated by the physical separation of the island from the mainland by the Swale. This is coupled with a sense of exposure which results from the lack of shelter and elevated, coastal position, this atmosphere can be both invigorating and bleak, depending upon weather conditions (Jacobs Babtie, 2004).

4.30 The Hoo Peninsula and marshes have a strong association with Charles Dickens. 'Great Expectations' was set here, with St James Church, Cooling being the setting for the opening scenes. Notable buildings are Cooling Castle and Cliffe Church, both dating from the 14th century.

4.31 The north Kent coast has many artistic connections, in particular 19th Century painters. The River Medway and Upnor Castle were subjects of Turner's paintings and engravings, and George Chambers, John de Jardin Snr., Francis Moltino, W. D. Doust and William Wyllie painted this coastal landscape. In the 20th century the watercolourist and art historian Martin Hardie worked in this area. More recently Vic Ellis, Rowland Fisher and Hugh Lynch are associated with the Medway Estuary (Jacobs Babtie, 2004).

Ecosystem services

4.32 The landscape of North Kent delivers a range of services that contribute to the economy and people's well being. The following section describes the ecosystem services that North Kent provides.

Provisioning services - such as food, fibre, fuel and water

Agriculture and forestry

4.33 Rural land use in North Kent is split roughly 50/50. Market gardening and mixed cropping dominate the higher elevations located along the spine of the Hoo peninsula, the north of the Isle of Sheppey and the lower slopes of the North Downs around Sittingbourne and Faversham, while livestock farming and rough grazing predominate the low-lying areas bordering the Thames, Medway and Swale Estuaries.

4.34 The quality of the agricultural land in the area is also largely defined by the same regions. Grades 1-3 very good to good are largely confined to higher elevations described above although there are some areas of grade 3 land located at Halstow and St Marys Marsh on the Hoo Peninsula. The grade 1 and 2 lands in the area are of very high quality (high likelihood of being 'best and most versatile land'), this area is traditionally associated with orchards and horticultural crops but the extent has declined. It includes some of the most valuable agricultural soils in the country.

4.35 As noted above, woodlands and forestry do not play a large role in the eco-system service of North Kent. There are isolated pockets of woodland which have more of a recreational role and there is some interest by a local landholder at Blean to utilise the coppice for bio-fuel heat generation on a local level (Jacobs Babtie, 2004).

Renewable energy

4.36 Alongside the above mentioned small scale use of coppice woodland for bio-fuels there is a large scale wind farm located off shore (the London Array). Phase 1 of the London Array Wind farm consists of 175 wind turbines producing electricity to power 480,000 homes a year. The generated electricity is fed into the electricity network via a sub-station at Cleve Hill (**www.londonarray.com/**).

Water resources

4.37 Surface water abstraction accounts for 25% of Kent's water supply and comes mainly from the River Medway abstraction at Maidstone. This is supported by releases from Bewl Reservoir, which is filled during periods of high river flow during the winter from the River Teise at Smallbridge, near Goudhurst and from the Medway at Yalding. Both Yalding and Smallbridge abstractions are tied to control flows based on a Minimum Residual Flow in the Medway at Teston gauging station. Small water supply surpluses are currently identified in

Medway and Swale and transfers are currently made from Medway into Thanet where there is a water supply deficit (Environment Agency 2004).

4.38 Southern Water Services response to “Mapping out the Future” suggested that investment in local infrastructure is likely to be required in most areas where significant growth is proposed, for example, Swale (Iwade and North Sittingbourne), Thanet and Medway.

Regulating services - such as climate regulation, water purification and flood protection

Carbon storage

4.39 Soils and bio-mass can perform an important role both in storing carbon and in carbon sequestration to support climate change mitigation. Fen peat soils and the peaty or organic deposits within loamy and clayey floodplain soils with naturally high groundwater are important carbon stores. Although fen peat soils are not common in the area, floodplain soils form extensive regions across the low-lying North Kent Marshes at the Hoo peninsula, the Isle of Sheppey and the Swale Estuary. Other habitats within the area can also carry out this function, for example the woodland at Blean is a significant carbon store.

Climate regulation

4.40 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), such as the Medway conurbation. It is also understood that rural areas with greater proportion of semi-natural habitats are cooler that urban areas (Forest Research 2010). The floodplains of the North Kent Marshes at the Hoo peninsula, the Isle of Sheppey and the Swale Estuary, as extensive rural areas, provide this function in the area.

Water quality

4.41 Groundwater quality is generally classed as good, with no detectable evidence of saline intrusion. There is one major groundwater clean-up underway. This relates to a former insecticide plant in Sittingbourne and it is possible that the groundwater under Sittingbourne and other urban areas along the coast have been affected by the long history of industrial activity. Marginal quality water can be found in the confined Chalk and Lower Tertiaries aquifers due to ion-exchange. The use of fertilisers and pesticides on the upper parts of the catchment could potentially affect groundwater quality. Throughout England, nitrate levels of surface and groundwater are increasing. This is a concern, as the Nitrate has to be removed before water can be supplied to customers and it can harm the environment. Most of this Catchment Abstraction Management Strategy (CAMS) area is not included in the Nitrate Vulnerable Zone (NVZ). Only the North Downs and an area to the south east of Faversham have groundwater NVZ designation. Farmers within a NVZ area have to follow DEFRA guidelines to ensure nitrate leachate is within set levels (Environment Agency 2004).

Flood protection

4.42 The flood plains of the main rivers and their tributaries and the coastal wetlands provide flood storage and therefore are likely to protect nearby properties and businesses.

Cultural services

Recreation

4.43 Recreation opportunities in North Kent provide great health benefits to a large population in the surrounding area, both local communities and South East London’s population. The green spaces, rivers, coastline, and recreational resources of North Kent have a particular value to the local community - an approximate population in North Kent of 600,000 (Dartford, Gravesham, Medway and Swale).

4.44 The Thames, Medway and Swale estuaries and the North Kent Marshes are recognised as one of the most important natural wetlands in northern Europe providing recreational resources as well as invaluable natural flood protection for London. They support mammals such as seals, globally important numbers of breeding and wintering birds, as well as rare plants and insects, and large parts are internationally protected. The marshes are popular places for the enjoyment of nature due to their big open skies providing exceptional panoramic views, a sense of remoteness and spectacular wildlife.

4.45 Away from the coastal areas there are recreation resources including numerous National and Local Nature Reserves (NNRs and LNRs) as well as country and amenity parks. National Nature Reserves include The Swale, Blean Woods, Elmley and High Halstow.

4.46 The key recreational assets within North Kent include:

- **The Saxon Shore Way**, which stretches for some 160 miles providing excellent access to the coast and spectacular stop off points. It takes in the Hoo Peninsular, Rochester and Riverside Country Park among many other interesting sites.
- **The Heron Trail** – an 18 mile (29km) circular cycling route on the Hoo Peninsula, between Upnor and Higham.
- **High Halstow NNR**, managed by the RSPB as part of their Northward Hill reserve, is a 52 hectare National Nature Reserve of scrub and woodland habitat, dominated by hawthorn and ancient oak woodlands, with regenerating elm woodland. The scrub has a diverse bird population, including long-eared owl and nightingale, while the oak woodland supports a large heronry and little egret colony.
- **Elmley NNR** – a 931 hectare National Nature Reserve that largely consists of flat, open grazing marsh at or below sea level. The reserve is important for large numbers of wintering waterfowl and birds of prey. The watercourses, seasonally wet ground and saltmarsh are also important for their plant and insect life.
- **Oare Marshes** – an internationally important local nature reserve for migratory, overwintering and breeding wetland birds, managed by Kent Wildlife Trust. The saltmarsh supports a unique set of plants tolerant of the salty conditions, while the freshwater dykes contain rare plants including water plantain. Common seals are often seen in the Swale Estuary.
- **Chatham Dockyard and Great Lines Heritage Park** – a unique heritage park of international importance developing from the historic defence lines protecting Chatham's key military installations.
- **Riverside Country Park** – which covers 100 hectares alongside the Medway Estuary and receives around 500,000 visitors per year (personal communication, Martin Hall, Greening the Gateway Kent and Medway). It includes Motney Hill and Berengrave Local Nature Reserves. There are various habitats within the park, including mudflats and salt marsh, ponds and reed-beds, grassland and scrub, which provide a haven for wildlife (**Medway Unitary Authority Website**).

4.47 Walking, picnicking, bird watching, riding, dog walking, cycling, fishing, sailing and jet skiing are some of the many recreational activities undertaken in North Kent. Each depends on access to a suitable landscape, sometimes with very specific features. North Kent provides many of these recreational opportunities to a substantial resident and surrounding population. Country parks provide facilities for walking, cycling and horse riding and other outdoor activities. A survey on visitor activities in the North Kent area found that walking and dog walking were the most popular activities, making up 85% of the responses (Fearnley and Liley 2011).

4.48 There are a large number of SSSIs and local wildlife sites within North Kent, of which a significant number have some level of public access, providing attractive green space for people to enjoy the outdoors and see nature at first hand. Other very popular sites include National Nature Reserves, such as the Swale and Elmley, and Local Nature Reserves including Oare Marshes and Seasalter Levels. There are also a range of coastal sites, woodlands at High Halstow and the Blean woodland, allotments, formal parks and sports pitches which offer a mosaic of locally valued green space.

4.49 The North Kent area contains approx 1200 km of rights of way which makes public rights of way one of the most important access and recreation features given the size of the urban population and the popularity of walking and dog walking in the area (Fearnley and Liley 2011).

Research and education

4.50 A large variety of education and research opportunities are provided by the natural environment in North Kent. These include natural features such as flora, fauna, geology, ecosystems, and the historic environment, for example, archaeology, land use patterns and other historic features.

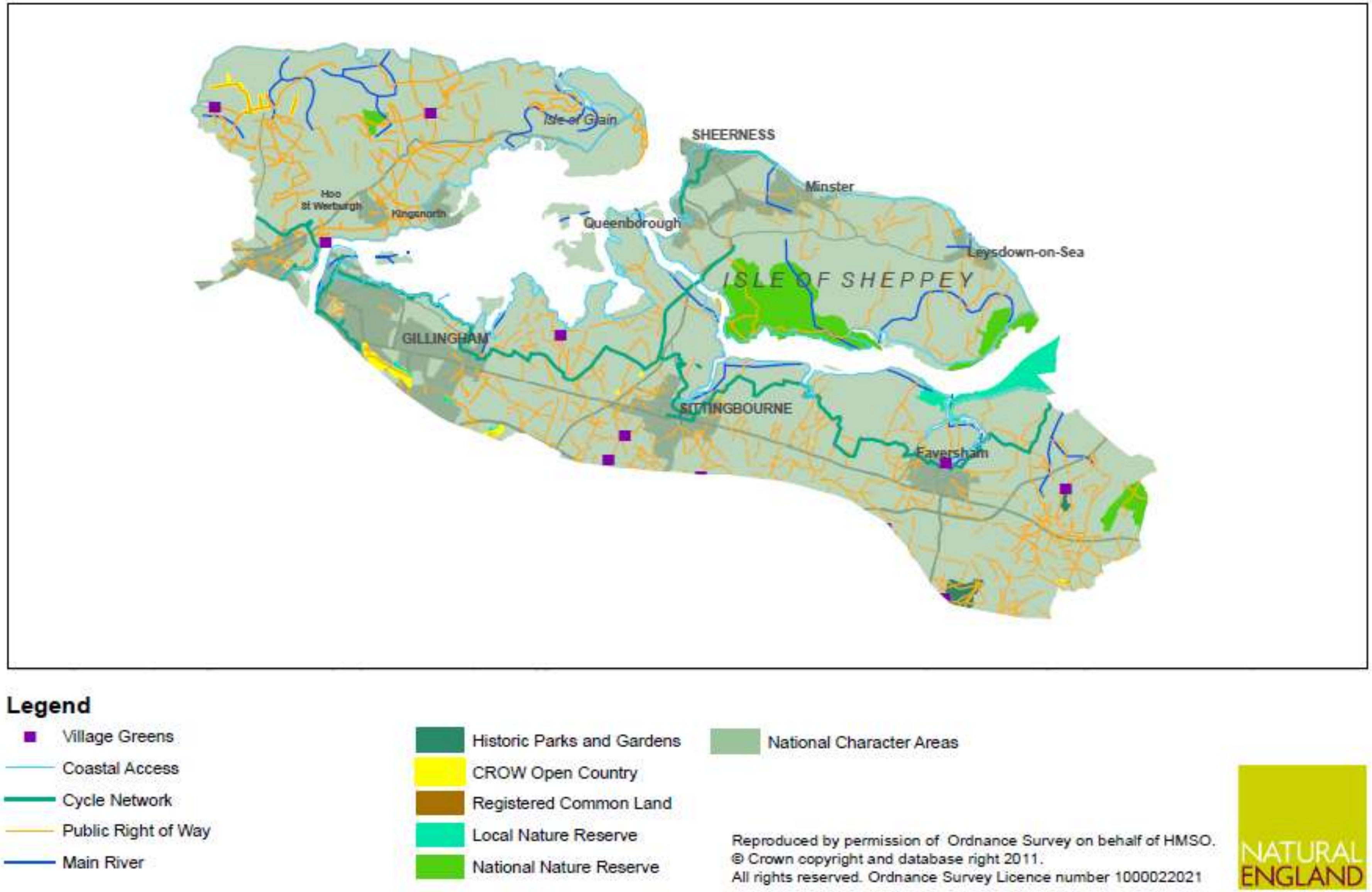


Figure 9 Map showing some access and recreation assets in North Kent

Support services such as nutrient cycling, oxygen production, soil formation and biodiversity

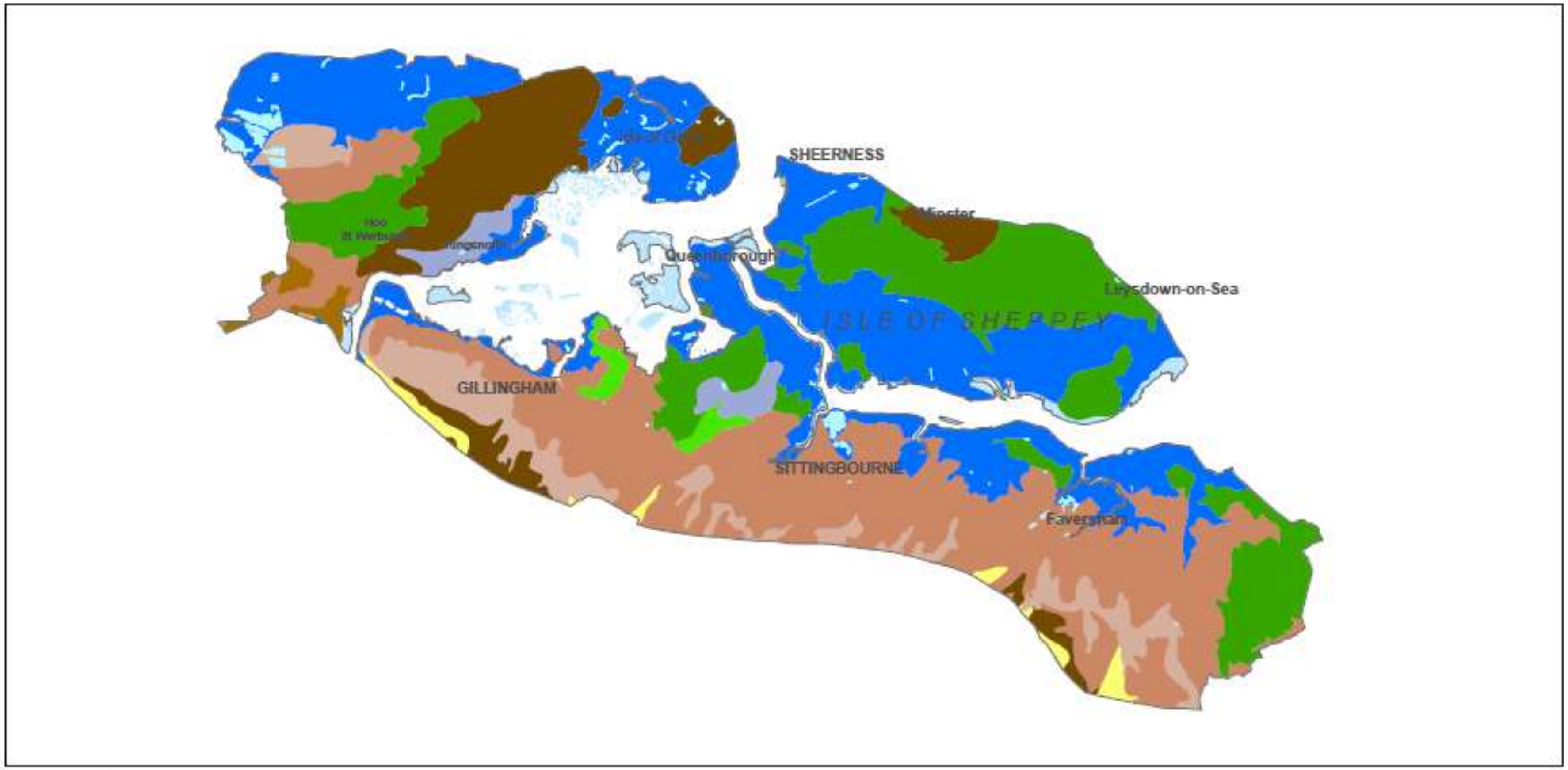
Nutrient cycling and soil formation

4.51 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 remain the building blocks of landscapes. Soils in low-lying areas are particularly vulnerable to sea level rise both in loss of area and in saline intrusion.

4.52 The soils within the area have been analysed used the Soilscape typology which loosely classes soils into 27 typologies: the figure below lists the 11 soil types within the Medway and Swale areas.

- **Salt marsh soils –** Extensive around the Swale and Medway Estuaries Covers approx 2% of study area.
- **Shallow lime-rich soils over chalk or limestone –** These cover approximately 8% of the area. They comprise shallow well drained calcareous silty soils over chalk typical of dry chalk valleys of the North Downs dipslope. 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** – These are largely confined to the broad valley floors in lower chalk valleys on the chalk outcrop of the North Downs dip slope. Covers about 7% of the study area.
- **Freely draining slightly acid loamy soils –** These soils are extensive, covering 25% of the study area and forming a band of land along the northern base of the North Downs dip slope. Soils are typically derived from aeolian (wind blown) silty drift. Soils are deep and well drained but have a weak structure and are liable to cap.
- **Slightly acid loamy and clayey soils with impeded drainage** – These soils are extensive in the study area (about 19%), comprising areas where thick loamy and clayey drift over chalk occurs at higher elevations on the North Downs, and where thick drift overlies clay at higher elevations on the Hoo Peninsular and Isle of Grain. Soils are slowly permeable; drainage and workability characteristics will depend upon the clay contents.
- **Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils –** These are extensive, covering approx 14% of the study area and are associated with clayey soils with impeded drainage derived from London Clay on the Isle of Sheppey, Hoo Peninsular and at various locations on the coastal plain including Iwade, Uplees and south west of Whitstable.
- **Loamy and clayey soils of coastal flats with naturally high groundwater** – These soils form extensive low-lying clayey marshland areas occurring on marine alluvium around the Thames, Medway and Swale estuaries, including on the Isles of Grain and Sheppey. Much is currently protected from flooding by sea walls and embankments. These soils cover approx 21% of the study area. They are the second most extensive soil type in North Kent, occupying approximately 50% of the Greater Thames Estuary NCA and a large area around the Isle of Thanet.

4.53 Supporting ecosystem services also include the process of **photo-synthesis**, which produces oxygen, which is necessary for most living organisms and **pollination**, which underpins much of our agriculture. Ecosystem changes will affect the distribution, abundance and effectiveness of pollinators and **biodiversity**, which underpins all the other services (see biodiversity significance section).



Legend

- 1 - Saltmarsh soils
- 3 - Shallow lime-rich soils over chalk or limestone
- 5 - Freely draining lime-rich loamy soils
- 6 - Freely draining slightly acid loamy soils
- 7 - Freely draining slightly acid but base-rich soils
- 8 - Slightly acid loamy and clayey soils with impeded drainage
- 17 - Slowly permeable seasonally wet acid loamy and clayey soils
- 18 - Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
- 21 - Loamy and clayey soils of coastal flats with naturally high groundwater
- 22 - Loamy soils with naturally high groundwater
- 31 - Water

NATURAL ENGLAND

Figure 10 Map showing soils in North Kent

Biodiversity

4.54 The Medway and Swale area has a wide range of biodiversity. It supports a total of 10 Sites of Special Scientific Interest (SSSIs), representing over 25% of the area within the Medway and Swale areas. Of these nationally important sites, 4 are National Nature Reserves, and internationally important sites include 1 Special Area of Conservation (SAC), 3 Special Protection Areas (SPAs) and 3 Ramsar sites. The area also supports 6 Local Nature Reserves (LNRs), and 3 important geological sites.

Designated sites, species and BAP Habitats

Internationally important sites:

South Thames Estuary and Marshes SPA and Ramsar, Medway Estuary and Marshes SPA and Ramsar, The Swale SPA and Ramsar, Queensdown Warren SAC

Nationally important sites:

Ellenden Woods SSSI, Northward Hill SSSI, Chattenden Woods SSSI, Church Woods (the Blean) SSSI, The Swale SSSI, Medway Estuary and Marshes SSSI, Sheppey Cliffs and Foreshore SSSI, South Thames and Estuary SSSI, Tower Hill to Cockham Wood SSSI, Dalham Farm SSSI.

National Nature Reserves:

Northward Hill, Blean Woods, The Swale and Elmley

Local Nature Reserves:

Berengrave Chalk, Darland Banks, Oare Marshes, South bank of the Swale, Seasalter and Foxes cross Bottom.

Important Geological Sites:

Lower Upnor Quarry, Francis Chalk Quarry RIG, Fort Amherst RIG

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

- Great Crested Newt *Triturus cristatus*
- Dormouse *Muscardinus avellanarius*
- Water vole *Arvicola terrestris*
- Adder *Vipera berus*
- Barn owl *Tyto alba*
- Hen Harrier *Circus cyaneus*
- Short-eared Owl *Asio flammeus*
- Avocet *Recurvirostra avosetta*
- Heath fritillary butterfly *Melitaea athalia*
- Shrill Carder Bee *Bombus sylvarum*
- Brown Banded Carder Bee *Bombus humilis*
- Scarce Emerald Damselfly *Lestes dryas*

Key UK Biodiversity Action Plan Habitats:

- Maritime cliffs and slopes
- Coastal and flood plain grazing marsh

- Mudflats
- Saline Lagoons
- Reedbed
- Woodland pastures and parkland
- Deciduous woodland
- Traditional Orchards
- Salt marsh
- Running water (rivers, estuaries)

4.55 The key UK BAP habitats found in the area are listed above. The most characteristic and valuable habitat types are rivers, floodplain habitats, farmland and arable.

4.56 The following are highlights of the importance of semi-natural habitats in the Medway and Swale area:

- Superb grazing marshes, salt marsh and mudflats – South Thames Marshes SPA and Ramsar, The Medway Estuary and Marshes SPA and Ramsar and the Swale SPA and Ramsar.
- Unique woodlands of high value – The Blean Complex.

4.57 The following paragraphs describe the most important and characteristic habitat types.

Grassland and arable land

4.58 Farmland dominates the area, largely in the form of arable land, although there is considerable horticulture across the Hoo Peninsular, and contributes significantly to the overall character and ecological value of the area and to the rural economy. Mixed farmland often supports a rich biodiversity and represents an important area for a number of nationally declining plant and animal species associated with agricultural land. Alongside grassland, other important agricultural habitats include hedgerows and arable field margins.

Rivers, streams and floodplain habitat

4.59 The Thames, Medway and Swale estuaries provide a range of important wetland habitats that support a diverse range of aquatic plants, invertebrates and over-wintering birds. 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. However, large areas of high nature conservation interest, such as floodplain grassland, reedbed and ditches are present. All of these wetland habitats carry statutory nature conservation designation, and all three are also areas of international importance, either SPA and Ramsar sites. North Kent is a hot spot for water voles, with Elmley maintaining the highest population concentration in the UK. The saline lagoons at Cliff Pools represent a significant proportion (11%) of the existing area of this increasingly threatened habitat within the UK.

Coastal habitats

Mudflats

4.60 Equally important as the terrestrial sections of the Thames, Medway and Swale SPAs are the extensive mudflats contained within the estuaries. These are formed from the deposition of fine sediment in areas of low tidal energy, particularly within river estuaries. This sediment is mainly silt and clay with a high organic content. These habitats support a high density of burrowing invertebrates such as lug worms, sand mason worms and bi-valves. They provide feeding and roosting areas for internationally important populations of migrant waterfowl and extensive foraging opportunities for the flocks of overwintering wildfowl and waders distinctive to the area.

Salt marsh

4.61 Salt marsh occurs on soft, shallow shores in sheltered coastal areas and estuaries, and predominantly occupies the upper, vegetated portions of intertidal mud flats lying approximately between mean high water tides and high water spring tides. Areas of salt marsh are located around the main river estuaries and narrow river channels which offer protection from disruption by rough seas. Salt marsh is a highly specialised and productive habitat which supports flora which is adapted to cope with sea water. Characteristic species include sea aster and salt marsh grass. Salt marsh is an important feeding ground for migrating and wintering bird species.

Maritime cliffs and slopes

4.62 Maritime cliffs and slopes are defined as sloping to vertical faces on the coastline where breaks in the slopes may be formed by slippage and/or coastal erosion. While there is no defined minimum height or angle of slope to distinguish a cliff, the extent of the cliff-top is determined by the landward extent of the maritime influence, (ie the limit of salt spray deposition). On the seaward side this extends to the limit of the supralittoral zone (immediately above high water) and so includes splash zone lichens and/or other species which occupy this habitat. The maritime cliffs in the area are soft due to their underlying geology, and are restricted to the North Sheppey Coast.

Saline lagoons

4.63 Saline lagoons are bodies of saline water that can be natural or artificial and are partially separated from the adjacent sea. They are an important and relatively scarce habitat that supports unique invertebrates, such as the lagoon cockle and ostracods, and are important for waterfowl, marshland birds and seabirds. Kent has a high proportion of the national saline lagoon resource with one of the largest areas at Cliffe Pools (142ha) (**Kent BAP website**).

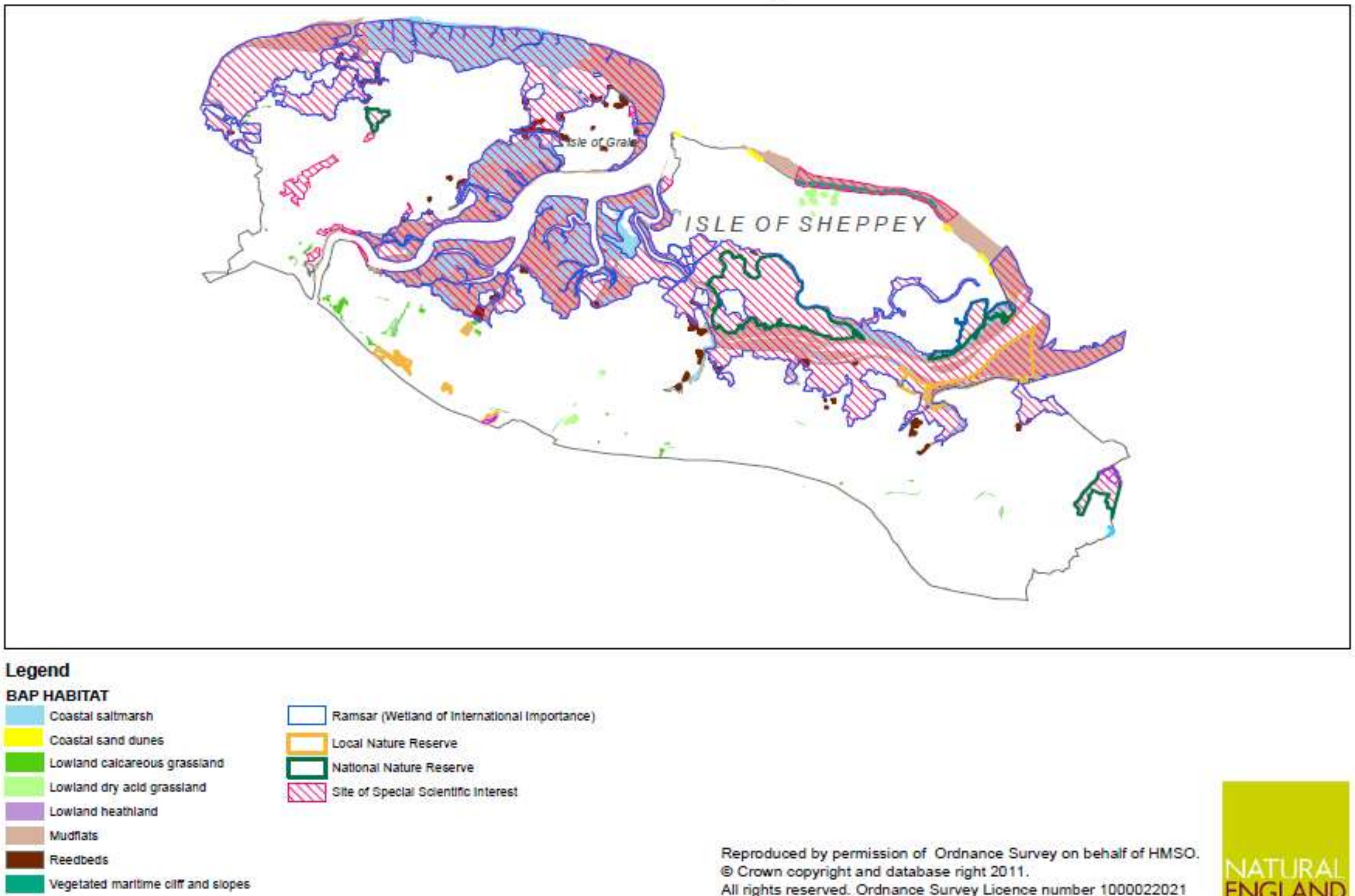
Summary: Key Natural Assets

4.64 The following are the most important aspects of landscape character, ecosystem services and biodiversity 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 and a sense of wildness in an area surrounded by dense populations and opportunities for recreation.
- A wide variety of flora and fauna and habitats including characteristic open marshland and estuary habitats.
- Cultural landscape including literary and artistic connections.

4.65 And the most important natural assets that provide this are:

- The distinctive geology of the area that provides the landform and the soils that support the traditional land uses in the Marshes.
- Over 22 statutory and non-statutory designated sites for biodiversity - floodplain grassland, mudflats, salt marsh and traditional orchards - key assets for biodiversity, landscape and access, together with a wealth of species.
- A well supplied Public Rights of Way network, and significant areas of open access - a key recreational asset.
- Historic landscapes.



NATURAL ENGLAND

Figure 11 Map showing BAP habitats in North Kent

Part 2 – Results of vulnerability assessment

4.66 This section summarises the assets in each category – geology and soils, habitats and species, 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

4.67 The following section details the climate change impacts geological experts have identified for geology features that contribute to landscape character and function in North Kent.

4.68 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. 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. However, this will only be the case if naturally functioning rivers and coasts are realised.

4.69 The bulk of geological assets within the assessment area consist of geomorphological processes, sand and shingle beaches, cliffs and former quarries. Rock exposures occur mainly in disused quarries, but also on the coast, where some nationally important cliffs are found. Areas of particular concern from a geodiversity perspective are the coastal cliffs on the Isle of Sheppey and the geomorphology associated with the soft sediment estuaries and rivers in the area.

More vulnerable

4.70 **Coastal cliffs and foreshore:** This includes a small area of coastline on the North Coast of the Isle of Sheppey, where the cliffs are designated as the Sheppey Cliffs SSSI. This SSSI is primarily of geological interest with the cliffs of Eocene London Clay constituting a classic fossil locality, but the area is also of botanical interest as the cliff vegetation includes the rare Dragon's Teeth. Since this feature consists almost entirely of a SSSI, which is designated for its cliff processes any impacts will be concentrated in this area.

4.71 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. 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). Foreshore lowering may lead to changes in sediment movement and might ultimately affect sediment regimes further along the coast and offshore.

4.72 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.

4.73 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.

Moderately vulnerable

4.74 **Fluvial and other geomorphological processes** such as solifluction, land slips, cliff falls and the fluvial and estuarine geomorphology associated with the rivers and estuaries are crucial to the landform of North Kent. These processes are mainly in relation to the coast, and the dominant estuaries of the Thames, Medway and Swale. Impacts on soft sediment coasts such as these may include changed distributions of coastal and river landforms in response to altered patterns of erosion and deposition, changes in seasonality of river flows, including increased occurrence and duration of droughts and low flows, increased frequency of flooding, enhancing rates of erosion, deposition and channel adjustment and increased coastal retreat, steepening, coastal squeeze and enhanced landslide activity on susceptible coasts (Prosser *et al.,* 2010).

4.75 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. With the focus on riverine and estuarine geomorphology in the study area, this will be a widespread and significant impact.

4.76 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).

Soils

4.78 The main soil typologies within the area are loamy clay based soils with high water tables, supporting floodplain grassland and arable. The main direct impact of climate change to these soils is likely to be increased wetness due to higher levels of winter rainfall. Drier summers and wetter winters are particularly important climate change variables for soils along with the consequences of extreme weather events such as flooding and drought. Of particular concern is the loss of land in the region due to sea level rise. This will impact both by direct land loss and by changes in soil type due to saline intrusion.

4.79 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).

4.80 The following section describes the vulnerability of the soils types found within the North Kent study area.

More vulnerable

4.81 **Saltmarsh soils:** 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.

4.82 **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

4.83 **Slightly acid loamy and clayey soils with impeded drainage:** Wetter winters and more intense rainfall will 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.

Moderately vulnerable

4.84 **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.

4.85 **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.

4.86 **Slowly permeable seasonally wet acid loamy and clayey soils:** Increased winter rainfall and increased rainfall intensity may lead to an increase in diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding.

4.87 **Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils:** Wetter winters and more intense rainfall will lead to increased wetness and risk of soil compaction, diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding. They are also sensitive to ‘shrink swell’ due to their 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.

4.88 **Loamy and clayey floodplain soils with naturally high groundwater:** Wetter winters and more intense rainfall will lead to increased winter flooding, leading to possible deposition of sediment, increased risk of soil compaction, increased run-off on sloping ground 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, but are valuable carbon stores.

4.89 **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

4.90 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.

4.91 Predicting the impact of climate change on individual species is complex as they need to be considered as part of a wider ecosystem and it is not always easy to determine the interplay between different aspects of that ecosystem on one particular species, including the knock on impacts of change in distribution or community composition on another species. Understanding the vulnerability of particular habitats provides a much fuller understanding of the likely implications for climate change on an area's biodiversity. Loss of habitat condition relating to designated sites and priority habitats is also a potential impact for all habitats.

4.92 The following impacts have been identified for the Medway and Swale biodiversity assets.

More vulnerable

4.93 **Rivers and streams:** 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 (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 in local hydrological conditions and impacts on habitat suitability and connectivity between habitats (Conlan *et al*., 2007).

4.94 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).

4.95 Increased pollution of waterbodies resulting from increased run-off will adversely affect 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.

4.96 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).

4.97 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). 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).

4.98 **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).

4.99 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.

4.100 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).

4.101 **Coastal and floodplain grazing marsh is vulnerable to increased flooding**, water logging 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). The North Kent Marshes are clay based and therefore tend to dry quickly leading to development of a crust. 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 disrupted (Mitchell *et al.,* 2007).

4.102 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).

4.103 Management changes also have the potential to impact on 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 to damage freshwater habitats of biodiversity value in coastal zone (Mitchell *et al.,* 2007). These impacts are particularly relevant to the South Thames, Medway and Swale SPA, Ramsar and associated SSSIs and Local Wildlife Sites.

4.104 **Salt marsh and mudflats** are highly vulnerable to rising sea level and the associated increase in wave energy, leading to erosion of the seaward edge. Sediments that would naturally be deposited further up shore can also prevented from doing so where coastal defences are in place. Habitat can be lost as it becomes 'squeezed' between rising sea levels and static defences. Salt marsh, like other intertidal areas, dissipates wave energy, thus reducing the risk of damage to sea defences and low lying areas. Given the importance of salt marsh to the ecological functioning of the coast, and to flood management, this habitat needs to be incorporated into plans for coastal realignment using existing areas of undeveloped land adjacent to the coast. Mudflats are also vulnerable to coastal squeeze and increased erosion which is likely to be exacerbated as coastal communities respond to climate change. The Thames Estuary 2100 Catchment Habitat Management Plan (Environment Agency 2008) assesses the current location of intertidal habitats and projects changes over the next 100 years. Due to coastal squeeze, salt marsh is largely projected to suffer loss of extent at the expense of expanding mudflats as the sea level rises and the habitat rolls back. The mudflats in the Medway and Swale estuaries are projected to expand in general due to the presence of numerous small islands, whereas the mudflats in the Thames Estuary will decrease (Environment Agency 2008).

4.105 **Maritime cliff and slope** habitat is particularly vulnerable to erosion and 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 habitat may be increasingly vulnerable to cliff erosion and more frequent landslides (Mitchell *et al.,* 2007). This is not wholly a negative impact as the reactivation of old landslide complexes may be beneficial to cliff habitats and species, however the habitat must have room to move and function naturally. 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 Sheppey Cliffs and Foreshore SSSI.

Moderately/more vulnerable

4.106 **Traditional Orchards:** The expansion of the range of fruit species and varieties further north may occur due to the increasing average annual temperature. This may also benefit certain warmth loving saproxylic invertebrates such as Noble Chafer (*Gnorimus nobilis*). However warmer winters and reduced rainfall are likely to suppress productivity due to less favourable conditions (winter chill) for fruit bud set and less moisture available for fruit growth. Increased winter rainfall may increase mortality or crop loss due to the unsuitability of fruit species to water-logged soils.

Moderately vulnerable

4.107 **Saline Lagoons** at Cliffe are unlikely to be impacted by sea level rise due to the presence and maintenance of sea defences. However, the habitat depends on continued saline influence through overtopping, leaky sluices and saline intrusion, and would be threatened if improvements to sea walls reduced these inputs or realignment of sea walls leading to a reduction in the extent of the habitat or changes in quality. These changes may be offset by the development of new habitat, however, any realignment at sites such as Cliffe would probably result in the loss of a larger area of the habitat than would reform naturally (**Kent BAP website**). Prolonged periods of drought may lead to drying out of pools and impacts on the species and ecosystem.

4.108 **Reedbed:** Increased winter flooding may result in a loss of bittern habitat although this is unlikely to impact on the Reedbed itself. Conversely, increased soil water deficits during drier summers may reduce water quality and constrain eco-system function.

National biodiversity climate change vulnerability assessment results

4.109 The national biodiversity climate change vulnerability assessment (Taylor and Knight 2011) is a GIS grid based model (200m^2) which uses a number of variables – value, sensitivity, physical adaptive capacity (topographic heterogeneity and structural habitat connectivity) and management adaptive capacity – to assess overall vulnerability of Biodiversity Action Plan (BAP) habitats based on biodiversity climate change adaptation principles identified by Defra (Hopkins *et al.,* 2007). This assessment allows us to add a spatially explicit element to the biodiversity vulnerability assessment for the North Kent Area. Figure 12 shows the results for the overall vulnerability assessment (including all habitats) for the study area.

4.110 The overall vulnerability results suggest the following are particularly vulnerable:

- Rivers – River Medway.
- Wetlands – Particularly grazing marsh.
- Coastal habitats – Salt marsh and mudflats.

4.111 The map gives an example of the vulnerability results produced for all habitats in the study area. Habitats in the area are highly vulnerable due to a number of factors – the high sensitivity of habitats to climate change, low topographic variability in the area and lack of management options that addresses the current sources of harm identified for this habitat in some areas (particularly water quality and supply indicators). The additional scoring associated with the high value of this area in conservation terms increases the overall assessment score.

4.112 The vulnerability scores for each variable for each grid square containing habitat can be identified to enable us to suggest 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 and once this has been decided we can target action on habitat management and connectivity in particular, in line with the Lawton review (Lawton *et al.,* 2010) and in collaboration with our partners, specifically the North Kent Environmental Planning Group.

4.113 The National Biodiversity Climate Change Vulnerability Assessment has been updated since its use in this report. For the latest information and data please **click here**.

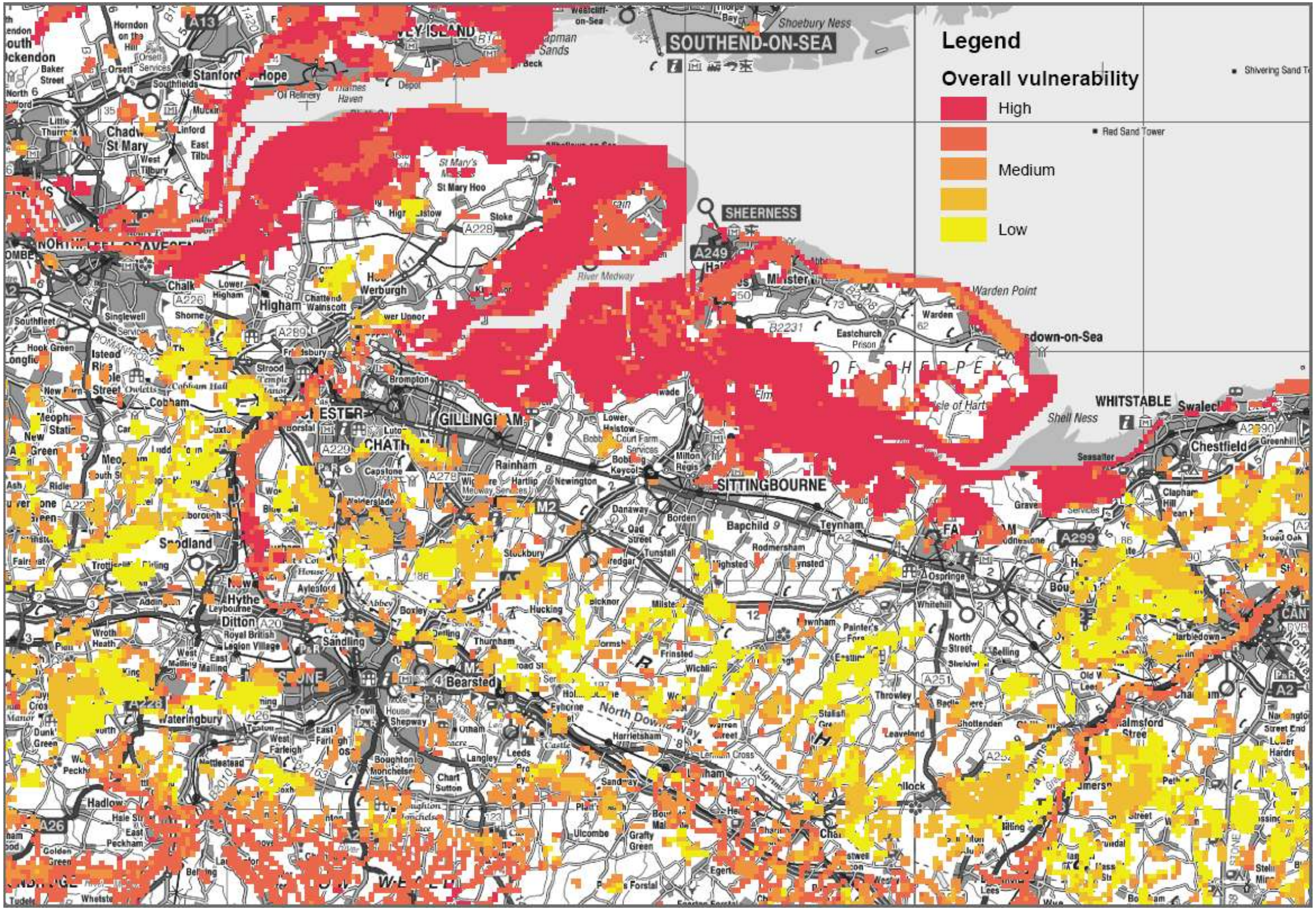


Figure 12 Map showing the vulnerability of all BAP habitats in North Kent; from the National biodiversity climate change vulnerability assessment

Historic environment

4.114 Many of the historic sites in the study area 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 changes in climate. Climate change is also going to bring increased challenges to the ongoing maintenance and management of the historic environment.

4.115 With the close connection between the historic environment and the rivers and estuaries in this area, sea level rise will have an increasing impact as the rate of rise increases in future years. The Isle of Grain to South Foreland and the Medway Estuary and Swale Frontage Shoreline Management Plans set out a large-scale assessment of the risks associated with coastal evolution and presents a policy framework to address these risks, including those to the historic environment. While the protection and management of heritage features is seen as essential to maintaining the social and historical value of the coast, the plan identifies the kinds of threat to the coastal environment from coastal erosion.

More vulnerable

4.116 **Historic wetlands:** These assets will come under pressure from changes in precipitation and are sensitive to both flooding and drying out. Cycles of flood and drought may lead to waterlogging, increased erosion of soils, increased siltation, vegetation succession and an increase in nutrient loading.

4.117 They may also come under pressure from indirect impacts such as increased demand for water, for household, agricultural and recreational use (Mitchell *et al.,* 2007), intensification of agriculture and increases in visitor numbers. Its capacity to adapt depends on water resources and ability to function naturally. The appropriate management of surrounding hydrology is essential.

Moderately vulnerable

4.118 **Upstanding and large scale historic assets:** There are many historic environment assets, reflecting the maritime, defence, industrial, trade and settlement heritage of the North Kent Coast, within the area, all of which have the potential to be affected by coastal defences and changes in erosion and flooding. These include historic fortifications, harbours and dockyards, military installations, coastal settlements, industry and many other features such as the preserved artefacts contained in buried landscapes. The ‘no active intervention’ or ‘managed realignment’ policies have the potential to result in the damage or loss of these assets. Where military and trade heritage assets are located immediately adjacent to the shoreline and sit behind sections of coast that will continue to be defended, they will in turn be maintained. Significant features that will receive continued protection include the following Scheduled Monuments; coastal artillery defences on the Isle of Grain, Upnor Castle, Chatham Dockyard, Oare Gunpowder Works, Castle Rough, Queenborough Castle and Sheerness Defences. However, where policies that promote long term realignment and erosion, ie No Active Intervention or Managed Realignment, have been planned, this will impact on historic environment assets as this coastal heritage resource is so extensive (SMP Main Documents). For example, the proposed policy of continued ‘No Active Intervention’ at Cockham Wood and for the Medway Islands will result in erosion of, and increased risk to, three Scheduled Monuments; Cockham Wood Fort, Hoo Fort and Darnet Ness Fort (SMP Main Documents). It is also important to recognise the impacts on other assets the coastal protection policy may cause, for example, squeeze of habitats against sea defences.

4.119 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 improved drainage in listed buildings, because of the restrictions of adapting existing roof coverings and rain water goods, or issues of cost or policy constraint.

Short, sharp rainfall is likely to cause greater erosion on historic earthworks and monuments and both flooding and drought may lead to changes in soil pH or moisture content (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 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).

Access and recreation

4.120 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 in encouraging greater participation in active recreation. This would not only deliver on health objectives to increase physical activity, but may reduce the use of cars for more local short journeys. 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

4.121 Linear routes in North Kent will be particularly vulnerable to changes at the coast from sea level rise, both directly and indirectly. The rise in sea level itself may lead to inundation and increased erosion of the footpaths and the realignment of sea defences, that often provide coastal paths, may also impact on this resource, although provision should be made for replacement of any losses.

4.122 Paths will also be impacted by increased winter rain, which can increase flooding, causing damage and erosion to paths, particularly those on slopes or with poor drainage, due to increased run-off or puddling.

4.123 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.

4.124 **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.

4.125 An increase in flooding events could potentially causing significant damage to access 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.

4.126 **Coastal recreation** areas are vulnerable to increased footpath and track erosion. North Kent will be particularly vulnerable to changes at the coast from sea level rise, both direct and indirect. The rise in sea level itself may lead to inundation and increased erosion of coastal access assets and realignment of defences may impact assets over the short to long term.

4.127 Country Parks, NNRs, LNRs and other nature reserves will be vulnerable to drought in summer, for example drying out leading to greater irrigation requirements, and flooding in winter leading to damage to sites and landscape. Coastal sites will also be vulnerable to the impacts of sea level rise.

4.128 Changes to the wildlife or landscape supported by such sites may have an impact on visitor preferences in the future, possibly leading to some sites becoming more or less popular than they are at present, for example, a loss of overwintering birds may affect the draw of the marsh reserves for bird watchers.

4.129 In sites which include mowed grassland, such as formal picnic sites, parks or sports facilities, warmer summer temperatures will increase the growing season for vegetation, while also requiring additional cutting back of vegetation to keep paths open. Periods of heat wave could also be detrimental to some sites, particularly those with mowed grass which are particularly vulnerable to drought. It has also been noted that in the 1976 drought increased visitor pressure at Wye and Crundale NNR in Kent and led to increased erosion (Hearne and Gilbert 1977).

Moderately vulnerable

4.130 **Woodland** access assets are vulnerable to increased fire risk in drier hotter summers, increases in ticks and potential for tick borne diseases and increased hazard from falling branches due to storm events. An increase in the use of woodlands for recreational purposes may result in increased disturbance and trampling, which may be locally detrimental to biodiversity but may encourage the planting and management of woodlands for wildlife (Mitchell *et al.,* 2007). 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. This may lead to the few woodland sites in the area being visited more often, for example the Blean Complex, or may lead to the increase of woodland planting in the area for recreational purposes.

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

4.131 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 (not in prioritised order).

4.132 (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

4.133 The distinctive form of North Kent, the open, low and undulating landscape, the extensive open spaces and the pervasive presence of water, will be impacted on by climate change for the most part through the impacts on geomorphological processes and from sea level rise. The impacts on water provision and distribution in the area from climate change, ie drier summers and wetter winters, will in turn affect fluvial geomorphology and erosion rates, for example, drying of rivers and streams, increased deposition of silt and flash flooding and storms.

4.134 Potential adaptation actions to address this vulnerability include:

- Reinstate naturally functioning coasts floodplains and implement Catchment Flood Management Plans, avoiding 'hard engineering' solutions where a solution supporting more natural processes would be successful.
- Maintain environmental flows in rivers and streams.
- Influence flood defence schemes to facilitate natural coastal and river processes, in particular the function of river channels and flood plains to relieve peak flows in suitable areas of the catchment.
- Review 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 existing coastal geological SSSIs such as Sheppey Cliffs.
- Allow for realignment of shorelines and adequate space and sediment for shoreline adjustment through strategic coastal planning. The Isle of Grain to South Foreland and the Medway Estuary and Swale Shoreline Management Plans should be and implemented to support the development of naturally evolving coastlines.
- Allow natural geomorphological processes to function where possible, for example, for quarries, if there is a possibility of loss of a geodiversity interest feature, implement 'rescue' excavations to salvage as much scientific data as possible.

Changes to agricultural areas

4.135 A consequence of climate change may be the intensification of agriculture with new crops and changes in agricultural production such as the move from cereal crops to oil seeds. This may result in changes in field patterns, the potential removal of field margins and existing hedgerows and small woodlands or other habitats, as well as new crops which will bring new colours into the landscape. Soil erosion in some parts, as a result of increased drought and flooding events will also affect agricultural areas. Intensification of agriculture in floodplains could also occur. Changes to levels of grazing driven by indirect climate change impacts and socio-economic drivers could have impacts on the character of the North Kent Marshes as the grazing marsh is such a key characteristic of the NCA. 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.

4.136 Planting of new woodlands due to increased demand for shade for recreation and possibly woodfuel provision would also change the landscape character as the landscape is largely un-wooded. The need to supply greater amounts of renewable energy may also result in increasing demand for growth of biomass crops. This could contribute to the intensification of agriculture in some areas and increases in certain crops, such as Miscanthus (Defra's maps show predominantly high potential Miscanthus yields and medium potential SRC yields throughout the area), will have an impact on the landscape. An increase in the area under cultivation and an expansion of arable farming as a response to longer growing seasons, new viable crops, changes in orchard and horticultural crops and the potential demand for food security in a changing climate may also result, potentially changing the landscape.

4.137 There is little doubt that climate change impacts will directly affect the types of crops which can be grown within North Kent area. Warmer temperatures, with reduced rainfall may lead to initial loss of crops and livestock then an increasing move towards more drought tolerant arable crops and root crops, which may increase the need for water, leading to greater use of irrigation systems. Longer growing seasons could potentially lead to double cropping with consequent higher fertiliser requirements and increased risks of eutrophication during increased winter rainfall. Higher winter temperatures may lead to increased pest survival and an increased use of pesticides. Damage from extreme events such as drought, flooding and storms may also impact the provision of food.

4.138 Soils store carbon and climate change impacts from drought and flooding and potential changes in agricultural practices could increase soil disturbance and reduce carbon stores. Increases in woodland cover and management may contribute to carbon sequestration but impacts on other valuable habitats, themselves good carbon stores, must be avoided.

4.139 Drought and flooding could lead to increased erosion and consequent loss of soil profiles. Also, changes in soil microbial activity and changes in agriculture will have an impact on this function leading to a knock on effect on their ability to process water and nutrients for the plants we eat, and to decompose and recycle our waste. Drought and flooding may also affect the provision of essential agricultural needs, raw materials and substrate for the development of infrastructure.

4.140 Potential adaptation actions to address the vulnerability of agricultural areas in North Kent include:

- Identify and target the most beneficial Environmental Stewardship Scheme options. These actions could involve promoting the farmland bird package of options for both ELS and HLS schemes and promoting wet grassland options where appropriate and further enhancing the arable landscape, providing opportunities for breeding and wintering bird populations, notably brent geese, targeted habitat recreation and the many options that create a more permeable habitat.
- 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, including biodiversity, of North Kent. Suggested actions could 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, consider changing land use, for example from arable to grass. Implement measure to increase 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. 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.
- Adopt soil and habitat management practices to ensure continued and enhanced carbon storage.
- Advocate land use practices that provide win-win responses to climate change, for example, encouraging agricultural adaptation alongside management of the landscape for biodiversity.
- Identify opportunities to support renewable energy production including growth of bio-fuel crops on poor quality land where appropriate.

Changes to wetland habitats and flood protection

4.141 The vulnerability of wetlands and rivers to reductions in flow or drying out during drought, and consequent impacts on water quality, could have a significant effect on the shape and character of the landscape in the study area as well as on biodiversity and the services these habitats 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, with diffuse pollution becoming a greater issue and reduced flows leading to impaired dilution and flushing abilities and leading to a reduction in water quality. This 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 impact on biodiversity, ecosystem services and the character of the area.

4.142 Reduced summer rainfall and increased demand could reduce local aquifer recharge and deplete water supply, with potential impacts on wetland sites. An increased demand for water, for household, agricultural and recreational use, due to higher summer temperatures, and increased droughts will exacerbate the vulnerability of freshwater habitats to the impacts of climate change (Mitchell *et al.,* 2007).

4.143 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.

4.144 Increased storm events and increased rainfall in the winter is likely to increase the risk of flooding of properties and agricultural land. Taking up strategic opportunities for reconnecting rivers with their floodplains, and delivering Catchment Floodplain Management Plan (CFMP) targets will deliver flood storage, save significant sums of money on maintaining potentially unsustainable flood defences and offer new opportunities for both biodiversity and access.

4.145 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.

4.146 Potential adaptation actions to address the vulnerability of wetland habitats 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.
- Restore hydrological connectivity between open waters, fleets and wetlands. Identify areas within the river catchments in the area where there is opportunity to enhance habitat connectivity, for example, create additional grazing marsh and wetland areas, helping reduce run-off and pollution such in agricultural landscapes and land identified for flood storage. This is in part delivered through Catchment Sensitive Advice work, one of the levers being Environmental Stewardship.
- Carry out catchment scale management to increase the ability of river catchments to retain rainfall and reduce artificially enhanced surface run-off through, improving permeability of surfaces, increasing soil organic matter, reducing soil compaction, re-creating semi-natural habitats, and introducing Sustainable Drainage Systems (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 and flooding.
- Discourage floodplain developments and raise awareness of the implications of these.

Changes to coastal areas

4.147 Impacts on coastal areas of North Kent from sea level rise, inundation, erosion and periodic flooding and drought may affect coastal habitats and features. Coastal changes may enhance the contrast between the more natural coastal habitats and features and the agricultural land and urban areas through changes in the transition areas, for example, stark defences and loss of intertidal habitats. Coastal realignment due to sea level rise may also lead to changes in some low lying areas, for example, increased inundation and intertidal habitats.

4.148 The change to the flat coastal character of the NCA is likely to emerge gradually over time but could be quite dramatic. Climate change is unlikely to have significant impacts on the underlying geology of the NCA, hence the shape and topography of the landscape is likely to remain. However, sea level rise will lead to squeeze and ultimately loss of coastal habitats on the seaward side of defences and lead to the need for either greater protection or inundation of the landscape on the landward side of defences, changing the current mosaic habitats which will change the composition of local wildlife and also the appearance of the landscape. Potential losses of salt marsh, mud flats and maritime cliff habitats as a result of sea level rise and increased erosion could lead to significant change to the coastal character of the NCA. Current or future hard engineering ‘solutions’ at the coast may impede natural processes and this may affect the area’s ability to respond and adapt to climate change impacts naturally.

4.149 Habitats such as salt marsh, mudflats and grazing marsh provide a flood protection service. Sea level rise may reduce the area of such habitats, resulting in a loss of flood protection. However, policies which support natural coastal processes, such as managed realignment, could act to enhance the role of habitats in coastal flood protection.

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

- Review designated site boundaries in order to identify where changes are appropriate for the management of the geological interest features in the future due to the impact of coastal erosion. Specifically review existing coastal geological SSSIs such as Sheppey Cliffs.

- Ensure the Isle of Grain to South Foreland and the Medway Estuary and Swale Shoreline Management Plans support the development of naturally evolving coastlines and allow for realignment of shorelines and adequate space and sediment for shoreline adjustment through strategic coastal planning process, and where possible to allow creation of new habitats (salt marsh and mud flats).
- Reinstate naturally functioning coasts, and avoid ‘hard engineering’ solutions where a solution supporting more natural processes would be successful.

Biodiversity

4.151 While the biodiversity section above discussed in greater detail the likely changes to habitats from climate change, these changes will also have an overall impact on landscape character and ecosystem services. For example, many wetland habitats are very vulnerable to drought, with increased summer temperatures potentially leading to impacts on fluvial processes, or such areas drying up. Increased winter rainfall however, could potentially see an increase in multi-functional wetlands, including for recreation, as part of a more holistic approach to flood alleviation. The loss of coastal habitats from sea level rise and coastal squeeze will also have an impact on the area. Changes in land use and management will undoubtedly have an impact on the composition of habitats. 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 features more than climate change.

4.152 Potential adaptation actions to address the vulnerability of biodiversity assets to the impacts of climate change include:

- Ensure best practise management of existing resource reducing the existing pressures on biodiversity. 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 the key to this approach; requiring modification to existing management practices and monitoring of the results to ensure the response is effective, for example, altering some management dates to respond to seasonal changes or developing buffer zones next to areas of more intensive land use.
- Increase resilience of existing habitats, through increasing their size and buffering.
- Increase the mosaic of habitats in the region 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 will also provide increased variability of habitats and microclimates.
- Proactive development of large scale habitat recreation as part of enhancing the green infrastructure within the area, with a focus on wetland creation schemes and supporting the roll-back of coastal habitats including sand dunes and salt marsh, including:
  - Significantly restore, create and re-link fragmented areas of coastal grazing marsh to create a robust habitat network.
  - Further restore and create estuarine habitats that include mudflats, saltmarsh, sand dunes, shingle, shell and sand banks, and subtidal sand and mud, supporting their adaptability to sea-level rise and maintaining opportunities for natural regeneration. Explore possibilities for compensation habitat in other locations where these will be lost to coastal squeeze.
- 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 landscape scale habitat networks as part of enhancing the green infrastructure within the area should be implemented. Opportunities for increasing our

understanding and focusing effort exist through the Biodiversity Opportunity Areas (BOAs) (South East England Biodiversity Forum 2008).

- Reflect potential for changes in species composition in conservation objectives, condition assessment and guidance for habitat management, for example the switch from lowland wet grassland to saltmarsh as a result of managed realignment.
- Be alert to potential new pests and diseases and plan for their management. Also, continue to monitor native and non-native species to assess changes in numbers and distribution and undertake monitoring to identify new species appearing within the area. 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 attitudes towards alien and invasive species may have to change.
- Begin to reappraise the boundaries of protected sites, particularly SSSIs, to protect their functionality. Create buffer zones around sites and linkages between them.
- Learn and apply lessons from other extreme weather events such as flooding or heat waves and their impacts on particular habitats or species in helping to develop future contingency plans for key conservation sites. We can also look to other locations with similar climates to that which England may experience in future to identify potential threats.

Historic environment

4.153 The historic assets of North Kent may change greatly through impacts on the built environment, alongside impacts on historic landforms and land uses. For example, changes in land use practices and patterns as a result of climate change will affect the current historic landscape character as new crops and practices out-compete more traditional ones. The significant maritime history and the character this provides in North Kent will be impacted by the effects of sea level rise. Loss or changes to historic environment assets could alter how people perceive and enjoy the area.

4.154 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 archaeology should be recorded. It is particularly important to record assets where losses are unavoidable.
- Provide advice to landowners on the appropriate management of scheduled sites (archaeological & historic parks and gardens). Identify and target the most beneficial Environmental Stewardship Scheme options for historic assets.
- Manage recreational pressure to take pressure off sites at risk from erosion.

Recreation

4.155 Warmer temperatures and reduced rainfall in summer may make the area increasingly attractive to local residents for recreation. This could benefit people's quality of life but it 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. Protecting and enhancing the recreational opportunities 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 area. 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 function 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. The impact of sea level rise on coastal recreational opportunities and activities could be significant. These changes in the physical landscape and on its natural and historical assets may impact on the way local people feel about and identify with their surroundings.

4.156 Despite potential impacts on recreation facilities, the study area is likely to continue to provide people with opportunities to enjoy the natural environment. Potential adaptation actions to address the vulnerability of recreation assets to the impacts of climate change and maximise opportunities for enjoyment include:

- Pursue large scale habitat recreation as part of enhancing the green infrastructure of the area. The Medway and Swale Green Grid Partnerships and their projects will be instrumental in this.
- 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 (ensuring use of appropriate species to avoid negative impacts on local biodiversity), encourage an increase in urban trees to provide summer shade and maintain and enhance habitat and 'green space' which provides a cooling function for the area.
- 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 drought periods.
- A combination of extreme weather events, sea level rise and heavy rainfall will increase the need for 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 any green infrastructure strategy and should utilise an adaptive management approach.
- Ensure access to research and education resources continue to be provided for the natural and historic environment in the face of potential losses.
- Help people to understand the potential landscape change in North Kent and encourage them to participate in decisions that will affect how the area could look and feel like in future.

Strategic adaptation actions

4.157 A number of strategic actions have been identified that would support the more specific actions above and provide an overarching framework for delivering adaptation in North Kent.

- **Cross boundary and cross sector linkages** outside the area covered by this study – across NCAs and across Local Authority boundaries - need to be planned, and opportunities taken to enhance climate change adaptation responses. There needs to be a focus on large scale adaptation to ensure adaptation actions do not create islands in the wider landscape.
- **Build climate change into the spatial planning agenda:** There are 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, green Infrastructure partnerships in Medway and Swale and projects that provide green infrastructure such as Milton Creek.
- **Development of multi-functional wetlands through re-connecting rivers with their floodplains:** There are opportunities to develop the network of ponds and wetlands etc, to provide water storage, restoration of flood plain function, as well as 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 etc needs to be taken forward now in joint approaches with partners, for example, the Environment Agency.

- **Coastal habitats and flood and erosion alleviation:** Sea level rise will impact on existing areas of mudflats and salt marsh. Policies should be adopted which support natural coastal processes and ensure the roll-back of these areas, so these habitats and functions will be maintained.
- **Planning and delivering landscape-scale restoration:** Restoring the landscape to ensure that a functioning ecological network of semi-natural habitat exists, delivering clean water and flood storage etc, 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 avoid conflicts between objectives. Following on from this, projects, both large and small, restoring and reconnecting the landscape need to be developed and taken forward. This assessment must also feed in to the national NCA review for the relevant NCAs (being carried out by Natural England).
- **Understanding and responding to land use change:** Farming in North Kent 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 put in place appropriate 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 help inform this. In addition, other mechanisms which provide support for specific types of desirable land management, such as grazing, also need to be developed.
- Promote **Environmental Stewardship scheme options** that enhance and retain landscape character. Work with landowners and land managers to maintain landscape features 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 resilience of existing habitats**, through increasing their size and buffering. 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).
- Use the results of the **national biodiversity climate change vulnerability assessment** 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 the area of existing habitat through targeted re-creation and restoration effort around existing patches. Adopt a landscape scale approach to extend habitats 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.
  - Maintain and increase ecological network connectivity.
- **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. 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 attitudes towards alien and invasive species may have to change.
- When developing contingency plans for key conservation sites, **learn and apply lessons from other extreme weather events** such as floods or heat waves and their impact on

particular habitats or species, 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.

- **Increase water retention capacity** within the catchment to support and enhance existing wetlands and where possible restore hydrological connectivity between open waters and wetlands.
- There is a need to increase **public awareness and understanding** of the potential impacts of climate change. For example, decision-makers and landowners in the area have a key role to play in developing appropriate policies and taking action. They will need a greater understanding of the changes we are likely to face and will need to accept that change is inevitable 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 North Kent 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.

4.158 The above responses provide an overall integrated strategic approach for increasing the resilience of the natural environment in North Kent to climate change. It is intended that these responses will influence the policy and work of key partners within the area. Demonstration projects to look at how responses to climate change might work on the ground should be undertaken at a smaller spatial resolution than NCA level.

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 North Kent. Some of the most vulnerable elements of landscape character and ecosystem services identified in this study are as follows:

- Coastal and fluvial geomorphological processes which help to shape the study area may be altered by increases in both erosion and sedimentation.
- Habitats in North Kent are likely to be vulnerable to climate change, for example, changes in habitat extents and species composition. Coastal and wetland habitats such as coastal and floodplain grazing marsh, salt marshes, mudflats, rivers, ponds and maritime cliffs, are particularly vulnerable.
- The national biodiversity climate change vulnerability assessment (Taylor and Knight 2011) overall results suggest the following are particularly vulnerable in North Kent:
  - Rivers – River Medway.
  - Wetlands – Particularly grazing marsh.
  - Coastal habitats – Salt marsh and mudflats.
- Historic wetlands are likely to be impacted by seasonal changes in precipitation. The extensive coastal historic buildings and historic landscapes will be vulnerable to sea level rise, increased rainfall penetration and erosion.
- Key access and recreation assets vulnerabilities include greater flooding and erosion of footpaths due to drought in summer, flooding in winter, sea level rise 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. Recreation assets at coastal and river locations are likely to be most vulnerable.
- It is likely that the landscape of North Kent will change due both to the direct impacts of climate change and the society's responses to change. 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.

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 there are many 'no 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 North Kent. For example, some of the proposed actions to address biodiversity adaptation to climate change will also provide benefits to access and recreation provision, the landscape character and the ecosystem services provided and soil conservation necessary to support agriculture. Some of the major suggestions 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 practise 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 practice 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 often 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.

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 study area. 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.

5.11 For instance, measures which promote naturally functioning systems, such as rivers and coasts, will 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 North Kent. It is intended that these responses will influence the 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 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.

5.14 For example, 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 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 It is inevitable that there will be conflicts when deciding on adaptation action, 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

5.16 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 potential reversibility of options, ie 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.

Accepting change

5.17 Related to the above section on difficult choices, we need to be ready to accept change in the landscape. The assets that currently comprise North Kent landscape character and ecosystem services have changed greatly over many years and they will continue to change, this time with anthropogenic climate change as an added factor. We are 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. Climate change, and our responses to it, has the potential to change the landscape and its assets dramatically and over a relatively short timeframe. These changes could be related to the species that make up the habitats associated with North Kent or the crops, livestock and processes that farmers use. This report has suggested a wide range of adaptation responses to conserve and enhance landscape character and ecosystem services but in order for North Kent 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 North Kent area are aware of this and can help provide and support adaptation measures.

Scale

5.18 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 North Kent and potential adaptation options. However, given the scope of the study and the size of the study area, 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.

5.19 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.

5.20 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 North Kent 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.

5.21 Adaptation actions can be implemented at a range of scales. Figure 13 provides a representation of where some of the adaptation options fit on the scale from large scale to small scale.

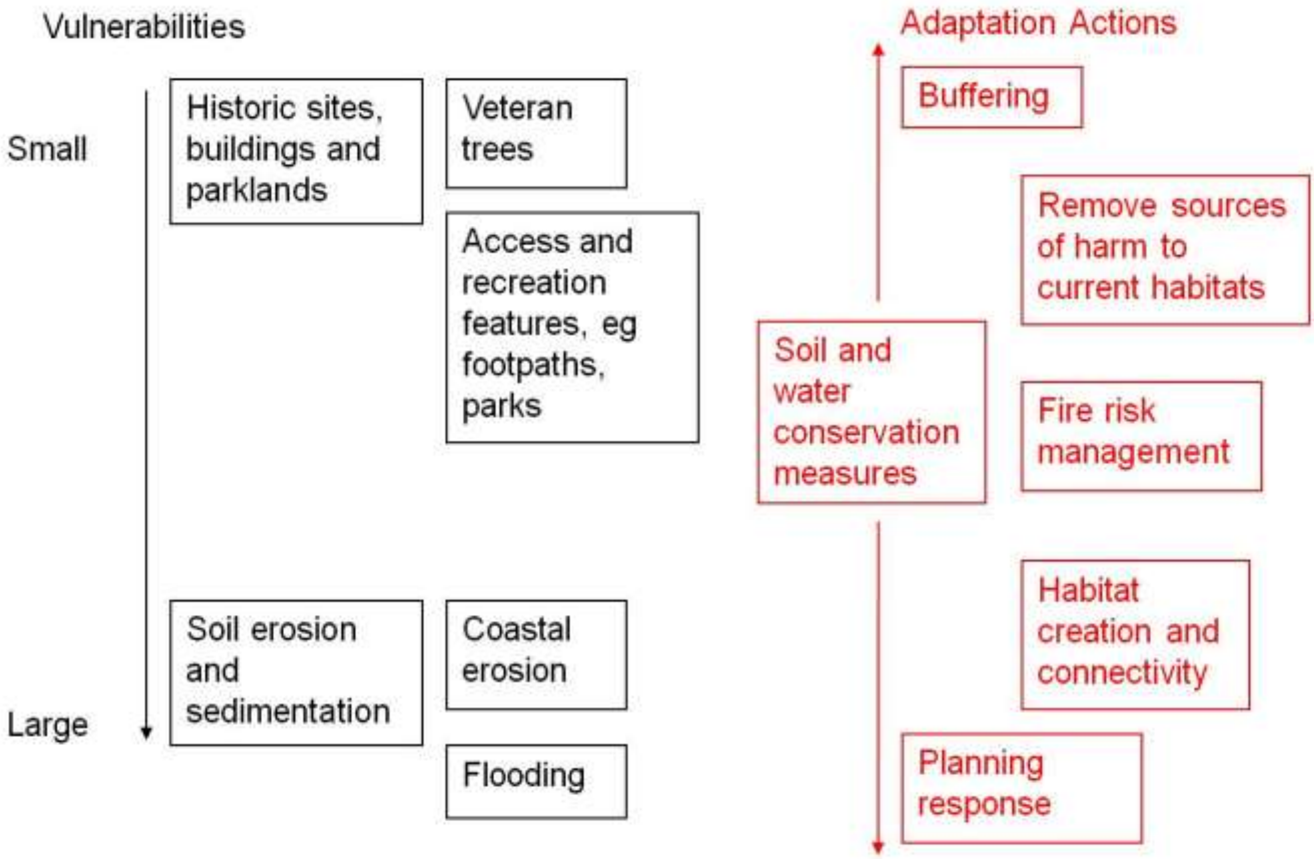


Figure 13 Range of scales for adaptation options

5.22 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.

5.23 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 and weaknesses

5.24 While this study serves as a useful starting point to pursuing adaptive responses to climate change in North Kent, 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 study area 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 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 climatic impacts on river systems. While many actions, such as buffering watercourses and re-naturalising catchments can occur within the study area, there is still often a need to deliver at a catchment scale to get the best results. 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 stakeholder engagement was limited to electronic consultation with internal specialists and key external partners. There has been no time for detailed research and only very limited time available for the project as a whole. A potential subsequent stage would be a more comprehensive consultation on the reports 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 another geographic unit). Other work in the area, for example the larger scale Biodiversity Climate Change Vulnerability Assessment (Taylor and Knight 2011), complement this study. The findings of 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.

5.25 Aside from these limitations, the findings presented should provide a useful starting point to focus work to adapt to climate change in North Kent. It also serves 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 to the study area.

Other pressures and constraints in addition to climate change

5.26 Climate change is likely to have a significant influence on the natural environment of North Kent. However, there are many other pressures and constraints that are having an impact now, and will continue to do in the future, such as development, agricultural changes, habitat destruction and pollution. Climate change will exacerbate these existing pressures and exert additional ones. Any management in North Kent must continue mitigation of all current pressures alongside adaptation to climate change.

Possible implementation of adaptation actions

5.27 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 North Kent.

5.28 When identifying adaptation actions, existing strategies, policies, tools and initiatives need to be considered. Some actions defined as climate change adaptation may already be occurring, potentially 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, the Kent Wildlife Trust, and the Green Grid Partnerships 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 Natural England's biodiversity climate change vulnerability assessment (Taylor & Knight 2011) should be used to further target appropriate win-win adaptation action in the North Kent area with partners.

5.29 In this study, we decided at the outset not to simply focus on a single NCA, but to look at two part NCAs that fall within 2 Local Authorities boundaries, as a pilot study in the area. 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 by this report will be relevant and cross boundary working must be pursued.

5.30 Economic and social solutions will need to proceed in tandem with those for 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.

5.31 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 constant review of plans will be required to ensure that management of assets and the landscape as a whole is truly adaptive.

5.32 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, 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.

5.33 The future of North Kent 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 high quality landscape assets that are a key part of the region’s natural and cultural heritage and identity.

6 References

BOWLER, D. E., BUYUNG-ALI, L., KNIGHT, T. M., PULLIN, A. S. 2010. Urban greening to cool towns and cities: A systematic review of the empirical evidence, *Landscape Urban Plan*. (2010), doi:10.1016/j.landurbplan.2010.05.006.

COUNTRYSIDE AGENCY. 1999. Countryside Character Volume 7: South East & London, The character of England's natural and man-made landscape, Greater Thames Estuary and North Kent Plain.

CLARKE, S.J. 2009. Adapting to climate change: implications for freshwater biodiversity and management in the UK. *Freshwater Reviews*, 2, 51-64.

CONLAN, K., WADE, T., ORMEROD, S., LANE, S., DURANCE, I. and YU, D. 2007. Preparing for climate change impacts on freshwater ecosystems (PRINCE). *Science Report:* SC030300/SR. Environment Agency, Bristol.

COUNTRYSIDE QUALITY COUNTS. Draft Historic Profiles. Greater Thames Estuary and North Kent Plain.

DOWNING, T.E. and PATWARDHAN, A. 2005. Assessing Vulnerability for Climate Adaptation. In: LIM, B. and SPANGER-SIEGFRIED, E. (eds.) *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures.* Cambridge University Press, Cambridge, p67-89.

ENGLISH HERITAGE. 2008. Climate Change and the Historic Environment.

ENGLISH NATURE. 1997a. Greater Thames Estuary Coastal Natural Area Profile, Essex, Hertfordshire and London Team.

ENGLISH NATURE. 1997b. North Kent Plain Natural Area Profile, Kent Team.

ENVIRONMENT AGENCY. 2004. The North Kent and Swale Catchment Abstraction Management Strategy, Final Strategy.

ENVIRONMENT AGENCY. 2008. Greater Thames CHaMP Summary Document, Thames Estuary 2100.

FEARNLEY, H. & LILEY, D. 2011. North Kent Visitor Survey Results. Footprint Ecology.

FOREST RESEARCH. 2010. Benefits of green infrastructure. Report to Defra and CLG. Forest Research, Farnham.

HANDMER, J.W. and DOVERS, S.R. 1996. A typology of resilience: Rethinking institutions for sustainable development, *Organization and Environment*, 9, 4, 482-511. (Reproduced in Schipper, E.L.F. and Burton, I. (eds.) *The Earthscan Reader on Adaptation to Climate Change*. Earthscan, London, p187-210).

HEARN, K. A. & GILBERT, M. G. 1977. The effects of the 1976 drought on sites of nature conservation interest in England and Wales, Nature Conservancy Council.

HELLER, N. E. and ZAVALETA, E. S. 2009. Biodiversity management in the face of climate change: A review of 22 years of recommendations. *Biological Conservation* 142, 14-32.

HM GOVERNMENT. 2011. The Natural Choice: securing the value of nature.

HOLLING, C. S. (ed.). 1978. Adaptive Environmental Assessment and Management. Chichester: Wiley. ISBN 0-471-99632-7.

HOPKINS, J.J., ALLISON, H.M., WALMSLEY, C.A., GAYWOOD, M. and THURGATE, G. 2007. Conserving biodiversity in a changing climate: guidance on building capacity to adapt. Defra, London.

IACCF. 2010. Biodiversity and Climate Change in the UK. (Eds. PROCTER, D.A., BAXTER, J.M., CRICK, H.P.Q., MORTIMER, D., MULHOLLAND, F., WALMSLEY, C.A.). JNCC, Peterborough. pp.16.

IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. PARRY, O.F. CANZIANI, J.P. PALUTIKOF, P.J. VAN DER LINDEN and C.E. HANSON, Eds., Cambridge University Press, Cambridge, UK, 976pp.

JACOBS BABTIE - The Landscape Assessment of Kent. 2004.

JENKINS, G., MURPHY, J., SEXTON, D., LOWE, J., JONES, P., KILSBY, C. 2009. UK Climate Projections: Briefing Report. Met Office Hadley Centre, Exeter.

JONES, R. and MEARNS, L. 2005. Assessing Future Climate Risks. In: LIM, B. and SPANGER-SIEGFRIED, E. (eds.) Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Cambridge University Press, Cambridge, p119-143.

KELLY, P.M. and ADGER, W.N. 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation, *Climatic Change*, 47, 4, 325-352. (Reproduced in SCHIPPER, E.L.F. and BURTON, I. (eds.) *The Earthscan Reader on Adaptation to Climate Change*. Earthscan, London, p161-186).

KENT BAP WEBSITE. URL: **www.kentbap.org.uk/habitats-and-species/priority-habitat/saline-lagoons/** [Accessed July 2013].

KENT RIGS GROUP. URL: **www.kentrigs.org.uk/** [Accessed July 2013].

LAWTON, J.H., BROTHERTON, P.N.M., BROWN, V.K., ELPHICK, C., FITTER, A.H., FORSHAW, J., HADDOW, R.W., HILBORNE, S., LEAFE, R.N., MACE, G.M., SOUTHGATE, M.P., SUTHERLAND, W.A., TEW, T.E., VARLEY, J., & WYNNE, G.R. 2010. Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra.

LONDON ARRAY WEBSITE. URL: **www.londonarray.com/the-project/** [Accessed July 2013].

MACGREGOR N.A. & COWAN C.E. 2011. Government action to promote sustainable adaptation by the agriculture and land management sector in England. In FORD J.D. & BERRANG FORD L. (eds) *Climate change adaptation in developed nations: from theory to practice*. Springer.

MEDWAY UNITARY AUTHORITY WEBSITE. URL: **www.medway.gov.uk/environmentandplanning/countrysidesites/riversidecountrypark.aspx** [Accessed July 2013].

MILLENNIUM ECOSYSTEM ASSESSMENT. 2005. Ecosystems and Human Well-Being. A Framework For Assessment. Island Press.

MITCHELL, R.J.; MORECROFT, M.D.; ACREMAN, M.; CRICK, H.Q.P.; FROST, M.; HARLEY, M.; MACLEAN, I.M.D.; MOUNTFORD, O.; PIPER, J.; PONTIER, H.; REHFISCH, M.M.; ROSS, L.C.; SMITHERS, R.J.; STOTT, A.; WALMSLEY, C.A.; WATTS, O.; WILSON, E. 2007. England biodiversity strategy – towards adaptation to climate change. Final report to Defra for contract CRO327l.

MORECROFT, M.D. and COWAN, C.E. 2010. Responding to climate change: an essential component of sustainable development in the 21st century. *Local Economy* 25,1–6.

MURPHY, J. M., SEXTON, D. M. H., JENKINS, G. J., BOOTH, B. B. B., BROWN, C. C., CLARK, R. T., COLLINS, M., HARRIS, G. R., KENDON, E. J., BETTS, R. A., BROWN, S. J., HUMPHREY, K. A., MCCARTHY, M. P., MCDONALD, R. E., STEPHENS, A., WALLACE, C., WARREN, R., WILBY, R., WOOD, R. A. 2009. UK Climate Projections Science Report: Climate change projections. Met Office Hadley Centre, Exeter.

NATIONAL SOIL RESOURCES INSTITUTE. 2005. Impacts of climate change on soil function. Unpublished report for Defra (project code SP0538). URL: **http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=12894&FromSearch=Y&Publisher=1&SearchText=SP0538&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description** [Accessed July 2013].

NATURAL ENGLAND. 2009a. Responding to the impacts of climate change on the natural environment: The Broads. NE114R, Natural England, Peterborough.

NATURAL ENGLAND. 2009b. Responding to the impacts of climate change on the natural environment: The Cumbria High Fells. NE115R, Natural England, Peterborough.

NATURAL ENGLAND. 2009c. Responding to the impacts of climate change on the natural environment: Dorset Downs and Cranborne Chase NE116R, Natural England, Peterborough.

NATURAL ENGLAND. 2009d. Responding to the impacts of climate change on the natural environment: Shropshire HillsNE117R, Natural England, Peterborough.

NOSS, R. F. 1983. A regional landscape approach to maintain diversity. *BioScience*, 33, 700-706.

OPDAM, P. and WASCHER, D. 2004. Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation* 117, 285–297.

PARRY, M. and CARTER, T. 1998. Climate Impact and Adaptation Assessment: A Guide to the IPCC Approach. Earthscan, London.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY. 2007. Ecosystem services. Postnote 281. London.

PROSSER, C. P., BUREK, C. V., EVANS, D. H., GORDON, J. E., KIRKBRIDE, V. B., RENNIE, A. F. and WALMSLEY, C. A. 2010. Conserving geodiversity sites in a changing climate: management challenges and responses. *Geoheritage*, 2, 123-136. DOI 10.1007/s12371-010-0016-7.

ROSENZWEIG, C. *et al*. 2007. Assessment of observed changes and responses in natural and managed systems in PARRY, M.L. *et al*. 2007 Climate Change 2007: *Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, U.K., and New York, N.Y., U.S.A. pp. 79–131.

SOUTH EAST HISTORIC ENVIRONMENT FORUM. 2008. Our Heritage and the Changing Climate – South East, English Heritage.

SMITHERS, R.J., COWAN, C., HARLEY, M., HOPKINS, J.J., PONTIER, H. and WATTS, O. 2008. England Biodiversity Strategy Climate Change Adaptation Principles: conserving biodiversity in a changing climate, Defra, London.

SOUTH EAST ENGLAND BIODIVERSITY FORUM. 2008. Biodiversity Opportunity Areas Map Website – URL: **http://strategy.sebiodiversity.org.uk/map.php** [Accessed July 2013].

SOUTH EAST HISTORIC ENVIRONMENT FORUM. 2008. Our Heritage and the Changing Climate – South East, English Heritage.

TAYLOR, S. D. and KNIGHT, M. 2011. Biodiversity climate change vulnerability assessment in the South East. Unpublished.

UK CLIMATE IMPACTS PROGRAMME. 2010. URL: **http://ukclimateprojections.defra.gov.uk/** [Accessed July 2013].

UK CLIMATE IMPACTS PROGRAMME. (n.d). Identifying adaptation options. URL: **www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf** [Accessed July 2013].

WALTERS, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. *Conservation Ecology* [online]1(2):1. URL: **www.consecol.org/vol1/iss2/art1/** [Accessed July 2013].

WILLIAMS, S.E., SHOO, L.P., ISAAC, J.L., HOFFMAN, A.A., and LANGHAM, G. Towards an integrated framework for assessing the vulnerability of species to climate change. *PLoS Biology*, vol 6, issue 12 p2621 – 2626.

WILLOWS, R. and CONNELL, R. 2003. Climate adaptation; risk, uncertainty and decision making. UKCIP Technical Report. UKCIP, Oxford.

Appendix 1 Vulnerability tables of key landscape assets

Table A Results of vulnerability assessment for geodiversity

Asset	Potential exposure	Sensitivity	Management capacity	Relative vulnerability
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 and coastal squeeze.	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.	**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.	Environmental: asset would be able to change and adapt naturally if permitted and space was available. Management: pressure from flood defences leading to impairment of natural processes. Use of hard engineered structures can reduce adaptive capacity.	**Moderately 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.	Environmental: asset would be able to change and adapt naturally if permitted and space was available. Management: pressure from engineering leading to impairment of natural processes reduces adaptive capacity.	**Moderately vulnerable**

Table B Results of vulnerability assessment for soils

ID	Soilscape typology	Potential exposure	Sensitivity and adaptive capacity	Relative vulnerability
1	Salt marsh soils	Sea level rise	Loss of land due to flooding by sea water. Consider whether mitigation is likely or desirable.	**More vulnerable**
6	Freely draining slightly acid loamy soils	Drier summers and increased winter rainfall	Increasingly drought-prone, increased risk of soil erosion on moderately or steeply sloping land where cultivated or bare soil is exposed. Adopting soil moisture conservation measures and land management changes will reduce impacts of erosion.	**Moderately vulnerable**
7	Freely draining slightly acid but base-rich soils	Drier summers	Increasingly drought-prone. Adopting soil moisture conservation will reduce impacts.	**Moderately vulnerable**
8	Slightly acid loamy and clayey soils with impeded drainage	Increased winter rainfall and increased storms	Become unstable and prone to erosion, fewer work days for arable cultivation and increased risk of soil compaction, increased run-off risk on sloping ground. Risks from waterlogging and erosion from water. Changes in land management practices to reduce erosion and compaction will reduce impacts; land use change may be required.	**Moderately/more vulnerable**
17	Slowly permeable seasonally wet acid loamy and clayey soils	Increased winter rainfall, increased rainfall intensity	Diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding. Land management techniques can minimise reduce impacts.	**Moderately vulnerable**
18	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	Increased winter rainfall, increased rainfall intensity	Diffuse pollution (for example, from applied manures, very fine sediment) or increased local flooding. Land management techniques can minimise reduce impacts.	**Moderately vulnerable**
20	Loamy and clayey floodplain soils with naturally high groundwater	Increased winter rainfall and increased storms	Winter flood risk increased, possible increased deposition of sediment, fewer work days for arable cultivation, increased risk of soil compaction, increased run-off risk on sloping ground, may be unstable and prone to erosion. Valuable carbon stores. Employ land management practices which minimise/reduce negative impacts, change of land use may be required, retain soil *in situ*.	**Moderately vulnerable**
21	Loamy and clayey soils of coastal flats with naturally high groundwater	Sea level rise	Loss of asset, increase in saline conditions due to sea level rise. Mitigation through management may not be possible, further consideration would be required.	**More vulnerable**
22	Loamy soils with naturally high groundwater	Increased winter rainfall and increased storms	Diffuse pollution or increased local flooding although drainage can be used where feasible, soil management measures required.	**Moderately vulnerable**

Table C Results of vulnerability assessment for habitats

BAP habitat	Potential exposure	Sensitivity and adaptive capacity	Relative vulnerability
Lowland mixed deciduous woodland	Hotter drier summers, higher winter temperatures, increased storms	Decline in woodland cover, shifts in the composition of vegetation types and species, competition from invasive species, shifts in regeneration patterns. Most adaptive woodland type due to variety and size of resource. Increase existing habitat and connectivity, adapt management and reduce other threats to allow overall habitat to adapt, may need to accept different mix of species.	**Less vulnerable**
Hedgerows	Decreased rainfall and changes in average temperatures	Sensitive to drought and indirectly to intensification of farming leading to their removal. Land use change is greatest threat, management/retention can allow adaptation.	**Less vulnerable**
Traditional Orchards	Increased average temperatures and warmer wetter winters	Increased average temperatures will supress fruit set while drier summers will constrain fruit growth. Wetter winters will create adverse water-logged conditions unsuitable for fruit tree varieties.	**Moderately/more vulnerable**
Maritime cliff and slope	Exposed to rising sea level and increased wave energy	Vulnerable to coastal squeeze and increased erosion but in this case has room to move in the short term, longer term impacts unsure.	**More vulnerable**
Saline Lagoons	Prolonged drought	Sea level rise impacts not relevant at Cliff as the lagoons are enclosed behind artificial sea defences, however, recharge of water will be necessary and prolonged drought could lead to drying out.	**Moderately vulnerable**
Running water (rivers and chalk streams)	Rising summer temperatures and reduced rainfall	Sensitive to drought and thermal stress. Increased water demand in extreme dry periods exacerbating ecological problems of low river flows. Increased pressure for flood defences may lead to less dynamic river systems and impact on proteced species.	**More vulnerable**
Ponds <1ha and ditch systems	Rising summer temperatures and reduced rainfall	Sensitive to increase temperatures and changes in rainfall. Dependent on ability to increase water rention or restoration of hydrological connectivity between open waters and wetlands.	**More vulnerable**
Coastal and floodplain grazing marsh	Potenitally exposed to rising sea level, reduced rainfall levels and extreme events	Senstive to flooding and inundation by the sea and periods of drought. This habitat has an important role in flood management and opportunities for habitat creation could compensate for habitat losses, dependant on water resources and ability to function naturally.	**More vulnerable**

Table continued...

BAP habitat	Potential exposure	Sensitivity and adaptive capacity	Relative vulnerability
Salt Marsh and Mudflats	Sea level rise, Tidal flooding, Erosion, Higher storm surge heights	Habitat sensitive to erosion of seaward edge and inundation. Also sensitive to increased wave energy. Loss of habitat for key bird species. Environmental: Salt marsh is likely to experience coastal squeeze when it is trapped between rising sea levels and fixed defences resulting in significant habitat loss. Management: area for salt marsh and mudflat to 'roll-back' is restricted by coastal squeeze realignment will be neccessary to maintain extent.	**More vulnerable**
Reedbed	Higher intensity rainfall combined with summer soil water deficit	Possible loss of bittern habitat due to flooding. Reduction in water quality due to summer drying and concentration of pollutants.	**Moderately vulnerable**
Cereal field margins and stubble	Hotter, drier summers, warmer, wetter winters	Changes in species composition, potential re-intensification of agriculture, increased use of pesticides and changes in seasonal farm practices. Land use change is greatest threat, can potentially be managed.	**Less vulnerable**

Table D Results of vulnerability assessment for historic environments

Asset	Potential exposure	Sensitivity	Adaptive capacity	Relative vulnerability
Below ground and Upstanding historic assets, for example, Cooling Castle, St James Church Cooling	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. Adapting management of historic buildings may be required, for example, flood protection.	**Moderately more vulnerable**
Historic routeways, for example, the Saxon shoreway	Drier summers Wetter winters	Sensitive to sea level rise, 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.	**Less vulnerable**
Large scale archaeological assets, for example, Forts, military defences such as Darnet Fort	Hotter summers Drier summers Wetter winters Sea level rise	Sensitive to sea level rise, 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.	Adaptive capacity largely depends on location and presence of coastal defences. Where protected management may need to be adapted.	**Moderately more vulnerable**
Relict boundaries – ditches, reedbeds relict saltmarsh boundaries	Hotter summers	Sensitive to vegetation growth. Intensification of agriculture may be more significant than direct impacts of climate change.	Changes in agricultural land practices will affect adaptive capacity.	**Moderately more vulnerable**
Historic Wetlands, for example, Elmley	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**

Table continued...

Asset	Potential exposure	Sensitivity	Adaptive capacity	Relative vulnerability
Non domestic buildings (farm buildings, for example, oast houses)	Hotter summers Drier summers Wetter winters Intense rainfall	Sensitive to damage from drying out, moisture related damage, flooding, structural pest infestations and vegetation growth.	Building management may need to be adapted.	**Less vulnerable**
Designed landscape, for example, Mount Ephraim	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.	**Less vulnerable**

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

Asset	Potential exposure	Sensitivity and adaptive capacity	Vulnerability
Informal greenspace	Increased summer temperature, decreased summer rainfall, increase in winter rainfall and frequency and intensity of storms.	Drying out of plants in drought, increased visitors, change in use patterns, for example, greater evening use, and activities, greater requirement for water and shade, flooding. Potential replanting and changes in management.	**Moderately vulnerable**
Linear routes	Drier summers, increased winter rainfall and heavy rainfall events and sea level rise.	Sensitive to erosion casued by soil dessication and loss from flooding and sea level rise. Paths on slopes or with poor drainage likely to be most sensitive. Repair, changes in management and diversions may be required, exposed routes on sloping land most vulnerable to erosion and routes at bottom of slopes vulnerable to flooding.	**More vulnerable**
Rivers	Reduced summer rainfall, increased summer temperature, increased winter rainfall and frequency and intensity of storms.	Reduction in water quality, potential health impacts, reduction in water levels, increased demand for water based recreation, flooding impacts. Management of resource, dispersal of visitors, promotion of responsible recreation, health and hazard warnings. Conflicts between natural processes and hard engineering.	**More vulnerable**
Woodlands	Increased summer temperature, decrease in summer rainfall, increase in winter rainfall and frequency and intensity of storms.	Fire risk, increase in ticks, changes in demand for woodland recreation, increased hazard from falling branches. Management and maintenance of resource, planting drought resistant trees, promotion of responsible recreation, fire prevention strategies, health and hazard warnings.	**Moderately vulnerable**
Coastline	Increased summer temperature, decrease in summer rainfall, increase in winter rainfall and frequency, sea level rise and intensity of storms.	Changes in demand for outdoor recreation, congestion in popular sites, damage to coastal access and recreation assets, loss of assets from sea level rise. Management and maintenance of resource, disperse people away from sensitive areas and promote responsible recreation. Ability to allow natural coastal processes impaired in some areas.	**More vulnerable**
Country Parks, NNRs, LNRs and other nature reserves	Increased summer temperature, decrease in summer rainfall, increase in winter rainfall and frequency, sea level rise and intensity of storms.	Changes in demand for outdoor recreation, potential for congestion, health impacts, drying out of vegetated areas, flooding. Potential replanting, changes in management, provision of shade, health and hazard warnings, promote responsible recreation, water efficiency.	**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

Impacts on coastal areas of North Kent from sea level rise, inundation, erosion and periodic flooding and drought may impact the variety and contrast between coastal habitats and features by reducing their variety. Coastal changes may also enhance the contrast between the more natural coastal habitats and features and the agricultural land and urban areas through changes in the transition areas, for example, stark defences and loss of intertidal habitats. Coastal realignment due to sea level rise may also lead to changes in some low lying areas, for example, increased inundation and intertidal habitats.

Other impacts to the variety and contrast of landscape character within North Kent are the indirect changes to agriculture and land use patterns that climate change will bring and the changes in seasonal colour and variation, for example, increased browning due to drought. Planting of new woodlands due to increased demand for shade for recreation and possibly woodfuel provision would also change the landscape character as the landscape is largely un-wooded. The need to supply greater amounts of renewable energy may also result in increasing demand for growth of biomass crops. 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.

An increase in the area under cultivation and an expansion of arable farming as a response to longer growing seasons, new viable crops, changes in orchard and horticultural crops and the potential demand for food security in a changing climate may also result, potentially changing the appearance of the landscape.

Distinctive form

The elements of landscape character that make up the distinctive form of North Kent, the open, low and undulating landscape, the extensive open spaces and the pervasive presence of water, will be impacted by climate change for the most part through the impacts on geomorphological processes and from sea level rise.

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

The change to the flat coastal character of the NCA is likely to emerge gradually over time but could be quite dramatic. Climate change is unlikely to have significant impacts on the underlying geology of the NCA, hence the shape and topography of the landscape is likely to remain. However, sea level rise will lead to squeeze and ultimately loss of coastal habitats on the seaward side of defences and lead to the need for either greater protection or inundation of the landscape on the landward side of defences, changing the current mosaic habitats which will change the composition of local wildlife and also the visual appearance of the landscape. Potential losses of salt marsh, mud flats and maritime cliffs as a result of sea level rise and increased erosion could lead to significant change to the coastal character of the NCA. Current or future hard engineering 'solutions' at the coast may impede natural processes and this may affect the area's ability to respond and adapt to climate change impacts naturally.

History

Many historic sites in North Kent have no doubt 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 change. The historic assets of North Kent 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. The significant maritime history and the character this provides in North Kent will be impacted by the effects of sea level rise.

Biodiversity

While the biodiversity section discusses in greater detail the likely changes in habitat and species composition from climate change, these changes will also have an overall impact on landscape character. For example, drought can significantly increase the stress on trees, making them particularly vulnerable to pests and diseases and significant losses of individual trees within woodland can have a radical impact on the overall tree canopy. In more subtle way, the changes in phenology will have a visual and character impact, for example, 'greening' earlier in the year. Many wetland habitats are very vulnerable to drought, with increased summer temperatures potentially leading to impacts on fluvial processes, or such areas drying up. Increased winter rainfall however, could potentially see the increase in multi-functional wetlands, including for recreation, as part of a more holistic approach to flood alleviation. The loss of coastal habitats from sea level rise and coastal squeeze will also have an impact on the landscape character of the area. Changes to habitats and the processes they carry out could have great impacts 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 features more than climate change.

Agriculture

As mentioned above, an indirect consequence of climate change is likely to be the intensification of agriculture with new crops and changes in agricultural production such as the move from cereal crops to oil seeds. This is likely to result in changes in field patterns, the potential removal of field margins and existing hedgerows and small woodlands or other habitats, as well as new crops which will being new colours into the landscape. Soil erosion in some parts, as a result of increased drought and flooding events will also impact agricultural areas. Intensification of agriculture in floodplains could also occur. Changes to levels of grazing driven by indirect climate change impacts and socio-economic drivers could have impacts on the character of the North Kent Marshes as the grazing marsh is such a key characteristic of the NCA. 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

Impacts on the built environment from climate change both direct and indirect are likely to be significant but potentially more manageable than some impacts. Traditional and historic 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 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, exposure to extreme weather and sea level rise impacts. 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 settlement.

Views

Impacts on coastal areas of North Kent form sea level rise, inundation, erosion and periodic flooding and drought and changing composition of habitats and land use patterns may impact the appearance of the landscape.

Indirect impacts such as wind energy development could also lead to changes in the expansive views the area provides through their impact on the open skylines. The changes in land use and management mentioned above will also have an impact on the views currently enjoyed in this area. Longer growing seasons, changes in crops, changes in land use patterns, for example, greater woodland area as a result of woodfuel demand, and changes in management may impact the typically wide open spaces and the long views.

Implications for ecosystem services

The environment can offer mechanisms to help adapt to climate change impacts, but these functions themselves can be compromised both directly and indirectly by climate change. Some of the implications for the NCA's key landscape functions are discussed below:

Provisioning services - such as food, fibre, fuel and water

Food

There is no doubt that climate change impacts will directly affect the types of crops which can be grown within North Kent area. Warmer temperatures, with reduced rainfall may lead to initial loss of crops and livestock then an increasing move towards more drought tolerant arable crops and root crops, which may increase the need for water, leading to greater use of irrigation systems. Longer growing seasons could potentially lead to double cropping with consequent higher fertiliser requirements and increased risks of eutrophication during increased winter rainfall. Higher winter temperatures may lead to increased pest survival and an increased use of pesticides. 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 impacted but other trees requiring higher temperatures, milder winters and longer growing seasons may be grown, although impacts on native woodlands must be avoided. Woodlands may suffer particular damage due to 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, 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

A requirement for increasing renewable energy generation could result in pressure for wind farm developments and increased pressure for the growth of biomass crops (Defra's maps show predominantly high potential Miscanthus yields and medium potential SRC yields throughout the area). This area has the potential to supply large amounts of renewable energy.

Water resources

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

Regulating services - such as climate regulation, water purification and flood protection

Carbon storage and sequestration

Soils store carbon and climate change impacts from drought and flooding and potential changes in agricultural practices could increase soil disturbance and will reduce carbon stores. 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 may also have an impact on supply and water quality.

Flood protection

Habitats such as salt marsh and mudflats and grazing marshes provide a flood protection service. Sea level rise may reduce the area of habitat at the coast resulting in a loss of flood protection. However, policies which support natural coastal processes, such as managed realignment, could act to enhance the role of habitats in coastal flood protection.

Increased storm events and increased rainfall in the winter is likely to increase the risk of flooding of properties and agricultural land. Taking up strategic opportunities for reconnecting rivers with their floodplains, and delivering Catchment Floodplain Management Plan (CFMP) targets will deliver flood storage, save significant sums of money on maintaining potentially unsustainable flood defences and offer new opportunities for both biodiversity and access.

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.

Support services such as nutrient cycling, oxygen production and soil formation

Nutrient cycling and soil formation

Drought and flooding leading to increased erosion and consequent loss of soil profiles. Also changes in soil microbial activity and changes in agriculture will have an impact on this function leading to a knock on effect on their ability to process water and nutrients for the plants we eat, and to decompose and recycle our waste. Drought and flooding may also affect the provision of essential agricultural needs, raw materials and substrate for the development of infrastructure.

Photo-synthesis and pollination

Photo-synthesis and pollination which underpins much of our agriculture may be affected by the impact climate change has on biodiversity. This will be through changes to the distribution, abundance and effectiveness of pollinators and biodiversity, which underpins all the other functions.

Cultural services such as education, recreation and aesthetic value

Recreation

Warmer temperatures and reduced rainfall in summer may make the area increasingly attractive to local residents for recreation. This could benefit people's quality of life but it 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. Protecting and enhancing the recreational opportunities 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 area. 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 function 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. The impact of sea level rise on coastal recreational opportunities and activities could be significant.

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 features, may be affected by climate change impacts on physical processes – erosion, landslips - and vegetation growth, or indeed the loss of a feature, for example, through sea level rise.

Sense of place

It is likely that the landscape of the NCA may change significantly 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, sea level rise in particular. These 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.

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 to enhance heterogeneity which will allow species to take advantage of local changes in microclimate within habitat types. The creation of transitional habitats between coastal and terrestrial habitats will also provide increased variability of habitats and microclimates.
- Identify and target the most beneficial Environmental Stewardship Scheme options. These actions could involve promoting the farmland birds package of options for both ELS and HLS schemes and promoting wet grassland options where appropriate.
- 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 area.
- Advocate land use practices that provide win-win responses to climate change, for example, encouraging agricultural adaptation alongside management of the landscape for biodiversity.
- Manage recreational pressure to retain feeling of remoteness, for example, spread the load of visitors, direct people away from most sensitive areas at most sensitive times, only when necessary and provide alternative routes. Possible development of new recreational routes to take pressure of those routes at risk from erosion.

Distinctive form

- Reinstate naturally functioning coasts 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.
- Influence flood defence schemes to facilitate natural coastal and river processes, in particular the function of river channels and flood plains to relieve peak flows in suitable areas of the catchment.
- 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 existing coastal geological SSSIs such as Sheppey Cliffs.

- Isle of Grain to South Foreland and the Medway Estuary and Swale Shoreline Management Plans 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 geomorpholgogial processes to function where possible, for example, for quarries, if there is a possibility of loss of a geodiversity interest feature, implement 'rescue' excavations to salvage as much scientific data as possible.
- Implement soil and habitat conservation measures (see more below) to support adaptation of land uses that contribute to the landscape character.
- Identify and target the most beneficial Environmental Stewardship Scheme options and support farmers through an appropriate diversification as part of an overall approach to encourage mixed sustainable farming.

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.
- Prepare emergency plans or install emergency measures to negate threats to historic assets.
- Provide advice to landowners to manage scheduled sites (archaeological & historic parks and gardens) appropriately.
- Manage soil and vegetation through agri-environmental schemes to protect buried sites likely to be damaged through changes in land use.
- Identify and target the most beneficial Environmental Stewardship Scheme options for historic assets.
- Manage recreational pressure to take pressure off sites at risk from erosion.

Biodiversity

- Significantly restore, create and re-link fragmented areas of coastal grazing marsh to create a robust habitat network with enhanced adaptation to climate change.
- Further restore and create estuarine habitats that include mudflats, saltmarsh, sand dunes, shingle, shell and sand banks, and subtidal sand and mud, supporting their adaptability to sea-level rise and maintaining opportunities for natural regeneration. Explore possibilities for compensation habitat in other locations where these will be lost to coastal squeeze.
- Identify and target the most beneficial Environmental Stewardship Scheme options, for example, further enhance the arable landscape, providing opportunities for breeding and wintering bird populations, notably Brent Geese.
- 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, 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.
- Encourage woodland management to provide woodfuel and biodiversity benefits.
- Implement soil and habitat conservation measures (see more below) to support adaptation of land uses that contribute to the landscape character.
- Avoid 'hard engineering' solutions where a solution supporting more natural processes would be successful, for example, river and coastal process.

Buildings and settlements

- Erection of sympathetic higher capacity rainwater disposal systems for listed historic buildings.
- 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 Green Infrastructure, flood guards and flood resilient materials appropriate to the age and structure of the building.
- Further investigate the long term needs with regard to renewable energy infrastructure, settlement pattern and building design to allow adaptation while retaining and enhancing landscape character.

Views

- Encourage land management and land use that retains the long open views characteristic of North Kent.
- Further investigate the provision of renewable energy and development, 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 prone to drought.
- 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 filtration to reduce the risks of 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.
- Restore hydrological connectivity between open waters and wetlands. Identify areas within the river catchments in the area where there are opportunities to create additional grazing marsh and wetland areas which will enhance habitat connectivity but also help reduce run-off and pollution such in agricultural landscapes.
- 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.
- Identify and target the most beneficial Environmental Stewardship Scheme options.
- 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 North Kent. Advised actions could be as follows:
  - 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 – while 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.

Renewable energy

- Identify opportunities to support renewable energy production including growth of bio-fuel crops on poor quality land where appropriate.
- Raise awareness of the potential need for change with the public. This may be required to facilitate acceptance of change in the landscape due to renewable energy provision.

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.
- 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).

Regulating services

Carbon storage

- Adopt soil and habitat management practices to ensure continued and enhanced carbon storage.
- 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 function for the area.

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.
- 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.

Flood protection

- Discourage floodplain developments and raise awareness of the implications of these.
- Implement naturally functioning floodplains and Catchment Flood Management Plans.
- 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.
- Carry out catchment scale management thorough improving permeability of surfaces using planting, creation of wet woodland, SUDS etc.
- 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.
- Allow for coastal realignment and adequate space and sediment for shoreline adjustment through strategic coastal process unhampered by coastal defences where possible to allow creation of new habitats (salt marsh and mud flats).

Cultural services

Recreation

- Proactive development of large scale habitat recreation as part of enhancing the green infrastructure. The Medway and Swale Green Grid Partnerships and their projects will be instrumental in this.
- 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 into 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 drought periods.
- Increase awareness that a combination of extreme weather events, sea level rise and heavy rainfall will increase maintenance on the rights of way network. 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.
- 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.
- Raise awareness 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 North Kent and to encourage them to think about visions of what they would like the area to look and feel like in future.

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.
- Take measures to keep soil *in-situ,* for example, 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.

Biodiversity

- Ensure best practise management of existing resource. 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 some management dates to respond to seasonal changes or developing buffer zones next to areas of more intensive land use.
- Increase the mosaic of habitats in the region 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 will also provide increased variability of habitats and microclimates.
- Proactive development of large scale habitat recreation as part of enhancing the green infrastructure within the NCA, with a focus on wetland creation schemes and supporting the roll-back of coastal habitats including sand dunes and salt marsh.
- Increase resilience of existing habitats, through increasing their size and buffering.
- 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 landscape scale habitat networks as part of enhancing the green infrastructure within the area should be implemented. Opportunities for increasing our understanding and focusing effort exist through the Biodiversity Opportunity Areas (BOAs) (South East England Biodiversity Forum 2008).
- Reduce existing pressures on habitat to increase resilience to climate change impacts, and especially to interactions between climate change and other pressures.
- Restore hydrological connectivity between open waters, fleets and wetlands. Identify areas within the river catchments in the area where there is opportunity to enhance habitat connectivity helping reduce run-off and pollution such in agricultural landscapes and land identified for flood storage.
- 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.
- Identify and target the most beneficial Environmental Stewardship Scheme options. 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 the switch from Lowland Wet Grassland to saltmarsh as a result of managed realignment.
- Be alert to potential new pests and diseases and plan for management. Also, continue to monitor native and non native species to assess changes in numbers and distribution and undertake monitoring to identify new species appearing within the area. 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.
- 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. We can also look to other locations with similar climates to that which England may experience in future to identify potential threats.

NATURAL ENGLAND

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

www.naturalengland.org.uk