

**An Assessment of the vulnerability of the
Natural Environment to climate change
in North West England using the
National Character Areas.**

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1. Background to Project

In November 2006, the North West Climate Change Partnership launched '*Rising to the Challenge - A Climate change Action Plan for England's Northwest*' (NWDA *et al* (2010). To help deliver this the Climate Change Partnership formed the North West Climate Change Unit in late 2007.

Natural England have responsibility for the delivery of Action 4.5 (now 10.5 from April 2010) of the NW Climate Change Action Plan. To undertake scoping studies *to assess the potential impacts of climate change on the region's landscape, sensitive habitats and species and the contribution of natural systems to carbon sequestration and reduced flood risk.*

- Natural England carried out a pilot project on a single National Character Area (CA) *The Cumbria High Fells* – one of four National Pilots - Natural England (2009). This has helped develop a pilot methodology and process that can be rolled out to further Character Areas.

The work undertaken here pilots an approach to investigate the natural environmental assets of the North West and get an idea of how vulnerable they are to climate change from now and into the middle of this century. It has not been done in any other region of England as yet and so is the first approach at doing this type of work and develops on from understanding gained in the Cumbria High Fells approach. This is a highly multifaceted picture and one that can never be fully understood. However, we can make some assumptions that certain factors help an area be more or less likely to cope with the affects of climate change.

This project aimed to achieve an overview of the vulnerability of the whole of the North West to climate change. The North West region has twenty nine National Character Areas (NCAs) that are partly or wholly within it. To investigate all of these areas in little over a year to the same level of detail as was done for the Cumbria High Fells would have proved impossible. The project therefore used a simplified methodology to build a general picture of relative vulnerability of the different NCAs across the region.

In parallel, to support the region-wide assessment, more detailed climate vulnerability studies are being done in six individual NCAs in the north west. The six NCAs were selected due to being categorised in a high, medium or less vulnerable category from this study. Although outside this report once complete they can be used to test how accurate this investigation has been from the high level data and assumptions that have been made.

The results of the project will help identify possible landscape-scale adaptation strategies that will help enable the North West to maintain the benefits we obtain from ecosystems and landscapes in the face of inevitable changes.

2. Introduction

The natural environment of North West England needs to be healthy now and in the future, enjoyed by people and used sustainably. However, the natural environment is changing, particularly as a consequence of land use change and climate change.

While the reduction of greenhouse gases is essential to reduce the extent of climate change, some impacts of climate change are now unavoidable. The natural environment is likely to be vulnerable to these impacts and it is therefore important to ensure that it has the capacity to adapt. Without such adaptive capacity, we put at risk our rich heritage of landscapes, wildlife and access to them, which are also key to many of the ecosystem services, such as climate regulation, flood alleviation and clean water that they provide.

2.1 What Makes the North West natural environment special

The North West is rich in wildlife and habitats. Thirty five out of the forty UK Biodiversity Action Plan (BAP) terrestrial and freshwater habitats are found within the North West. The region holds significant proportions of the England resource for some habitats, particularly those found in the uplands, coast and estuaries and lowland wetlands. Examples include around 18% of the English resource of upland heathland, 25% of blanket bog, 20% of sand dunes, 34% of intertidal mudflats and saltmarsh, and 56% of lowland raised bog.

On average around 60% of this biodiversity habitat area lies within statutory designations of Sites of Special Scientific Interest (SSSIs), Special Protection Area (SPA), Special Area of Conservation (SAC) and/or Ramsar Sites and is thus protected by legislation. The region has the largest area of SSSI with 200,000 ha covering 18% of the region; of this 13% is also designated as SPA, SAC or Ramsar Site. This demonstrates the range and quality of biodiversity and geology in the region. The largest SSSIs cover intertidal or high moorland areas; elsewhere sites tend to be small and fragmented, particularly in the south of the region.

The remaining 40% of biodiversity habitat area in the North West lies outside statutory designations and is largely unprotected. When considering climate change these biodiversity habitats are of equal importance to those found within the statutory protected sites. Expansion will be necessary to safeguard areas but needs to occur where multiple benefits will also be delivered. Even with significant changes to our climate the areas that are important and significant now are likely to remain areas that contain the highest quality natural environment (Hopkins et al, 2007) in the future.

2.2 Why should we conserve our Natural environment in the North West?

Natural environment matters for a whole variety of reasons: ethically, emotionally, environmentally and economically. It is at the very foundation of our society and the basis of our economic success and wellbeing.

Because our survival depends upon it

Living things, the rocks and soils, water and air interact to provide a range of conditions that support life on Earth. If the ecological systems that sustain life on Earth collapse or radically change, our very existence is threatened. Soil biodiversity alone influences a huge range of processes and functions vital to ecosystems, as we have demonstrated in our peatland

report. <http://naturalengland.etraderstores.com/NaturalEnglandShop/NE257> We have begun to explore, initially in our Uplands and using mainly existing data have created an ecosystem services atlas to attempt to map out where they may be found.

<http://naturalengland.etraderstores.com/NaturalEnglandShop/NE209>

Because our economy and lifestyles depend upon it

From the harvesting of fish to the growing of timber, biodiversity provides the source for an enormous range of products we consume and use. Many pharmaceuticals, as well as soaps, starches, rubber, oils, dyes and fabrics, have been derived from wild plant products and many more are yet to be discovered. At the larger ecosystem scale, biodiversity plays a critical role in regulation of the atmosphere, of the water cycle and the nutrient cycles of the soil. From flood control to soil conservation, the annual contribution of these services is worth millions of pounds. The report [No charge? Valuing the natural environment](#) sets out the contribution that nature makes to our economy (such as clean water, carbon storage) to ensure that its value is recognised. We have explored this in far more detail in the North West through our Natural Economy North West project.

<http://www.naturaleconomynorthwest.co.uk/>

Because it inspires and enriches our lives

We gain enjoyment and recreation from nature and open spaces. It provides endless motivation for enquiry, from schoolchildren to scientists. We have recently started to explore this in more detail in our Upland Vision Document.

<http://naturalengland.etraderstores.com/NaturalEnglandShop/NE210>

Because to do otherwise is wrong...

To let species become extinct and to treat nature as if it has been designed for our convenience is ethically immoral.

2.3 Current thinking on resilience of the Natural Environment to Climate Change.

All areas of the North West contain many varied attributes, including geology overlaid by sediments, soils, height, coastal location, etc. Many of these will be affected in some way by climate change. These attributes will vary both in the influence climate change will have on them in each geographic location, and their relationship with each other, this in turn determines the areas characteristics.

The natural environment is a highly complex system and climate change is likely to have complex and unpredictable effects. For example, adjustments by plants to the changes in climate in turn could affect the species they interact with – competitors, pollinators, herbivores (with knock-on effects on predators), and species that rely on the habitat for shelter, nest sites, and so on. The communities of plants and animals that are familiar to us now could change. The effects of climate change are likely to be exacerbated by the fact that habitats in the UK have been highly influenced and modified by human activities and in some cases are in poor condition. A number of types of changes are possible (Hopkins et al. 2007; see also Mitchell et al. 2007).

Phenology

The study of changes in timing of seasonal events, such as flowering, bud burst and migration has seen the general trend of earlier spring and summer events. The major impact

of this shift are life cycles of species that have evolved together no longer occurring together. Such as nesting times and caterpillar abundance.

Species Abundance

As conditions have become more favourable for certain species numbers have increased. Climate change effects that are creating circumstances that are less favourable, like long dry periods in summer, can also have big negative impacts on species numbers.

Range Changes

Many of our more mobile species at the northern limit of their distribution are now moving northwards and into higher climate, as the climate becomes favourable for them. In the North West this is particularly significant as many UK species with a southern distribution have traditionally had their northern distribution boundary in Northern Lancashire and Southern Cumbria. Many of these are now expanding their range into Cumbria.

Habitat preference

As climate changes it is often preferable for species to switch into cooler microclimates within habitats such as longer grassland from shorter swards. Other species are being forced to move as they get earlier and greater spring growth in plants so making conditions unfavourable for their life cycles.

Ecosystem function

It is clear that our understanding of climate change impacts on ecosystem services is less advanced than that on species changes. However some changes are starting to be experienced such as changes in biomass in European woodland or decomposition rates within bogs.

2.4 What makes one area more likely to cope with climate change than another?

This is a highly multifaceted picture and one that can never be fully understood, we can make some assumptions that certain factors help an area be more or less likely to cope with the affects of climate change.

When evaluating the impacts of climate change on landscapes, the terms robust and resilient are potentially useful. However, there are subtle differences between the terms.

Resilience is defined in the climate change literature as ‘the ability of a system to recover from the effect of an extreme load that may have caused harm’ (UKCIP 2003). Within the ecology literature as ‘the speed with which a community returns to its former state after it has been disturbed or displaced from that state’ (Bregon et al. 1996).

Robustness is defined in the climate change literature as ‘the ability of a system to continue to perform satisfactorily under load’ (UKCIP 2003). Within the ecology literature the term **dynamically robust** is used to describe ‘a community that is stable within a wide range of environmental conditions and characteristics’ (Bregon et al. 1996).

In terms of climate change and the natural environment, a **resilient** landscape can be thought of as one that can recover following an extreme climate event (such as a storm or flood) although recovery may not be to the same condition as it was in prior to the event. Recovering from climate change will involve a shift in state; recovery to the status quo will

not be sustainable in the long term. A **robust** landscape can be thought of as one that continues to function under the stresses caused by prolonged changes in temperature and rainfall. In order to continue functioning a robust landscape must possess the ability to change in response to climate change e.g. species need to be able to move and adapt to the new conditions.

In 'Conserving biodiversity in a changing climate', Hopkins et. al. (2007) list a number of factors that are likely to make landscapes better able to cope with climate change impacts (see Box 2.1)

Box 2.1 - Conserving Biodiversity in a changing climate (Hopkins et al. 2007)

Those landscapes which are richest in terms of their current biodiversity are also more likely to be most varied in terms of their habitat mosaic and thereby most likely to allow some species to adapt to a changing climate by dispersing to nearby habitat patches in the future.

The following characteristics are worth maintaining and enhancing:

- a) *Diverse and structurally varied vegetation.* Different types of vegetation have different microclimates and some species may be able to adjust to climate change by expanding the range of vegetation types they occupy, or by moving from one type of vegetation to another.
- b) *Semi-natural habitat on a range of slope and aspect.* Microclimate varies considerably with slope and aspect. At sites with varied topography species adversely affected by higher temperature and summer drought on south-facing slopes may be able to move to cooler, more humid north facing slopes. Quite small differences in topography, for example on different sides of a hillock, may provide the topographical variation required if the magnitude of change is not too great.
- c) *Uninterrupted semi-natural vegetation over a range of altitude.* For some species the response to climate change will be to move to higher areas, where climate is generally cooler and wetter. Hence, uninterrupted habitat within mountains and hills will allow the dispersal of species but montane species on the highest peaks are likely to be left with nowhere to go. This and the following point demonstrate the principle of connectivity.
- d) *Uninterrupted semi-natural habitat across coastal zones.* Coastal areas have complex microclimates compared to inland areas and there is large climate variation over distances of less than one kilometre at the coast meaning species may find suitable nearby habitat patches as climate changes.
- e) *Diverse water regimes.* Climate change is likely to have a complex effect upon water regimes. Summers are expected to become drier while winters are likely to become wetter and rainfall may become less evenly distributed, with more heavy rainfall events and flooding. The most complex range of habitats, and therefore the most aquatic and wetland species, are likely to survive in landscapes where there is variation from open water to dry land. A diversity of wetland conditions is most likely to persist where the open waters and wetlands are fed by a combination of surface drainage, ground water and aquifers.

In this study we used the characteristics above, combined with information obtained from other studies on the vulnerability of the natural environment to climate change, to estimate how resilient or susceptible different areas in the region might be to climate change. We assumed that the greater number of attributes conferring resilience that occur in any one area, the more it is likely to be able to cope with the changes ahead from climate change (see section 2).

What adaptation responses should be made?

Future actions taken to help the natural environment cope with climate change will be essential. Some very useful guidelines on what needs to be considered in any management decisions we make have been developed. Recent publications have highlighted that the adaptation actions must not constrain the ability of other areas or sectors to adapt to climate change, or our efforts to mitigate it; Two recently published sets of summary principles are listed below (Boxes 2.2 & 2.3);

Box 2.2 - General principles for sustainable adaptation (Macgregor & Cowan 2010)

- i. Action in one sector must not unreasonably limit the ability of another sector to adapt, shift vulnerability from one actor to another, or unreasonably increase greenhouse gas emissions.** In other words, adaptation should not exacerbate either the causes or negative consequences of climate change.
- ii. Decisions should be based on a whole systems approach, not focused on individual sectors.** Many adaptation responses to address socio-economic factors will have wider consequences for natural systems, and vice versa. We will need integrated sustainable action across sectors.
- iii. Adaptation should seek to increase resilience of systems and address all aspects of vulnerability, not just reduce exposure to potential impacts.** Actions must be taken in the face of uncertainty in relation to future climate changes, socio-economic change, and the interaction between them. Therefore it is important to build resilience to cope with a wide range of possible risks, across a range of plausible futures.
- iv. Approaches to adaptation must be flexible and not limit future action.** Adaptation solutions should avoid committing us to a single pathway. The application of ‘adaptive management’ approaches can help ensure flexibility. This allows early adaptation action while reducing the risk of over-committing or acting inappropriately. New approaches to adaptation will need to be tested and monitored at the appropriate scale so we can learn from experience and revise our approaches accordingly.

Box 2.3 - Summary of England Biodiversity Strategy Climate Change Adaptation Principles (Smithers et al. 2008)

Take practical action now

- ❖ **Conserve existing biodiversity;** The richness of future biodiversity, even in a changing world, will depend largely upon the biodiversity we conserve today.
- ❖ **Conserve protected areas and all other high quality habitats;** have characteristics that will continue to favour high levels of biodiversity.
- ❖ **Reduce sources of harm not linked to climate;** By reducing other sources of harm we will help natural systems be more resilient to Climate Change Areas.
- ❖ **Use existing biodiversity legislation and international agreements.** Enable effective action now to remedy potential shortcomings.

Maintain and increase ecological resilience

- ❖ **Conserve the range and variability of habitats and species;** It is impossible to predict which localities will continue to have climate conditions for species or habitats. Diversity of ecosystems, in terms of physical features and habitats, should be maintained.
- ❖ **Maintain existing ecological networks;** further habitat fragmentation and isolation should be avoided, implementing recovery through the spatial planning system.
- ❖ **Create buffer zones around high quality habitats;** reduce potentially damaging edge effects by creating the same or complementary habitats adjacent to them.
- ❖ **Take prompt action to control spread of invasive species.** They are known to cause significant habitat degradation and so should be prevented where this can be sustained.

Accommodate change

- ❖ **Understand change is inevitable;** the structure and composition of habitats has never been static. Species will respond individualistically to climate change and we should seek to work with the grain of change and natural processes.
- ❖ **Make space for the natural development of rivers and coasts;** changing rainfall patterns and rising sea levels mean we need to accept the role of erosion and deposition in shaping the environment.
- ❖ **Establish ecological networks through habitat restoration and creation;** The success of species dispersal can be promoted by enhancing protected areas and creating new habitat, restoring degraded habitat, and sympathetically managing areas between existing habitats in the wider environment.
- ❖ **Aid gene flow;** The ability of a species to adapt to change is correlated with genetic diversity and population size, so conservation should seek to maintain or create large populations.
- ❖ **Consider the role of species translocation and ex-situ conservation;** Translocation (introduction, reintroduction and restocking) and captive-breeding programmes may be used to conserve some species.
- ❖ **Develop the capacity of institutions and administrative arrangements to cope with change;** We need to be effective in an uncertain world, so working towards a future of potentially different circumstances, learning from experience and sharing information more widely within and between organisations will be an important cultural shift.

Box 2.3 – Continued.

- ❖ **Learn from experience and respond to changing conservation priorities.** Conservation targets need to be regularly reviewed to ensure resources are directed towards priorities as some species increase, others decline and habitats change in character.

Integrate action across partners and sectors

- ❖ **Integrate adaptation and mitigation measures;** Conservation contributes to carbon management through peat bog or native woodland creation. Mitigation actions should not harm the biodiversity & recognise opportunities for biodiversity and so contributing to adaptation.
- ❖ **Integrate policy and practice across relevant economic sectors;** Conservation can be interwoven with other activities for effective delivery of ecosystem good & services.
- ❖ **Build and strengthen partnerships;** which are fundamental part of CC adaptation strategies Engagement with stakeholders and local communities is crucial to developing adaptation actions that will work best on the ground.
- ❖ **Raise awareness of benefits of the natural environment to society.** wider appreciation that adaptation is in the interests of individuals, communities and business will increase demand and support for implementation.

Develop knowledge and plan strategically

- ❖ **Undertake vulnerability assessments of biodiversity and associated ecosystem goods and services without delay;** Vulnerability to climate change is ‘ the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007). This will help identify priorities and develop appropriate actions.
- ❖ **Undertake scenario planning and implementation of no regrets actions;** need to make strategic decisions by embracing uncertainty and addressing the full range of variation in projected changes and their impacts. It is important to avoid selection of one future in the hope it will become true.
- ❖ **Pilot and monitoring new approaches;**
- ❖ **Identify potential win-win solutions and ensuring cross-sectoral knowledge transfer;** concentrate on actions that deliver several adaptation measures at once.
- ❖ **Monitor actual impacts and research likely future impacts.**
- ❖ **Improve understanding of the role of biodiversity in ecosystem services.** need better understanding of ways in which ecosystem services will be affected by CC.
- ❖ **Research knowledge gaps with stakeholder participation.** Climate change adaptation has cross-sectorial implications. Ensuring stakeholders have common understanding of and commitment to new evidence is essential to develop policy and practice.

3. Climate Change projections for the North West region of England

This section provides an overview of the UKCP 09 climate projections for the North West region. This is presented in a different summary format to that which can be obtained from the web site <http://ukclimateprojections.defra.gov.uk/>. The first section has tabulated written data for the time period 2020, 2050 & 2080, this is to help provide clarity on the variation that is likely to be experienced and how future emissions will also change the outcomes. The sea level rise data for the North West has been included for use when considering coastal impacts and inundations. The mapped section is to highlight one or two examples of how within the North West the spatial distribution of temperature and precipitation will vary in different locations as it does today but these may change in future.

3.1 UKCP09 NW Key findings - data in table format

How has this data been tabulated.

The outputs from the key findings part of UKCP 09 for the NW <http://ukclimateprojections.defra.gov.uk/content/view/2150/680/> come in the form of:

Under low emissions, the central estimate of increase in **winter mean temperature** is 1.2°C; it is very unlikely to be less than 0.4°C and is very unlikely to be more than 2°C. A wider range of uncertainty is from 0.3°C to 2°C

In tabulated format we represented this as **1.2 °C** (0.4 to 2 °C) and left out the wider range of uncertainty

Under low emissions, the central estimate of change in **annual mean precipitation** is 1%; it is very unlikely to be less than -3% and is very unlikely to be more than 7%. A wider range of uncertainty is from -4% to 7%.

In tabulated format we represented this as **1%** (-3 to 7%) and left out the wider range of uncertainty

Table 3.1 - UKCP09 for the NW - showing range of possibilities.

2020s	Emissions scenario		
	Low	Medium	High
Winter Mean Temp.	1.2 °C (0.4 to 2 °C)	1.2 °C (0.5 to 2 °C)	1.2 °C (0.3 to 2 °C)
Summer Mean Temp	1.6 °C (0.8 to 2.5 °C)	1.5 °C (0.6 to 2.5 °C)	1.5 °C (0.6 to 2.5 °C)
Summer Mean Daily Max Temp	2 °C (0.6 to 3.5 °C)	1.9 °C (0.4 to 3.5 °C)	1.8 °C (0.5 to 3.3 °C)
Summer Mean Daily Min. Temp	1.5 °C (0.6 to 2.6 °C)	1.5 °C (0.5 to 2.6 °C)	1.4 °C (0.5 to 2.5 °C)
Annual mean precipitation	1% (-3 to 7%)	0% (-4 to 6%)	0% (-4 to 6%)
Winter Mean precipitation	4% (-3 to 14%)	6% (-1 to 14%)	4% (-3 to 13%)
Summer mean precipitation	-5% (-19 to 9%)	-7% (-22 to 9%)	-4% (-18 to 10%)

These climate projections are fairly constant, as they are mostly determined by emissions that we have already released.

2050s	Emissions scenario		
	Low	Medium	High
Winter Mean Temp.	1.8 °C (0.8 to 2.8 °C)	2 °C (1 to 3 °C)	2.2 °C (1.2 to 3.3 °C)
Summer Mean Temp	2.4 °C (1.1 to 3.8 °C)	2.6 °C (1.2 to 4.1 °C)	3 °C (1.4 to 4.7 °C)
Summer Mean Daily Max Temp	3 °C (1 to 5.3 °C)	3.3 °C (1 to 5.8 °C)	3.8 °C (1.3 to 6.5 °C)
Summer Mean Daily Min. Temp	2.3 °C (0.9 to 3.9 °C)	2.5 °C (1 to 4.4 °C)	2.9 °C (1.3 to 4.9 °C)
Annual mean precipitation	0% (-6 to 6%)	0% (-5 to 6%)	0% (-6 to 7%)
Winter Mean precipitation	8% (0 to 20 %)	13% (3 to 26%)	13% (3 to 27 %)
Summer mean precipitation	-13% (-32 to 8%)	-17% (-34 to 1%)	-17% (-36 to 3%)

These climate projections have a greater variation and are determined by a combination of previous emissions release but also emissions over the next 20 years.

2080s	Emissions scenario		
	Low	Medium	High
Winter Mean Temp.	2.3 °C (1.3 to 3.6 °C)	2.6 °C (1.4 to 4.1 °C)	3.2 °C (0.3 to 2 °C)
Summer Mean Temp	2.8 °C (1.3 to 4.6 °C)	3.7 °C (0.6 to 2.5 °C)	4.7 °C (2.5 to 7.3 °C)
Summer Mean Daily Max Temp	3.6 °C (1 to 6.6 °C)	4.7 °C (1.7 to 8.3 °C)	6 °C (2.4 to 10.1 °C)
Summer Mean Daily Min. Temp	2.8 °C (1.1 to 4.9 °C)	3.8 °C (1.6 to 6.4 °C)	4.6 °C (2.2 to 7.8 °C)
Annual mean precipitation	0% (-5 to 8%)	0% (-6 to 8%)	0% (-8 to 12%)
Winter Mean precipitation	15% (4 to 30%)	16% (3 to 35%)	26% (9 to 50%)
Summer mean precipitation	-15% (-34 to 4%)	-21% (-42 to 0 %)	-27% (-50 to 0%)

These climate predictions have the greatest variation and are determined by the speed society moves to a low carbon society.

3.2 Projected Changes in Sea Level

Table 3.2

Changing Sea level in the North West	2040	2080
Liverpool	+15cm	+ 32 cm
Blackpool	+15cm	+ 30 cm
Barrow-in- Furness	+14cm	+ 30 cm

Based on the 'Central Estimate, Medium Emissions' scenario (UKCP 09), which equates to scenario A1B of IPCC. (Global rise of 2 °C by 2080)

High-plus-plus (H++) mean sea level scenario

The concept of an extreme sea level rise (H++ scenario) for vulnerability testing at the top end of our estimated uncertainty range. This is the highest expected sea level rise even in a worst case situation with the loss of far more Arctic and Antarctica glaciers than has been predicted in most of the models. Sea level increases are given from present day (1980–1999) to 2095 for H++, but no time series is presented.

In summary, our H++ scenario range for time-mean sea level rise around the UK is 93 cm to approximately 1.9 m. Beyond our qualitative statement that the top of this range is very unlikely to occur in the 21st century we make no attempt here to assign a precise probability to this event.

The use of the H++ scenario might seem extreme, as it is 4-5 times greater than the UKCP09 estimate for sea level rise in the North West, but with many climate change impacts adapting to a 1.9 m sea level rise might not be significantly greater than adapting to a 30 cm rise. Also if having invested in adaptation and then finding that this proves to be inadequate all gains will be lost, but taking the highest likely figure means that any investment is secured in the long term.

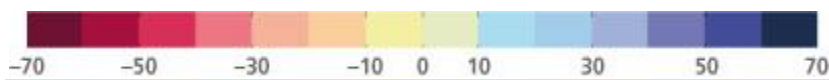
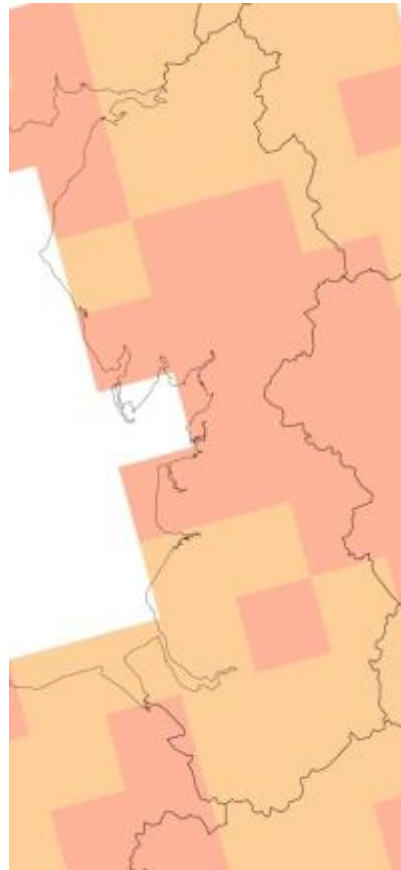
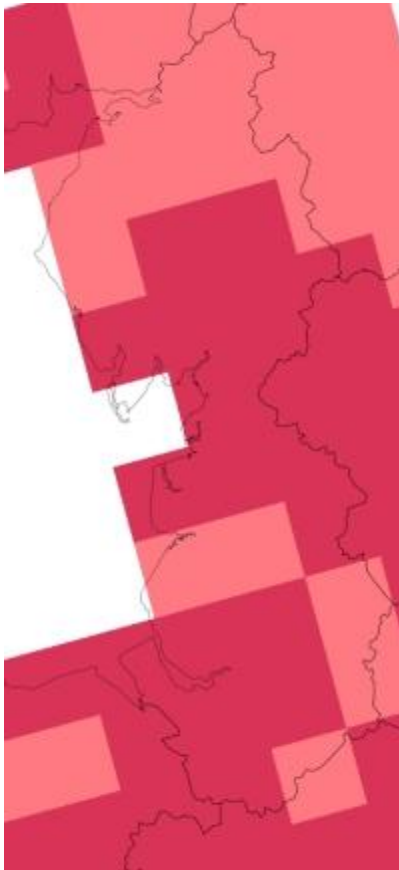
3.3 To demonstrate geographical variation of climate change scenarios across the North West England

Change in summer mean precipitation for the 2080s under a medium emissions scenario

10% probability level:
very unlikely to be less than

50% probability level:
central estimate

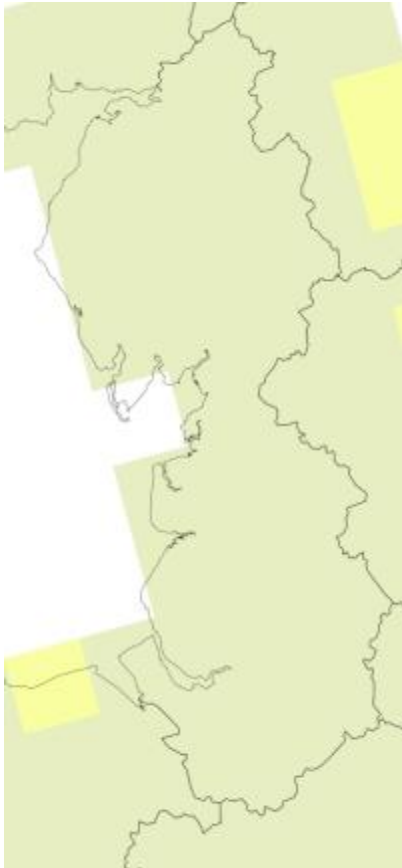
90% probability level:
very unlikely to be greater than



Change in summer mean precipitation (%)
Medium emissions

Change in winter mean precipitation for the 2080s under a medium emissions scenario

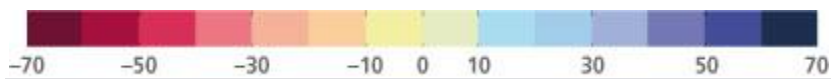
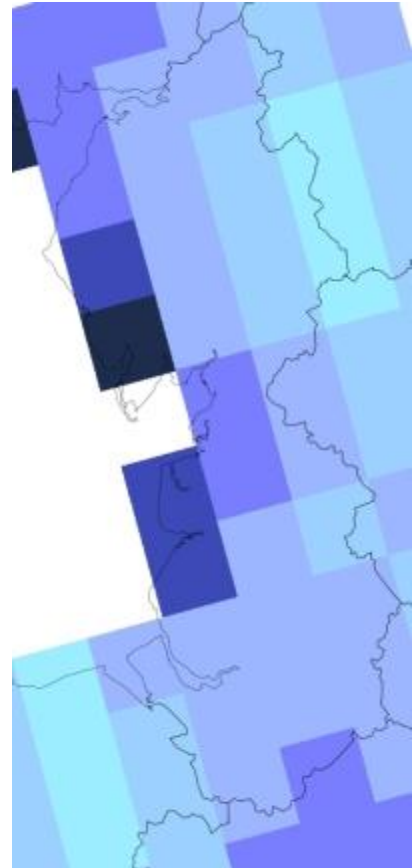
10% probability level:
very unlikely to be less than



50% probability level:
central estimate



90% probability level:
very unlikely to be greater than



Change in winter mean precipitation (%) Medium emissions

3.4 Climate data and use of General Trends

In order to identify the vulnerability of aspects of the natural environment to climate change, at this stage in our understanding, it is only necessary to know the broad changes in climate variables suggested by the UKCIP scenarios (e.g. increase in winter rainfall, increase in frequency of storms, see below). This is due to the wide variation in the likely response the natural environment will show and the complexity of the interactions and responses between species and habitats. This project does not use one specific climate change scenario (e.g. 2080s, high emissions) to identify adaptation responses as it is highly uncertain what the future will look like. The project therefore aims to develop responses which are valid for a range of climate scenarios.

It is important to remember that climate change may result in an increase in extreme events as well as gradual changes. The headline messages include an increase in the frequency of extreme events such as intense rainfall and heat waves. The impact of extreme events on the natural environment is likely to be significantly different to those caused by gradual changes in climate variables. In some cases the combination of gradual trends and extreme events may increase the vulnerability of assets e.g. gradual warming and drying may result in soil erosion which could result in isolated or veteran trees becoming more vulnerable to being blown over during a storm event. change in climate variable and impacts that where considered; hotter and drier summers, , warmer & wetter winters, more frequent storms, sea level rise, drought, longer growing season, increased soil moisture deficit, flooding, water-logging of soils, coastal erosion, coastal flooding and higher winds

4. Methodology

This section describes the methodology we adopted to initially assess the natural environment's vulnerability to climate change for the North West region in 2009. It has taken work done on the Cumbria High Fells Character Area project and applied a simplified approach across all the Landscape Character types in the region. A number of different geographic structures exist this project chose the National Character Areas (NCA) as the geographic unit of study. The methodology described below was initially consulted on with colleagues inside and outside of Natural England. Due to the short time frame the study used data that was quickly and easily available.

The aim of the regional vulnerability assessment was to assess the exposure of an area and its natural assets to the impacts of climate change and its capacity to adapt. The approach involved a high level screening of the whole region, at the scale of National Character Areas, to assess which areas and features of the region appear most vulnerable to climate change. Following this, impact and adaptation assessments are being carried out on a range of different risk categories for National Character Areas to test how effective the findings and assumptions were. The results and findings of these studies are not included within this report.

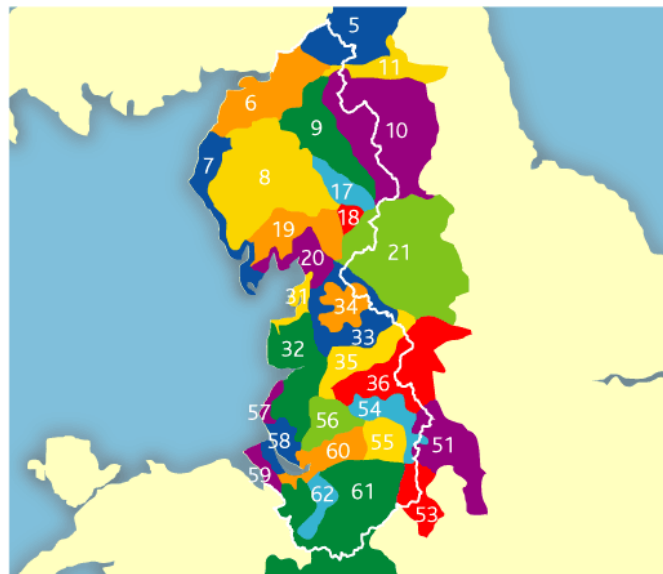


Figure 4.1: NW National Character Areas

Step 1 - Determine features which make areas of the North West vulnerable to the impacts of climate change.

In the first stage we identified the variables that were used to screen the entire region. This included factors or features of the chosen geographic unit which make them vulnerable to the impacts of climate change. Vulnerability is a function of exposure to climate change, how sensitive the system is to those changes and its ability to adapt (adaptive capacity).

A robust and resilient landscape is likely to possess extensive, permeable habitat networks and exhibit heterogeneity within and between habitats. Landscapes robust to climate change are likely to possess the following features (Hopkins et al. 2007 see Box 2.1): high permeability of species; variation in topography – slope, aspect and height; soil diversity; numerous land cover types; diverse and structurally varied vegetation and diverse water regimes.

There are other aspects that will inform how vulnerable an area is and how they may react to climate change impacts such as; Agricultural type and variety. Hydrological impacts & flood risk vulnerability, % of BAP habitat in the CA, % of SSSI in CA. % of woodland cover in the CA. Pollution and other impacts reducing resilience Agri- environment take up and extent. And the proportion of urban and rural areas.

Some of the attributes are easily quantifiable for example where we are looking at % cover of a known attribute like woodland cover; these were used in the quantitative screening (step 4). Others such as variation in topography are harder to quantify meaningfully and so are covered in the qualitative screening (step 3).

Step 2 - Identify significant climate change impacts in the region

The UKCP 2009 projections for the North West region were used to identify what the main impacts of climate change are likely to be.

The projections and impacts were not described in detailed terms; a simple quantitative description (e.g. increased frequency of tidal flooding due to sea level rise, wetter winters, dryer summers). The impacts were also considered when carrying out the screening exercise, as for example a sea level rise of 0.5 m will have far less impact on our coast than a sea level rise of 2 m.

Step 3 - Screen Character Areas using qualitative data

The relative vulnerability was assessed using informed judgement and GIS data layers to assess landscape features that do not have the possibility of empirical data processing. The Character Areas were screened using a matrix, as shown in Table 4.2 below. These were chosen on the basis of how climate change may affect each part (table 4.1) according to a red, yellow & green scoring system; **Coastal Location** was used as areas away from the coast will not be affected by sea level rise. **Elevation** was used to separate areas that will be lower and so at greater risk of sea level inundation. **Topography** was key as an undulating area has greater micro climates and so more areas for species and plant communities to exploit. **Vegetation diversity** gives greater places for species to adapt with changing temperature and moisture patterns. **Land Cover** is similar but also considers wider land use such as arable, grassland with the natural habitats. **Soil Diversity** this affects communities and water regimes and with more variety the greater opportunity exists to move short distance to find favourable conditions for species to live. **Major Agricultural type** helps determine how intensively the land is being farmed. With Dairy and Arable farming being more intensive (and so generally less Natural Environment functions that help support species outside of known wild life sites). Extensive grazing systems (often on poorer upland land) generally have greater wild flowers for example in hedgerows bottoms and rivers sides areas.

The seven attributes were then totalled for example in the Bowland Fells has 7 green attributes making it of lower vulnerability where as the Lancashire and Amoundness plain had 6 red attribute and one green making it likely to be far more vulnerable. These were then listed in order of results from least vulnerable to most (Appendix A) and split into the top, middle and bottom by thirds.

Table 4.1 - Qualitative Attributes & Data sources

<u>Screening Attribute</u>	<u>Justification</u>	<u>Main Data Used</u>	<u>Criteria</u>
Coastal Location	Through sea level rise – a more vulnerable location	Maps	A CA next to the coast – Yes /No
Elevation	Lower lying land at greater vulnerability from Climate Change	Maps & height data	Low Lying/ Medium / High
Topography	A greater variation of height within an area gives greater micro –climates and so make it more resilient to CC	Maps & height data	Flat / Varied
Vegetation Diversity	The greater the Vegetation diversity the more resilient to CC – data from bap habitat inventories.	BAP Habitat Inventories	Low / Medium / High – with comment
Land Cover Variation	The greater the variation in land cover the more resilient to CC	Land Cover Map 2000	Low / Medium / High – with comment
Soil Diversity	The greater the soil diversity the more resilient to Climate Change – data from http://www.landis.org.uk/soilscapes/	Soilscapes	Low / Medium / High – with comment
Major Agriculture Type	Extensive agriculture is likely to have a greater resilience to CC.	LDU Landuse on webmap & CQC Evidence file	Extensive / Intensive agriculture Sheep production, Beef production, Dairy, Arable, Mixed

Table 4.2 – Example; Qualitative vulnerability assessment

See Appendix A for complete table

Character Area	Coastal Location	Elevation	Topography	Vegetation Diversity	Land Cover Variation	Soil Diversity	Agriculture Type	Total All
Bowland Fells (34)	No	High	Varied	High – Blanket Bog, Upland Heathland and woodland	High – Mosaic of Heathland, blanket bog, acid and neutral grassland	High – From Peat and upland acid soils	Extensive sheep and beef production.	0 0 7
Bowland Fringe and Pendle Hill (33)	No	Med	Varied	Low – Mainly woodland	Low – majority improved grassland	High – majority clays with peat and limestone in some areas	Intensive Beef and Dairy production	3 1 3
Morecombe Coast & Lune Estuary (31)	Yes	Low Lying	Flat	Low – Majority is Flood plain and grazing marsh	Low – Improved grassland and some arable with greater variation on coast	High– free draining acid soils with peat influence and sand dune soils	Intensive dairy with more extensive grazing on the coastal habitats	6 0 1
Lancashire and Amounderness Plain (32)	Yes	Low Lying	Flat	Low – Majority is Flood plain and grazing marsh	Low – Improved grassland with arable dominating in the south, saltmarsh on cast in areas	Very High– from sandy soils, to fen peat, with wet clays and salt marsh soils.	Intensive dairy in north with market gardening in the south with areas of arable surrounding, Rough grazing on coast.	6 0 1

Step 4 - Screen Character Areas using Quantitative approach

The second assessment was carried out using data from various sources. They were all converted into the same geographic unit so could be directly comparable with each other in each column. Each attribute or column would give a figure for the highest for any NCA, all the way through to the lowest amount, often expressed as a percentage of the area as the NCAs are of variable sizes. The figures were then ranked to give the highest and lowest for each individual attribute within the 29 NCA of the NW region.

The attributes were chosen on aspects that make the natural environment of one area more robust and resilient from that of another as in step 1. (Hopkins et al 2007); **Percentage cover of Open Countryside** was used on the basis of areas with greater green space will have more potential than those that are predominantly built on; **Percentage of woodland Cover** the greater an area has the more potential species have to use this and numbers that are possible; **The number of national top 20 BAP habitats** this data set lists how important an area is in the national context of BAP habitats. If a NCA is one of the top 20 places for any particular BAP habitat resource nationally it will get score. As NCAs with many important key sites for BAP habitats will get greater scores they are more likely to have greater resilience to climate change; **Percentage Cover of BAP habitat inventories** the higher the cover the more potential an area will be able to cope; **Percentage cover of Less Favourable Area (LFA) land** this data set lists all the areas of poorer agricultural land (thin soils, high rainfall & altitude leading to poor growing conditions) it is used here as a surrogate for the wider benefits to the natural environment that these physical constraints will give and the more opportunities species still have to exploit opportunities in these less intensively used areas. **Percentage of Sites of Special Scientific interest (SSSI's)** Our best quality sites and the greater we have in any NCA the more potential the area has to cope with climate change. **Percentage of ancient woodland** are the woodland sites that have had continuous woodland use and consequently have a richness of species far greater than at other woodland sites. They give a good indication of disturbance over time with the higher remnants amounts found mostly in the least disturbed areas. **Percentage of agri-environment cover in the NCA** is the largest input of management resource to improve the natural environment, the greater this resource the more potential an area has to cope with climate change.

The attribute ranking scores for each NCA were then added together. This overall result was then ranked again and sorted to give a list of the lowest scores (the most resilient NCAs) through to the highest figures (the NCA of greatest vulnerability) in the NW region (see example in table 4.3 & Appendix B). This was then split into thirds to give a most resilient (green) , medium (yellow) and highest vulnerability (red).

Table 4.3 : Example showing selected results for data and how it was ranked

NCA name	JCA No.	% LFA	NW Rank	% SSSI area in C	NW Rank	% cover of Ancient woodland	NW Rank	Agri Env % cover from 2000+	NW Rank
BORDER MOORS AND FORESTS	5	100.0	1	13.4	11	0.18	25	30.2	19
SOLWAY BASIN	6	12.5	18	8.0	15	1.04	10	68.3	6
WEST CUMBRIA COASTAL PLAIN	7	22.4	17	6.7	17	1.03	11	52.2	11
CUMBRIA HIGH FELLS	8	95.4	8	18.0	6	2.67	3	51.4	12
EDEN VALLEY	9	0.0	23	2.7	21	2.62	4	43.6	14
NORTH PENNINES	10	99.7	5	46.8	1	0.43	18	74.1	3
TYNE GAP AND HADRIAN'S WALL	11	60.6	14	7.0	16	0.56	16	71.2	5
ORTON FELLS	17	95.1	9	13.2	12	1.32	8	89.7	1
HOWGILL FELLS	18	100.0	1	17.9	7	0.43	19	60.7	8
SOUTH CUMBRIA LOW FELLS	19	93.3	11	6.0	18	7.06	1	80.5	2
MORECAMBE BAY LIMESTONES	20	43.9	16	17.7	8	6.35	2	43.1	15
YORKSHIRE DALES	21	99.0	6	29.6	4	0.29	22	60.0	9
MORECAMBE COAST AND LUNE ESTU	31	0.7	20	14.2	10	0.23	23	23.2	24
LANCASHIRE AND AMOUNDERNESS P	32	0.0	23	2.7	21	0.16	26	41.1	16
BOWLAND FRINGE AND PENDLE HILL	33	68.7	12	3.1	20	1.57	6	71.7	4
BOWLAND FELLS	34	99.9	4	39.1	3	0.69	14	38.1	17
LANCASHIRE VALLEYS	35	63.0	13	0.1	27	1.61	5	27.6	20
SOUTHERN PENNINES	36	94.0	10	17.6	9	0.80	13	26.4	21
DARK PEAK	51	98.7	7	13.0	13	0.22	24	61.8	7
SOUTH WEST PEAK	53	100.0	1	46.7	2	0.93	12	47.0	13
MANCHESTER PENNINE FRINGE	54	53.2	15	0.1	27	1.21	9	3.9	29
MANCHESTER CONURBATION	55	1.7	19	0.0	29	0.39	20	4.8	28
LANCASHIRE COAL MEASURES	56	0.3	22	0.5	25	0.43	17	14.2	25
SEFTON COAST	57	0.0	23	24.3	5	0.00	28	8.1	26
MERSEYSIDE CONURBATION	58	0.0	23	0.4	26	0.00	28	8.0	27
WIRRAL	59	0.0	23	9.1	14	0.04	27	30.3	18
MERSEY VALLEY	60	0.0	23	3.5	19	0.30	21	25.5	23
SHROPSHIRE, CHESHIRE AND STAFFO	61	0.4	21	0.9	24	0.67	15	56.9	10
CHESHIRE SANDSTONE RIDGE	62	0.0	23	1.8	23	1.56	7	25.8	22
Average cover		48.4		12.6		1.20		42.7	

Step 5 – Screen Character Areas to look at Habitat Connectivity.

When it comes to the layout of habitats within an area some assessment of how well species can move through the NCA according to the amount, distribution, quantity and type of adjoining land use to those habitat patches needs to be made. Larger patches will in general be more resilient to climate change or where patches are functioning together networks of habitat patches. For this assessment we took the England Habitat Network dataset (English Nature, 2006) (Catchpole, R.D.J. ,2008) and according to four habitat splits they had determined made an assessment of how well each NCA was covered. An assessment was done for the grassland network; heathland network; mirefenbog network & woodland network. With an overall assessment also being done in case these networks joined to a more continuous extent or would function better in combination.

The individual NCA where scored on how many functioning networks the data showed. It was also considered how many might with some planning be made to function more effectively. This was split into 3 groups; Highly vulnerable areas (red) with no functioning networks; moderate vulnerability areas (yellow) with the potential to restore some functioning networks in the future and the least vulnerable areas (green) with at least one functioning habitat network shown by the data set. (see Table 4.4 for example below).

Table 4.4- Example of Habitat Network Analysis Tables

See Appendix C for complete tables

Areas at High Risk from Climate Change

Character Area	Grassland Networks (statutory & None)	Heathland Networks (statutory & None)	MireFenBog Networks (statutory & None)	Woodland Networks (statutory & None)	All Networks	Total Networks
Solway Basin (6)	None present	Much of the lowland raised bogs might act as lowland heathland	Most extensive in NW side	Some woodland networks – good down the river valley woodlands	Patches of isolated areas – not complete network	0
Morecombe Coast & Lune Estuary (31)	A couple of patches	None present	Isolated sites	Some woodland but not extensive	Small Patches of isolated areas – not complete network	0
Shropshire, Cheshire & Staffordshire Plain (61)	Isolated patches	Small isolated sites	None present	Most extensive and progressively better towards the east and the Peak edge	Reasonable - Has the potential to restore the woodland network.	0
Lancashire and Amounderness Plain (32)	Scattered isolated patches	Small isolated sites	Isolated sites	Best in south and east, but not mostly isolated patches.	Patches of isolated areas – not complete network	0

Step 6 – Produce combined regional vulnerability scores for each NCA.

This step amalgamates the information from steps 2-5 and any other relevant information and regional studies to assign an overall score of relative vulnerability to each Character Area. The results from above were all categorised into high (coloured red), moderate (coloured yellow) and at greater resilience (coloured green) to climate change. The three assessments results were given equal weighting for the purposes of combining results. They were split into seven groups from all green: 2 green: 1 green – 2 yellow: all yellow: one red – 2 yellow: 2 red – 1 yellow : all red. (see table 6.1 – for final results).

These were split into 3 broad character area types;

High vulnerability – (mostly coloured red) these areas have the least natural environment assets with the consequential reduced resource input, likely to be low lying and at risk from coastal flooding with rising sea level.

Moderate vulnerability – (a mixture of red, green & yellow assessment of attributes) might be able to move these from here to a better state than the high risk ones and quicker, by applying resource differently.

Greater resilience to climate change – mostly coloured green. these are the areas of key assets and delivery now, and traditionally have had a higher resource input. Greater amount of natural vegetation and good variation in topography.

5. Results

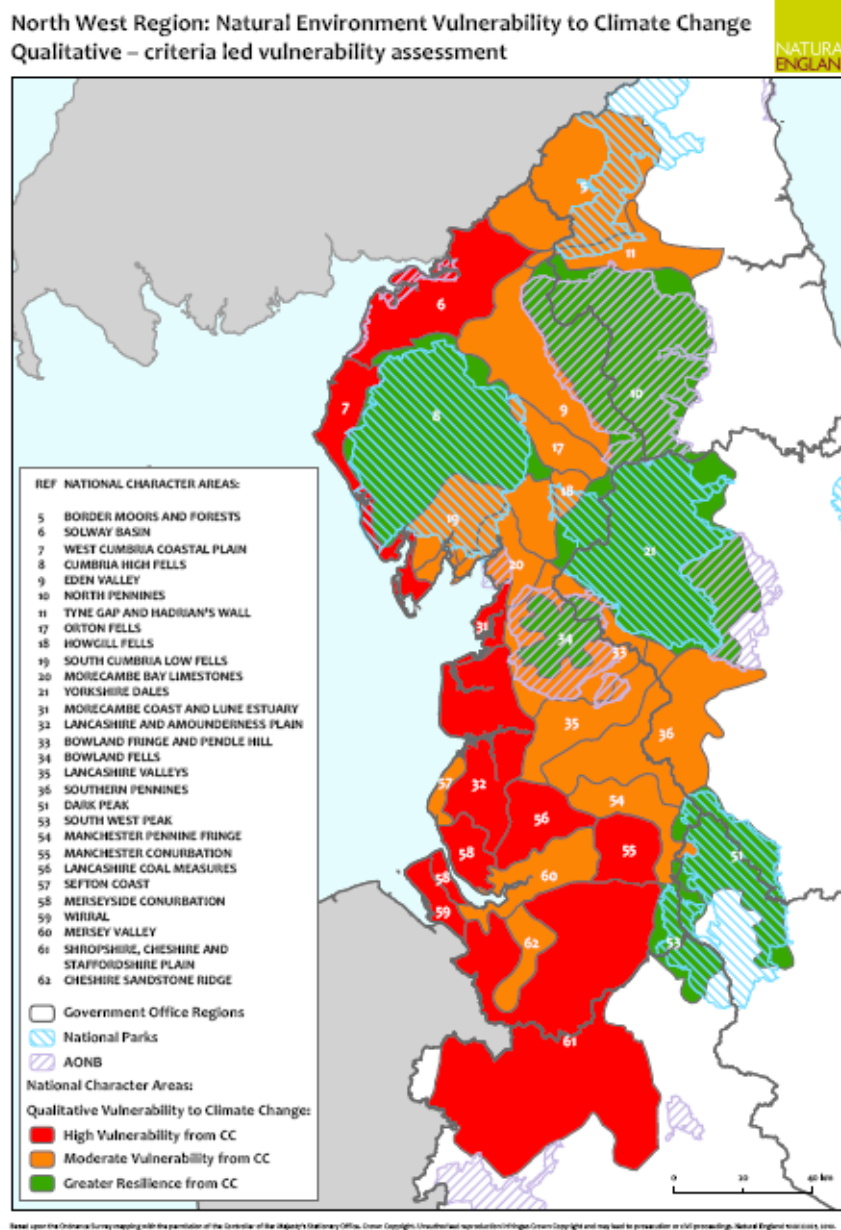
The results section is split into the three approaches for handling the different aspects of the information available before being amalgamated into an overall results table.

The findings from the assessment are expressed as High vulnerability, Medium vulnerability and Greater Resilience to climate change. These are represented on the map as red, yellow and green.

5.1 Qualitative – criteria led vulnerability assessment

The findings from this qualitative criteria led assessment are expressed as colours which split the NCAs up into three broad categories when considering the natural environment, High Risk, Medium Risk and Greater Resilience to climate change.

Map 5.1



Areas at relative higher vulnerability from Climate Change (Red)

These generally are lower lying or coastal locations, an even topography, with small and

fragmented semi- natural vegetation remaining. They have poorer natural environment assets and by their nature have been intensively managed. All of these factors suggests the natural environment is vulnerable to climate change impacts.

Character Areas: Solway Basin (6); Morecambe Coast & Lune Estuary (31); Shropshire, Cheshire & Staffordshire Plain (61); Lancashire and Amounderness Plain (32); Lancashire Coal Measures (56); Wirral (59); West Cumbria Coastal Plain (7); Merseyside conurbation (58); Manchester Conurbation (55)

Areas of relative moderate vulnerability to Climate Change (Yellow)

There is much greater variation in the NCAs in this category, some because they have a coastal location but have reasonable semi-natural vegetation and land use diversity. These areas have greater natural assets than the high risk areas above, such as the Sefton coast. Others further from the coast have a greater topographical variation but have small fragmented patches of semi-natural vegetation and intensive land use. The final grouping is those areas with moderate levels of attributes, which are neither high or low in the regional context and at this NCA scale. It is quite possible that this group has the greatest potential to be moved into a more resilient state.

Character Area: Eden Valley (9); Morecambe Bay Limestones (20); Lancashire Valleys (35) Mersey Valley (60); Bowland Fringe and Pendle Hill (33); Manchester Pennine Fringe (54); Sefton Coast (57); Tyne Gap and Hadrian's Wall (11); Cheshire Sandstone Ridge (62); Howgill Fells (18); Orton Fells (17); South Pennines (36); Border Moors & Forests (5); South Cumbria Low Fells (19)

Areas of greater relative resilience to Climate Change (Green)

These have good vegetation and soil type coverage, less intensive land use in a varied topography away from the coast. Interestingly they are all nationally designated National Parks or Areas of Outstanding Natural Beauty. These areas are perhaps our greatest assets and as such have received the greatest resource inputs and protection over the last 60 year period, this may contribute to the better scores they have received.

Character Area: North Pennines (10); Dark Peak (51); Bowland Fells (34); South West Peak (53); Cumbria High Fells (8); Yorkshire Dales (21)

5.2 Quantitative – data led vulnerability assessment results

The data led vulnerability assessment used data sets that are readily available and mostly created by Natural England. The approach took these datasets and converted them into amounts for NCAs that can be directly comparable between areas, as described below. This was an attempt at trialling an approach, to see if it gave meaningful results, rather than coming to a complete conclusion. It is envisaged extra data sets and other information will come to light in the future which will assist this process.

% of open countryside – This goes from a 100% cover of the Border Moors and Bowland Fells down to 19% for Manchester conurbation and 16% for Merseyside. There is a block of NCAs above the 50% cover mostly associated with the major cities and surrounding areas. The top 20 NCAs are all above 80% cover.

% woodland Cover – by far the highest is the Border Moors at 42.8%, but this predominantly conifer plantation as this area contains Kielder forest. The other two high woodland cover areas are South Cumbria Low Fells (15.8%) and Morecambe Bay Limestones (12.8%) with far more of a mixture of native and conifer plantation. These are both well above the 6.67%

regional average, there are 8 NCAs that sit above this figure, with the lowest being 0.8 % cover for the Howgill Fells, surprising for a very rural and upland area.

% Cover of Ancient Woodland sites – these sites are ones that have been in continuous woodland cover since the last ice age. They are extremely important, non replaceable with the richest biodiversity. They give a good indication on how communities have valued and managed woodlands in the past. The 2 NCAs with significantly higher than average cover are South Cumbria Low Fell (7.06%) and the Morecambe Bay Limestones (6.35%). The other higher areas in the region of 2% cover are mostly in Cumbria and the Pennines. These sites should be, where feasible, expanded with appropriate planting around them to allow them to be buffered in the light of climate change.

Number of top 20 National Ranks for BAP habitats (by area) for NCA – this data indicates how important the area is for habitats in the national context. The data is derived by looking at each habitat and listing the top 20 NCAs that have this by area. An area such as the Yorkshire Dales has 11 national important habitats, indicating that this area is a mosaic and not just rich in one single habitat but many different ones in significant proportions. It has to be acknowledged that the larger CA have greater possibility of getting high scores.

Percentage cover of BAP Inventory (not woodland) – here we list the cover of BAP Inventory habitats, these give a good indication at this regional scale of semi natural vegetation cover. With the understanding that the greater cover of habitats the more likely the an area will be resilience. It would also be useful in the future to think about the condition of these habitats .

Percentage of SSSI (Sites of Special Scientific Interest) in NCAs – these are considered our best sites and consequently have greater protection. These data give a good indication of the health of an area, with higher percentages indicating a more resilient landscape. The results for this attribute vary from the North Pennines (46.8 % of area) to very low percentage covers around Manchester with no or very small single sites in the NCA.

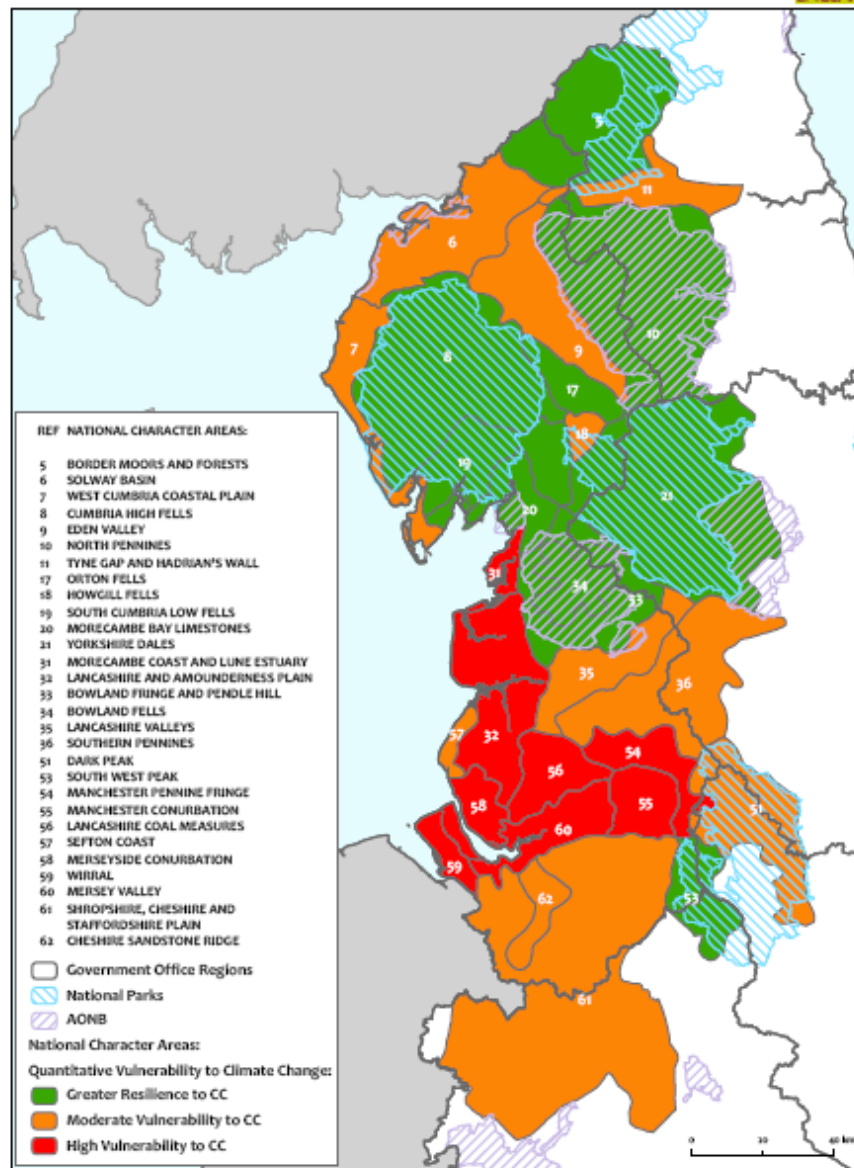
Percentage of LFA (Less Favoured Area) in CA – the LFA is an area considered to be of poorer agricultural land, set up to provide farmers a support mechanism where physical conditions are hard. The nature of these areas mean that an extensive farming system is the general rule. These areas have a higher percentage of semi- natural vegetation, and semi-improved grasslands that are not of BAP habitat quality but will deliver more benefits than more improved system. Mostly these areas are in the uplands and the use of this data set attempts to bring in some of the benefits of a less intensive system.

Percentage of Agri- environment schemes in the NCA – this data set was included to look at active management. Agri – environment schemes run for 10 years and have had a number of major changes and different schemes in this time.

A data set was used that expresses the agri–environment spend of all schemes in a pounds per hectare (Ha) format. In any single hectare where more money is spent, the greater the amount spent on capital works and habitat improvement, the higher the likelihood of improved adaptation. This information is then totalled across the individual NCA. These are expressed as a percentage of the area to reduce the effect of larger NCA areas seeming to have greater adaptation.

Map 5.2

North West Region: Natural Environment Vulnerability to Climate Change
Quantitative – data led vulnerability assessment



Based upon the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office. Cover: Copyright. Unauthorised reproduction is illegal. Cover Copyright and may be used in full proceedings. Natural England, 2015.

Areas at relative higher vulnerability from Climate Change (red)

The areas picked out here by the data are often the most built up along the Mersey valley between Liverpool, Wirral and Manchester conurbations up into the Lancashire plain and Preston and Wigan urban areas. They have lower amounts of BAP vegetation and woodland cover.

Character Areas: Morecambe Coast & Lune Estuary (31); Lancashire and Amounderness Plain (32); Lancashire Coal Measures (56); Wirral (59); Merseyside conurbation (58); Manchester Conurbation (55) Mersey Valley (60); Manchester Pennine Fringe (54);

Areas of relative moderate vulnerability to Climate Change (yellow)

This categories can be split into three broad groups. Some similarities exist between similar landscapes but in different locations, valleys such as the Lancashire, Eden and Tyne all sit

within these areas and are of similar type of landscape. The upland areas of South Pennines, Howgill Fells and South West Peak no one factor is significantly lower in these areas. The last grouping is the Cumbria & Lancashire coastal NCAs and Cheshire plain and ridge. These have greater agricultural management with lower semi-natural vegetation covers.

Character Area: Eden Valley (9); Lancashire Valleys (35) Sefton Coast (57); Tyne Gap and Hadrian's Wall (11); Cheshire Sandstone Ridge (62); Howgill Fells (18); South Pennines (36); Dark Peak (51); Solway Basin (6); West Cumbria Coastal Plain (7); Shropshire, Cheshire & Staffordshire Plain (61);

Areas of greater relative resilience to Climate Change (green)

Predominantly upland areas with high levels of woodland and other semi-natural habitats, often associated with our designated landscapes.

Character Area: North Pennines (10); Bowland Fells (34); South West Peak (53); Cumbria High Fells (8); Yorkshire Dales (21); South Cumbria Low Fells (19); Bowland Fringe and Pendle Hill (33); Orton Fells (17); Morecambe Bay Limestones (20); Border Moors & Forests (5);

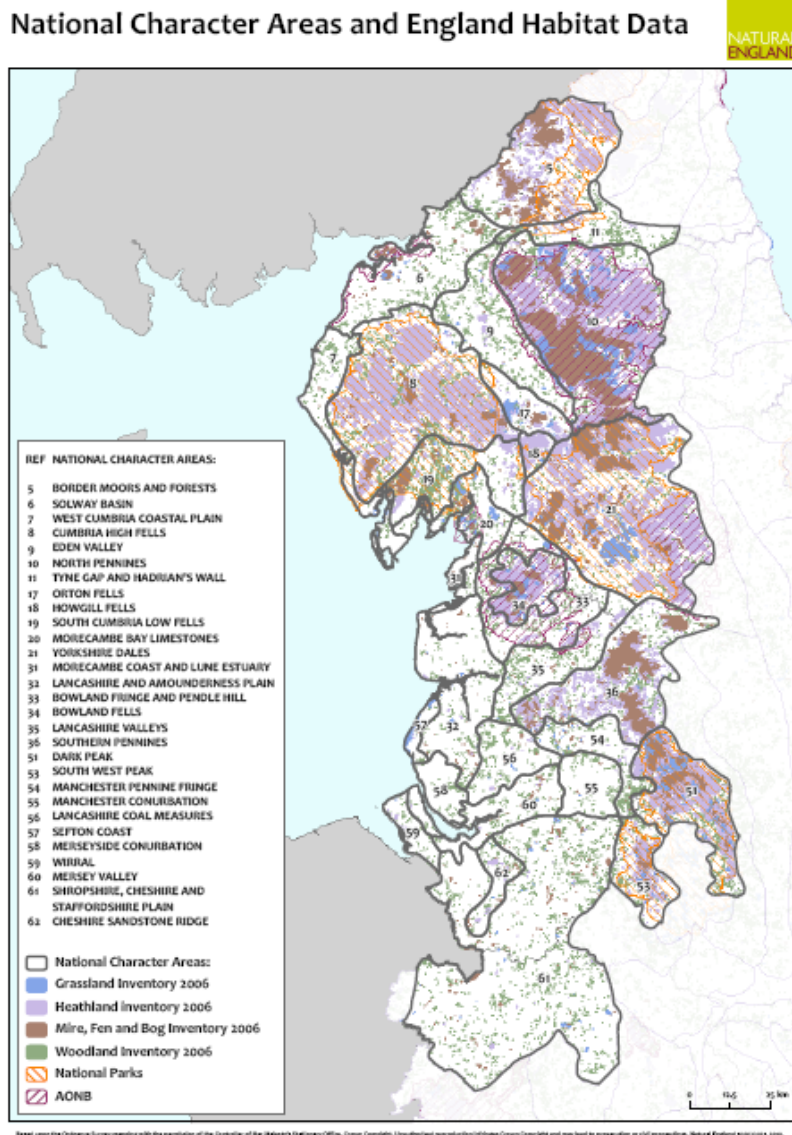
Table 5.2 – Quantitative Results Tables

NCA name	JCA No.	% LFA	NW Rank	% SSSI area in C	NW Rank	% cover of Ancient woodland	NW Rank	Agri Env % cover of Ha	NW Rank
BORDER MOORS AND FORESTS	5	100.0	1	13.4	11	0.18	25	30.2	19
SOLWAY BASIN	6	12.5	18	8.0	15	1.04	10	68.3	6
WEST CUMBRIA COASTAL PLAIN	7	22.4	17	6.7	17	1.03	11	52.2	11
CUMBRIA HIGH FELLS	8	95.4	8	18.0	6	2.67	3	51.4	12
EDEN VALLEY	9	0.0	23	2.7	21	2.62	4	43.6	14
NORTH PENNINES	10	99.7	5	46.8	1	0.43	18	74.1	3
TYNE GAP AND HADRIAN'S WALL	11	60.6	14	7.0	16	0.56	16	71.2	5
ORTON FELLS	17	95.1	9	13.2	12	1.32	8	89.7	1
HOWGILL FELLS	18	100.0	1	17.9	7	0.43	19	60.7	8
SOUTH CUMBRIA LOW FELLS	19	93.3	11	6.0	18	7.06	1	80.5	2
MORECAMBE BAY LIMESTONES	20	43.9	16	17.7	8	6.35	2	43.1	15
YORKSHIRE DALES	21	99.0	6	29.6	4	0.29	22	60.0	9
MORECAMBE COAST AND LUNE ESTUARY	31	0.7	20	14.2	10	0.23	23	23.2	24
LANCASHIRE AND AMOUDERNNESS PENINSULA	32	0.0	23	2.7	21	0.16	26	41.1	16
BOWLAND FRINGE AND PENDLE HILL	33	68.7	12	3.1	20	1.57	6	71.7	4
BOWLAND FELLS	34	99.9	4	39.1	3	0.69	14	38.1	17
LANCASHIRE VALLEYS	35	63.0	13	0.1	27	1.61	5	27.6	20
SOUTHERN PENNINES	36	94.0	10	17.6	9	0.80	13	26.4	21
DARK PEAK	51	98.7	7	13.0	13	0.22	24	61.8	7
SOUTH WEST PEAK	53	100.0	1	46.7	2	0.93	12	47.0	13
MANCHESTER PENNINE FRINGE	54	53.2	15	0.1	27	1.21	9	3.9	29
MANCHESTER CONURBATION	55	1.7	19	0.0	29	0.39	20	4.8	28
LANCASHIRE COAL MEASURES	56	0.3	22	0.5	25	0.43	17	14.2	25
SEFTON COAST	57	0.0	23	24.3	5	0.00	28	8.1	26
MERSEYSIDE CONURBATION	58	0.0	23	0.4	26	0.00	28	8.0	27
WIRRAL	59	0.0	23	9.1	14	0.04	27	30.3	18
MERSEY VALLEY	60	0.0	23	3.5	19	0.30	21	25.5	23
SHROPSHIRE, CHESHIRE AND STAFFORDSHIRE PLAIN	61	0.4	21	0.9	24	0.67	15	58.9	10
CHESHIRE SANDSTONE RIDGE	62	0.0	23	1.8	23	1.56	7	25.8	22
Average cover		48.4		12.6		1.20		42.7	

5.3 Habitat Network Analysis of CA in North West Region

This work also looked at the England Habitat Network (English Nature, 2006) which splits networks up into broad groupings: woodland network; heathland network; grassland network and the amalgamation of Mire Fen Bog (which combines Fen habitats, Lowland Raised Mosses & Blanket Bogs into one category as they are all peat based systems).

Map 5.3.1



Areas at relative higher vulnerability from Climate Change (red)

Woodland is the only habitat that appears to be present in anything close to what could form a network outside isolated areas such as on the lowland peats of the Solway mosses.

Character Areas: Eden Valley (9); Morecambe Coast & Lune Estuary (31); Lancashire and Amounderness Plain (32); Wirral (59); Merseyside conurbation (58); Manchester Conurbation (55) Mersey Valley (60); Manchester Pennine Fringe (54); Solway Basin (6); West Cumbria Coastal Plain (7);

Areas of relative moderate vulnerability to Climate Change (yellow)

Often have remnant networks that with targeted response have the potential to be restored into a functioning network.

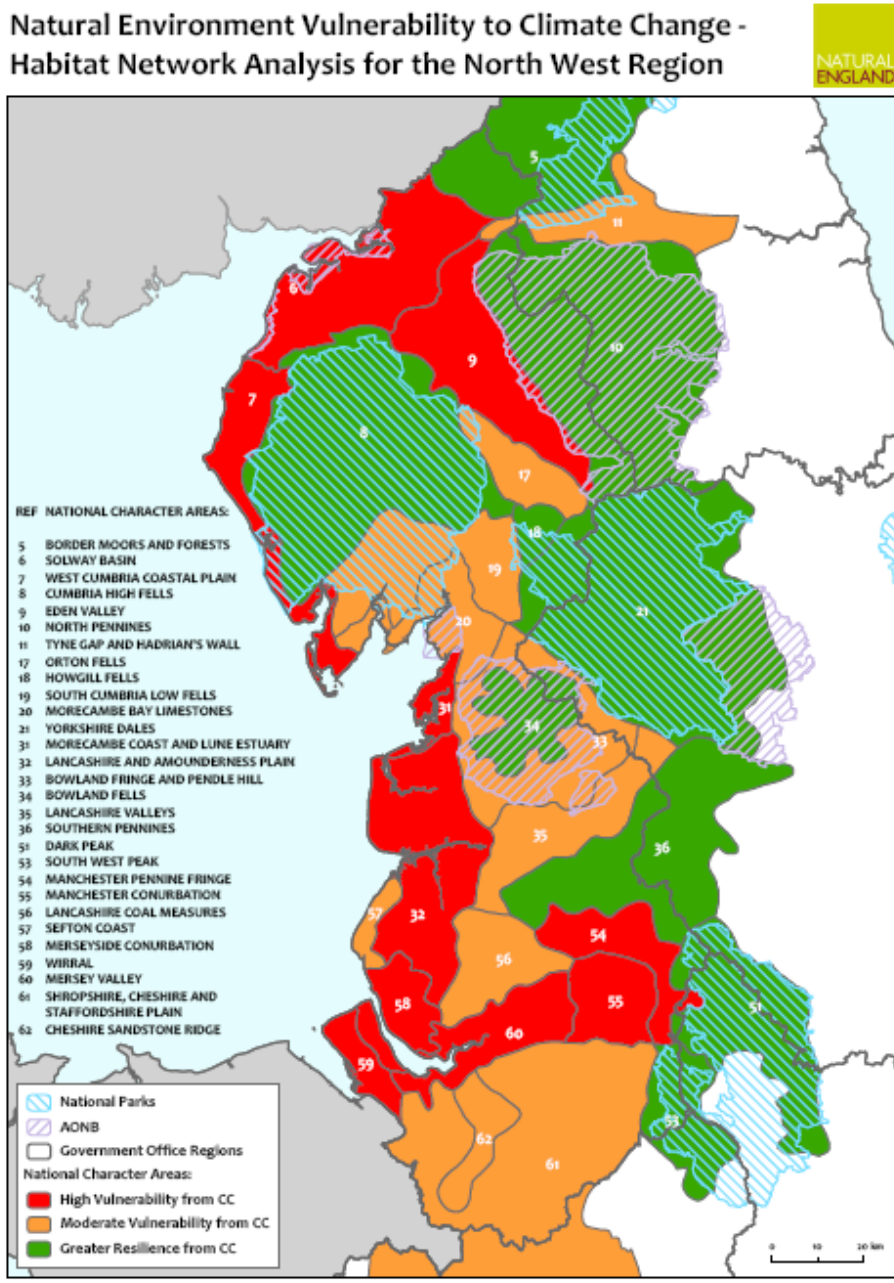
Character Area: Lancashire Valleys (35) Sefton Coast (57); Tyne Gap and Hadrian's Wall (11); Cheshire Sandstone Ridge (62); Shropshire, Cheshire & Staffordshire Plain (61); Morecambe Bay Limestones (20); South Cumbria Low Fells (19); Orton Fells (17); Bowland Fringe and Pendle Hill (33); Lancashire Coal Measures (56);

Areas of greater relative resilience to Climate Change (green)

These areas are well served with habitat networks with at least one complete functioning network present.

Character Area: North Pennines (10); Bowland Fells (34); South West Peak (53); Cumbria High Fells (8); Yorkshire Dales (21); Border Moors & Forests (5); South West Peak (53); Dark Peak (51); South Pennines (36); Howgill Fells (18);

Map 5.3.2



5.4 Combination of three NCA vulnerability approaches.

No NCA had a highly vulnerable area with a green area, the results were largely compatible with NCAs moving up or down a vulnerability score but at no point moving from top to bottom, this implies the methods were complimentary rather than contradictory. The use of the three study approaches also reinforced aspects of each other, but accepts that each different approaches had strengths, that the others did not always possess. It is also the case that some approaches left out aspects of vulnerability as they were not represented well in the data sources.

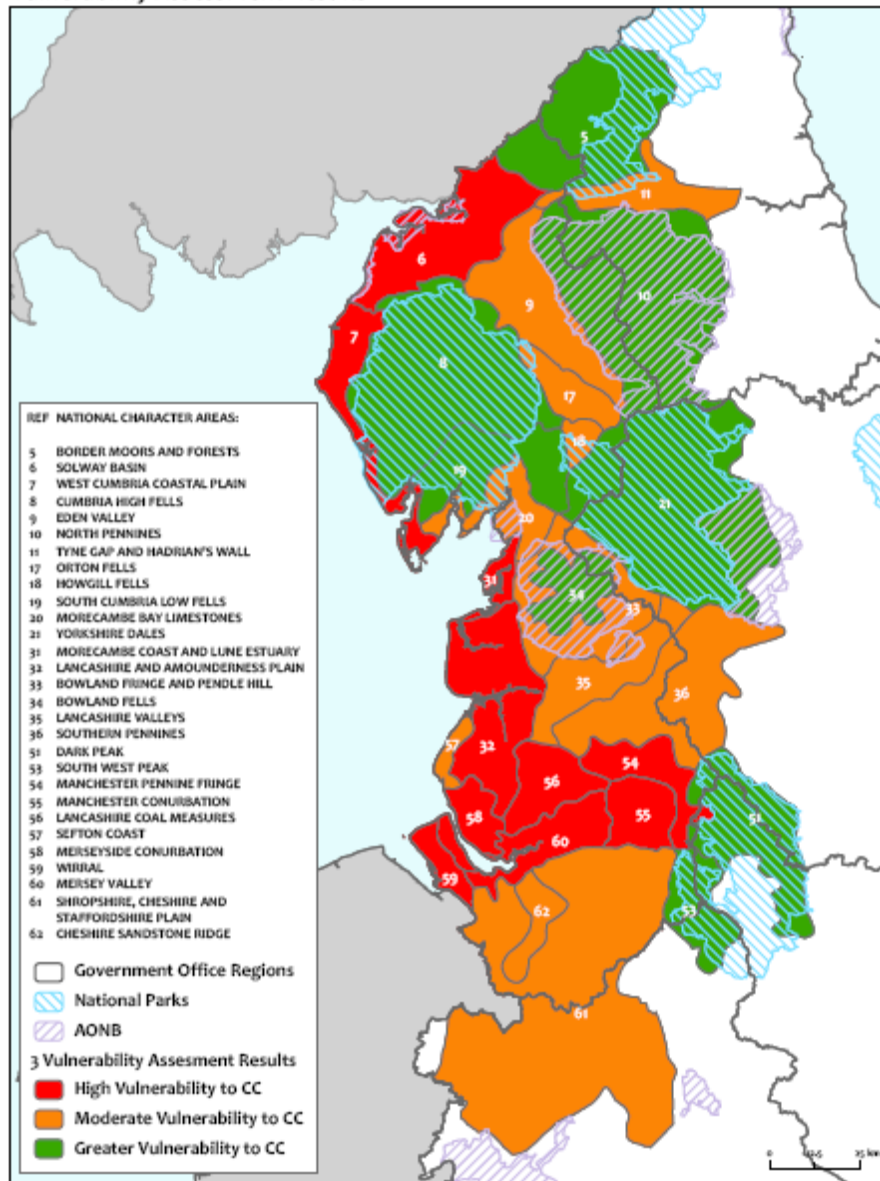
Table 5.4 – Final results table for Character Areas in the NW

JCA No.	NCA name	Total area (ha)	Sort category
8	CUMBRIA HIGH FELLS	199007	1 all green
10	NORTH PENNINES	214563	1 all green
21	YORKSHIRE DALES	239984	1 all green
34	BOWLAND FELLS	37395	1 all green
53	SOUTH WEST PEAK	86605	1 all green
5	BORDER MOORS AND FORESTS	127156	2 two green - one yellow
19	SOUTH CUMBRIA LOW FELLS	69140	2 two green - one yellow
51	DARK PEAK	42568	2 two green - one yellow
17	ORTON FELLS	29281	3 one green - two yellow
18	HOWGILL FELLS	10360	3 one green - two yellow
20	MORECAMBE BAY LIMESTONES	39966	3 one green - two yellow
33	BOWLAND FRINGE AND PENDLE HILL	74090	3 one green - two yellow
36	SOUTHERN PENNINES	119715	3 one green - two yellow
57	SEFTON COAST	8989	3 one green - two yellow
9	EDEN VALLEY	80956	4 all yellow
11	TYNE GAP AND HADRIAN'S WALL	43424	4 all yellow
35	LANCASHIRE VALLEYS	55424	4 all yellow
62	CHESHIRE SANDSTONE RIDGE	22042	4 all yellow
61	SHROPSHIRE, CHESHIRE AND STAFFORDSHIRE	366247	5 one red - two yellow
6	SOLWAY BASIN	98350	6 two red - one yellow
7	WEST CUMBRIA COASTAL PLAIN	49293	6 two red - one yellow
54	MANCHESTER PENNINE FRINGE	39295	6 two red - one yellow
60	MERSEY VALLEY	44718	6 two red - one yellow
31	MORECAMBE COAST AND LUNE ESTUARY	13211	7 all red
32	LANCASHIRE AND AMOUDERNNESS PLAIN	98594	7 all red
55	MANCHESTER CONURBATION	34223	7 all red
56	LANCASHIRE COAL MEASURES	40584	7 all red
58	MERSEYSIDE CONURBATION	28679	7 all red
59	WIRRAL	16516	7 all red

The table above shows how the results were amalgamated together from the three assessments to give the overall conclusions about the vulnerability of the natural environment in the NW. These were then represented in the 3 categories for mapping. The top eight getting a green vulnerability from Cumbria High Fells through to the Dark Peak; The middle groupings of yellow from Orton fells to the Shropshire, Cheshire plain all got a medium vulnerability. With the lowest ten getting high red vulnerability scores.

Map 5.4

North West Region: Natural Environment Vulnerability to Climate Change Overall Conclusions 2010 Map: by Amalgamation of Three Vulnerability Assessment Results



Based upon the Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright. Unauthorised reproduction of this Crown Copyright map is prohibited in all proceedings. Natural England, 2010.

The overall results show that many of our protected landscapes are often also our most resilient areas. In fact all the green areas above have a National Park or AONB within the NCA. The most highly at risk areas correspond with our most built up areas, but also form a significant barrier to movement of species up through the North West. The low lying and coastal locations are also at high risk from sea level inundation and habitat degradation. They do have a significant potential to recreate habitats and landscapes so improving this situation. The moderate areas are often in a state that with a little more resource input they may be able to be moved to a less vulnerable state.

6.0 Discussion

It is an important consideration that this work looks at the relative impacts across the North West. All areas will be under severe pressure due to climate change and are going to need adaptation of the natural environment so that species and habitats that presently occupy an area can adapt or move with the changing climate. The geographical unit of the Character Area was chosen. However, other geographic units such as Natural Area, River Catchment, Local Authority Boundary, Landscape Description Unit, National Parks or AONBs could be used with this methodology and potentially meaningful results.

The following section discusses what was found in each of the three separate parts to this investigation; the Qualitative vulnerability assessment; Quantitative vulnerability assessment and habitat network analysis of each NCA.

6.1 Discussion on Qualitative vulnerability assessment

When looking at the natural assets, there are some we can influence and others that we cannot. Coastal location, topography and soil diversity are set attributes not possible to influence or change. But others such as vegetation diversity and land cover can be influenced and changed in future, through taking future opportunities that will become available. This study has tried to highlight differences within the region at the NCA scale to get further understanding of where to do more in depth work to expand our understanding of how climate change will affect different part of our region's natural environment.

Larger NCAs seem to come out as being more resilient, areas such as the Yorkshire Dales and Cumbria High Fells, cover big areas and so have a larger number of assets within them. Smaller NCAs such as the Howgill Fells, which sits between these two larger NCAs, has similar topography, but is significantly poorer in assets. It is difficult here to determine the degree to which size influences resilience compared to the other two being some of the richest areas of natural environment in the country.

6.2 Discussion on Quantitative vulnerability approach.

The attributes described above were readily available and chosen for their ability to highlight the resilience of the area to climate change. We also looked at other attributes such as the cultivated land area and data on general pollution (that would reduce the capacity of the area to cope with climate change) but discarded these on either supplementing existing data or being too general to separate areas.

It is clear that using the ranking of attributes, that as more data sets are added, any one single set of figures has less influence on changing the overall outcome of the results. Some areas may well be characteristically strong in half the attributes and very weak in others, this may give an unclear reading, although it would give a middle ranking, which may represent the area well.

In this study all attributes were given equal weighting but as we progress our understanding may well decide that some are more key to an areas resilience than others.

In comparison with the criteria led analysis some areas do significantly better than in the criteria – led assessment, such as the Morecambe Bay Limestones, the Orton Fells.

It does highlight where our best areas are in terms of woodland cover, BAP habitats, etc. but is not so strong on the negative impacts e.g. coastal inundation. Designated landscapes still all do well in comparison to our low lying coastal areas which are far more developed and have intensified land use.

6.3 Discussion on habitat Networks

Much of this analysis is a very quick summary of what is a far more complicated and in-

depth area of work than this analysis can do justice to (see Catchpole, R.D.J. ,2008). It is clear though that habitat connectivity is key to climate change vulnerability and so a idea of how each NCA differs or functions was imperative in any analysis.

The Network data also analysed land use from satellite data (Landcover, 2000), this works on the premise that some land use like acid grassland in the case of the heathland network is far more permeable than other land use like improved grassland for species. This is backed up with good research data at the local scale. In our analysis there was some questions raised over the Howgill Fells NCA. This area has very little heathland habitat remaining within it, but due to the mosaic of acid grassland, as a predominantly complete network of heathland, it is likely that this is not as extensive a network as the data implies.

The Mire/Fen/Bog network data includes a large proportion of the blanket bog habitats which would be a far more functioning habitat network within the heathland network. In the lowlands some of the fen habitats may function better with the grassland network than the more heather dominated communities.

In all these cases the analysis took the data at face value and did not start to adjust the results in the light of more in-depth local knowledge, as this may cause a bias in the results where the author may not be so familiar with other local circumstances.

Data Gaps and inaccuracies

On the Orton Fells area, a limestone ridge with extensive areas of limestone pavement interspersed with limestone grasslands with heathland on the deeper soils. There are a number of good patches of habitat with a large blank area in between. On closer investigation this area is the Great Asby National Nature Reserve an area of very good limestone pavement and grassland. This highlights that the BAP inventories that are used within this study are still far from perfect. The land use satellite data also struggles to determine the difference between acid and calcareous grasslands. Both these sets of data have more recently been updated and when available in summer 2010 a new run of this assessment will be run.

There are also habitats that are very useful to aid species movement like scrub and hedgerows, small woodland that we do not have in any national (or regional) format that could be applied across the region. These gaps will also be true of the quality of the habitats we have. As an area with good quality hedges will function very differently from an area that is highly flailed and gapped hedge environment with little useable habitat for species.

6.4 Discussions on the combined assessments.

The results were amalgamated together from the three assessments to give the overall conclusions about the vulnerability of the natural environment in the NW. These were then represented in the high vulnerability, moderate vulnerability and greater resilience to climate change.

The overall results show that many of our protected landscapes are often also our most resilient areas. In fact all the green areas above have a National Park or AONB within the NCA. The most highly at risk areas correspond with our most built up areas, but also form a significant barrier to movement of species up through the North West. The low lying and coastal locations are also at high risk from sea level inundation and habitat degradation. They do have a significant potential to recreate habitats and landscapes so improving this situation. The moderate areas are often in a state that with a little more resource input they may be able to be moved to a less vulnerable state.

Overall Discussion

Species movement into the south of the North West region is likely to be in through North

Wales and up along the Pennine fringe (Gilchrist, 2009). This makes the Wirral area along the Mersey corridor and the Manchester fringe into the Sefton coast key areas to allow species to move up, though in this analysis of the NCA's they seem to be some of the most poorly connected.

The high vulnerability areas are mostly isolated patches within fragmented landscapes which do not have the potential to join up. It is generally thought, in the literature, that to ever get these to reconnect into a functioning network would be very costly and mostly undesirable for the gains it might make. Concentration should be given to getting existing sites into the best condition and buffering these.

The moderately vulnerable areas do not have a functioning network but are often remnants of a recently functioning network and with a concerted effort would allow the reestablishment of at least one network. The major action in these areas is to focus on getting at least one network re-established through a targeted approach to restoration and recreation of communities.

The least vulnerable areas have at least one functioning network from the data and often more than one with the potential for re-establishment of others. The focus here is on strengthening weak links in existing networks and reconnecting areas that are remnants of old networks.

We also need to consider the wider linkages between areas, and to consider the ecological limits of soils and climate (i.e. you cannot ecologically recreate habitats to get complete networks in all places due to biological limits). Actions need to be clearly prioritised in order to avoid networks competing for space.

There may also be mechanisms such as targeting species movement pathways, for example by targeting greater agri-environment spend onto a particular river valley that connects areas. Or creating areas where organic farming is incentivised, as this would allow more favourable conditions and greater potential for species movements through these areas. The Weaver Valley Park in Cheshire gives a good framework where greater integration and benefits could be obtained for species movements within the wider benefits of this project.

As a region we are at the forefront of much of this work through the Cheshire Econet project which has already started to implement how this would work in practice.

http://www.cheshirewestandchester.gov.uk/environment/srep/nhe_econet_ecointro.aspx

More detailed impact and adaptation assessment at individual NCA scale, using the vulnerability assessment methodology Natural England has developed through its latest set of NCA scale vulnerability studies (an updated and improved version of the methodology used in the Cumbria High Fells) of six areas, two from each risk category, would produce more in depth adaptation response strategies and ground truth this regional approach. The results from this more in-depth work using 'local technical experts' may well be able to be used to extrapolate out some of the results into other areas in future. An area such as the Sefton Coast CA, which contains the largest area of sand dune habitat, may have results that could be applied to the other sand dune systems in other CAs not initially in the six CA studied

7. Conclusions & Recommendations

The Natural Environment of the North West Region will go through many changes in the future not just due to climate change but also through other drivers of change. This assessment does not try to consider these factors and how these are likely to change or improve vulnerability but accepts that our understanding of these changes is key.

Any adaptation of the natural environment should follow the overarching principles of sustainable adaptation (Smithers et al. 2008, Macgregor & Cowan, 2010).

The natural environment is changing in the light of climate change, this is not something that can be solved in the short term and much of the change is locked in due to historic and future emissions of carbon dioxide. This change is now unavoidable and as such we need to work with these changes and not against them. This makes it essential that the natural environment of the region is allowed as much opportunity to become as resilient as possible. This involves working together in a joined up, coherent way to achieve healthy natural systems that connect well together and function ecologically. To achieve this there is a need to:

- ❖ Retain what habitats presently exist, getting them in the best condition possible as quickly as possible. Our focus while maintaining SSSI condition needs to switch onto improving habitat condition for the wider BAP habitats.
- ❖ Allow rivers and coast to operate in as natural a way as possible, within unavoidable constraints, by providing them space.
- ❖ Minimise non climate pressures such as pollution and development onto habitats much of which is outside the statutory designations will if allowed to happen continue to undermine the natural environments ability to adapt to climate change.
- ❖ Expand the amount of naturally functioning natural habitat to reduce the areas vulnerability.
- ❖ Create a long term view of how habitat connectivity can be improved and strengthened within the North West Region.
- ❖ Recognise that adapting our natural environment will have wider benefits to society, through greater green infrastructure as a whole and help to improve our ecosystem services functions. That to understand the changes that we will be seeing from climate change we need good long term data sets that monitor species change at the same site and over time

Land use pressures will increase in the next 20 years; with an increasing population and standards of living meaning more food is required, loss of land through coastal inundation and the fact that much of the north west climate will be in fact be getting more favourable for food production due to climate change. This is in contrast where the majority of the major food production areas of the world will be reducing production. This makes it very import that we start to discuss about how we use land in the North West and plan for the future use as much as possible. Allowing space for natural systems to function is an important part of this, but needs to be integrated into other key land uses.

The results from this assessment highlight that attributes such as coastal location, vegetation structure & diversity, topography and hydrology do make certain areas more or less vulnerable to the impacts of climate change. Certain of these attributes will change in future and others are set and not possible to vary. Our designated landscapes all seem to

have a higher resilience but it is not clear if this is due to 60 years of greater resource input, that their higher landscape appreciation and value is due to the greater amount of features historically being present or due to greater topographical variation of these landscapes.

It is also clear we have a potential win – win in terms of adapting our natural environment and locking in carbon by restoring many of our peat and especially our lowland moss and fen based systems. With approximately 40% of these nationally in the North West giving out large amounts of greenhouse gases, it will be essential to move very quickly to lock this carbon back into the soil. This action will also help us adapt some crucial areas particularly of the lowland Lancashire peat, and will have the added advantage of filling in the coastal link up from the Sefton coast into the Ribble Estuary.

It needs to also be clear that some climate change mitigation measures if not implemented to the benefit of the natural environment have the potential to severely undermine the ability of the natural environment to adapt in the light of climate change.

Much of the present work done by varied bodies throughout the region already deliver a large amount of adaptation for the natural environment in the north west. These climate change adaptation actions are commonly not done for these reasons, but are now being understood for their wider benefits. Natural England is starting to bring examples of this under its 'Adaptation Underway' area of work.

This analysis has looked at information on what is present at this point in time, which will be updated in future. It would be possible to look at future implementation and consider how this would adjust the vulnerability of an area. This might include changes in agriculture, forestry & woodland planting targets with delivery of BAP targets for restoration.

- ❖ The NW Biodiversity Partnership has done opportunity mapping for expansion of BAP habitat. It would be quite possible to run this analysis with the presumption that this has been implemented and see how this would affect the vulnerability of an area to climate change. This would give a good indication as many habitats will only be restorable in certain locations due to ecological constraints.
- ❖ The Forestry Framework has proposals to significantly increase tree cover this needs to be focused on connecting and buffering habitats in key areas and routes.

This project has looked briefly at habitat connectivity and can see that an agreed approach of the future direction of where we should start to create species movement pathways through our region should be started;

- ❖ We should be looking to create a number of natural environment pathways up through the North West region. For example a coastal route from Wales up through the Wirral and Sefton coast on through the Fylde and up into Morecambe Bay for terrestrial species associated with the coastal zone; a route that builds onto the Cheshire Econet which comes up the Cheshire Sandstone ridge and up through the Mersey Valley and Lancashire Coal measures; and a route to run up the Pennine chain on our eastern side.

Much of the focus to create healthy natural systems and allow space for restoration of new habitats has great advantages to us as a society, through greater recreational and tourism potential. It also will strengthen our ecosystem services and so deliver wider benefits. It is

clear from this study that our most popular areas for recreational and tourism are some of the most likely to be less vulnerable to the impacts of climate change.

Amalgamation results of three assessments

This work is very much about trying to re-evaluate where we should focus effort particularly in a political and economic climate that is likely to be seeing greater resource squeeze. It is considered that areas of moderate vulnerability has the greatest potential to be moved into a more resilient state. But the position of CA is also important and some strategically positioned locations such as the Mersey Valley, Wirral key parts of the large plains of Cheshire & Lancashire would also seem key places to consider.

This project has tried to bring together readily available information and apply it to the National Character Areas of the North West to make an initial assessment of how vulnerable the natural environment is to climate change. This is the first time such an assessment has been taken in England in any region. We are still in the early stages of building our understanding to how our natural environment will change and adjust in the coming decades to climate change; however, we hope these results will help inform future conservation projects and partnerships in the North West

7.1 Next Steps for Vulnerability Assessments in the Region

Other approaches to climate change vulnerability assessment

This approach has looked at landscape functionality through the NCAs and how likely they are to be affected by climate change. It is quite possible to approach a vulnerability assessment of the natural environment in the north west region through a number of other approaches. This section discusses the advantages and disadvantages of other approaches and how they may add to our understanding. It is the intention to work on a number of these aspects over the coming years to build our understanding further.

The six phase 2 CA studies in the NW region

To increase our understanding further and test some of the findings from the work written up here six further studies have been started in the region two in each risk group. These will use the phase 2 pilot guidance developed on from what was learnt in phase 1.

The final CA studies are on; the Solway Basin, Morecambe Bay Limestones, North Pennines, Lancashire & Amounderness Plain, Bowland Fells, Bowland Fringe & the Sefton Coast. This is very much a Partnership approach with NE facilitating a diverse range of partnerships to do these studies. The results of these will then be looked at to see if we can take this in-depth and geographically specific knowledge and apply it to other areas in the region, perhaps using the landscape framework if it is usable in this format. If further funding is forth coming we may look to do other CA in the region as partnerships or we provide capacity and continue to increase our understanding.

Vulnerability of Habitats

This approach looks at each habitat in the region individually to understand how at risk from climate change they may be. For example plant communities like mountain heathland which are at the tops of mountains and so with hotter and dryer summers will be under greater stress will be highly vulnerable to climate change. Others like grasslands will be far less vulnerable. This could be mapped across the region. The disadvantage of this approach is that some habitats in different geographical locations will have different vulnerabilities. A

habitat such as lowland heathland that occurs on the coast and inland may be highly vulnerable due to sea level rise or reduction in coastal microclimates at the coast than those inland which will experience more change.

Vulnerability of Soils

The soils of the region have a number of different attributes and are likely to be more or less vulnerable to climate change. In the National Impacts Templates some work on assessing how vulnerable the different soil types are to climate change (down to soilscape level). These could then be classified into high, medium or low vulnerability and mapped at a regional level to see if we have areas of higher risk or where they might occur spatially. This does not take into account location, which would also influence the results.

Slope and soil types against vulnerability due to location (tops of mountains and Coastal) would also be important to consider in vulnerability.

The North West Landscape Character Framework & Vulnerability of Landscape types

The regional landscape framework splits the region into different landscape types (see below), and has been developed as a result of the European Landscape Convention over the last two years in the NW. It is envisaged that taking the work to date it would be possible to vulnerability assess the landscape types and then look at how different locations might be more or less vulnerable within this framework. This will give a different more in-depth breakdown of vulnerability and so build our understanding further.

Priority Map

A map showing those CAs where the priority is to increase habitat, those where we should increase quality of existing habitat, and those where we should strengthen services by targeted restoration.

A Partnership Way forward.

The vulnerability to climate change of the regions natural environment is crucial to many sectors of life from clean water, farming, cooling our cities, climate regulation and our tourism economy to name a few. To build our understanding and help implement this ongoing process Natural England welcome thoughts, comments, data and other projects that support this process. We already are working with many regional partnerships to deliver these finding if you would like more information or can offer further support please feel free to contact ian.crosher@naturalengland.org.uk .

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