Community Climate Change Adaptation

A proposed model for climate change adaptation and community resilience in a rural setting

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'Over many years of work all over the world, I've learned that if we organize in the same way that the rest of life does, we develop the skills we need: we become resilient, adaptive, aware, and creative. We enjoy working together. And life's processes work everywhere, no matter the culture, group, or person, because these are basic dynamics shared by all living beings."

Margaret Wheatley, Finding Our Way: Leadership for an Uncertain Time (2007)

ACTion with communities in cumbria

champions community and rural issues

ACT is the community development organisation and Rural Community Council for Cumbria

ACT has over 60 years experience of assisting communities to achieve their aspirations

ACT successfully champions community and rural issues in Cumbria

At ACT we...

... encourage community led initiatives

... provide practical advice, support and training

... offer independent facilitation

... raise awareness of local needs to improve the relevance and responsiveness of services

... champion the interests of communities – locally, regionally and nationally

... assist communication between local people and the agencies and authorities that impact on their daily lives

... gather and use data to better understand and target our work

... assist national agencies and the private sector to deliver participative projects with communities

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Glossary of Terms

Adaptation: Initiatives and measures to reduce vulnerability to the impacts of climate change.

Anthropogenic climate change: human-induced climate change arising principally from the burning of fossil fuels since the Industrial Revolution.

Carbon: Though a chemical element, the term carbon is often used in the context of climate change to refer to carbon dioxide or, more generally, greenhouse gas emissions. The term is often used interchangeably with CO2.

Carbon sink: a reservoir that accumulates and stores CO2 from the atmosphere. These include natural sinks such as oceans, soils and trees/plants, as well as artificial sinks such as landfills or carbon capture and storage projects.

CO2: Carbon dioxide, the principal greenhouse gas associated with climate change.

Greenhouse gas: a gas that traps heat from the sun in the Earth's atmosphere (hence the term 'greenhouse effect'). Greenhouse gases (ghg) include carbon dioxide, methane and nitrous oxide, among others.

Mitigation: initiatives and measures to reduce greenhouse gas emissions and enhance carbon sinks.

Abbreviations

ACT: ACTion with communities in Cumbria

EA: Environment Agency

ghg: greenhouse gas

LDNP: Lake District National Park

LDNPA: Lake District National Park Authority

SFRA: Strategic Flood Risk Assessment

Executive Summary

1. Introduction

The Cumbrian floods of November 2009 were devastating for many individuals, communities and businesses. Around 1,300 homes and businesses were destroyed, there was widespread damage to roads, bridges and footpaths, and significant economic costs. This event has pushed flooding up the agenda for many communities, public agencies and third sector organisations. It has brought with it widespread recognition that climate change is now a reality in Cumbria, with extreme weather events expected to become more frequent and and more intense over coming decades.

Efforts to address climate change have so far focused primarily on mitigation, that is, initiatives intended to reduce the emission of greenhouse gases and limiting the extent of climate change. However, it has become increasingly apparent that even if we do reduce our emissions, we are nevertheless likely to experience a certain amount of climate change from historical emissions. This has led to the recognition that we must begin to adapt, reducing our vulnerability and increasing our resilience to the unavoidable impacts of climate change. There are two levels of adaptation response required to address climate change:

- **Preparation**: the development of emergency plans that can be initiated when inevitable climate emergencies occur; and
- **Prevention**: the prevention of those emergencies happening in the first place so that, for example, heavy rainfall does not necessarily result in a flooding emergency, or in water pollution.

Action with Communities in Cumbria has been commissioned by the Lake District National Park Authority to prepare a model for climate change adaptation and community resilience planning in a rural setting – the Ullswater catchment in Cumbria. This report provides an evidence base for identifying climate change risks relevant to the Ullswater valley, and links this to concerns raised during direct community engagement. It identifies a range of possible responses that might help the community to become more resilient, from reactive community emergency planning to proactive and longer-term land management strategies. The approach used in this project is designed to be applicable to other rural communities.

The project has taken place as part of the Lake District National Park Partnership's Whole Valley Planning initiative, which is a geographical approach to partnership working, involving local people, visitors, businesses, farmers and public agencies. Valley Planning allows these different groups within a particular area to come together and agree a plan for the future of their valley.

While the primary focus of the report is climate change adaptation, the range of possible responses outlined here are designed to link, where possible, with mitigation efforts, which remain a key priority for the Lake District National Park.

2. What is community resilience?

A resilient community is one which is able to respond effectively to economic, social or environmental change. In the context of climate change a resilient community is able to prepare for, respond to and recover from climate emergencies, and also adapt to the more gradual changes taking place within the wider landscape and society. In order to do this a community must be cooperative and flexible, have access to good information, and have good communication networks and high levels of social capital.

3. How is our climate changing?

There is consensus among the international scientific community that human activities (principally the burning of fossil fuels since the Industrial Revolution) are responsible for most of the warming we have seen since the middle of the 20th Century. In addition to an increase in average global temperature, there has been a marked increase in weather extremes, including heatwaves and flooding. Human-induced climate change is likely to have increased the risk of events such as the Autumn 2000 flooding in England and Wales by more than 90%.

There is little doubt that extreme weather events will become more common and more intense over coming decades, and that global temperatures will continue to rise. However, there is less certainty over how these trends will play out regionally. Most research to date suggests that the north west of England will experience hotter dryer summers, and warmer wetter winters as a result of climate change. There is mounting evidence, however, to suggest that the rapid melting of the Arctic sea ice (itself a consequence of global warming), may in fact result in colder snowier northern English winters, and possibly wetter summers, as cold moist air from the Arctic moves south.

The fact that 'global warming' may not result in straightforward warming in all areas, and that weather systems will change differently, and unpredictably, in different parts of the world, has led some to adopt the term 'global weirding' to describe the changes that climate change will bring. The one thing that is certain, though, is that our climate will become, and is already becoming, more unpredictable, and our communities must therefore adapt to cope with a wide range of possible eventualities.

4. Climate change impacts

Climate change is already having, and will continue to have, many direct and indirect impacts on our economy, society and environment. A significant amount of research has gone into identifying specific potential impacts that might occur in the UK and also locally, in the Lake District. This work has been drawn together in this report, to determine the most important climate change impacts for the Ullswater community. These have been grouped under the following key themes:

- Flooding;
- Peat bogs and soils;
- Water quality and quantity;
- Agriculture and forestry;
- Non-native species;
- Natural environment and ecosystems;

- Infrastructure and services;
- Tourism;
- Community health and wellbeing;
- Property; and
- Cultural heritage.

5. How can the Ullswater community respond to climate change?

The report identifies a set of 11 priority actions for the Ullswater valley. These are response-focussed, highlighting the adaptation and mitigation measures that could be adopted by the community to address the key climate change impacts identified:

Adapting to climate change in the Ullswater Valley:

Priority actions

1. Tree planting can reduce soil erosion, flood risk and pollution, and sequesters carbon.

Trees and other vegetation help to bind the soil, and so reduce the amount of water, sediment and nutrient pollution reaching rivers and lakes. They slow the rate of water run-off compared with most other vegetation cover. This helps to prevent flooding and water pollution, including algal blooms like blue-green algae, all of which are expected to worsen with climate change. Trees also absorb carbon dioxide, so they help to limit climate change. Landowners can earn an income from woodland creation, as there are grants available, and it is possible to sell the carbon which the new woodland will store.

2. Restoring damaged peat bogs improves their capacity to regulate and purify water, and store carbon.

Peat bogs in the northern uplands have traditionally been drained for agriculture and sporting interests. The drying out of these bogs has led to loss of vegetation and increased soil erosion, which in turn can reduce water quality and increase the risk of flash flooding. Their carbon storage potential and habitat value is also affected. Blocking drainage ditches can help restore the natural functions of peatlands.

3. Maintaining farm drainage, and keeping drains clear of debris, can help reduce flood risk

Landowners can help alleviate flooding and waterlogging by maintaining their drainage infrastructre. Local people can also help to keep drains in their area free of leaves and other debris, thereby reducing the risk of surface water flooding.

4. Improving water storage and distribution and minimising water use can help summer droughts

Droughts are expected to become more common over coming decades. This could lead to competition between locals, tourists, agriculture and the natural environment for increasingly scarce water resources. Water consumption can be minimised through maintaining farm water storage and distribution systems,

installing low-flow devices in showers and taps, placing a brick in toilet cisterns and reducing water wastage.

5. Reducing surface water run-off into rivers and lakes helps prevent water pollution

If water containing silt and nutrients runs into watercourses, it poses a threat to freshwater species and can lead to algal blooms. Planting trees, restoring peat bogs, avoiding soil compaction and over-grazing and maintaining footpaths can all help to reduce soil erosion and run-off. Optimising the application of fertilisers and using phosphate-free laundry detergents can also help reduce pollution.

6. Improving habitats can enhance biodiversity and increase the resilience of the naural environment to climate change

Climate change is likely to result in the earlier timing of spring events (e.g. egg-laying), the northward and upslope migration of species and habitats, an increase in non-native species and habitat damage. Protecting, expanding and linking existing habitats, and maintaining a diverse landscape, could enhance biodiversity and increase the ability of natural systems to adapt to a rapidly changing climate.

7. Improving public transport system, and providing work spaces in the valley, could reduce disruption during extreme weather

Climate change is likely to increase disruption to transport, supply chains, emergency services and communictions networks from flooding and other extreme weather events. An improved and integrated public transport system, which makes use, when possible, of boat transport, could reduce reliance on road access, improve the visitor experience and reduce transport-related carbon emissions. Providing local communal work spaces would reduce the need to leave the valley to work.

8. Flood-proofing properties

Flooding events will continue to become more common over coming decades. Floods can damage properties and businesses, increase insurance premiums and pose a risk to people's physical and mental health. Installing flood-protection measures in at-risk properties during renovations – for example, solid flooring, durable kitchen units, and high-level electrical wiring, sockets – can reduce the impact and help in the recovery.

9. The use of natural insulation in traditional buildings can prevent condensation, reducing the risk of respiratory illness

Installing conventional insulation in buildings designed to 'breathe' can cause condensation and mould build-up, which can lead to respiratory illness. This is likely to worsen with the projected increase in prolonged periods of wet weather. The use of natural, breathable insulation, such as sheep's wool or wood fibreboard, which regulates air and moisture, can improve air quality and

health and maintain building integrity. These products generally have a lower carbon footprint than their conventional counterparts.

10. Preserving key local services helps to maintain strong communities

Successful adaptation to climate change will require strong community cooperation, which in turn requires good social links between community members. Local services, such as schools, post offices and pubs, form an important part of the social fabric of any community, and so preserving these is critical.

11. Sourcing of local food and drink can support local producers, increase resilience and reduce carbon emissions

Climate change, particularly global water shortage, is likely to disrupt global food production and result in food price volatility, resulting in an increasing need for local food production. Developing a market for local produce by supporting local producers could help to increase self-reliance within the valley and reduce emissions associated with food transport.

A photo of the Ullswater valley, annotated with these priority actions, has been developed as a visual tool to accompany this report. It is intended that it be displayed in public places within the valley. It can also be accessed via the ACT website.

6. Community engagement

Two meetings with the Ullswater community have been held so far, as part of the Valley Planning process. Eight key themes emerged from this process as being of particular importance. These are:

- Managing the environment;
- Water;
- Employment & Economy;
- Sustainable tourism;
- Heritage;
- Community Services;
- Public Transport, parking and roads; and
- Housing.

These themes link closely with the key climate change impacts identified in this report. This provides a good basis from which to engage the community further on community-led climate change adaptation and mitigation responses.

7. Conclusions and next steps

This report has demonstrated a clear need to address climate change risks in Ullswater, and presents a range of responses that could be developed by the community (in particular landowners and farmers) in conjunction with the relevant agencies, to deliver both mitigation and adaptation outcomes. It provides a model that is widely applicable across other rural communities.

The report recommends a number of next steps to ensure the model is used by communities in both Ullswater and other rural areas in the Lake District, Cumbria and beyond:

- Assemble a climate change working group, consisting of agencies and members of the local community, to drive forward and oversee the use of this model in Ullswater. This group will be part of the wider Valley Planning initiative being trialled in Ullswater;
- Use of an annotated photo of the Ullswater valley (produced as part of this project) as an engagement tool for communities;
- The Lake District National Park Partnership could include the model within their Valley Planning approach across all Lake District valleys;
- ACTion with Communities in Cumbria could take the model to the community resilience sub-group, seeking support for rolling out the approach across Cumbria; and
- The Lake District National Park Authority will disseminate project learning among local, regional and national networks and other relevant organisations, including other national parks.

1. Introduction

ACTion with Communities in Cumbria (ACT) has been commissioned by the Lake District National Park Authority to prepare a model for climate change adaptation and community resilience planning in a rural setting. This report represents the evidence-base, from which a community-led plan can be developed. Funding for the project has been provided by Defra.

1.1 Background

The following provides an overview to the history of the project and how it came into being.

1.1.1 Community Resilience 2010-2012

This model has benefited from the Big Lottery Funded Flood Recovery and Community Resilience Programme 2010-2012, coordinated by Cumbria Council for Voluntary Services. Within this programme, ACT produced the Ten Step Community Emergency Plan[1], held a key 'Power for Change' conference [2], and formed a new Community Resilience sub group linked to the Cumbria Resilience Forum. The Terms of Reference of this group included providing endorsement and expertise for initiatives such as this model.

1.1.2 Community Engagement in Ullswater 2011-2013

A catchment-wide approach to community engagement with Ullswater began in December 2011 through an informal meeting with parish council representatives (from Barton, Dacre, Martindale, Matterdale, and Patterdale), ACTion with Communities in Cumbria (ACT), and the Lake District National Park Ranger. The scope and potential of a cluster approach to issues and challenges shared by all the parishes was discussed, and an 'in-principle' agreement to go ahead with more formal engagement was made. This was followed up in April 2012 with a gathering of the parishes, again with a workshop which identified concerns and needs. This prepared the ground for the adoption of the Ullswater Catchment as a Lake District National Park pilot for valley planning, the results of which have contributed evidence to this model.

1.1.3 Borrowdale Community-led River Management Case Study

In April, 2010, ACT was asked to facilitate and support a community and multi-agency group to undertake research and development of a new approach to limiting flood risk on the River Derwent and its tributaries in Borrowdale. This resulted in the delivery of a report – Whole Valley Planning, Borrowdale: A River Management Plan (June 2011)[3] – and the formulation of a set of learning points which influenced the development of the Lake District National Park Partnership's valley planning initiative. A case study of the Borrowdale project is provided in Appendix 1.

1.1.4 Valley Planning

Valley Planning – or as it is also known, Whole Valley Planning – was initiated in Borrowdale following the devastating floods of November 2009. Another community-based valley planning initiative, stirred by extreme visitor management and car parking challenges, began in Wasdale in 2012. Ullswater was selected to be a pilot for this

community-led valley planning approach in 2013, because the catchment is more typical of most other catchments in the Lake District; it has a distinctive range of assets, and carries a range of challenges and opportunities which allow more general learning from valley planning to be shared with other valley communities. The description of valley planning used by the Lake District National Park Partnership is as follows:

> Valley planning will set out what people want to see happening in their area in the future. It is a geographical approach to partnership working that will improve delivery of community aspirations. By involving local people, visitors and businesses it will establish what they want to change, keep the same or improve in their area. The process will include:
>
> - People who live in the area
> - Local businesses and farmers
> - Parish Council
> - Visitors to the area
>
> Valley planning will interpret the National Park Vision at a local level. The Vision states that the ambition for the national park is to be "A place where its prosperous economy, world class visitor experiences and vibrant communities all come together to sustain the spectacular landscape, its wildlife and cultural heritage".
>
> The Lake District National Park Authority is getting members from the community and members of the partnership together as part of this initiative. These include local specialist interest groups as well as other established locality working groups. They will identify what is important by reviewing existing evidence from an area. Examples include visitor surveys, housing and employment surveys, and community plans. It is essential that this project compliments other activity in the area. A working group will develop in the area to take forward ideas that people agree on. We or any one of our partners may have a role in delivering part of the plan in the future. There will be more details on who is doing what once the plan has been developed [4]

The Friends of the Lake District have also recently produced a document entitled Whole Valley Planning: A Guide for Communities (2013).[5]

1.2 Project aims and objectives

This project aims to establish a model for climate change adaptation and community resilience planning in a rural setting.

It brings together three crucial strands of work within the National Park and Cumbria:

- The **Cumbria Local Resilience Forum**, which has a Strategic Objective to "develop a strategy for progressing community resilience at a local level";
- The development of a **community-led 'valley planning'** approach, which aims to give a clear picture of what the community wants for its future, to inform activity in the area. Valley Planning is a Strategic Priority for the Lake District

National Park Partnership, a partnership of twenty-four organisations who work together to achieve common aims for the National Park;

- The **Low-carbon Lake District Initiative**, which provides a strategic response to climate change across the National Park.

Community resilience is increasingly seen as a tool for adaptation which can convert, at times and places which match the journey towards resilience, into mitigation. This project will look at two interrelated aspects of climate adaptation and resilience:

1. **Prevention**: what can be done to mitigate the worst effects of climate change? For example, what land management practices help to control erosion and limit runoff, thereby lessening flooding? How can buildings and infrastructure be designed or adapted to make them more resilient to future climate effects?
2. **Preparedness**: how can an area respond to a sudden climate impact, such as flooding, high winds, heavy snow or a prolonged period of drought? What plans can be put in place in advance? Work has been done in this area by the Local Resilience Forum (LRF) and this work will be the starting point for the project.

The project will pilot the approach in Ullswater, with a view to rolling it out to other valleys, if successful. The project objectives are:

- To establish a model for climate change adaptation and community resilience planning in a rural setting.
- To strengthen links between the community resilience strategy of the LRF and the Lake District's valley planning process.
- To develop a robust approach to prevention, mitigating the worst effects of climate change and extreme weather events (eg through land management, buildings and infrastructure)
- To develop and test responses to sudden climate impacts, such as flooding or high winds, in an upland rural area.
- To engage with local, regional and national stakeholders, using networks of organisations working on climate adaptation and community resilience.

The specific project outputs will be:

- This report, which presents the evidence base, and provides a reference document, from which an adaptation model can be developed;
- A detailed stand-alone executive summary of the report, to be accessible to a wider community audience;
- A community-facing map or photo of the valley, to include headline messages highlighting key climate change impacts and possible responses;
- Two community engagement workshops, the findings from which have been summarised in this report;
- The formation of a specific climate change working group (to include members of the community and agency representatives) to progress the model in Ullswater;

- Proposed application of model to other catchments in the Lake District and Cumbria; and
- Dissemination of the findings to the North West Climate Change Partnership and other interested groups (including other National Parks).

1.3 Ullswater: community, place and economy

1.3.1 Community

The profiles for the five Ullswater parishes of Barton, Dacre, Martindale, Matterdale, Patterdale can be accessed through the Cumbria Observatory and provide information on population, age structure, household composition and tenure, car ownership and general health:[6] The published data for 2001, reproduced in Table 1, below, provides this summary for Ullswater Parishes:

Table 1: Summary data for Ullswater parishes

Parish	Population	Proportion of population over 45	Owner Occupation	Lone Pensioners	Long Term Illness	Proportion with no car
Barton	232	45%	72%	16%	15%	7%
Dacre	1326	45%	72%	16%	16%	8.5%
Martindale (not a parish)						
Matterdale	526	45%	73%	14%	18%	7.2%
Patterdale	460	45%	70%	17%	16.5%	16%

1.3.2 Place

The following description is taken from the current World Heritage Site nomination document[7].

Ullswater valley contains most of the landscape ingredients which typify the essential character of the Lake District. In its lower sections, Ullswater has relatively wide vistas but these quickly reduce towards the valley head where high crags surround the lake and the smaller side valleys. Ullswater is the second largest of the lakes after Windermere and has a distinctive dog-leg shape, with three distinct reaches over its 14.5 km length. This pattern is a result of glacial scouring of the valley bottom which now forms the bed of the lake, leaving three discrete basins. The uppermost stretch of Ullswater, around Patterdale, is oriented north-south. The middle section, from Silver Point to Kailpot Crag is oriented east-north-east to west-south-west and the lower section of the lake, to its outflow into the River Eamont, is aligned north-east to south-west.

The topography of the valley is varied due to distinct differences in the underlying geology. The land surrounding the lower lake, from Howtown to Pooley Bridge and along the northern shore from Glencoyne to Watermillock comprises gentle slopes

down to the lake, covered in good soils which form the basis of the rich lakeside pastures. This is based on the more easily eroded geology of the Skiddaw Slates and contrasts with the harder, jagged mountain scenery surrounding the upper lake. Here, a series of small glacially formed valleys splay out like fingers to the west (Glencoyne, Glenridding, Grisedale, Deepdale) to the south (Dovedale) and on the east (Boredale, Bannerdale and Martindale). The small and picturesque lake of Brotherswater covers part of lower Dovedale.

The northern end of the valley opens out into more rolling open country which also includes a number of small but prominent and shapely fells such as Dunmallard Hill, Great Mell Fell and Little Mell Fell. The latter two are formed from localised conglomerate geology.

Ullswater provides a major route of access into the central Lake District from Pooley Bridge at its northern end. The principal road follows the northern shore to Patterdale at the head of the lake, and then rises over the heights of Kirkstone Pass to Ambleside and Troutbeck. The route northwards out of the valley joins the natural east-west route of communication between Penrith and Keswick and there are minor routes both east and west from Ullswater over high ground to adjacent valleys.

In the upper valley a number of large becks flow down the fell sides via the side valleys to feed Ullswater. The River Eamont exits from the northern end of Ullswater to join the River Eden east of Penrith. Other notable natural features include the waterfall at Aira Force on the north side of the lake and the various small tarns in the surrounding fells, including Angle Tarn above Hartsop, Grisedale Tarn, Red Tarn below Helvellyn and Hayswater (dammed to form a small reservoir).

The Ullswater valley also has extensive areas of native woodland, much of it in former medieval parkland on the northern shore. These include the north facing slopes of Glenamara Park at the head of Ullswater, which provides a spectacular view of the lake, and the ancient parkland around Glencoyne. There is also significant native woodland on the southern shore, below Birk Fell, Hallinhag Wood and in Barton Park. There are also areas of conifer plantation around Pooley Bridge, at Swinburn's Park and around Patterdale Hall.

1.3.3 Economy

Tourism is the biggest industry in the area, followed by agriculture and forestry. The profile for Ullswater based on 2001 data (and therefore for guidance only) was as follows:

- 11% of population in full-time jobs
- 32% in part-time jobs
- 24% self employment
- 11% unemployed
- 18% retired
- Employment 1: Hospitality
- Employment 2: Agriculture & Forestry

Currently, in 2013, a good pre-contract agreement for broadband is in place which will offer significant benefits for the rural economy.

2. What is Community Resilience?

This summary of community resilience is based principally on the following texts:

- Norris, Stevens, Pfefferbaum, Wyche and Pferffbaum (2007) Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness; and
- Wilding and Nick of Carnegie UK Trust - Fiery Spirits Community of Practice (2011) Exploring Community Resilience in Times of Rapid Change.

2.1 Community Resilience as a cultural development

Cumbria has a remarkable tradition in social capital (sense of community, place and participation) and has demonstrated, over the centuries, flexible resources and adaptability when confronted with extreme weather events or livestock disease or government policies inimical to rural life and work in the uplands. The story of the remarkable persistence of Cumbrian hill farming over at least a thousand years is a journey of family and community resilience across generations.

Community Resilience is a metaphor; it has taken the term 'resilience' and transferred its meaning into a process, a journey as distinct from an outcome. It is distinguished by its transformational character and in order to be dynamic and beneficial, it requires the following:

- Social Capital (sense of community and place, participation)
- Flexible resources (robust, rapid, and creative; diversity=strength)
- Adaptability rather than stability
- Active super-networking
- A credo; a clear goal and directions with creative thinking about pathways between these:
    - Inclusive, creative culture
    - Cross-community links
    - Localised economy within ecological limits
    - Healthy, engaged people

'…community resilience has extraordinary value as a strategy for disaster readiness. Unlike many stressors, disasters happen to entire communities. Members are exposed together and must recover together. At minimum, if their aim is to build collective resilience, communities must develop economic resources, reduce risk and resource inequities, and attend conscientiously to their areas of greatest social vulnerability. They must engage local people in every step of the mitigation process, create organisational linkages and relationships in advance of disasters, and boost and protect naturally occurring social supports. They must plan- but also plan for not having a plan, which means that community organisations must appreciate flexibility, develop decision-making skills, and cultivate trusted sources of information. In a nutshell, disaster readiness is about social change.' [8]

Community resilience is shaped then, by contemporary circumstances, and in our own region, the twinned challenges of climate change and economic depression; climate related events are happening unpredictably, and the financial resources are not available to deal with these.

Community resilience as a cultural phenomenon comes to the foreground as an asset when communities are confronted with the unknown unknowns; when they need to be planning for situations where there is no plan; and then when they engage with the complex, profound, and time-varied requirements of recovery.

2.2 Community Resilience (hazard mitigation, emergency and recovery)

The practical core of community resilience in upland Cumbria requires the concentration of diminishing resources on foreseeable events and 'at-risk' communities.

Always, the formula will be: how do we create and support a readiness which will allow expensive institutional emergency services to go where the need is greatest in terms of risk and population; and this does mean, in Cumbria, that the remotest communities, often in the valleys and uplands, will need to take on the resilience challenge.

2.3 Communities of place

In Cumbria, communities with shared geographical boundaries, histories and futures are typical and widespread. These are, unless otherwise stated, the communities referred to in this model.

2.4 Communities of practice

'Since the beginning of time, human beings have shared cultural practices reflecting their collective learning: from a tribe around a cave fire, to a medieval guild, to a group of nurses in a ward, to a street gang, to a community of engineers interested in brake design. Participating in these 'communities of practice' is essential to our learning. It is the very core of what makes us human beings capable of meaningful knowing.'
(Wenger, Communities of Practice and Social Learning Systems, Sage Publications, 2000).

So, in Cumbria, the Cumbria Resilience Forum, and the Communities Resilience sub Group are communities of practice, as are the Lake District National Park Partnership. Third sector organisations like ACTion with Communities in Cumbria and Cumbria Council for Voluntary Services fundraise in order to devote time and resources to coordinating communities of practice with communities of place.[9]

3. How is our climate changing?

3.1 Recent changes and human influence

The greenhouse effect is caused by the trapping of heat in the earth's atmosphere by greenhouse gases (principally carbon dioxide and methane). The Earth's natural greenhouse effect makes it over 30^0 C warmer than it would be otherwise, making it habitable for humans. However, the increased greenhouse gas emissions from human activities (in particular the burning of fossil fuels) since the Industrial Revolution have enhanced the natural greenhouse effect.

Though the climate has always been subject to natural variation (as we see from day to day), the Intergovernmental Panel on Climate Change (IPCC) – the internationally recognised authority on climate change – concluded that the rapid rate of change witnessed over the last few decades is unprecedented (the warmth of the last half century is unusual in at least the previous 1,300 years [10]). Furthermore, it stated that "most of the observed increase in global average temperatures since the mid-20th century is very likely [i.e. probability of greater than 90%] due to the observed increase in anthropogenic [i.e. human-induced] greenhouse gas concentrations" [11]. This is demonstrated in Figure 1, which shows a comparison between global average surface temperature taking into account a) both natural and human factors; and b) natural factors only (solar and volcanic activity). It is clear from these graphs that only by including human factors do the models fit with actual observed temperatures.

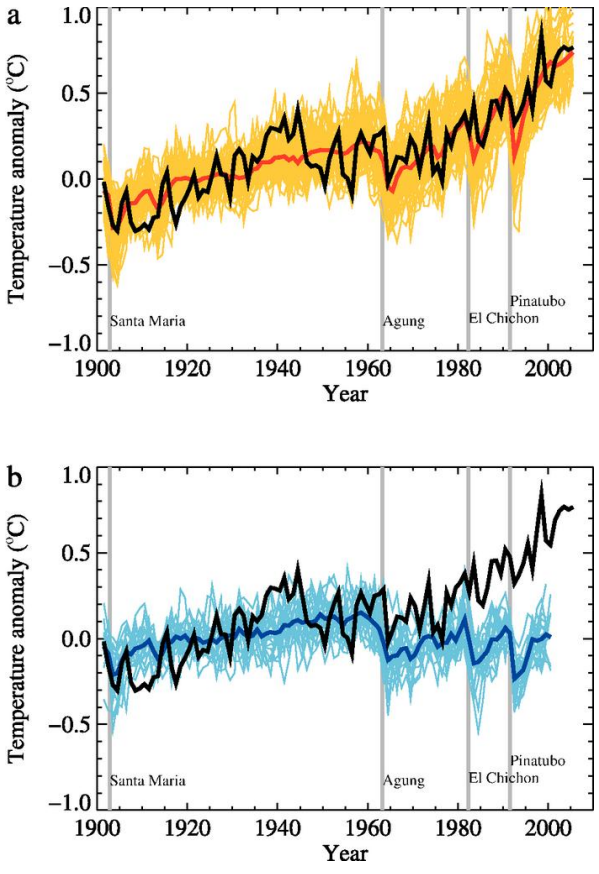

Figure 1: Comparison between global average surface temperature taking into account a) both natural and human factors; and b) natural factors only (solar and volcanic activity) [12]. The black line on each graph refers to observed global average surface temperatures over the 20th century (the figures given on the y-axis are relative rather than actual temperatures). In graph a) the observed temperature is compared against computer simulations that take into account both natural (e.g. solar radiation and volcanic eruptions) and human influences on the climate, with the red line representing the average. Graph b) shows the observed temperature compared against simulations that take into account only natural factors (the average represented by the blue line).

The European Environment Agency (EEA) has recently published a report on climate observations in Europe [13]. Among its findings were that:

- the last decade (2002-2011) was the warmest on record (land temperatures 1.3°C warmer than pre-industrial average);
- heatwaves have increased in frequency and duration;
- precipitation has decreased in southern Europe and increased in Northern Europe;
- Arctic sea ice was at record lows in 2007, 2011 and 2012, falling to nearly half the minimum extent seen in the 1980s;
- melting of the Greenland ice sheet has doubled since the 1990s;
- glaciers in the Alps have lost ~2/3 of their volume since 1850; and
- global average sea level has risen by 1.7mm/year in the 20th century, and by 3mm/year in recent decades.

In the UK, new climate records have also been set; the Spring of 2011 was the warmest on record [14], while the Met Office has confirmed that 2012 was the wettest year on record for England [15].

In addition to changes in average climate conditions, there has been a marked increase in weather extremes. No computer simulation can conclusively attribute a specific extreme weather event to climate change[16]. Nevertheless, scientists are now able to demonstrate a probabalistic link between individual events – or an increase in their number – and the human influence on climate[17] [18]. Using a probabalistic approach, researchers estimated that it is very likely (confidence level >90%) that human influence has at least doubled the risk of an event like the 2003 European heatwave[19]. More recently researchers have found, by generating thousands of models, with and without human influence, that human-induced greenhouse gas emissions are 'very likely' to have increased the risk of the Autumn 2000 flooding events in England and Wales by more than 20%, and 'likely' to have increased the risk by more than 90% [20].

3.2 Future climate projections

3.2.1 Global projections

Climate change is predicted to result in increasingly hot average global temperatures, widespread melting of snow and ice, rising sea levels, and more frequent extreme weather events, including droughts, heatwaves, floods, forest fires and tropical storms[21] [22] [23]. Precipitation projections are for an increase in the monsoon regions and at mid-high latitudes, and a decrease in the sub-tropics[24]. Temperature increases are predicted to be highest at the poles and, in particular, the Arctic[25]. Sea level rise is very likely to continue at a rate of at least 0.2m each century based on thermal expansion alone[26], but could rise by as much as 0.5-1.4m by 2100[27].

There is broad international consensus that measures should be taken to limit the global mean temperature rise to 2°C, in order to avoid 'dangerous' climate change[28]. However, many climate scientists believe there is now little or no chance of achieving

this[29] [30]. Some scientists have suggested a 4°C rise could be possible by the end of the century [31] [32], while other research points to a possible 6°C rise [33] [34].

3.2.2 UK and North West projections

Although sea levels, temperatures and precipitation are all set to rise globally, the regional changes in climate are not so easy to predict – especially changes in precipitation (rainfall and snow)[35].

The UK Climate Projections [36] use past climatic data to provide information on how the UK's climate might change over the remainder of this century. It acknowledges the uncertainties in predicting future climate by giving a range of possible climate outcomes. They suggest a general UK trend towards hotter drier summers and warmer wetter winters is most likely, but there is a wide range of uncertainty associated with these projections. Table 2 indicates the projections for the North West of England. It includes the three probability levels – bottom, central and top (i.e. 50% probability of being the central estimate, and 10% probability of being less than the bottom or more than the top estimates). The medium emissions scenario is often used as a best-estimate of likely climate outcomes. However, estimates are included here for both the medium and high emissions scenarios, in recognition of the belief among many climate scientists that we are heading for the high emissions scenario [37].

The figures show an increase in average winter and summer temperatures of up to 4.8°C and 7.3°C, respectively, by the 2080s, with an increase in the average daily maximum and minimum temperature of up to 10.1°C and 7.8°C, respectively, over the same period. It also suggests that the North West could become, on average, between 10% wetter and 12% dryer by the 2080s, with winters projected to become between 3% ad 50% wetter, and summers between 0% and 51% dryer. It is clear from these figures that there is a wide range of uncertainty associated with the estimates, which illustrates the difficulty in predicting future climate due to the huge number of variables that must be taken into account.

Table 2: UKCP09 north west climate projections for the medium and high emissions scenarios [38]

Period	Likely range of estimate*	Increase in winter mean temperature (^{0}C)		Increase in summer mean temperature (^{0}C)		Increase in summer mean daily maximum temperature (^{0}C)		Increase in summer mean daily minimum temperature (^{0}C)		Change in annual mean precipitation (%)		Change in winter mean precipitation (%)		Change in summer mean precipitation (%)	
Emissions scenario:		Medium	High	Medium	High	Medium	High	Medium	High	Medium	High	Medium	High	Medium	High
2020	Bottom	0.5	0.3	0.6	0.6	0.4	0.5	0.5	0.5	-5	-6	-1	-4	-23	-19
	Central	1.2	1.2	1.5	1.5	1.9	1.9	1.5	1.4	0	0	6	4	-8	-5
	Top	2.0	2.0	2.5	2.5	3.5	3.3	2.6	2.5	6	6	14	13	9	10
2050	Bottom	1.0	1.2	1.2	1.5	1.0	1.3	1.0	1.3	-6	-7	3	3	-36	-37
	Central	1.9	2.1	2.6	3.0	3.3	3.8	2.5	2.9	0	0	13	13	-18	-18
	Top	3.0	3.3	4.1	4.7	5.8	6.5	4.4	4.9	6	8	26	27	1	2
2080	Bottom	1.4	1.9	2.0	2.5	1.6	2.3	1.6	2.2	-8	-10	3	9	-43	-51
	Central	2.6	3.1	3.7	4.7	4.8	6.0	3.7	4.6	0	1	16	26	-22	-28
	Top	4.0	4.8	5.9	7.3	8.3	10.1	6.4	7.8	8	12	34	50	0	-2

* Range considered ‘very unlikely’ (i.e. 10% probability) to be less than the bottom estimate or more than the top estimate

In contrast to the UKCP09 estimates for warmer winters and hotter summers, there is mounting evidence that the decline of Arctic sea ice has played a critical role in recent cold and snowy winters at mid-latitudes [39]. It has been suggested that Arctic sea ice loss – caused by warming in the region – could be altering atmospheric circulation patterns in the Northern Hemisphere (effectively pushing cold air southward) and raising the risk of anomalously cold European winters[40] [41] [42] [43]. Furthermore, the increased moisture content in the air from melting sea ice could be resulting in heavier snowfall in Europe[44]. This process could also lead to cooler, wetter summers on average in the UK[45] [46]. This research is ongoing[47], and there is certainly no consensus on this issue among scientists yet. If true, however, despite the apparently contradictory message for regional climate change it is consistent with an overall pattern of increasing global temperatures.

Notwithstanding the difficulties in predicting regional variations in climatic change, the recent trend of increases in extreme weather events – in particular flooding and heatwaves – will undoubtedly continue. The IPCC[48] concluded that "it is very likely [i.e. probability of greater than 90%] that hot extremes, heat waves and heavy precipitation events will continue to become more frequent". UKCP09 projections suggest that, whatever happens with average precipitation, it is likely to fall as more intense events[49]. This is supported by the recent research on Arctic sea ice melting, which suggests an increase in higher frequency extreme weather, including hot extremes[50]. The evidence for changes in storminess is not as conclusive as it is for other extremes – indeed, future wind speeds, for example, are not included in the UKCP09 projections[51] – but based on observed trends and basic physical concepts it is nevertheless plausible to expect an increase in storminess[52].

The term 'global weirding' has been adopted by some to acknowledge the fact that 'global warming' will not necessarily result in straightforward warming in all areas, rather that weather systems will change differently in different parts of the world, and that those changes will often be unpredictable and based on several potential feedback mechanisms. Our climate will become (indeed is already becoming) more unpredictable, and our communities must therefore adapt to cope with a wide range of possible climatic eventualities.

4. Climate change impacts

Climate change is undoubtedly one of the greatest threats currently facing us. It is already having, and will continue to have, many direct and indirect impacts on our economy, society and environment. The UK Climate Change Act 2008 (UK Parliament, 2008) introduced a legally binding framework for tackling climate change. It includes a requirement for a UK-wide Climate Change Risk Assessment (CCRA) to be carried out every five years, and the subsequent preparation of a National Adaptation Programme to respond to the identified risks. The recently published CCRA [53] presents an evidence-based assessment of the main risks and opportunities to the UK from climate change over the remainder of this century and is, at present, the most comprehensive review of its kind. This project responds in part to the findings of the CCRA, but also to the more specific work carried out across the Lake District by various agencies over recent years. It should be noted, however, that the potential impacts identified in the CCRA are based largely on the broad climate outcomes from the UKCP09 projections – warmer wetter winters and hotter dryer summers (though it does not rule out the possibility of changes outside the ranges given). As we have seen, there is mounting evidence that the UK's climate might in fact become cooler, at least in the short term, in response to the melting of Arctic sea ice, so this must be borne in mind when identifying possible impacts and responses.

4.1 Overview of work on impacts to the Lake District and North West of England

A significant body of research has been carried out into the potential impact of climate change on the Lake District. Natural England carried out a study in 2009, which identifies impacts to the landscape and natural environment in the Cumbria High Fells Character Assessment Area, the majority of which falls within the lake District National Park[54]. Their more recent Character Area Climate Change pilot project was carried out to ensure that decision-making takes proper account of impacts on the natural environment, communities and their livelihoods. The project also aimed to identify the local responses required to safeguard the natural environment in the area.

The LDNPA published its Low Carbon Lake District report [55] which identifies a range of climate change impacts to all aspects of the National Park. The focus of this report was primarily climate change mitigation. The Lake District Partnership Plan[56] recognised the social and economic implications of climate change: greater demand for water from other parts of the UK and greater pressure on land for agriculture, energy crops and building. It distinguished between the changes that will immediately affect residents and visitors and those that will be more gradual or subtle, such as the loss of species and habitats, but whose cumulative effect could radically alter the look and feel of the Lake District.

The findings of the recent CCRA have been extrapolated to determine climate change risks and opportunities relevant specifically to the North West of England[57]

and the Lake District National Park[58]. The latter found the key potential impacts to the Lake District to be:

- Extreme weather events, including more intense winter rainfall;
- Migration of habitats to higher altitudes and resulting loss of vulnerable species;
- Loss of indigenous species, and an increase in non-native species;
- Changes to rivers and lakes (water levels, water quality and nutrient status);
- Increased water resource requirement;
- Changes to woodlands (storm damage and drought);
- Drying out of peat; and
- Accelerated erosion and landslips.

A list of potential climate change impacts relevant to Ullswater has been compiled based on the assessments discussed above, and is provided in Appendix 2. The impacts are based principally on the findings of the CCRA and the Lake District Adaptation report[59]. However, some refer to specific areas in the Valley. Alongside the impacts have been added a number of possible adaptation and mitigation responses, which will be discussed further in Section 5.

4.2 Summary of key impacts on communities in Ullswater

In terms of the landscape and biodiversity, Natural England has assessed the climate change vulnerability of the Ullswater catchment as Low because, as an 'upland valley', it has a varied topography with extensive areas of high quality habitat and reasonable habitat connectivity. It suggests the main climate change implications in such areas are due to changes in water levels in rivers and lakes (i.e. greater in winter and lower in summer)[60].

There will be impacts associated with relatively gradual changes in temperature and precipitation patterns, and there will be others associated specifically with the increased frequency and magnitude of extreme weather events. Very often it is likely to be the combination of impacts that will have the strongest impact (for example several heavy rainfall events in succession could saturate the ground and overwhelm the drainage network, while hot dry summers could result in compacted ground which could prevent the infiltration of subsequent rainfall.

Sections 4.2.1 to 4.2.11 below provide an overview of the key potential impacts for Ullswater. Section 5 provides an overview of potential responses. These are summarised in Table 3. It should be noted, however, that other changes – for example to the Common Agricultural Policy (CAP), the economy, population, etc – will also interact with climate impacts and could either worsen or lessen its effect.

Table 3: Summary of impacts and possible responses to climate change in Ullswater

Issue	Impact	Adaptation response	Mitigation response
Flooding	Increased frequency and intensity of flooding (particularly in Patterdale, parts of Pooley Bridge, sections of the A592 and along Glenridding and Grisedale Becks), resulting in • Risks to physical and mental health • Damage to properties and local businesses, with consequent impact on insurance premiums and house prices • Disruption of transport, supply chains, emergency services and communications networks • Damage to visitor offer • Threat to viability of hill farms • Habitat damage • Water pollution (principally from nutrient and silt-run-off)	• Woodland planting to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Peatland restoration to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Maintenance of drains to prevent flooding • Preparation of a community emergency plan for flooding and other extreme weather events	• Tree planting and peatland restoration to enhance carbon storage capacity of the land • Developing a woodfuel economy to replace fossil fuels, through woodland planting • Create supportive environment for local business start-ups and food businesses to reduce transport of goods and workers • Develop integrated public transport network, including boat transport, to reduce need for travel (retain and increase existing amenities/work spaces and community assets in the village) • Use of natural building and insulation materials (such as sheeps wool), which generally have a lower carbon footprint than their conventional counterparts • Raise awareness among locals and visitors on the need to for climate change mitigation measures

Issue	Impact	Adaptation response	Mitigation response
Peat bogs and soils	Drying out of peat bogs and soils, and increasing heavy rainfall, reducing their potential to regulate the water cycle, store carbon, provide important habitat and grow crops	• Peatland restoration to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Reduction of stocking rates in uplands to prevent soil erosion	
Water quality and quantity	Potential reduction in water availability, coupled with increased demand, resulting in competition between locals, visitors, agriculture and the natural environment. Reduction in water quality due to warmer water temperatures and higher influx of sediment and nutrients	• Woodland planting to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Peatland restoration to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Maintenance and upgrading of farm water storage and distribution systems to prevent water leakage • Reduction of household water use • Reduction of phosphate pollution through catchment sensitive farming and use of phosphate-free laundry detergents	

Issue	Impact	Adaptation response	Mitigation response
Agriculture and forestry	Threat to agricultural productivity from increased flooding and waterlogging of land; droughts; reduction in soil quality (soil erosion, compaction and soil nutrient depletion), livestock heat stress; lamb mortality from prolonged wet periods; pests and disease (in particular bluetongue). Damage to trees from storms, droughts, waterlogging, pests, disease and wildfires	• Changes to agricultural practices, e.g. timing of lambing, control of nutrient and silt run-off from farmland • Ensure changes in agricultural practices are sustainable and that any intensification due to longer growing seasons does not impact negatively on biodiversity and soil quality • Introduction of tolerant crop, grass, livestock and tree species to reduce impact of extremes of climate and certain pests and diseases • Management on non-native species • Future-proofing of livestock housing against heatwaves and other extreme weather • Exploiting potential for local woodfuel economy and potential for longer summer growing seasons • Adopting sustainable grazing regimes, and expanding and linking existing habitats to protect biodiversity	
Non-native species, pests and disease	Warmer climate favouring non-native species, which could pose a risk to native species	• Management on non-native species	

Issue	Impact	Adaptation response	Mitigation response
Natural environment and ecosystems	Earlier timing of spring events, Upslope migration of species and habitats and habitat damage, resulting in disruption to food webs, competition for climate space and habitat fragment,ation, with possible local extinction of some species	• Raising awareness among visitors of the measures needed to respond to climate change and to protect the natural environment • Ensure changes in agricultural practices are sustainable and that any intensification due to longer growing seasons does not impact negatively on biodiversity and soil quality • Ensure careful and sustainable visitor management to prevent negative impact on natural environment (including improved / integrated public transport provision) • Management on non-native species • Adopting sustainable grazing regimes • Avoid habitat fragmentation to ensure species have best chance of shifting in response to climate change • Peatland restoration and linkage of important habitats to enhance biodiversity	
Infrastructure and services	Increased strain on drains and sewers, and disruption to transport, emergency services, supply chains, IT, communications and power supply from flooding, storm damage and extreme heat.	• Developing integrated public transport network, including boat transport, to reduce reliance on private cars and roads, particularly during extreme weather events • Establishing local ‘hubs’ from which locals can work and operate small businesses without having to travel outside the valley	

Issue	Impact	Adaptation response	Mitigation response
Tourism	Disruption to tourist trade from extreme weather and access restrictions, but potential for increased visitor numbers if summers become warmer and longer	• Developing integrated public transport network, including boat transport, to reduce reliance on private cars and roads, particularly during extreme weather events • Raising awareness among visitors of the measures needed to respond to climate change and to protect the natural environment • Educate visitors about the changing landscape and the measures necessary for the community to adapt to climate change • Reduction of phosphate pollution through use of phosphate-free laundry detergents by tourist businesses • Improve visitor offer for wet-weather activities	

Issue	Impact	Adaptation response	Mitigation response
Community health and wellbeing	Risk of injury, illness or death from extreme weather events, and of respiratory problems from mould build-up in damp houses. Increased risk of mental health problems among those affected by flooding	• Retaining of local services (e.g. post office and schools) to maintain community cohesion • Flood-proofing of properties at risk of flooding • Preparation of community emergency plan • Use of natural, breathable building materials in historic (pre-1919) buildings to prevent condensation and mould build-up and consequent respiratory health problems • Development of mutual insurance companies with insurance premiums dependent on validated community emergency plans	
Property	Increased insurance premiums for at-risk buildings and agricultural land, with insurance becoming unaffordable or unobtainable for some, and consequent impacts on mortgage markets and house prices. Increased risk of condensation and mould build-up	• Flood-proofing of properties at risk of flooding • Preparation of community emergency plan • Use of natural, breathable building materials in historic (pre-1919) buildings to prevent condensation and mould build-up and consequent degradation of building integrity and character • Development of mutual insurance companies with insurance premiums dependent on validated community emergency plans	

Issue	Impact	Adaptation response	Mitigation response
Cultural heritage	Loss of cultural heritage through potential damage to buildings (e.g. from flooding, wind driven rain and mould build-up), changes in agricultural practices and changes to inconic landscape (e.g. from changes to species and habitats to possible tree planting and renewable energy schemes designed to address climate change)	• Use of natural, breathable building materials in historic (pre-1919) buildings to prevent condensation and mould build-up and consequent degradation of building integrity and character • Protection and enhancement of landscape character through protection of habitats and species	

4.2.1 Flooding

Flooding is perhaps the most significant natural hazard facing the UK[61] , and is certainly the most visible direct climate change impact. The Cumbrian floods of November 2009 (the like of which are predicted to increase in frequency) are believed to have resulted in tourist revenue losses of ~£15.4m[62], with 73% of tourist businesses reportedly having suffered some economic loss, 15% describing the loss as major, and a further 6% suffering closure[63] [64]. Around 1,300 homes and businesses were destroyed in Cockermouth, Keswick, Ulverston, Workington, Kendal and other smaller communities, and Six bridges collapsed across the county[65], resulting in the tragic death of a policeman[66]. Flooding is an overarching issue that affects every area of the community and, as such, it is discussed specifically here, as well as in relation to other issues in the following sections.

Flooding is generally caused by heavy rainfall, and in Ullswater will fall into four categories:

- Fluvial (or river) flooding, which occurs when the volume of rainfall exceeds the capacity of a river, which then overflows or bursts its banks. This is a particular problem in steep-sided valleys like Ullswater, where the rainwater runs quickly off the hillsides and into the rivers below. This type of flooding has been identified as the predominant source of flood risk in the Lake District[67].
- Lake flooding, when high lake levels overwhelm the adjacent land. This is a particular issue on the A592 alongslide the lake.
- Pluvial (or surface water) flooding, which occurs when rainwater is unable to soak into the ground or drain away because the drains have become overwhelmed or the ground surface does not allow infiltration. The rainwater therefore accumulates at the surface.
- Sewer flooding, which occurs when heavy rain overwhelmes the sewers, or the sewers become blocked. In either instance, the sewers back up and the resulting floodwater becomes contaminated with sewage.

Flooding can become a greater problem due to cumulative weather events. For example, if heavy rainfall saturates the ground, it will be less able to cope with the next heavy rainfall event. Conversely, if a long dry spell results in compacted ground or accumulations of debris in drains, heavy rainfall will be unable to infiltrate the ground (or drains), resulting in faster surface water runoff.

The Environment Agency (EA) produces flood maps for the whole country, and delineates flood risk according to the following classifications:

- Zone 3 (high probability): areas subject to flooding up to (and including) once in every 100 years on average.
- Zone 2 (medium probability): areas subject to flooding once in every 1,000 years on average

- Zone 1 (low probability): areas subject to flooding less than once in every 1,000 years.

The EA flood map for Ullswater is presented in Appendix 3a and shows several sections of the A592 to lie within the high probability (Zone 3) floodplain, including sections around Pooley Bridge, Glenridding, Watermillock, the Outward Bound Centre and a long section between Aira Point and Glencoyne. Much of the land immediately to the east of the River Eamont (i.e. part of Pooley Bridge and some of the land to the north of the town) lie within Zone 2 and Zone 3 floodplains. Likewise, the low-lying area around Jenkins Field and Glenridding Bridge, and around Glenridding Beck, is indicated to be in a Zone 3 flood plain. In addition, large parts of Patterdale and Hartsop, and the area between the two (including the road towards Kirkstone Pass) are shown to be at risk of flooding.

A Strategic Flood Risk Assessment (SFRA) has also been carried out for the Lake District National Park to collate known sources of flooding, identify areas with a low, medium and high risk of flooding (based on EA mapping), recommend appropriate land-uses within flood affected areas and possible flood measures to prevent risk to property and life [68]. In some areas the SFRA maps may differ slightly from those provided by the EA in that they are more detailed and include the latest modelled flood extent. They also include localised drainage issues and an additional floodplain classification – Zone 3b. This is a 'functional floodplain', i.e. areas subject to flooding up to (and including) once in every 20 years on average. These areas are subject to relatively frequent flooding, which may include fast flowing and/or deep water.

SFRA maps are provided for Pooley Bridge and Glenridding, and are reproduced in Appendix 3b. No areas of functional (Zone 3b) floodplain are shown on these maps, and the floodplains broadly reflect the EA's flood mapping.

In addition to the EA and SFRA flood risk maps the EA has been preparing maps indicating areas at risk from flash flooding (i.e. where a river or stream reacts very quickly to rainfall, generating dangerous flood depths and high water flow rates that pose a threat to life). In the Ullswater catchment, maps have been prepared for Glenridding and Patterdale (see Appendix 3c). For Glenridding, the area at risk from flash flooding broadly follows the area at risk from medium probability flood events along Glenridding Beck. However, also at risk is the area around Gillside Cott and Birkside. Specific features within the area at risk from flash flooding include the sewage works and over 20 properties. For Patterdale, the flash flood risk areas fall within the area at risk from medium/high probability flood events and include the land alongside Grisedale Beck and much of Patterdale itself, including the Mountain Rescue Centre, Fire Station, Police Station and Grisedale Bridge. It also includes several properties. A full list of rapid response catchments (i.e. those at risk from flash flooding) is provided in Appendix 3d.

The EA is also currently working with County Councils across the country to develop maps for surface water flooding, though there is no timescale for completion of these

in the Ullswater Valley.

None of the flood maps currently take into account future climate change, though this is planned as part of the National Flood Risk Assessment[69]. However, as a general rule, the potential extent of an extreme flood shown on the Flood Map might in future become more 'normal' as a result of climate change. i.e. what is now a medium probability event may become a high probability event over the coming years and decades.

The key flood-related impacts that have been identified for the Ullswater valley are summarised below and also discussed in the relevant sections that follow.

- **Strain on existing drainage and sewer networks**, which will be unable to cope with the extra capacity, thereby increasing the risk of flooding.
- **Sediment run-off into rivers** - more frequent heavy rainfall is likely to increase the run-off of sediment and gravel into rivers, which in turn is likely to increase flooding still further. The fellsides around the western half of the Ullswater catchment have been identified by the Forestry Commission as generally having medium to high vulnerability to erosion, while the eastern half has generally high vulnerability (see Appendix 4a, Map 12). Furthermore, much of the catchment has high vulnerability to stream bank erosion (Appendix 4a, Map 15). Again, this is likely to increase with climate change.
- **Disruption to transport and communications networks** - flooding of transport and communication networks will have a disproportionately high impact on rural, relatively isolated communities such as those in Ullswater (particularly as the main routes into the valley, along the lake shore and from the Kirkstone Pass, are in high flood risk zones). As well as local people being unable to travel out of the valley, it is likely to disrupt local businesses and supply chains, with staff unable to get to work, goods unable to be delivered and visitors unable to travel within and to the valley. It will also disrupt the emergency services at times when they are likely to be in particularly high demand. In addition, flooding may result in the possible loss of energy and communications supply. Flooding can also be associated with landslides, which would exacerbate transport disruption if they were to occur on roadsides.
- **Reduced agricultural productivity** –flooding is likely to result in the loss of, or damage to, both low-lying grazing land and that further up the fellsides, as the land becomes more susceptible to waterlogging, and the risk of soil compaction, nutrient run-off and soil erosion becomes greater. Furthermore, prolonged wet weather and waterlogging may pose a risk to livestock, particularly newborn lambs. The loss of valuable in-bye fields with high nutrient grazing for sheep is crucial to the sustainability of the hill farming system, without which, or with reduced in-bye, the flocks cannot be fed well enough to be let out onto the high fells.

- **Damage to visitor offer**, with increased path damage, as well as damage to natural and man-made tourist assets and reduced visitor appeal.
- **Health issues** – While the risk of flood-related deaths and injury remains fairly low, the flooding of homes and businesses can have huge knock-on effects on mental health; dealing with the aftermath of flooding can be extremely challenging, time-consuming and stressful for those affected, and there are reports of people having lost their jobs, suffered family break-ups and financial / insurance difficulties, and people unable to move back into their homes following the 2007 flooding in Hull[70.] Several studies have found that vulnerable people are at particular risk from extreme weather events and, in particular, flooding.[71]
- **Water pollution**, from sediment and nutrient run-off into watercourses, potentially leading to development of algal blooms. This could impact on aquatic species, and could also have economic impacts if access to the lake is restricted during the tourist season.
- **Habitat damage**, from landslides and soil erosion
- **Flood rik to properties** – an increasing number of properties are likely to become at risk of flooding over the coming decades. Apart from damage caused to the building fabric and contents, this is likely to push insurance premiums up and increase the number of households for whom insurance may become unaffordable, or even unavailable, with knock-on impacts on mortgage markets. It should be noted that the insurance industry is currently reviewing its approach to providing flood insurance, and there is, as yet, no guarantee that insurers will be obliged to offer this for all properties beyond 2013.[72]

4.2.2 Peat bogs and soils

Soils perform a range of vital ecosystem services (e.g. crop production, water regulation and purification, carbon sequestration, etc.) and provide important habitats. If summers become hotter and dryer, and we experience more extreme heavy rainfall, this will alter their ability to provide these services – soil drying could lead to the loss of soil organic matter (the principal energy source for soil organisms), while both drying and flooding could result in biodiversity loss (and therefore potential loss of ecosystem function), and soil erosion. The drying out and cracking of peat bogs in particular could reduce their capacity to act as both a water and a carbon store[73]. Additionally, parched vegetation will reduce the aesthetic value of the landscape, so vital for the visitor economy.

Soils are also at risk of compaction and loss of vegetation cover from fell walkers (over 8 million people use the Lake District paths annually [74]) and livestock[75], and this can cause soil erosion and sediment transport to watercourses [76]. Overgrazing is a particular issue in the uplands.

4.2.3 Water quality and quantity

As we have seen, there is considerable uncertainty over projections for precipitation. While there is confidence that precipitation will occur as more intense events, there is less certainty over the total volume in any given season[77], though the projections generally show the North West summers becoming hotter and dryer[78].

Given the uncertainty, it is prudent to assume that water may become scarcer during dryer summers, exacerbated by hotter temperatures, population growth and higher visitor numbers. This could result in the following problems:

- **Competition for increasingly scarce water resources,** between locals, visitors, agriculture, the natural environment, and any future hydropower schemes that may be developed in the valley in response to climate change and fossil fuel depletion. This increased competition is likely to result in household water shortages.
- **Dryer soils and vegetation**, reducing their ability to perform ecosystem services (e.g. crop production, water regulation and purification, carbon sequestration, etc.) and provide important habitats. Dryer soils are also susceptible to soil erosion, which can in turn lead to poor water quality.
- **Low river flows and poor water quality** – low summer river flows resulting from prolonged dry spells (and exacerbated by increased water abstractions for public supply and agriculture) reduce contaminant dilution potential, and can therefore result in poor water quality – it is expected that some upland headwaters may dry out completely during future summers [79]. Furthermore, warmer water temperatures can impact on aquatic species and ecosystems and, together with higher nutrient concentrations, could result in the development of algal blooms [80] (such as those that resulted in the cancellation of the Great North Swim in Windermere in 2010 – an event attracting ~9,000 participants and 20,000 spectators[81], bringing an estimated £1.5 million in tourism revenue to Cumbria[82]). A reduction in lake levels can also reduce their attractiveness to visitors.
- **Water pollution**, from sediment and nutrient run-off into watercourses, potentially leading to development of algal blooms. This could impact on aquatic species, and could also have economic impacts if access to the lake is restricted during the tourist season.

An increase in heavy rainfall and flood events will also impact on water quality through the run-off of sediment and nutrients into watercourses.

4.2.4 Agriculture and forestry

Agriculture and forestry are the dominant activities that shape the Lake District landscape. Climate change impacts on these industries will have a knock on impact on the natural environment, tourism, water management, and cultural heritage.

The principal threat to agriculture in the valley seems, at this stage, to be flooding

and waterlogging. More days of saturated soil and flooded land results in loss of grazing land and the need for either a reduction in stocking rates or a longer housing period and supplementary feeding costs[83]. Vehicular access to fields can become difficult or impossible if the ground is waterlogged, and can result in rutting, soil compaction and erosion. Prolonged wet weather could also pose a risk to newborn lambs [84].

In addition to the increased risk of flooding from climate change, there is a drive by the various agencies to renaturalise the rivers and use the natural floodplain as flood storage. However, the in-bye land in the riparian zone and wider floodplain is critically important for farmers at certain times of year (e.g. during tupping, lambing and dipping), and there are concerns that allowing these areas to flood could make upland farm businesses unviable[85]. This problem is likely to worsen as heavier rainfall events become more frequent.

If summers become hotter and dryer there will be an increased risk of drought and water shortages, leading to soil moisture stress and, in turn, a reduction in crop, grass and tree growth. This may affect the timing of agricultural practices and increase the need to buy-in feed[86]. Livestock (particularly hill breeds) may also suffer from heat stress[87], with consequent impacts on fertility, milk yields and livestock health. Furthermore, if summers become hotter and dryer, the fire risk from peat, bracken and forests will increase, posing a threat to the area's important forestry industry, and putting livestock and people at risk. It has been suggested that the risk of wildfires in the Lake District could increase by approximately 30%[88].

Agriculture and forestry may also come under threat from pests and disease, whose survival and reproduction rates may increase if winters become warmer. In particular, there could be an increase in the frequency of bluetongue outbreaks (research suggests a possible link to climate[89]), and also a number of tree pests and diseases; Red Band Needle Blight could affect over half of UK pine forests by 2050, while Green Spruce Aphid could affect up to 26% of spruce forests over the same period[90].

While the projections for storminess are uncertain, there could be an increased risk of wind damage to trees. As well as the direct damage to trees themselves, and therefore the forestry industry, this could also result in damage and disruption from trees falling onto roads (causing transport and supply chain disruption) and power cables (which could cut off electricity supply). Visitor access is also likely to be disrupted during such events, and there is the additional, albeit small, risk of injury or death from fallen trees or wind-blown objects. However, where semi-natural woodland is of a similar age structure, storm events can open up areas in which young tree regeneration can take place[91].

If the provisional research findings showing an increase in cold, snowy winters are correct, this could threaten livestock and crops. Thousands of ewes and lambs are believed to have died during recent heavy spring snowfall [92], while the delay in warm spring weather could impact on crop and grass growth.

Notwithstanding the potential threats to agriculture and forestry, the projected warming (if indeed warming does occur in the Lake District) could extend the growing season and allow for new crops to be introduced, and currently marginal land to be cultivated (though any agricultural intensification could impact negatively on biodiversity and ecosystems).

4.2.5 Non-native species

There is some evidence that climate change could result in the introduction and/or proliferation of invasive, non-native species. Flooded winter rivers leave behind sediment, and clear more space along river banks which, when flows are reduced in summer, leaves more bare soil for colonisation by Himalayan balsam[93] and Japanese knotweed. Furthermore, these vigorous weeds crowd out native plants, so when they die back in winter, the river banks are left bare, increasing vulnerability to erosion[94], creating a vicious circle.

Freshwater systems are also susceptible to colonisation by new species. For example, there are concerns that roach, which have been introduced but whose numbers are restricted by an unsuitable climate, could expand its range into the Arctic Char ecological niche[95].

4.2.6 Natural environment and ecosystems

Changes in climate conditions could have a particularly heavy impact on the natural environment. Some species may become extinct as they, or the species on which they depend, are unable to adapt quickly enough. The ability of species to adapt may be hindered also by increasing pollution, habitat fragmentation and agricultural intensification. Healthy ecosytems are vital to the economy, society and environment of the Lake District. Some of the key climate change impacts on the natural environment are:

- **Earlier timing of spring events** – for example earlier arrival of birds and butterflies, earlier bud burst and egg-laying, etc., which will affect food webs and have a detrimental impact on certain species and ecosystems.
- **Northward and upslope movement of species and habitats.** This is likely to threaten a number of arctic-alpine species and upland birds which inhabit montane habitats in the Lake District (e.g. stiff sedge, mossy campion, and the mountain ringlet butterfly[96]), as temperatures rise and their geographical range thus becomes more limited. Cold-water species such as the Arctic Char could also be threatened by warmer water temperatures[97] (though this species is not understood to be present in Ullswater).
- **Increase in non-native species**: Some non-native species are likely to favour to a warmer climate[98]. These may pose a risk to existing species, particularly specialist species that require specific niche environments.
- **Habitat damage**: warmer water temperatures, associated with increased water pollution (caused by increased run-off of sediment and nutrients into watercourses and potentially reduced dilution potential from lower flows) could

impact negatively on freshwater species. Damage to peatland and soil habitats could also occur as a result of both soil drying and increased heavy rainfall.

4.2.7 Infrastructure and services

The principal impact to infrastructure and services is likely to be from the increase in frequency of heavy rainfall events. This will increase the strain on existing drainage and sewer networks, which will be unable to cope with the extra capacity, thereby increasing the risk of flooding (note that the sewage works in Glenridding lies within the medium risk flood zone and also within the area identified by the EA as being at risk from flash flooding – see Appendices 3b and 3c). As discussed in Section 4.2.1, flooding is likely to disrupt locals, visitors, local businesses and supply chains. It could also disrupt the emergency services at times when they are likely to be in particularly high demand (note that the Fire and Police Stations, and the mountain rescue centre, are all located within a high flood risk zone, and the area at risk of flash flooding). In addition, flooding may result in the possible loss of energy and communications supply. Flooding can also be associated with landslides, which would exaccerbate transport disruption if they were to occur on roadsides. Any increase in storminess could also result in disruption to infrastructure; trees falling onto roads could cause transport and supply chain disruption, while fallen trees on power cables could cut off electricity supply.

ICT and power supply can also be disrupted during heatwaves, as overhead cables overheat, and energy transmission equipment becomes less efficient[99].

While the climate projections generally suggest increasingly warm winters (in which case we would expect to see fewer snow-related risks to infrastructure), the recent evidence linking Arctic sea ice loss with colder, snowier UK winters (as discussed in Section 3) could, if correct, result in increasing disruption from heavy snowfall and ice. This would have a particularly severe impact on those travelling over the Kirkstone Pass (affecting supply chains, emergency services, etc.).

4.2.8 Tourism

Any extreme weather is likely to impact on tourism in the Valley. Flooding could increase path damage, as well as cause damage to natural and man-made tourist assets, thereby reducing visitor appeal. If summers become hotter and dryer, the increased risk of wildfires could impact on tourism, both in terms of people's perceptions of safety, the need to close affected areas and a potential deterioration of the landscape[100 101].

Climate change is likely to impact on landscape character - while broad habitat types are unlikely to change dramatically as a result of climate change, the characteristic species that occupy those habitats may change, and some species may even become locally extinct by the 2050s[102], thereby subtly altering the appearance of the landscape[103].

We are also likely to see more midges[104]. This, in turn, could affect outdoor activities

and tourism[105], as it does in Scotland (an Edinburgh University study estimated that midges cost the Scottish tourist industry ~£300m in lost revenue each year, with 86% of first-time visitors saying they would advise their friends not to travel there during the midge season[106 107]).

Notwithstanding the negative consequences of climate change, the potential improvement in the summer climate could increase the appeal of tourist destinations in many northern latitude destinations[108 109], including the Lake District. An extended and busier tourist season would generate more (and potentially less seasonal and better paid) jobs in the area. It would enable young people to remain in their community, reducing the 'brain drain' from the valley. It may also help preserve services and local businesses that would otherwise struggle to continue (e.g. public transport, village shops, post office)[110]. Conversely, if winters become colder and snowier, this would provide recreational opportunities for winter climbers and skiers on Raise and the surrounding fells. However, any increase in visitor numbers could also exaccerbate existing problems such as traffic congestion, pollution, high prices for local goods and unaffordable housing for locals[111]. Furthermore, tourism infrastructure is usually financed by local taxpayers[112]. The tourist industry in the Lake District rests on a fundamental paradox; the problems associated with the continued development of tourism compromise the natural attractions on which it depends[113], causing damage to the landscape (e.g. litter, erosion, fires, vandalism, disturbance to livestock), and increasing the risk to fragile habitats and species[114 115].

4.2.9 Community health and wellbeing

Climate change could impact directly on the health of individuals. As discussed in Section 4.2.1, the flooding of homes and businesses can have huge knock-on effects on the mental health of those affected. Other extreme events, such as extreme cold weather, snowfall, heatwaves, etc, could also impact negatively on health. Several studies have found that vulnerable people are particularly badly affected by such events [116].

Climate change (and, in particular, warming) could also increase the risk of pests and disease that might impact on human health. There could be an increase in the number of biting insects such as ticks[117], which could increase the risk of Lyme disease. Those with respiratory conditions may be affected by increased mould growth in buildings resulting principally from prolonged wet periods, but also exacerbated by the widespread installation of non-breathable insulation and other building materials that can cause condensation build-up (see below). Conversely, if summers become warmer, this may present more opportunities to spend time outdoors taking exercise, which could serve to improve health and wellbeing.

4.2.10 Property

The flood risk maps indicate several properties in the valley to already be at risk from flooding, and this number is likely to increase over coming decades. Apart from damage caused to the building fabric and contents, this is likely to push up insurance premiums and increase the number of households for whom insurance may become

unaffordable, or even unavailable, with knock-on impacts on house prices, local businesses and mental health.

Increasing concerns over climate change and resource depletion have resulted in the need to improve energy efficiency, with the principal focus being on insulation. Many properties in Ullswater were built before 1919, and will therefore be of solid wall construction, generally of natural permeable materials. They rely on passive ventilation systems to allow them to 'breathe'. While they can be draughty, with lower energy efficiency, the design of historic buildings (if left untouched) makes them less prone to condensation [118]. Energy improvement measures, most of which have been designed for modern buildings to improve airtightness, are not necessarily compatible with historic buildings. Modern materials (e.g. vapour control layers, cement renders, plasters and pointing, many paints and coatings, and many insulation types) tend to be impermeable, and may interfere with a building's natural ventilation, resulting in the build-up of moisture, toxins (such as VOCs, which are present in a wide range of modern products such as carpets, chip board, paints, etc) and mould spores, which are responsible for many respiratory conditions and, in serious cases, cancer. The projected increase in prolonged periods of wet weather, and consequently condensation, could damage building fabric through the build-up of mould, and the increased potential for pest infestations.[119]

4.2.11 Cultural heritage

The cultural heritage of the valley is tightly connected with its climate, landscape and traditional stone buildings. In Ullswater this asset is currently being inventorised as part of a World Heritage Site nomination, and the value of this is described in a section on Ullswater from the current nomination document, reproduced in Appendix 5.[120]

While climate change may result directly in subtle changes to the landscape, greater changes are likely to result from our response to climate change. Changes in agricultural and forestry practices (e.g. possible agricultural intensification in response to longer growing seasons, and increases in forest cover, etc.) as well as a likely increase in renewable energy installations, could alter the traditional landscape character. Traditional buildings may become at increased risk from flooding, extended periods of rainfall and the build-up of mould. Climate change may also impact on traditional practices and ways of life which could threaten the cultural identity of the Ullswater community.

5. How can the Ullswater community respond to climate change?

Efforts to address climate change have so far focussed primarily on mitigation – i.e. initiatives intended to reduce the emission of greenhouse gases into the atmosphere, thereby limiting the extent of climate change. However, it has become increasingly apparent that even if we do reduce our emissions (and there is no clear indication yet that this is happening), we are nevertheless committed to a certain amount of warming from historical emissions that persist in the atmosphere and oceans. This has led to the recognition that we must begin to adapt to a changing climate. Adaptation refers to initiatives that reduce the vulnerability of natural and human systems to the unavoidable impacts of climate change. Adaptation includes both preparing for inevitable climate emergencies (e.g. extreme weather events) and preventing changes in the climate from impacting too heavily on our systems. While the principal focus for this report is adaptation, any adaptation response should be compatible with the Lake District National Park's goal of reducing the Park's carbon budget. As such, all three responses – preparation, prevention and mitigation – are discussed in the following sections.

Land managemers in particular will play a critical role in both mitigating and adapting to climate change in Ullswater.

5.1 Climate change adaptation

Regardless of the success of climate change mitigation initiatives, we are committed to some degree of climate change because of a) the persistence of historical greenhouse gas emissions in the atmosphere; and b) the delayed response of the oceans. The impact of climate change on any society, and the sustainability of its social, economic and environmental systems, depends not just on the physical weather or climate event, but also on the vulnerability and exposure of that society. This in turn depends on its ability to adapt to future changes in climate (averages, variability and extremes)[121]. Adaptation and risk management reduce vulnerability and exposure, thus reducing the disaster risk and increasing resilience to the risks that cannot be eliminated[122].

Under the Climate Change Act (2008), the UK government is required to prepare a National Adaptation Plan to address the risks and opportunities identified in the CCRA (discussed in Section 4). This is due to be published later this year, and should provide guidance for businesses, local authorities and members of the public on increasing climate change resilience. Furthermore, the IPCC's fifth assessment report, due to be published in 2014, is expected to expected to put greater emphasis on assessing the socio-economic aspects of climate change and the implications for sustainable development, risk management and the framing of a response through both adaptation and mitigation [123].

One of the principal barriers to taking adaptive action is the uncertainty associated with future climate projections [124] – while we know that the global climate is warming,

and that we can expect to see an increase in extreme weather events as a result, we have seen in Section 3 that there is much uncertainty over how climate change will play out in Cumbria. The UKCP09 'medium' projections [125] are generally used as a best estimate of what we might expect, but we need to plan our community response to cope with a wide range of possible climatic eventualities. The uncertainty can thus be overcome by adopting a flexible approach. The UK climate impacts programme [126] provides guidance on identifying and selecting appropriate climate change adaptation options, which is useful for communities involved in planning. The options fall under four broad categories:

- **No-regrets options** – measures that are worthwhile whatever the extent of future climate change. These include measures that are cost-effective under current climate conditions (for example measures to combat flooding) and become more so under projected climate changes.
- **Low-regrets options** – measures that are relatively low-cost, for which the benefits, although primarily realised under projected future climate change, may be large.
- **Win-Win options** – measures that both minimise climate risks and maximise other social, environmental or economic benefits (e.g. measures – such as peatland restoration – which provide adaptation benefits but also contributes to mitigation efforts).
- **Flexible or adaptive management options** – measures that involve incremental adaptation options, rather than large-scale adaptation, thereby reducing the risks associated with being wrong.

Whichever response is adopted, successful adaptation will require the engagement of an informed community with a willingness and ability to adapt [127]. The following sections provide information on measures the community of Ullswater might adopt, sometimes with the support of other agencies and organisations, that could help them to become more resilient to the impacts of climate change. Such measures are separated into two main categories of response: preparedness and prevention.

5.1.1 Preparedness

Being prepared involves a recognition that we will inevitably experience more frequent and more intense extreme weather events which, when they occur, may require an emergency response. While such events may often be unexpected, it is nevertheless possible to prepare for them in advance.

Cumbria Strategic Partnerships has looked into the impacts of extreme weather on local services, communities, economy and the natural environment in Cumbria and has identifiied the need to increase community-based resilience, particularly in communities at risk from flooding. It also recognised the need to develop IT capacity to enable staff to work remotely from home, thereby minimising problems associated with transport disruption during extreme weather events [128]. It suggests that Cumbria is generally poorer than the rest of the UK for connectivity, and this will

continue to constitute unnecessary disruption when extreme events cause travel difficulty.

The Cumbria Local Resilience Forum was brought together in 2005 and consists of all agencies and organisations involved with emergency response, who work together to help communities prepare for, respond to, and recover from different kinds of emergencies. The Forum cooperates and shares information among local responders, and puts in place arrangements for warning and advising the community and businesses about emergencies [129]. The Local Resilience Forum also holds a Community Risk Register, which considers the likelihood and potential impact of a range of hazards that could occur in Cumbria. This forms the basis for supporting the preparation of emergency plans. The register can be accessed via the following link: http://www.cumbria.gov.uk/eLibrary/Content/Internet/538/755/41159115519.pdf. An extract of the risk register showing risk for extreme weather events is included in Appendix 6.

ACTion with Communities in Cumbria has prepared a 10-step Community Emergency Planning Toolkit which invites communities to ask the question: 'How would my community survive the first 48 hours of a serious emergency?' and provides a method that can be followed by any community to help them prepare for emergencies. The ten steps are as follows:

1. Getting together;
2. Organising the work;
3. Knowing the unknowns;
4. Identifying skills and resources;
5. Legal issues;
6. Organising key facilities;
7. Keeping in touch;
8. Activating your emergency plan;
9. Taking control; and
10. Testing your plans.

Instead of preparing plans for specific emergencies, it is useful to identify the people, resources and facilities that might be needed, and be prepared to use these flexibly, depending on the situation. They can then be deployed for any emergency, whether that be flooding events, storms, heatwaves, droughts, wildfires or pest and disease outbreaks. A copy of the Community Emergency Planning Toolkit can be found at: http://www.cumbriaaction.org.uk/images/uploads/dt032_cep_tookit_&_cover_%28website%29.pdf.

5.1.2 Prevention

In addition to preparing for inevitable climate emergencies, it is necessary to also look at preventing some of those emergencies from happening in the first place so that, for example, heavy rainfall does not necessarily result in a flooding emergency, or in water pollution. The following sections provide a range of possible adaptation options. The list is neither comprehensive nor prescriptive, but outlines a range of options that could be explored further depending on the wishes and needs of the community.

5.1.2.1. Flood mitigation

Flood risk managemenet needs to be carried out in a holistic way so that measures to alleviate flood risk in one area do not negatively impact on other areas, or on the natural environment. The following actions may be explored as a potential to alleviate flood risk in Ullswater.

Adaptive rural land-use

Rural land-use can have an effect on catchment scale flood-risk. The Eden Rivers Trust has recently been working with a number of other partners to investigate whether and where in a river catchment measures such as woodland planting, re-meandering of river channels, putting woody material back into rivers and reducing soil compaction could help reduce downstream flood risk.[130] The work forms part of the EU-funded ALFA project (Adaptive Land-Use for Flood Alleviation), which aims to protect people against flood-risk by creating new capacity for water storage in river catchments. One means of achieving this is to create new flood plains in areas that have not flooded recently. It is suggested that these project areas only be flooded in extreme situations to protect citizens in more vulnerable areas up- or downstream from the project areas, thereby preserving present land-use functions where possible. It recognises the need to find optimal combinations between river and other functions, such as agricultural land-use, recreation and nature preservation or development [131].

The re-naturalisation of watercourses and creation of floodplains in areas currently used as grazing land, while potentially helping to alleviate flood-risk in some areas, can threaten the viability of upland farms by potentially removing valuable grazing land. This strategy must therefore be employed cautiously. Notwithstanding this, current stocking levels are leading to overgrazing (and therefore soil erosion and water management issues) in some parts of the Lake District,[132] [133] and will need to be considered alongside adaptive land-use issues.

Woodland planting

Woodland planting in the upper catchment is a contentious issue. Many farmers are concerned that tree planting along river banks can exaccerbate flooding. Indeed, poorly designed or managed forests, or those planted in unsuitable locations, can cause eutrophication, increase sediment delivery and contribute to local flooding.[134] However, if correctly sited, trees and other vegetation can help to bind the soil and offer an effective approach to regulating the water cycle, reducing sediment loss and

preventing flooding downstream. They have the potential to reduce sediment loss at source, to limit sediment and nutrient run-off to watercourses, to protect river banks from erosion, and to encourage sediment deposition within the floodplain.

The Forestry Commission has assessed the opportunities for woodland creation to help manage sediment in the Lake District, by identifying the main sediment sources and the pathways to watercourses[135]. The data are represented in a series of maps, a selection of which are reproduced in Appendix 4a. Maps 17 and 19 highlight the priority areas for woodland planting to reduce sediment delivery to watercourses and stream bank erosion, respectively. Parts of the Ullswater catchment fall within the high priority areas for each. In addition, the map in Appendix 4b indicates the areas in the south western Ullswater catchment where riparian woodland planting could help bind river banks together to reduce erosion and siltation that are currently affecting water quality.

The Forestry Commission recognises that if the opportunities identified are to be realised, there will be a need to increase the value of, and improve the synergy between, available incentives to secure land use change[136]. The recent introduction of the Woodland Carbon Code (WCC) – a voluntary standard for UK-based woodland creation projects that aim to sequester carbon – may provide such an incentive. It enables landowners to sell carbon credits generated through new woodland creation[137]. The Lake District National Park Authority recently commissioned a report exploring the potential for a Lake District branded carbon market based on woodland creation under the WCC, which found that there is likely to be significant demand for Lake District carbon. The full report is due to be published over the coming months, and is likely to be available through the Carbon and Land Management section of the Lake District National Park .

The Forestry Commission and Natural England have developed the Woodland Potential calculator [138], which uses local information for each of the 159 National Character Areas (areas defined by a combination of landscape, biodiversity, geodiversity and economic and cultural activity) to determine the appropriate level of woodland creation in each area (expressed as the percentage uplift). This work is currently under public consultation; however, it gives an indication of the woodland creation potential in the Cumbria High Fells - an additional 14,000ha in total by 2060, equating to a 7% increase in woodland cover – much higher than the national average of 4.7% (see Table 4). While this is for the whole of the Cumbria High Fells, it gives an indication of the potential scale of uplift in Ullswater.

Table 4: Woodland creation potential in the Lake District

National Character Area (NCA)	Land total	Existing woodland		Achievable uplift by 2060		Target woodland by 2060	
	ha	ha	% (current)	ha	% (target)	ha	% (total)
Cumbria High Fells	199,007	18,024	9.1	13,919	7.0	31,943	16.1
National Woodland Potential	13,045,420	1,292,137	9.9	618,993	4.7	1,911,130	14.6

Peatland restoration

Peat bogs in the northern uplands have traditionally been drained to improve their agricultural viability. The consequent drying out of these bogs can lead to loss of vegetation, increased soil erosion and dessication (which can cause peat to be so dry that it prevents water infiltration) which, in turn, can increase flash flood risk. The blocking of these traditional drainage ditches (or grips) can help to restore natural drainage patterns and encourage re-vegetation, reduce erosion, and minimise the knock-on effect of flooding downstream [139]. However, blocking of grips must be carefully targeted, with the greatest effects resulting from blocking grips with large upslope catchments. Blocking needs to start at the highest point of the grip and proceed downward to prevent water build up and erosion behind lower dams[140]. Note that re-vegetation must not include colonisation by trees, which serve to dry out peat bogs further.

While the restoration of peatlands is unlikely to have a dramatic impact on flood risk (indeed, the water table in intact peat bogs is generally close to the surface, making its capacity to store more water low, and leading to rapid water run-off), restoring the hydrological balance that will prevent erosion and encourage re-vegetation on the bog can help slow down run-off compared to bare peat, and can therefore be useful in reducing flow peaks, and provide an essential time-window to enable adaptive response from potentially impacted communities[141].

Drainage maintenance

Landowners can help alleviate flooding and waterlogging by maintaining their drainage infrastructre [142]. Community members can also help to keep drains in their area free of leaves and other debris, which could reduce the risk of surface water flooding.

5.1.2.2. Resilient peatlands and soils

Restoration of peatlands (as discussed above) can help to improve upland habitats, reduce soil erosion and the loss of soil organic carbon and increase biodiversity. It also helps peatlands to regulate the water cycle and act as a carbon store.

Reducing stocking rates in the uplands, and maintaining footpaths so that fell walkers stick to the paths, can help to prevent soil erosion in these vulnerable environments [143].

5.1.2.3. Resilient water environment

Many of the climate change impacts on water availability and quality can be addressed through changes to land and farm management.

Farmers and landowners can minimise the impact of drought conditions by upgrading their water storage and distribution systems and reducing water loss from cracked pipes [144]. Local people can minimise their water use by becoming more aware – Waterwise provides a number of tips for reducing water-use, including the installation of aerators on existing taps, etc [145]. Tourist businesses can also raise awareness among vistors on the need to preserve water (for example by asking guests to keep their towels for more than one day to prevent excessive washing, as many guesthouses do already).

Several of the solutions required to address water quality issues are similar to those required to mitigate flood risk: woodland creation and peatland restoration.

Woodlands and other vegetation help to bind soils and attenuate water run-off, thereby minimising the transfer of silt and nutrients into watercourses. Woodland can reduce phosphate pollution through nutrient uptake and the trapping of soil-bound material [146]. Map 18 in Appendix 4a highlights the priority areas for woodland planting to reduce diffuse phosphorous pollution, with parts of the Ullswater catchment – particularly in the east – being in a high priority area. Tree planting along streams and lake shores can help shade water during heatwaves, thereby reducing the risk to freshwater species from increased water temperatures.

Water derived from peatlands is naturally of very high water quality. However, high sediment and associated particulate organic carbon loads from water coming out of degraded peat can reduce water quality. Catchment-based solutions to restore peatlands and increase vegetation cover by blocking drainage channels appears to also restore water quality by stopping surface erosion[147].

Reducing sources of pollution from farms can be achieved through Catchment Sensitive Farming, which is supported by Natural England and the Environment Agency. The Bassenthwaite Catchment Sensitive Farming project has been successful in reducing the amount of phosphate applied as fertiliser and targeting manure and slurry where it is needed most [148].

It is not only farmers and landowners who can help to prevent water quality degradation. There are several examples of partnership projects in the Lake District aimed at improving water quality. Nurture Lakeland is working with Windermere Reflections on a campaign to encourage locals, businesses and visitors to use phosphate-free laundry and dishwasher products in order to reduce the amount of phosphate entering the lake[149] [150]. This could help prevent the development of algal blooms. The Loweswater Care Project (LCP) was formed in 2008, also to address

the problem of blue-green algae. A partnership was established between local people, agencies, scientists and anyone else interested in Loweswater, who came together on equal terms to pool their knowledge to identify possible causes and solutions – in particular how to manage water [151]. Basenthwaite Reflections also has projects designed to preserve the water quality of the lake [152]. These partnerships may offer useful examples of projects that could be adopted by the Ullswater community to improve water quality.

5.1.2.4. Resilient agricultural and forestry

Given their importance in determining the resilience of the Ullswater community to climate change, it is vital that agriculture and forestry are themselves resilient. Tolerant crop, grass, livestock and tree species may need to be introduced into Lake

District farming and foresry to reduce the impact of extremes of climate and certain pests and disease. Farmers may need to future-proof livestock housing and water storage and distribution systems against heatwaves, droughts and other weather extremes, and/or consider planting trees for use as shading. In some cases the timing of certain activities (e.g. lambing) may need to be reconsidered to allow for changing seasons. Woodland managers may need to consider the inclusion of fire breaks to minimise the risk from wild fires, and plan future planting with consideration to potential wind-throw damage.

Farmers may be able to exploit the projected longer summer seasons, though any intensification will need to take into account the knock-on impacts on the natural environment and the wider catchment. Likewise, forest managers may benefit from a thriving woodfuel economy, which could also help to bring undermanaged woods back into active management [153]

The future of agriculture in the Lake District may depend more strongly on the future of the Common Agricultural Policy (CAP) than to changes in climate, at least in the short and medium term. Approvals for CAP reform are due by the end of 2013, with a view to having reforms in place from January 2014 [154]. At this stage there is expected to be a slight reduction in direct payments, and a larger proportion of the payments is expected to relate to 'greening' measures.

5.1.2.5. Managing non-native species

There are several schemes already active in Cumbria to help manage non-native species. The South Cumbria Rivers Trust is coordinating action on freshwater invasive non-native species thoughout Cumbria, and provides information on species, relevant policies, work being carried in the county, and how people can get involved [155]. The Bassenthwaite and Windermere reflections programmes also have projects to address this issue [156] [157]. These provide models that could be adopted in Ullswater.

5.1.2.6. Resilient natural environment

Natural England has advocated an 'adaptive management' process to respond to the impacts of climate change on the natural environment. This involves modifying

existing practices and carefully monitoring the results to ensure the response is effective [158]. The key to increasing the resilience of the natural environment is maintaining and enhancing natural habitats.

Historic management of the fells has been unfavourable for the ecosystems that occupy them and, as such, the majority of habitats are less resilient to climate change than they might have been[159]. Work to protect biodiversity in the Cumbria High Fells has so far concentrated on sustainable grazing regimes (intensity, seasonality and type of animal) on upland SSSI habitats, which has been carried out by local landowners changing the grazing behaviour of their stock. This needs to be expanded into the extensive areas of other BAP habitats within the Cumbria High Fells[160] (i.e. semi-natural habitat types identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan[161]).

Diverse landscapes are more resilient and better able to adapt to changes. Farmers and landowners can enhance diversity by expanding and linking habitats so that species can move through the landscape, and also improving the condition of, and increasing diversity within, existing habitats through changes in management. The planting of native woodlands higher up the fellside also allows species to move up into it in response to climate change[162].

Developing resilient habitats and habitat networks can be achieved through Nature Improvement Areas and agri-environment schemes. However, the future of these is likely to depend on the outcomes of the forthcoming CAP reforms. At this stage the reforms are expected to include 'greening' as a mandatory element of direct farm payments, intended as a means of incentivising land management for biodiversity and ecosystem services.

5.1.2.7. Infrastructure and services

Integrated public transport

Working with transport providers and the authorities to develop an integrated public transport network could help alleviate weather-related disruption to transport, supply chains and the emergency services. Given the vulnerability of the A592 to flooding, there may be options for developing boat transport along the lake between Patterdale / Glenridding and Pooley Bridge. This could enable commuters, visitors and the emergency services to travel within the valley even if the road becomes impassible. The Lake District National Park is currently working on an integrated travel scheme in Windermere, which again could be considered for Ullswater.

Improved communications

It is understood there are plans in place for introducing Broadband to the Ullswater valley. This would enable more people to work from home, and would also make it easier for small businesses to operate from the valley.

5.1.2.8. Sustainable tourism

Recreation and tourism are very important for the local economy. The visitor

experience can be further enhanced by the landscape and habitat improvements that will result from the climate change adaptation actions recommended here.

If summers become hotter, and visitor numbers increase, more intensive visitor management strategies may be required to support sustainable tourism and to prevent prevent environmental degradation – and indeed the degradation of visitor experience [163]. On the other hand, the tourist industry may need to adapt to weather extremes by making provision for more wet weather and indoor activities.

Tourist businesses are in a good position to help with adaptation efforts, both directly and indirectly. Accomodation providers can opt to use phosphate-free detergents to reduce nutrient build-up in the lake, thereby minimising the risk of algal bloom development. Nurture Lakeland's Love your Lakes campaign with Windermere Reflections provides practical information on this[164.] Research suggests that increasing awareness among visitors can help National Park managers implement measures that restrict recreational access, because visitors understand the need for this action [165.] Tourist businesses can therefore help to increase awareness of climate change impacts and adaptation among visitors,and to promote sustainable tourism – whether that be advising visitors to keep to the footpaths to prevent habitat damage, or on issues associated with habitat protection.

5.1.2.9. Resilient communities

A resilient community is one which can work together to help solve common problems. The continued provision (and enhancement) of local services and 'hubs' (e.g. post office, school, etc) are likely to be critical in maintaining the community bonds necessary to maintain cohesion.

Improved communications networks are likely to provide more oportunities for people to work from home rather than travelling outside the valley to work. Furthermore, there may be opportunities to create office 'pods' in the villages, from which individual home workers may work in a communal space. Such measures may increase the vibrancy of the valley.

Flooding and other extreme events are likely to impact most heavily on the vulnerable (e.g the elderly), and these people may need support from neighbours following such events.

Flood-affected households and communities often experience difficulties obtaining insurance cover. Further work is required to assess the feasibility of forming a mutual insurance company, with eligibility and sensible premiums dependent upon validated community emergency plans. This provides an incentive for at-risk communities such as Ullswater to work together on flood-risk management and could achieve consistency in premiums over the long term.

The Transition Network provides information on community-led initiatives to increase resilience to climate change, which could be useful for the Ullswater community [166]. Local Transition initiatives include SLACC (South Lakes Action on Climate Change) [167] and PACT (Penrith Action for Community Transition) [168], while Transition North

West provides a networking platform for groups and individuals to share ideas, skills and knowledge [169].

5.1.2.10. Resilient property

'Flood-proofing' of buildings

Existing buildings in the valley that are likely to become at increasing risk from flooding can protect themselves in a number of ways. During flood events, the placement of a temporary watertight seal across doors, windows and air bricks can help prevent water ingress [170] (anecdotal evidence suggests that a community in Burneside has a roll of industrial cling film that can be used for such purposes). If properties are being renovated it might be worth considering 'flood-proofing' them against future events. Such measures might include installation of solid flooring, durable kitchen units (i.e. plastic or stainless steel instead of chipboard), high level electrical equipment, wiring and sockets, use of replacable plasterboard, non-return drainage valves and careful sealing of pipework[171].

Protection of building integrity and character

For historic (pre-1919) buildings that need to 'breathe', the use of natural insulation materials (such as sheeps wool and wood fibre board, whose thermal properties compare favourably to many standard insulation types), can improve energy efficiency while still allowing the building to regulate moisture and air flow. Though these materials can be more expensive per metre than the cheapest insulation types, they often require a smaller thickness to provide the same thermal efficiency, thereby reducing cost.

Some energy efficiency improvements can also erode the character of buildings, which could threaten the cultural heritage of the area. An example might be the installation of uPVC windows. In many cases, refurbishing existing timber, single-glazed windows to prevent draughts, and hanging heavy curtains, can be more cost-effective, and have a lower lifetime carbon footprint, than replacing them with new uPVC windows [172]. English Heritage has demonstrated that upgrading original windows can match the air infiltration standards of factory-made windows at a relatively modest cost [173].

Sustainable energy efficiency

Cumbria Action for Sustainable Living (Cafs) [174], based in Penrith, is a useful local resource – they can provide information to householders and businesses to improve energy efficiency in a sustainable way. It may be beneficial for the community to host a workshop for local builders, tradesmen and home-owners on adapting properties for possible future climates.

5.1.2.11. Retaining our cultural heritage

The natural and built environment will have to change in response to climate change. However, many of the suggested adaptation actions could help minimise the erosion of cultural heritage (for example preserving building integrity and character by using

natural materials, and restoring peat bogs to their former condition).

All members of the community can help to build on the existing culture of the valley, by creating a community based on resilience, cohesion and awareness of the importance of the natural environment in providing vital functions and services.

The World Heritage Site nomination bid currently in development will, if successful, require a 21st Century management approach to the Lake District valleys based on climate change risks and the development of community resilience. The heritage asset of Ullswater is outlined in Appendix 5.

5.2 Climate change mitigation

Climate change mitigation is one of the Lake District National Park's key priorities. As part of the Low Carbon Lake District initiative, it has set itself a carbon budget, with the aim of reducing this by 1% each year [175]. Some of the key contributors to the Lake District's carbon footprint (and therefore areas for potential improvement) are:

- Road transport;
- Food and drink / accomodation; and
- Energy use in buildings.

Climate change mitgation can be achieved in either of two ways: 1) reducing emissions at source; and 2) storing atmospheric CO2 in long-term carbon 'sinks'. Both methods are applicable to climate change mitigation in Ullswater. The Carbon Budget report presents a range of mitigation options for the National Park [176].

Adaptation responses should be compatible with the Lake District's priorities for mitigation, and vice versa. Certainly, adaptation responses that support mitigation efforts should be prioritised, while those that increase emissions (such as installing air conditioning in houses) should be avoided where possible. Fortunately, many of the adaptation responses suggested within this report also serve to reduce atmospheric greenhouse gas concentrations. A summary of the key mitigation measures is provided below.

Managing land for carbon

Tree planting and peatland restoration, in addition to being effective adaptation measures, also have a large role to play in mitigating climate change. Soils and vegetation act as long-term carbon stores, soaking up carbon from the atmosphere and locking it up in the ground or in plants and trees. Work is currently underway to find a method of measuring the extent of carbon savings this could generate, so that it can be included in the carbon budget[177]. Upland land-use needs to be managed to protect soil carbon stores and improve the ability of upland habitats (such as blanket bog, scrub and woodland) to sequester carbon dioxide. A Higher Level Stewardship agreement involving graziers and the landlord on Mungrisdale Common, near Blencathra, provides an example of how this can be achieved through agri-environmental agreements [178].

The Lake District National Park, in conjunction with the University of Cumbria, is currently developing a carbon management toolkit for land managers. This is intended as a simple tool that will allow land owners and managers to determine how much additional carbon could be sequestered on their land if they were to manage their land for carbon (e.g. by planting different types of vegetation and trees, restoring peatlans, etc.). It also gives an idea of possible income streams from adopting various land-uses, which should act as an incentive for landowners and farmers. This toolkit should be available soon on the Lake District National Park website.

Developing a woodfuel economy

Assuming woodlands are adequately restocked, the use of biomass fuel for heating instead of gas or electricity can reduce carbon emissions. It should be noted that the adoption of biofuels globally has had some negative consequences (for example, competition for land use between biofuels and food has led to food price rises and therefore hunger in many developing countries [179]). However, in areas such as Ullswater, in which the land used for forestry would be unlikely to have otherwise been used for significant food production, the cultivation of a woodfuel economy makes sense.

Low carbon transport

One of the aims of the Low Carbon Lake District initiative is to reduce the use of private cars. Working together to develop an effective and integrated public transport system to suit the needs of locals and visitors could help to achieve this. Furthermore, the introduction of Broadband to the valley could provide more opportunity for people to work from home, and for local people to set up businesses closer home, thus reducing the need to travel.

Low carbon building materials

Installing insulation is the cheapest and most effective way of improving the energy efficiency of buildings. Natural insulation materials that can help to reduce condensation in old (pre-1919) houses also tend to have lower carbon footprints than their conventional counterparts, thereby reducing emissions still further.

Local, seasonal food

Accomodation, food and drink made the second largest contribution to the Lake District's carbon footprint, after transport [180]. Increasing the proportion of food and drinks produced locally can reduce food miles (i.e. the distance food must travel from producer to consumer), and associated emissions.

Wider awareness

Visitors are vital to the local economy, and also a key contributor to the region's greenhouse gas emissions. It is therefore important that they become involved in both adaptation and mitigation efforts. Raising awareness among visitors of the need to address climate change could help in adaptation and mitigation efforts – they

are more likely to support changes to the landscape and access restrictions, etc. if they understand why these measures are necessary.

6. Community Engagement

The uplands are also a source for flooding, and inappropriate land management can appreciably increase flood risk. In the future, a warming climate, changes in precipitation or inappropriate management could convert peatlands from a carbon sink to a carbon source. The greatest threat to these valuable assets, however arises from a lack of recognition that these are embedded in social and economic systems – in other words, their sustainability is reliant on the sustainability of upland communities. [181]

6.1 February 2013 facilitated meeting

A meeting on 7 February 2013, attended by 82 residents and agency support officers, highlighted a range of community needs that have been categorised into eight key areas of interest. A Vision was then developed for each of these, as follows:

- **Management of the environment: Maintaining the balance** – 'Ullswater valley is beautiful and it is unique in its direct access to the lakeshore. All efforts should be directed to maintaining a balance between development, community needs and nature-value. In particular, there should be close monitoring of the impact-cost of tourism on the natural assets of the area, and the income and employment that tourism generates.'
- **Water: A common-sense approach** – 'A common-sense approach is needed for beck management and farmers have a role in managing drains and watercourses in Ullswater.'
- **Employment & Economy: Employment-led sustainable development** – 'To work towards a year-round economy which is diverse, locally based, IT and broadband supported for home-workers, based on renewables, and geared towards sustaining families and the community. In particular there is an opportunity to forge stronger links with agriculture.'
- **Sustainable Tourism: Sustainable tourism which works for the community, the natural environment and the visitor** – 'To develop a tourism economy which is sustainable because it maintains Ullswater's unique natural and community assets through a year-round service, welcoming and encouraging visitors to stay longer and enjoying learning about the natural environment. This requires higher quality professionalism in which there is flexibility and joined up thinking about development opportunities and a shared understanding of the best tourism products for visitor management'.
- **Heritage: Ullswater heritage is special and needs to be protected, developed where appropriate, and communicated more widely** – Ullswater heritage (vernacular architecture, community history, natural environment, geology) is special and needs protection, appropriate development, and effective communication. Ullswater is a living place and

cannot be a museum.'

- **Community Services: The Ullswater community is dynamic, welcoming and has a voice which needs to be heard** – 'The needs of the community should have a bigger role in all planning, and there needs to be a balance struck between visitors and locals in all decision making. The population needs to include more younger people.'
- **Public Transport, parking and roads** – **'**Ullswater needs an integrated, flexible transport service which takes care of the environment, the local community and visitors.'
- **Housing: Ullswater needs housing which allows more people to live and work in the valley** – 'Policy changes are needed to ensure affordable and available housing for the local community; without this the community will decline.'

Within these themes, the following perspectives and concerns relate to climate change mitigation and adaptation:

- Natural Environment & Water
    - Climate change impacts so evident that there needs to be community induction and training in how to cope and adapt
    - More trees need planting
    - Local communities should be used to tidy up woods and collect wood for heating
    - All drains (surface water, underground, road sewers) need regular and, during rainy periods, more frequent maintenance
    - River banks maintenance so fields are not flooded
    - Develop a conservation/wildlife economy
- Community services (reduce carbon footprint)
    - Begin a 'shop local' campaign
    - Investigate scope for using a 'local pound' to keep money in the valley
    - Improve and maintain existing shops and services (including post office, health services)
    - Develop local activities and facilities for young people
    - A one-stop shop communications hub for problem solving
    - Swiss style transport system, carbon free and multi-use and affordable for local people
    - Low or no cost parking for locals
    - Keep money from car parking in valley

    - Develop cycleways
    - Better footpaths for families
- Housing
    - Affordable housing for local people
    - Limit the number of second homes
    - Local occupancy clauses enforced
    - Community-led housing solutions
- Education and learning
    - Local schools need to focus on local environment
    - Keep schools open!
    - Make available more learning facilities for schools
    - Develop new educational centres (like TICs)
- IT/Broadband
    - More people working from home
    - Effective local communications

6.2 March 2013 facilitated meeting

All the community evidence gathered on 7th February was collated and themed and returned to all participants on 26th March, who were invited to score actions and comment on vision statements. Thirteen respondents returned written scores and these were included in the prioritisation and action planning session on 26th March, which had 36 participants. The headline priorities from this session makes it very clear that the climate change challenge and its impact on water management leads the community concerns. These link into overlapping links with employment and economy, and Ullswater heritage.

Action	Scores	Theme
Efforts should be made to maintain the river-banks so that fields are not flooded	44	**Water**
Develop a conservation/wildlife economy with investment back into the natural environment – businesses to pay to improve the environment	36	**Employment and Economy**
Water pollution is always an issue and needs monitoring	21	**Water**

Action	Scores	Theme
More information on Ullswater heritage needs to be gathered and made available to residents and visitors.	20	**Ullswater Heritage**
Ensure there are good paths and bridleways to provide access to natural environment which protects it	19	**Management of Environment**
Improve/maintain existing shops and services including post office	19	**Community Services**
Keep school open- provide further education at school	18	**Community Services**
Housing solutions should be community–led; not imposed from outside	18	**Housing**

During the 26th March meeting community representatives 'signed up' as members of particular theme groups. It is anticipated that the model developed in the present report will be further developed in association with the 'Water' and 'Management of Environment' groups.

6.3 Farming community engagement

During 2011, the Ullswater Catchment was included in a Nature Improvement Area (NIA) bid – **Cumbria Lakes to Fells**. This entailed engagement with farmers from the Ullswater catchment on 29th November, 1st December, and 8th December 2011. These meetings highlighted a number of farmer concerns about the NIA bidding process and the need for much earlier and respectful consultation. But they also revealed suggestions for farmer activities which support and complement the Valley Planning engagement undertaken in 2013, as follows:

- Mutual training with agency staff to develop shared appreciation of nature conservation as part of viable farm businesses;
- Tree planting;
- Ditch management; and
- Repairing river banks where washed-out.

The NIA bid was not successful, but there was a compensatory small scale project initiated in 2012 – **Cumbria Connections** – which has been reviewing farmer needs and perspectives through a series of meetings facilitated by the Cumbria Farmer Network (http://www.thefarmernetwork.co.uk/cumbria/), one of which was attended by Terry McCormick, co-author of the present report (4th March 2012). These later

consultations highlighted the following as potential activities:

- Habitat creation (tree planting; digging ponds/scrapes);
- Developing sustainable drainage systems; and
- Sustainable sourcing and use of water.

6.4 Summary of scope for community supported climate adaptation in the Ullswater Catchment

This extensive and in-depth community engagement in the Ullswater Catchment from 2011-2013 confirms concerns and commitments which, with timely facilitation and agency support, can be converted into collaborative action for community emergency planning and remedial protection (adaptation), and medium to long term mitigation measures. This collaborative action can be guided by the present model for community resilience in a rural setting.

7. Conclusions and Next Steps

This report has demonstrated that there is a need to address climate change risks in Ullswater, and that there are many responses that could be developed by the community (in particular landowners and farmers) in conjunction with the relevant agencies, to deliver both mitigation and adaptation outcomes. The findings of the desk-based review of climate change impacts fits well with the concerns of the local community, which have come out during the public workshops.

It is clear that there are some potential conflicts between the needs of farmers and the need to address climate change (i.e. the potential loss of vital in-bye land in efforts to renaturalise the watercourses). By working in partnership it is hoped that agreements can be reached that satisfy all parties, as has happened in Borrowdale.

It is hoped that this report can be used as a supporting document, and that the findings can be used both to inform the community on climate change impacts, justify further action on climate change in the valley, and to provide information on possible adaptation measures. At this stage the next steps for the project are considered to be:

- To assemble a climate change working group, consisting of agencies and locals, to oversee the use of this model in Ullswater. This group should to feed into the wider Whole Valley Planning initiative being trialled in Ullswater;
- Use of annotated photo of the Ullswater valley (produced as an output from this project) as an engagement tool for communities;
- The Lake District National Park to include the community climate change resilience model within their Whole Valley Planning approach across all Lake District valleys;
- ACTion for Communities in Cumbria to take the model to the community resilience sub-group to seek support for rolling out the approach across Cumbria; and
- The Lake District National Park to disseminate project learning within the North West Climate Change Partnerships network and other relevant national organisations (including other national parks).

8. Appendices

Appendix 1: Borrowdale Whole Valley Planning case study

Whole Valley Planning: Borrowdale case study

Introduction

The River Derwent and its tributary, Stonethwaite Beck, flows northward through the Borrowdale valley and into Derwentwater, to the south of Keswick, in the north eastern Lake District. The upper Derwent catchment is relatively narrow, with steep sided valleys, rocky mountain tops, mossy heathland, grassland and mires. The valley bottom consists of grassland and is used for rearing livestock. It is the wettest part of the country, with up to 4000mm of rainfall having been recorded in the mountains. The numerous watercourses within the valley influence the landscape character and change dramatically with the seasons and depending on rainfall. They are subject to flash flooding due to the high rainfall, steep topography and poorly developed soils. The Parish of Borrowdale consist of four main villages – Grange, Rosthwaite, Stonethwaite and Seatoller – with a number of smaller hamlets in between (Thorneythwaite, Longthwaite, Seathwaite and Watendlath). There are just over 200 dwellings (many of which are holiday homes), and the permanent population is approximately 350 people.

Background

Over the last ten years or so, the Borrowdale community has become increasingly concerned about the frequency and severity of flooding in the valley, and the impact that this is having on their livelihoods. In particular, farmers and others are concerned that increased rates of bank erosion and gravel deposition, together with more frequent periods during which the river bed runs dry in summer months, are threatening the viability of farming and other activities within the valley bottom.

Honister Flooding 2009

On 19 November 2009 314mm of rain fell on Seathwaite in one 24 hour period. This was a new record for England. The widespread flooding in the Derwent catchment during this period resulted in wholescale channel change, with many of the rivers (particularly in the lower Derwent) cutting new courses. Bank reinforcements failed, embankments were breached, and huge volumes of gravel were transported and deposited within the channel and on the adjacent floodplains. These floodplains are used as in-bye land, and are the main productive land in this steep-sided valley, used by farmers to graze stock during the winter. The farmers were concerned that the likelihood of future flooding had become greater because of the gravel deposits left on the river bed by the floods.

Four public agencies have a stake in the management of the River Derwent: Natural England (NE), Environment Agency (EA), Lake District National Park (LDNP) and National Trust (NT). The latter manages almost 12,000ha in the Borrowdale area, including farms, fell, common land, woodland, lakeshore, islands and half of Derwentwater.

River Derwent, Borrowdale (gravel management)

However, no single agency has a budget for flood-risk mitigation in the valley, with limited resources now focussed on areas with larger populations. Furthermore, tighter environmental regulation and a drive to renaturalise river courses over recent years has meant that farmers are no longer able to extract gravel or install bank protection and maintain defences as they used to. In the months following the flooding there was no indication of the emergence of an integrated solution. The immediate threat was to those who farmed land next to the river, and they became concerned over the lack of progress. HRH the Prince of Wales became involved and asked the agencies to urgently address the problem.

In April 2010, ACT was asked to facilitate and support a community and multi-agency group to undertake research and development of a new approach to limiting flood risk in the valley. An ad-hoc leadership group was convened – including representatives from the four agencies as well as ACT and NFU – to overcome the impasse that had developed from the EA withdrawing from rural maintenance and the farmers being unable to carry out works themselves. It was agreed that a community/farmer-led whole valley planning approach be adopted.

The Whole Valley Planning approach uses similar ideas to Community Futures, which is designed in the belief that investment in local community planning, involving people in the process and building and strengthening community organisations, will contribute to sustainable community development. This has been implemented in Loch Lomond and the Trossachs National Park.

The Project

The Borrowdale Whole Valley Planning Group consists of the leadership group (LDNPA, NE, NT, EA, NFU, ACT) and representatives from Borrowdale Parish Council, three affected farms and the wider Borrowdale community. The day-to-day running of the project was managed by a sub-group consisting of ACT, EA and NFU, the latter also being the budget holder and cash flow manager. It was set up to develop a collaborative approach to land management and community planning in Borrowdale, with the aim of maintaining and strengthening the farming and natural environment assets for the benefit of farmers, residents and the wider community. River and flood management are seen by the group as medium and long-term challenges.

The first meeting, on 29 June 2010, involved establishing agreement over the

location of high-risk flooding, which were scored in terms of their urgency. This part of the meeting was led by the farmers. The group supported a direct intervention on the highest risk areas (between New Bridge and Stepping Stone) which, by mid-August, had been successfully resolved. At the same meeting, it was agreed that there was a need to establish an evidence-base on which to base decisions on gravel removal. It was decided that this should take the form of a river/gravel management plan for the River Derwent and its tributaries, to address the remaining 'hotspots', taking guidance from the work being undertaken at the time in Patterdale. One of the principal focuses of the project was to research the potential for farmers to provide an environmental service in the form of river bed and bank restoration. There was a tacit agreement throughout the process that the best people to undertake further interventions, once the plan was in place, were the farmers themselves, who could gain a supplementary income from doing so.

An external consultant was appointed in December 2010 to undertake the gravel management plan, through close collaboration with the Group and its farming representatives. Its objectives were to:

- provide, in a single document, the context that would allow the regulatory authorities to determine consent applications for the valley as a whole;
- inform the community about how their river functions;
- investigate a farmer-led land and ecosystem services management model for the Borrowdale Valley that could be replicated in other catchments;
- undertake, on behalf of farmers, outline business/development planning of this oportunity to determine the viability of this strand of activity so that it could be included in their business models; and
- provide an assesment of the mechanism through which maintenance works can be undertaken and resourced.

The report, which was published in June 2011, was written in plain English to ensure it is easily understandable by the wider community, using maps and visul aids to assist in effective communication of the findings. It identified nine key 'hotspots' where flood-related issues are most acute, and assessed and prioritised management action, providing landowners and managers with information to establish a targeted management action programme. A broad indication of costs was also provided; it was recognised that many of the short-term, low-cost management activities could be undertaken as part of the existing farm maintenance process (requiring collaboration between land managers – e.g. National Trust and LDNPA – and farmers, with farmers acting as paid contractors), while works requiring significant expenditure would have different funding requirements. The management plan presented a range of reactive actions to start solving key problems over the following five years (e.g. gravel removal, management of riparian vegetation and

River Derwent, Borrowdale (gravel management)

maintenance of some existing bank protection), and proactive actions, which could deliver long-term, sustainable solutions that work with natural river processes (e.g. control of sediment entering the channel through gulley planting).

The Challenges

The Borrowdale valley is in a particularly environmentally sensitive area, with Stonethwaite Beck and the River Derwent downstream of the Stonethwaite Beck confluence forming part of the River Derwent and tributaries Site of Special Scientific Interest (SSSI) and also the River Derwent and Basenthwaite Lake Special Area of Conservation (SAC). The site is of interest for a range of priority habitats, diverse plant assemblages and presence of key European Species and, as such, any in-channel works need to be designed to avoid smothering aquatic plants and fish spawning/nursery areas and nutrient build-up through silt generation.

Water quality deteriration fine sediment into Derwentwater (Nov 2009 Flood)

Initial group meetings were very confrontational, with a general feeling that nothing would be achieved and the problem was intractible. Group members had very different and, in many cases, conflicting views and objectives with regard to flood management in the valley – the agencies generally felt there should be greater understanding that past management practices have degraded the environment, are not ecologically or financially sustainable, and are not allowable under current legislation. One group member in particular was concerned that gravel removal and restoration of the river bank, while perhaps effective in the short-term, would require ongoing funding to sustain it (with each new flood likely to damage the bank and deposit more gravel), and was therefore not necessariliy a good use of funds. Farmers , on the other hand, wanted to protect their in-bye land by maintaining existing engineering solutions, and generally felt that the agencies placed unneccessary restrictions on this. The message that farmland is not valued as highly by the agencies as more densely populated areas was also a difficult one for those affected. A further problem is that the High Level Stewardship (HLS) scheme – a tool intended to incentivise long-term environmental stewardship by farmers – does not adequately cover the riverine environment at present.

The process was inherently slow; reaching consenus is time-consuming and, even when this has been achieved, it can take many months to get consent to work in the river, and to meet other legislative requirements. This proved a frustration for the

farmers, who would have liked to see immediate practical action.

It was felt by some that the group could have consulted more widely with the community on the conclusions reached, and that representation was not as diverse as it could have been; it was farmer-centric, with the community represented by three farmers and one local business, resulting in what some believed to be a narrow focus. In small communities such as Borrowdale, there tend to be limited numbers of people interested enough, or able, to commit time to projects of this nature. This may have been, in part, because the Group focussed on just one issue – flooding – in contrast to the Ullswater group, which had a wide suite of interests to be tackled by groups within the valley. Furthermore, there was a reluctance among the community to formalise the Group into a legal entity (e.g. charity or community interest company) to ensure the long-term sustainability of the project, mainly because of the financial risks and other responsibilities associated with becoming a Trustee or member.

Perhaps the principal ongoing challenge, however, is the increasing lack of financial resources.

The Achievements

The project provided a forum in which farmers and agencies could learn from each other by engaging in frank discussions in a trusting environment. Agencies were able to provide information which heightened awareness among other Group members of legislation and natural river processes. Equally, farmers were able to provide invaluable local knowledge of how different parts of the river behave, and which parts flood first. In this way, the Group moved from being combative to being a genuine partnership in which members were able to reach consensus through compromise and collaborative problem-solving.

The completion of the gravel management plan provided the evidence needed to progress works in such a way that was both effective for farmers and sensitive to environmental regulations and national flood management policy. Following completion of the management plan, consents were given for gravel removal works on two further sites. This work was carried out during summer 2012 by the community, with a small grant from the Lake District National Park Authority. A further two removal sites, and one restoration site, are also ongoing. There was in-principle agreement that ongoing maintenance work of hotspots (“little and often”) could be carried out.

The process allowed for greater involvement of farmers in wider landscape management concerns. This is particularly valuable for issues associated with rural watercourses, which do not fit into the Environment Agency’s ‘people and property’ remit. As part of a competitive tender one of the farmers submitted a quote for carrying out the work and he got it, showing that this approach of involving farmers provides good value for money.

The Borrowdale Whole Valley Planning Group is currently exploring its association

with Borrowdale Parish Council and the Derwent 7 – a formally constituted group, with legal, financial and governance structures already in place, consisting of representatives from seven parishes in and around Keswick. This could help to ensure the long-term sustainability of the project without the need to establish a separate organisation.

The project has provided a pilot for the Whole Valley Planning approach, and a model of working that is replicable both for other issues in Borrowdale, and across other catchments.

The Learning

The project has resulted in the formulation of a set of 10 key learning points which have influenced the Lake District National Park Partnership's Valley Planning initiative:

1. Farmers must be at the centre of decisions made about matters which concern their land;
2. An inclusive community infrastructure is required;
3. Communities must be given a voice to enable land management agencies to work with them collaboratively;
4. Natural valleys allow for community engagement which fits with the existing ecosystems;
5. Collaborative principles need to be worked out in practice in real actions, with real people, in real places;
6. No one partner can have an absolute hold over decision-making. Legal requirements are the only absolutes;
7. Terms of reference must be made for the short, medium and long term from the outset, and they should reflect the vision of the partnership. Development of a project-specific evidence-base is an essential foundation to this;
8. Independent facilitation is vital;
9. Flood mitigation/water management challenges act as strong motivators for collaborative working; and
10. Plans can be drawn up in a relatively short time frame.

Contact Details

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A copy of the report "Whole Valley Planning, Borrowdale: a River Derwent Management Plan" can be accessed via the Derwent 7 website: http://derwent7.files.wordpress.com/2011/01/borrowdale-final-report-june2011.pdf

Pictures provided by John Malley, National Trust

Appendix 2: Climate change impacts and responses for Ullswater

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
Changes in average climate conditions			• Woodland planting to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Peatland restoration to regulate water cycle, reduce flooding, prevent soil erosion and reduce silt/nutrient run-off • Maintenance of drains to prevent flooding • Preparation of a community emergency plan for flooding and other extreme weather events • Reduction of stocking rates in uplands to prevent soil erosion • Maintenance and upgrading of farm water storage and distribution systems to prevent water leakage • Reduction of household water use • Reduction of phosphate pollution through catchment sensitive farming • Changes to agricultural practices, e.g. timing of lambing, control of nutrient and silt run-off from farmland • Ensure changes in agricultural practices are sustainable and that any intensification due to longer growing seasons does not impact negatively on biodiversity and soil quality • Introduction of tolerant crop, grass, livestock and tree	• Tree planting and peatland restoration to enhance carbon storage capacity of the land • Developing a woodfuel economy to replace fossil fuels, through woodland planting • Create supportive environment for local business start-ups and food businesses to reduce transport of goods and workers • Develop integrated public transport network, including boat transport, to reduce need for travel (retain and increase existing amenities/work spaces and community assets in the village) • Use of natural building and insulation materials (such as sheeps wool), which generally have a lower carbon footprint than their conventional counterparts • Raise awareness among locals and visitors on the need to for climate change mitigation measures
Gradual and seasonal changes to the climate	Agriculture and forestry	Longer growing season resulting in increased crop, grass and timber yields and reduced costs for livestock housing		
		Inappropriate grazing and/or poaching of soils		
		Changes in agricultural land classification		
		Changes in land management practices and timing required, affecting specified dates in agri-environment agreements, etc		
		Outbreaks of new and existing pests and disease for livestock (e.g. bluetongue), crops and trees (e.g. green spruce aphid and red band needle blight), principally due to warmer wetter winters		
	Business and services	Impact on species, habitats and ecosystems that change the natural environment that tourism relies on		
		Increase in visitor numbers as part of a broader northward shift in tourism		
		Increased risk of algal blooms during warmer summer months (higher nutrient concentrations) and wetter winter months (higher nutrient run-off)		

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
	Health and wellbeing	Fuel poverty for those with hard to treat homes (this risk could be reduced due to warmer winters, but fuel poverty will depend more on energy prices and building quality than on climate change)	species to reduce impact of extremes of climate and certain pests and diseases • Management on non-native species • Future-proofing of livestock housing against heatwaves and other extreme weather • Exploiting potential for local woodfuel economy and potential for longer summer growing seasons • Adopting sustainable grazing regimes, and expanding and linking existing habitats to protect biodiversity • Raising awareness among visitors of the measures needed to respond to climate change and to protect the natural environment • Avoid habitat fragmentation to ensure species have best chance of shifting in response to climate change • Peatland restoration and linkage of important habitats to enhance biodiversity • Developing integrated public transport network, including boat transport, to reduce reliance on private cars and roads, particularly during extreme weather events • Establishing local 'hubs' from which locals can work and operate small businesses without having to travel outside the valley • Reduction of phosphate pollution through use of phosphate-free laundry detergents by tourist businesses • Improve visitor offer for wet-weather activities • Retaining of local services (e.g. post office and schools)	
	Natural environment	Impact on species, habitats and ecosystems due to changing phenology and climate space, etc (possible breakdown in ecosystem function and loss of ecosystem services)		
		Increased strain on natural environment from increased visitor numbers		
		Changes in landscape due to climate change mitigation and adaptation measures (tree planting, peatland restoration, renewable energy systems, etc)		
Extreme weather events				
Flooding / waterlogging / prolonged wet periods	Agriculture and Forestry	Loss of grazing land		
		Livestock health problems		
		Reduction in soil quality (compaction, loss of nutrients, etc)		
		Increased erosion		
		Increased lamb mortality		
		Tree damage		
		Soil erosion		
	Business and services	Path damage and visitor access restrictions		

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
		Transport disruption (local commuters and visitors)	to maintain community cohesion • Flood-proofing of properties at risk of flooding • Use of natural, breathable building materials in historic (pre-1919) buildings to prevent condensation and mould build-up and consequent respiratory health problems and degradation of building integrity and character • Development of mutual insurance companies with insurance premiums dependent on validated community emergency plans	
		Supply chain disruption (due to transport disruption)		
		ICT / power supply disruption (particular problem for home workers and local businesses)		
		Loss of man-made / natural tourist assets		
		Reduced visitor appeal		
	Health and wellbeing	Increased mortality from flooding events (e.g. bridge failure in West Cumbria)		
		Increased mental health problems due to flooding		
		Particular risk to vulnerable people		
		Disruption to emergency services / transport links during flood events		
		Increased insurance premiums		
		Increased risk of respiratory health problems from mould build-up in buildings		
	Natural environment	Increased soil erosion		
		Increased water pollution (silt and nutrient run-off from mountains and sewage/drainage overflow), including eutrophication (algal blooms)		
		Geomorphological changes		
	Buildings and infrastructure	Flooding of road networks (risk of road damage)		

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
		Increased risk of landslides onto road and/or buildings		
		Drain/sewer overflow, causing water pollution		
		Flood damage to buildings		
		Damage to buildings from wind-driven rain		
		Damage to buildings from mould build-up		
		Damage to buildings – loss of cultural heritage		
		Impact on buildings / agricultural insurance		
		Flooding of energy infrastructure)		
Heatwaves and Droughts	Agriculture and forestry	Reduction in water availability for agriculture		
		Dryer soils resulting in reduced crop and timber yields and increased soil erosion		
		Lower groundwater recharge		
		Livestock heat stress resulting in reduced milk yields, fertility and livestock health		
		Increased wildfire risk, with potential damage to woodlands, livestock and farm buildings		
	Business and services	ICT / power supply disruption from overheated cables (particular problem for home workers and local businesses)		
		Competition for increasingly scarce water resources between local community and tourist businesses		

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
		Poor water quality leading to algal blooms and unattractive dried up lakes and rivers		
		Parched vegetation reducing attractiveness of landscape		
		Visitor access restrictions due to wildfire risk		
	Health and wellbeing	Increase in heat-related morbidity/mortality		
	Natural environment	Public water supply-demand deficit – competition for scarce resources (agriculture, energy, industry, public, natural environment)		
		Low summer river flows and increased water temperature (impact on aquatic species)		
		Low groundwater recharge (lowering of groundwater table)		
		Drying out of peat bogs		
		Dryer soils resulting in soil erosion		
		Decline in terrestrial surface water quality due to reduced contaminant dilution		
	Buildings and infrastructure	Restriction in water for energy generation (hydropower)		
Windstorms	Agriculture and forestry	Windthrow damage to trees		
	Business and services	Transport disruption (and therefore supply chain disruption) due to fallen trees		

Physical change	CCRA Theme	Impact	Possible adaptation response	Link to mitigation
		ICT / power supply disruption from fallen trees (particular problem for home workers and local businesses)		
		Visitor access restrictions due to fallen trees		
	Health and wellbeing	Risk of injury from fallen trees and other debris		
		Disruption to emergency services		
	Buildings and infrastructure	Storm damage to ICT / power supply		

Appendix 3a: Environment Agency flood map for Ullswater

Ullswater Valley Flood Map

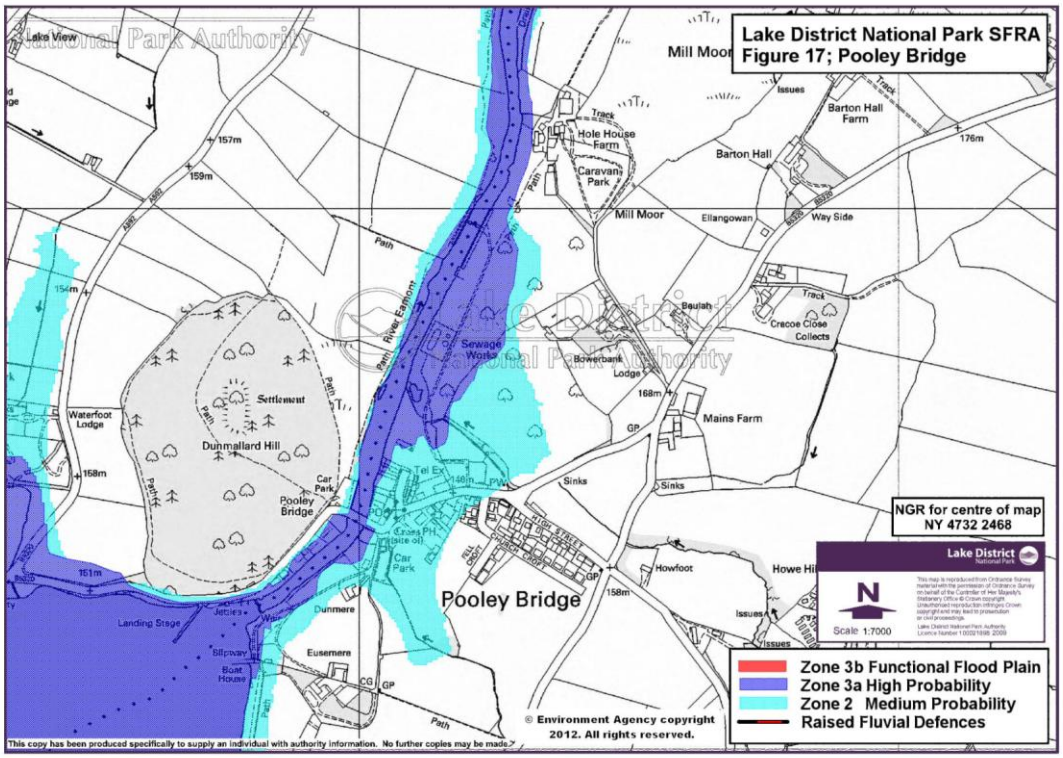
Environment Agency

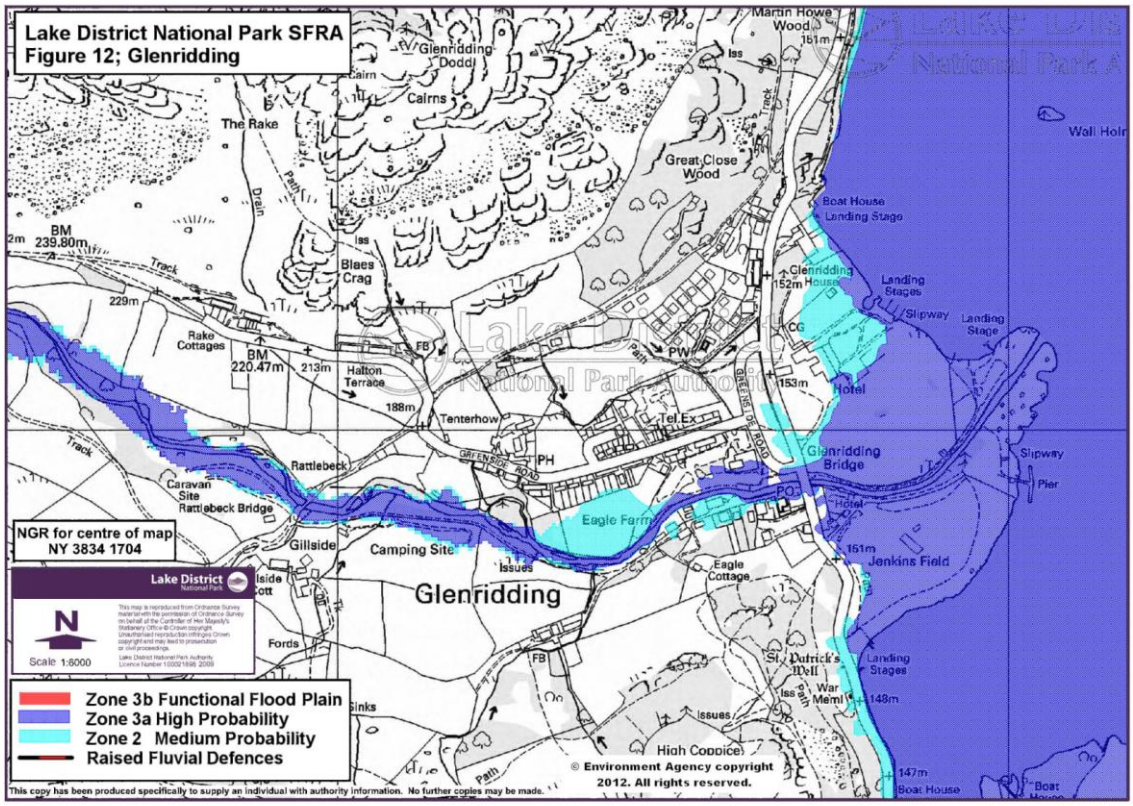
Legend
- Flood Map - Flood Zone 3
- Flood Map - Flood Zone 2

N W E S

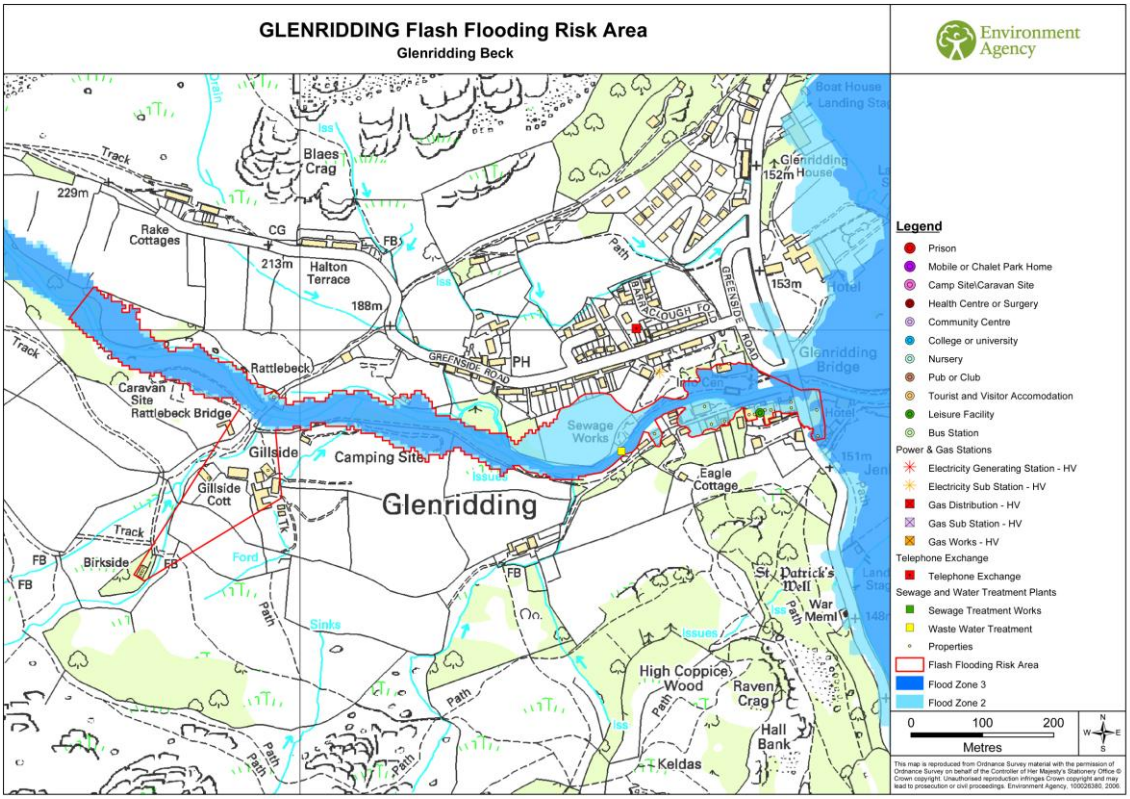
0 600 1200 1800 2400 m.

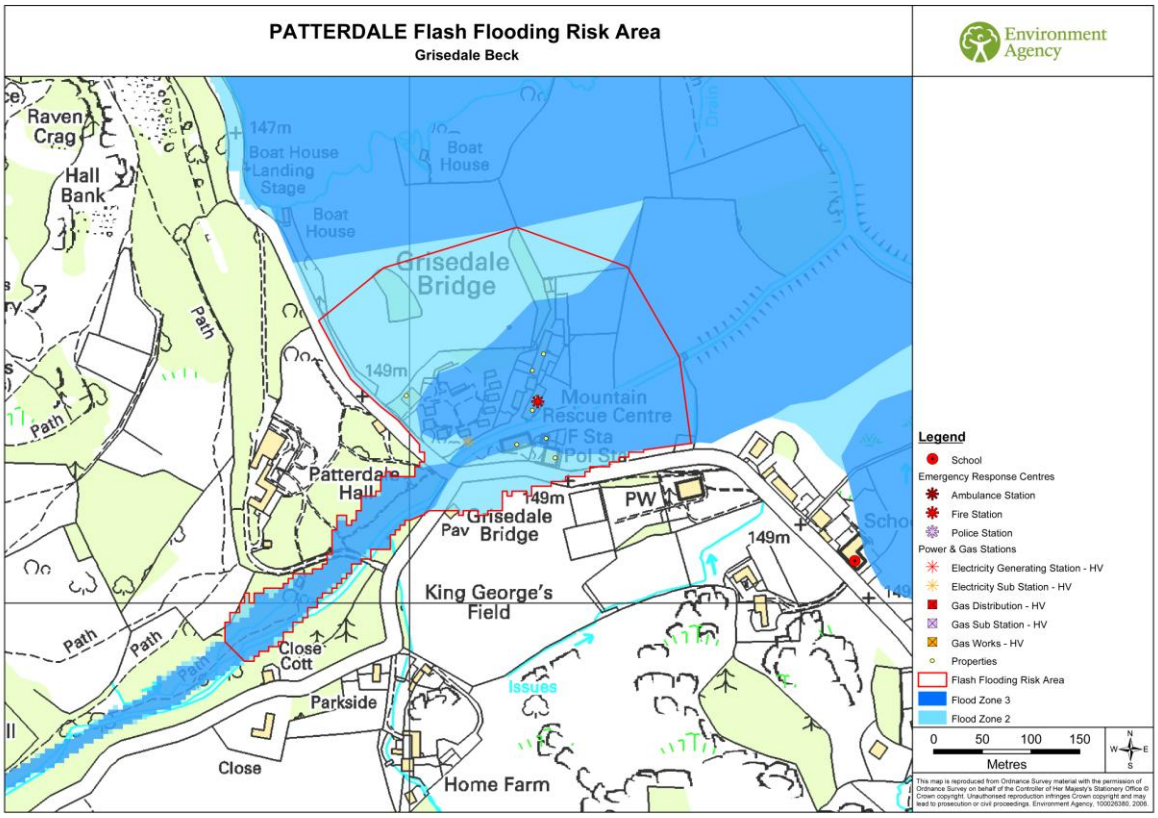
Appendix 3b: Lake District Strategic Flood Risk Assessment flood maps for Glenridding and Pooley Bridge





Appendix 3c: Environment Agency flash flood maps for Glenridding and Patterdale





Appendix 3d: Environment Agengy rapid response catchments

Cumbria flood risk communities

Rapid Response Catchment North Area List

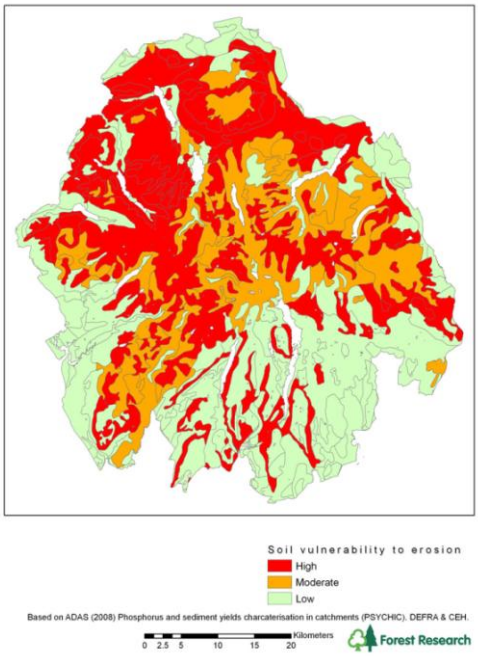
Local Authority	Communities at risk	Level of Risk	Flood Warning Area	Properties
Allerdale	Bassenthwaite - Halls Beck and Chapel Beck	High		36
	Braithwaite - Coledale beck	Very High		117
	Branthwaite - River Marron	Medium		9
	Bridgefoot - Lostrigg Beck	High		32
	Caldbeck - Gill Beck/Whelpo Beck/Cald Beck/Bowten Beck	High		38
	Cockermouth - Rivers Derwent & Cocker	Very High	Yes	975
	Dearham - Row Beck	Medium		5
	Keswick - River Greta	Very High	Yes	913
	Keswick - Cuddy Beck	Very High		145
	Rosthwaite - Stonethwaite Beck	High		18
	Seatoller - Hause Gill	Medium		17
	Stainburn - Scale Beck and Unnamed Beck	Medium		42
	Ullock - River Marron	Medium		16
Barrow	Dalton-in-Furness - Poaka Beck	Very High		175
	Dalton-in-Furness - Hagg Gill	High		26
Carlisle	Stockdalewath - River Roe	Medium		29
	Talkin - River Irthing	Very High		66
Copeland	Braystones - River Ehen	Medium		24
	Cleator - River Ehen	High		78

	Cleator Moor - Nor Beck	Medium		43
	Egremont, River Ehen	High	Yes	309
	Egremont, Skirting Beck	Very High		192
	Ennerdale Bridge - River Ehen and Croasdale Beck	High		60
	Thornhill (Low Mill) - River Ehen	Medium		10
	Calder Bridge - River Calder	Medium		29
	Duddon Bridge - River Duddon	Medium		10
	The Green - Black Beck	Medium		24
Eden	Hartley - Hartley Beck	High		63
	Warcop - Crooks Beck	Medium		21
	Appleby-in-Westmorland - River Eden	Very High	Yes	312
	Bolton - River Eden	High	Yes	2
	Crosby Ravensworth - Lyvennet and Dalebanks Beck	High		32
	Drybeck - Drybeck	Medium		7
	Great Ormside - River Eden	Medium		15
	Kirkby Thore - Troutbeck	Medium		6
	Maulds Meaburn - Lyvennet Beck	Medium		24
	Glenridding - Glenridding Beck	High		27
	Patterdale - Grisedale Beck	High		12
	Penrith - Thacka Beck	Very High	Yes	922
	Bampton Grange & Bampton - Haweswater Beck	Medium		19
	Eamont Bridge - River Eamont	Very High	Yes	112
	Greystoke - North Petteril Beck	Very High		66
	Newton Reigny - River Petteril	Medium		7

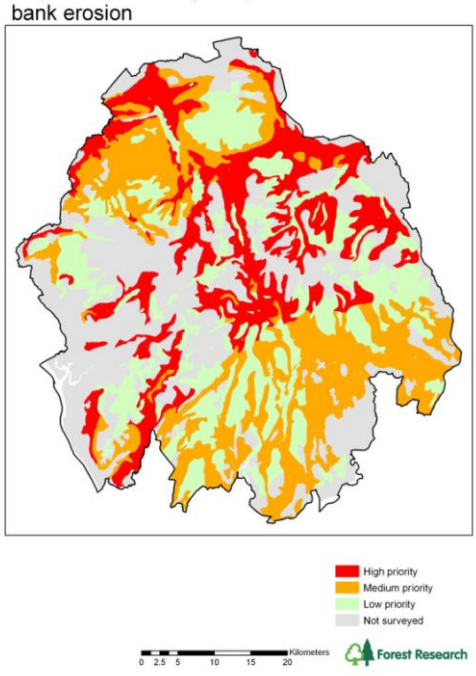
	Highbridge (near Ivegill) - River Roe	Medium		14
	Millhouse - River Caldew	High		11
South Lakeland	Beetham - River Bela	Medium		7
	Milnthorpe - River Bela	Medium		29
	Stainton - Stainton Beck	Medium		14
	Ambleside - Fisher Beck	Very High		111
	Ambleside - Brathay and Rothay	Very High		65
	Ambleside - Scandale Beck	Medium		13
	Ambleside - Stock Ghyll	Very High		416
	Grasmere - River Rothay and Easedale Beck	Very High		180
	Troutbeck Bridge - Trout Beck	Very High		95
	Coniston - Church Beck and Yewdale Beck	Very High		228
	Spark Bridge - River Crake	Medium		15
	Ulverston - Dragley Beck	Very High		567
	Burneside - River Kent	High	Yes	176
	Kendal - Rivers Kent and Mint	Very High	Yes	1609
	Kendal - Stock Beck	Very High		337
	Staveley - River Kent and Gowan	Very High		344
	Backbarrow - River Kent and Gowan	High		77
	Cartmel - River Eea	Very High		151
	Cark - River Eea	Very High		90
	Flookburgh - River Eea	Medium		39
	Rusland - Rusland Pool, Forces Beck and Ashes Beck	High		19
	Milthrop, Sedbergh - River Rawthey	High		12

Appendix 4a: Forestry Commission sediment maps

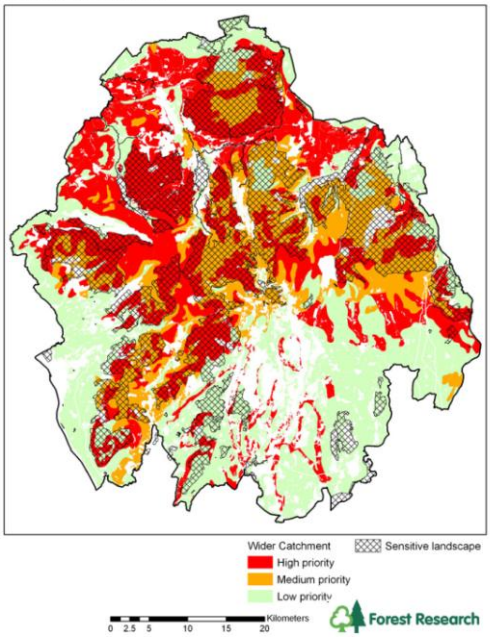
Map 12 Vulnerability of soils to sediment loss



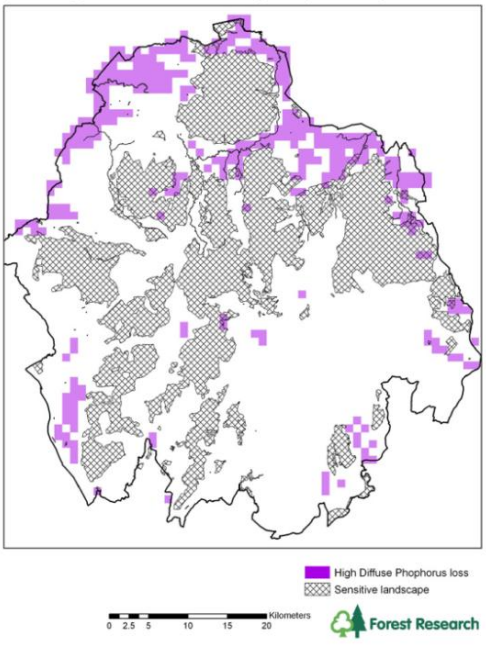
Map 15 Vulnerability of riparian soil to stream bank erosion



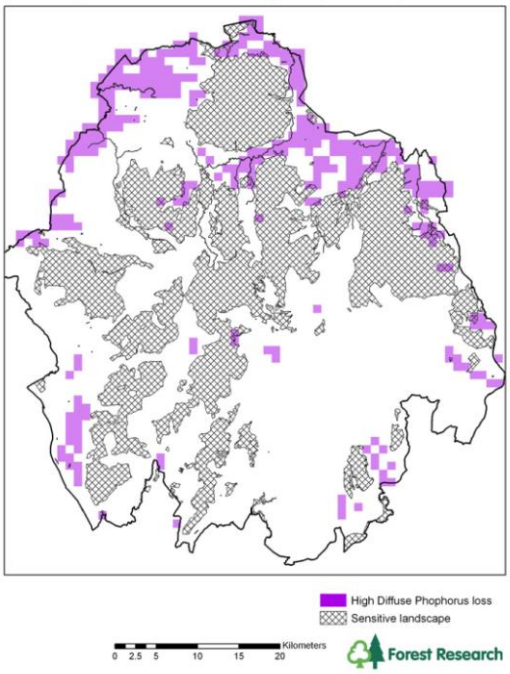
Map 17 Priority areas for woodland planting in the wider catchment to reduce sediment delivery to watercourses



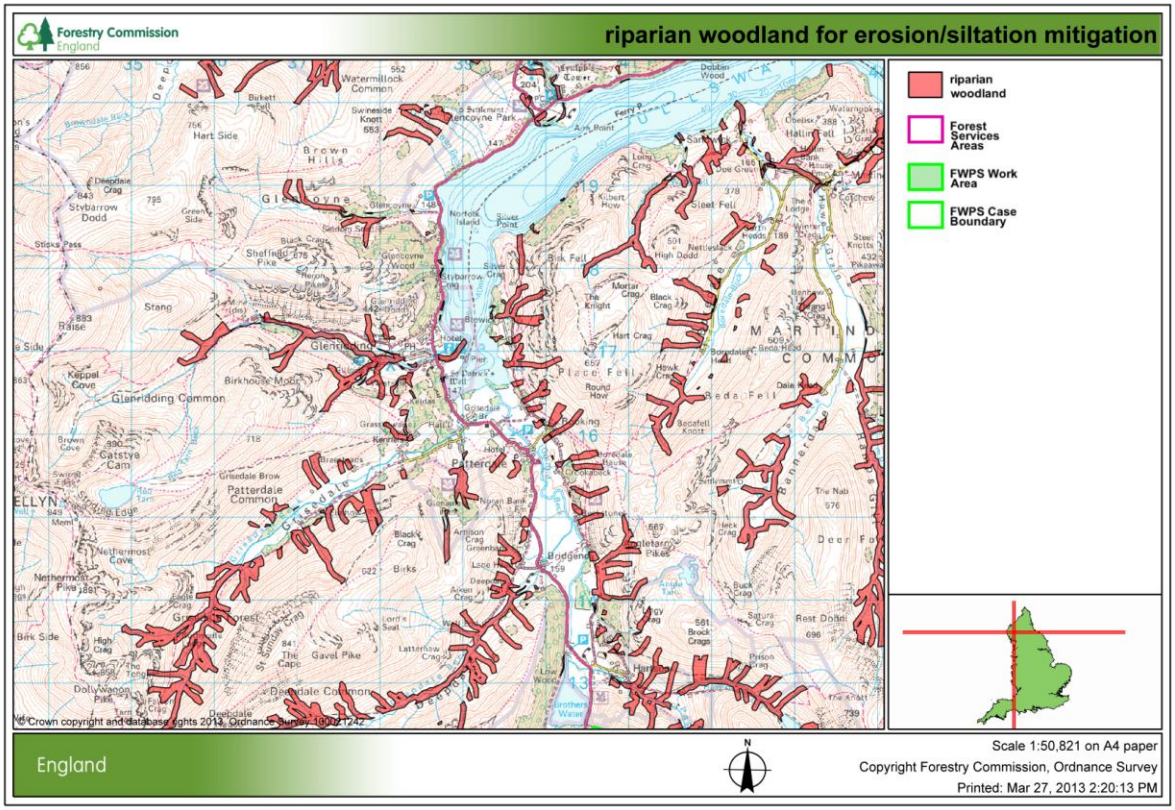
Map 18 High priority areas for new woodland planting to reduce diffuse phosphorus pollution



Map 18 High priority areas for new woodland planting to reduce diffuse phosphorus pollution



Appendix 4b: Forestry Commission riparian woodland map



Appendix 5: A profile of Ullswater: extract from World Heritage Site nomination document

Ullswater Heritage

The Ullswater catchment is one of twelve Lake District catchments which are currently included in nomination of the Lake District to be a World Heritage site. The following summary of the natural environment and heritage asset that the valley represents is taken from the nomination document. The high value of this outstanding natural environment and its heritage highlights the future management challenges for these catchments in an era of climate change risks and economic depression. This model based on the Ullswater Catchment seeks to meet this challenge.

"…take a flight of not more than four or five miles eastward to the ridge of Helvellyn and you will look down upon …Ullswater, stretching to the east…"

W. Wordsworth, Guide to the Lakes.

The remains of prehistoric settlement in Ullswater are extensive and span the period from the Neolithic to the Iron Age. The earliest evidence for human activity in the area comprises a significant example of rock art at the head of the valley near Patterdale, which date to the Neolithic or early Bronze Age. Sites of similar date are also found on the high ground of Askham Fell, southeast of Pooley Bridge, including stone circles, a stone alignment, burial cairns and burnt mounds.

The evidence for later prehistoric activity is even more extensive and includes an important series of enclosed hut circle settlements and two hillforts at Maiden Castle and Dunmallard Hill. The relatively high number of later prehistoric settlements around Ullswater suggests a higher density of occupation than in other valleys in the Lake District, possibly due to the importance of Ullswater as a route of communication and the good agricultural soils around the lower lake.

The Romans constructed marching camps and a fort at Troutbeck, just to the northwest of Ullswater, together with roads to connect these with forts at Penrith and Ambleside. The Roman road from Ambleside, known as High Street, was probably constructed along the route of an earlier prehistoric trackway and runs along the tops of the fells on the south-eastern side of Ullswater.

In the early medieval period (6/7th centuries AD) a monastery was built at Dacre which is mentioned in the writings of the early English historian the Venerable Bede. The site is now occupied by a church dating from the 12th century and there are fragments of carved stone crosses of 8th to 10th century date and an unusual group of carved stone animals. There is another potentially early church site at Barton where the nave and central tower of the present church date from the 12th century but the circular form of the churchyard may indicate an ecclesiastical centre of much greater antiquity.

Other significant medieval sites include Dacre Castle (14th century) and Pele towers

at Askham Hall and Hutton John. The castle at Dacre is perhaps the finest example of a fortified medieval site in the Lake District and has additions of the 17th century in medieval style. Askham Hall has a Pele tower of the 14th century with additions in the 16th century. The stately house at Dalemain, with its Elizabethan and Georgian additions, also originated as a medieval tower.

Agriculture

The pattern of agriculture in the Ullswater varies according to the potential afforded by the topography and this variation is reflected in the character of the field systems and enclosures throughout the valley. On a broad scale, the better soils on the gentle slopes on the north shore between Gowbarrow Park and Pooley Bridge supported the development of extensive arable fields which are now under pasture. This contrasts markedly with the opposite lakeshore where the proximity of steep crags for much of its length reduced the opportunities for anything other than rough grazing. Exceptions to this are the small areas of flatter land at Sandwick and Howtown where fields have been created.

Evidence for the enclosure of former medieval common fields can be seen in the existing pattern of walls around the villages of Hartsop, Patterdale, Pooley Bridge and around Sandwick on the eastern shore. However the pattern of medieval intakes on the fell side of the open fields, so common in other Lake District valleys, is restricted here to the smaller side valleys such as Grisedale and Boredale. In Ullswater the visible pattern of later enclosure is a mixture of the irregular patterns that have developed around single ancient farms (seen on both sides of the lake), former medieval parkland (for example Glenamara, Glencoyne and at the head of Martindale), and the large, regular fields resulting from parliamentary enclosure around the lower lake. This is interspersed with stands of native woodland and ornamental parkland on the lake shore, particularly on the north side at Aira Point and Oldchurch.

Herdwick farming features strongly in Ullswater and the valley contains some of the most significant Herdwick farms, including Hartsop Hall and Glencoyne. Traditionally some of these have had the largest flocks in the area. William Green included a list of the largest Lake District Herdwick flocks in his *The Tourist's New Guide* of 1819 and noted that Patterdale Hall had a flock of 1700, Glencoyne had 900, and Hartsop Hall had 800. The farm at Glencoyne is one of the largest current Herdwick farms in the Lake District due in part to its large area of enclosed land as well as open fell.

Industry

The principal industries in the Ullswater valley were lead mining and slate quarrying, and some of the archaeological remains of these are of national significance. Lead mining in the valley probably dates from the medieval period, but the earliest dated feature is a lead smelting site at Hoggett Gill of the late 17th century. Large scale lead mining began in the late 18th century and reached peaks of production in the 19th and early 20th centuries. Important remains survive at Hartsop Hall mine and Myers Head, the latter being a well-preserved example of a late 19th century mine (it

was rapidly abandoned due to flooding). However the largest lead mine was at Greenside, west of Glenridding, which operated from the late 18th century until 1961. The impressive remains of adits, wheelpits, processing floors and spoil tips at Greenside provide testimony to a long period of sustained and innovative lead extraction. Greenside was the first metal mine in the UK to adopt electricity for tramming and winding and it adopted the best technology of the time for smelting and silver refining. In the 111 years between 1825 and 1935 the Greenside Company produced over 106,000 tons of lead and the Basinghall Mining Syndicate produced 50,000 tons from 1936 to 1961.

Buildings and settlement

The principal settlements in the Ullswater valley are the villages of Patterdale, at the head of the lake, Glenridding, and Pooley Bridge at the northern end. None of these are particularly large although Pooley Bridge was awarded a market charter in the 13th century. In addition there a number of small hamlets located at key positions around the lake, including Sandwick and Howtown on the eastern shore, Dockray and Watermillock on the northern side and Hartsop at the southern end of the valley.

To the east of Ullswsater the principal villages are Askham and Helton, both laid out on classic medieval plans and surrounded by strip fields fossilized from that period.

The principal medieval church for the area was at Barton, to the northeast of Pooley Bridge, and small chapels at Patterdale and Martindale (dating from the 17th century) served the further reaches of the large parish. Both the chapels have been rebuilt in later periods, the church at Patterdale being constructed in 1853 to a design by the architect Anthony Salvin.

The valley is rich in examples of early vernacular architecture, with several key examples in the hamlet of Harstop, describe by William Wordsworth in the early 18th century as "*remarkable for its cottage architecture*". Here a fine collection of farmsteads constructed from local slate are positioned along the ancient bridleway from the Kirkstone-Patterdale road to High Street. Most of the buildings date from the 'Statesmen' period of the 17th and 18th centuries and are classic examples of Lake District vernacular. The buildings are typically constructed from massive stone and slate rubble walls, often white-washed, and roofed in slate with squat chimneys. At least four originally had spinning galleries, of which two survive today.

Stone built farmhouses of similar date are scattered throughout Ullswater and its side valleys, including Winter Crag, Hen How and Dalehead in Martindale, the group of farms at the mouth of Deepdale and one of the best farmhouse groups in the valley at Glencoyne. Glencoyne dates from the early 17th century and features typical white-washed walls, slate roof and massive circular chimneys. It has fine internal wooden fittings and a plaster panel dated 1629.

Higher status buildings include Hartsop Hall, dating from the 16th century and twice extended before 1800 and Watermillock House dating from 1686, a good example of high quality architecture of the late 17th century.

Industrial production in the Ullswater valley in the past included both small scale activities and major extractive industries. Many of the native woods in the valley were used for charcoal production and examples of charcoal pitsteads can be seen in Dovedale and Glenamara Park. As was typical for the Lake District valleys, the becks were used to power a variety of mills and the remains of a corn mill survive adjacent to Hartsop. A rather better preserved example of a corn-drying kiln also survives in the hamlet.

Ullswater was one of the most highly regarded Lake District valleys by lovers of picturesque scenery as its winding course gives rise to a theatrical succession of views. In addition it was easily accessible to the vast majority of visitors due to its close proximity to Penrith, yet its upper reach penetrated deep into some of the most formidable mountain scenery that the Lake District affords. From an early date, therefore, it formed an essential ingredient of a Lake District tour.

Before the vogue for Lake District tourism arose in the second half of the 18th century, Ullswater was little frequented by outsiders. Gentry houses of long standing stood within a few miles of the lower lake at Dalemain, Dacre and Hutton John, but only Watermillock House, the seat of the Robinson family, enjoyed lake views and even here (according to Dorothy Wordsworth) only from the first-floor rooms.

Ullswater was not the subject of any formal stations in West's *Guide to the Lakes* although he did recommend visiting it via a couple of different routes in order to see *'The bold winding hills, the intersecting mountains, the pyramidal cliffs, the bulging, broken, rugged rocks, the hanging woods, and the tumbling, roaring cataracts, are parts of the sublimer scenes presented in this surprising vale'.* These dramatic views contrasted with the more cultivated areas *'intersected by hedges, decorated with trees'.* Finding the correct viewpoints was difficult for West. Too high and the lake's lost its 'dignity'; too low and the winding path of the lake could not be appreciated. Gray had already visited in 1769 but West felt that he had missed some of the lake's most picturesque places by not travelling to the south end of the lake which had more curved bays and rocky islands. At the north end, West recommended Dunmallard, an ancient monument, as a good viewing point. He then recommended the middle reach of the western shore and Gowbarrow Park which he considered to be the finest part of the lake. Patterdale Hotel formed his next recommendation, then Watermillock for the echo of firing canon. Early tourists were also directed to the ancient deer park at Gowbarrow, which extended along nearly half of the north-western lake shore and included the celebrated waterfall of Aira Force. Among the houses that attracted attention were the magnificently isolated farmhouse at Glencoyne, and Patterdale Hall, home of the Mounsey family, so-called 'Kings of Patterdale'.

Ullswater was enjoyed by visitors seeking picturesque scenery for some decades before the first villas were built along its shores. Peter Crosthwaite's map of the lake, first published in 1783, shows Lyulph's Tower, the Gothic hunting lodge of the Earl of Surrey (later Duke of Norfolk) in Gowbarrow Park, as well as boat houses belonging to the Robinsons of Watermillock, the Hasells of Dalemain, the Earls of Surrey and

the Dukes of Portland. Although Lyulph's Tower perpetuated an age-old aristocratic use of the Lake District for hunting grounds (as did some of the boathouses, which were there to assist in conveying hunting parties), its form reflected the new taste for the picturesque: the elevated site and faceted front elevation were calculated to make the most of views up, down and across Ullswater, and the delights of Aira Force were only a stone's throw away.

More conventional villas followed Lyulph's Tower in the 1790s. Among the earliest is Eusemere Hall, built by the anti-slavery campaigner Thomas Clarkson (1760-1846) on an estate acquired in 1795. Situated close to the lake foot, its elongated main front looks directly up the lake towards the distant mountains. At the opposite end of the lake Glenridding, which stands almost directly on the lake shore with a long vista down the lake, was built by the Revd Askew, Rector of Greystoke, sometime between 1798 and 1817, and is associated with an attractive lakeside walk. Some of the earliest villas overlooking the upper lake were much more modest 'cottages' such as Goldrill Cottage and Gillside Cottage, both in Patterdale and both occupied, in the first decade of the 19th century, by friends of the Wordsworths. Dorothy Wordsworth's *Journals* and the letters of the Wordsworth circle describe numerous visits to them. In 1806 Wordsworth himself purchased a nearby plot of land at the southern end of the lake with the intention of building a house, but the project was abandoned and it was a subsequent owner who erected the present Broad How in the 1830s, shortly after Wordsworth relinquished the land.

In the summer of 1810 John Marshall, flax-spinner of Leeds, and his wife Jane rented Watermillock House, formerly the seat of the Robinsons, for the first of a number of summer visits. Charmed by the area, and the proximity to their friends the Wordsworths, in 1815 they built Hallsteads as a summer residence, capitalising on a point of land (Skelly Nab) benefiting from views along two of Ullswater's three reaches. The Wordsworths were frequent visitors and a nearby house known as Old Church was also acquired to accommodate the overflow when guests were numerous.

As the century advanced the Marshall clan acquired a huge presence in the Lake District landscape, with all of John Marshall's surviving sons being settled in properties of their own. The eldest, William, purchased Patterdale Hall from the Mounseys in 1824, and in 1836 financed the building of the local school. On John Marshall's death in 1845 his youngest son Arthur inherited Hallsteads while William embarked on a lavish rebuilding of Patterdale Hall to Italianate designs by Anthony Salvin. The retention of the Mounsey house within the new building may owe something to Salvin's typically respectful treatment of earlier fabric, but it may also be connected with Wordsworth's urgings: a number of other houses with which Wordsworth was associated about this date retain a vernacular core. Salvin nevertheless transformed Patterdale Hall into a palazzo befitting one of the great industrialists of the age, set in extensive gardens designed by William Andrews Nesfield and commanding the head of the lake. Although Patterdale Hall remained unsurpassed by other villa builders on Ullswater its star faded within a generation: by

the 1870s the Leeds flax-spinning business was in difficulties and the family's ambitions were increasingly circumscribed.

Another fine house of the early 19th century, now the Outward Bound School at Watermillock, was built as a gentleman's residence around 1815. Mention should also be made of Lowther Castle, a country house of 1806 -14 built on the site of a medieval hall. Now a picturesque ruin, it is set within extensive, mature parkland and has a fine group of estate houses of 1766-73 by Robert Adam.

Early commentators regretted the poor accommodation encountered by travellers to Ullswater. Clarke's *Survey of the Lakes* (1787) notes that the Sun Inn had boats for hire, but lacked a dining room fit for gentlefolk, while the little inn at Patterdale was simpler still. The accessibility of Ullswater to outsiders improved with the opening of a station at Penrith on the Lancaster to Carlisle railway in 1846, and the opening of the Kendal & Windermere Railway in 1847. Ullswater, in contrast to the other major lakes (Windermere, Derwent Water, Bassenthwaite Lake, Coniston Water), never acquired a direct rail link but coaches, often operated by hotel proprietors, offered regular services to and from the stations, and from the mid-19th century they were augmented by lake steamers, two of which, now restored, still operate on the lake between Pooley Bridge and Grlenridding. Substantial hotels were built at Patterdale and Glenridding, both of which acquired an increasingly resort-like character despite continuing mining activity above Glenridding.

Ullswater is rich in Wordsworthian associations. Most famously, Glencoyne Wood at the southern end of the lake was the place where, in April 1802, William and Dorothy Wordsworth saw daffodils by the lakeshore. The encounter is described in detail in a celebrated entry in Dorothy's **Grasmere Journal**, and later inspired Wordsworth's most famous poem. '**I Wandered Lonely as a Cloud'**. William and Dorothy made regular excursions to Ullswater to visit their friends the Clarksons at Eusemere Hall and the Luffs at Side in Patterdale.

Ullswater is also the setting for one of the most celebrated passages in Wordsworth's **Prelude**. In Book I, he describes how, as a schoolboy, he stole a boat - "*an act of stealth / And troubled pleasure*" and rowed it out onto the lake. Although the location of the boat – a willow tree "*Within a rocky cave*" – no longer exists, it is suggested that Glenridding Dodd is the "*huge cliff*", which, "*As if with voluntary power instinct / Upreared its head*", to seemingly admonish the young poet and trouble his dreams.

Coleridge first encountered Ullswater on a walking tour with Wordsworth in November 1799. In his **Notebook** he recorded his impressions:

"I have come suddenly upon Ullswater, running straight on the opposite Bank, till the Placefell, that noble Promontory runs into it, & gives it the winding of a majestic River, a little below Placefell a large Slice of calm silver."

Later, in **A Guide Through the District of the Lakes**, Wordsworth recalled, from that same visit, witnessing a natural phenomenon, "*deep within the bosom of the*

lake, a magnificent Castle, with towers and battlements".

This turns out to be a reflection of Lyulph's Tower, which, at that moment was "*altogether hidden from my view by a body of vapour stretching over it.*"

Lyulph's Tower, and Aira Force, on the western side of the lake, are celebrated in Wordsworth's poem '**The Somnambulist'**. Aira Force (or more specifically the valley in which it lies) is also the subject of a delightful, late-published poem by Wordsworth, rejoicing in the tranquillity of the valley, where an ash tree makes "*A soft eye-music of slow-waving boughs*". Coleridge, however, has mixed views of this celebrated waterfall, describing the chasm in his **Notebook** as "*very fine*", but the waterfall as looking like "*a long-waisted Lady-Giantess slipping down on her Back*"

In his *Guide*, Wordsworth describes in detail a walk through nearby Martindale in 1805 with Dorothy and his friend Charles Luff. This secluded valley remains little changed from Wordsworth's day, and buildings, including the church and Dale End farm, still exist.

Unlike some of the other major valleys in the Lake District, early tourist interest in Ullswater did not lead to the threat (as then perceived) of a railway link into the valley. However the vast potential of Ullswater to supply water for the needs of the growing cities of northwest England in the 19th century did attract attention. In the second half of the 19th century the City of Manchester began to assess the potential of the various lakes for supplying the needs of its growing population and expanding industries and Ullswater was initially considered as the principal supply. Ullswater was eventually discounted in favour of Thirlmere and the threat receded.

However the increasing need for water abstraction throughout the 20th century led to renewed pressure on Ullswater. In the 1960s Manchester revived its ambition to abstract water from the lake but now the environmental movement in the Lake District was organised and able to act. The Friends of the Lake District was prominent in a vocal campaign against the proposals, including petitions and important interventions in the national press. Opposition to Manchester's Private Bill in the House of Lords was headed by Lord Birkett of Ulverston who pleaded that Ullswater should not suffer the same fate as Thirlmere and Haweswater. As a result the House of Lords rejected various key clauses in the Bill in 1962.

In 1965 Manchester returned to the issue and sought a Statutory Order to permit water abstraction at Gale Bay. The proposals were put to a Public Enquiry in Kendal at which a large number of amenity bodies with a concern for the protection of the Lake District landscape gave evidence, including the National Trust and the Council for the Protection of Rural England. This time consent for water abstraction was given, although the strong opposition managed to modify substantially the proposal in order to prevent construction of a tunnel through Longsleddale and to ensure that the lake would not be drawn down below its natural level. Although water is now abstracted from Ullswater, it is effected in a manner that does not damage the visual amenity of the lake and its surrounding cultural landscape.

Other environmental successes achieved during the

20th century, led principally by the Friends of the Lake District, were the undergrounding of the electricity line along the southern and eastern shoreline of Ullswater between Sandwick Bay and Glenridding. This was carried out by the Westmorland and District Electricity Company following negotiations. The Friends also took a lead from 1938 in the attempt to resolve the problem of the pollution of Ullswater by the effluent from Greenside lead mine. In 1942 The Friends instigated legal action and pollution had been substantially reduced by 1944.

The significance of the Ullswater valley was recognised by the National Trust very soon after its establishment with one of its early and key Lake District acquisitions in 1906 being the purchase of Gowbarrow Park. This property included the scene of daffodils recorded by Dorothy Wordsworth and later by William in his famous poem and also included the picturesque waterfall of Aira Force. The appeal leaflet made the suggestion "*Why not nationalise the English Lake District?*"

The National Trust also acquired a number of farms around Ullswater, including Hartsop Hall, which was the first to be acquired by the Trust from the state under National Land Fund procedures. The major property of Glencoyne was given to the National Trust by the Scott family in 1948 and Howe Green farm, Hartsop, came to the Trust when Lake Farm Estates Ltd was wound up in 1977.

Appendix 6: Extract from Cumbria Community Risk Register

Extract from Cumbria Community Risk Register: Climate change risks relevant to Ullswater.

Note: local communities should amend this general Cumbria table to reflect their local conditions and experience

Full risk register available at:

http://www.cumbria.gov.uk/eLibrary/Content/Internet/538/755/41159115519.pdf

Likelihood	Impact	Rating	Descriptor
4 (significant)	5 (catastrophic)	very high	local fluvial flooding
3 (moderate)	4 (significant)	very high	local/urban flooding (fluvial or surface run-off)
3 (moderate)	3 (moderate)	high	localised, extremely hazardous flash flooding
2 (minor)	3 (moderate)	high	heat wave
3 (moderate)	2 (minor)	medium	storms and gales
3 (moderate)	2 (minor)	medium	low temperature and heavy snow
2 (minor)	2 (minor)	medium	forest or moorland fire
1 (limited)	3 (moderate)	medium	drought

Appendix 7: Useful links

Community resources and case studies:

- Climate ready - www.environment-agency.gov.uk/research/137557.aspx
- Climate Ready Clyde – http://www.adaptationscotland.org.uk/4/110/0/Area-based-project-Glasgow-and-Clyde-Valley.aspx
- Climate resilient communities - www.claspinfo.org/resources/climate-resilient-communities
- Climate local - http://www.local.gov.uk/web/guest/the-lga-and-climate-change/-/journal_content/56/10171/3574359/ARTICLE-TEMPLATE
- Climate UK - www.climateuk.net
- UK Climate Impacts Programme - http://www.ukcip.org.uk/tools/

9. References

[1] http://www.cumbriaaction.org.uk/images/uploads/dt032_cep_tookit_&_cover_(website).pdf

[2] http://www.cumbriaaction.org.uk/images/uploads/emergency_planning_may_2012.pdf

[3] http://derwent7.files.wordpress.com/2011/01/borrowdale-final-report-june2011.pdf

[4] http://www.lakedistrict.gov.uk/caringfor/projects/valleyplanning

[5] http://filesdown.esecure.co.uk/SolwayActionGroup/WVP_7th_Feb.pdf

[6] http://www.cumbriaobservatory.org.uk/elibrary/Content/Internet/536/642/1369/39364151046.pdf

[7] http://www.lakeswhs.co.uk/documents/LakeDistrictWHS_NomDom_Public.pdf

[8] Norris, Stevens, Pfefferbaum, Wyche and Pferffbaum (2007) Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness

[9] McCormick, T. (2013) Supporting Change in the Development of Community Resilience in Cumbria 2012-2017. Report available through ACTion with Communities in Cumbria

[10] IPCC (2007) Summary for Policymakers. Online: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spm.html

[11] IPCC (2007) Summary for Policymakers. Online: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spm.html

[12] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/figure-9-5.html

[13] http://www.eea.europa.eu/pressroom/newsreleases/climate-change-evident-across-europe

[14] World Meteorological Organization Statement on the Status of the Global Climate in 2011.

www.wmo.int/pages/publications/showcase/documents/WMO_1085_en.pdf

[15] http://www.metoffice.gov.uk/news/releases/archive/2013/2012-weather-statistics

[16] Schiermeier, Q. (2011) Increased flood risk linked to global warming: likelihood of extreme rainfall may have been doubled by rising greenhouse-gas levels. Nature Climate Change 470: 316.

[17] Pall, P., Aina, T., Stone, D.A., Stott, P.A., Nozawa, T., Hilberts, A.G.J., Lohmann, D. and Allen, M.R. (2011) Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000. Nature 470: 382–385

[18] Coumou, D. and Rahmstorf, S. (2012) A decade of weather extremes. Nature Climate Change 2: 491-496

[19] Stott, P. A., D. A. Stone, and M. R. Allen, 2004: Human contribution to the European heatwave of 2003. Nature, 432, 610–614

[20] Pall, P., Aina, T., Stone, D.A., Stott, P.A., Nozawa, T., Hilberts, A.G.J., Lohmann, D. and Allen, M.R. (2011) Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000. Nature 470: 382–385

[21] IPCC AR4 (Hegerl, G.C., Zwiers, F. W., Braconnot, P., Gillett, N.P., Luo, Y., Marengo Orsini, J.A., Nicholls, N., Penner, J.E. and Stott, P.A. (2007) *Understanding and Attributing Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (eds.)]. Cambridge University Press: Cambridge, and New York, NY.)

[22] Stott, P.A., Gillett, N.P., Hegerl, G.C., Karoly, D.J., Stone, D.A., Zhang, X. and Zwiers, F. (2010) Detection and attribution of climate change: a regional perspective. *Wiley Interdisciplinary Reviews: Climate Change* **1** (2): 192-211.

[23] Berkeley Earth Group (Brillinger, D., Curry, J, Jacobson, R., Muller, E., Muller, R, Perlmutter, S., Rohde, R., Rosenfeld, A, Wickham, C. and Wurtele, J (2011). *Berkeley Earth Surface Temperature Analysis*. Online at: http://berkeleyearth.org/Resources/Berkeley_Earth_Summary.pdf)

[24] Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt, 2007: Technical Summary. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[25] ibid

[26] Royal Society (2010) Climate change: a summary of the science

[27] Rahmstorf, S (2007) A semi-empirical approach to projecting future sea-level rise. *Science* **315 (5810)**: 368–370

[28] United Nations Framework Convention on Climate Change

[29] Anderson, K. and Bows, A. (2011) 'Beyond 'dangerous' climate change: emission scenarios for a new world'. Philosophical Transactions of the Royal Society A, 369: 20-44

[30] UNEP (2012) The emissions gap report 2012. Online: http://www.unep.org/pdf/2012gapreport.pdf

[31] Nicholls, R. J., Marinova, N., Lowe, J. A., Brown, S., Vellinga, P., de Gusma, D., Hinkel, J., Tol, R. S. J., (2011) Sea-level rise and its possible impacts given a 'beyond 4◦C world' in the twenty-first century. Phil. Trans. R. Soc 369: 161-181

[32] http://www.eea.europa.eu/pressroom/newsreleases/climate-change-evident-across-europe

[33] International Energy Agency, World Energy Outlook 2011: Executive Summary. www.iea.org/Textbase/npsum/weo2011sum.pdf

[34] http://www.pwc.co.uk/sustainability-climate-change/publications/low-carbon-economy-index-overview.jhtml

[35] CCRA evidence report

[36] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[37] Carter, J. (2012) The trajectory of climate change. Online: http://www.tcpa.org.uk/data/files/TheTrajectoryofClimateChange.pdf

[38] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[39] Liua, J. Curry, J.A., Wang, H., Song, M. and Horton, R.M. (2012) Impacts of declining Arctic sea ice on winter snowfall. PNAS 109(11): 4074-4079. Online: http://www.pnas.org/content/109/11/4074

[40] Wu, Q., and Zhang, X. (2010) Observed forcing-feedback processes between Northern Hemisphere atmospheric circulation and Arctic sea ice coverage, J. Geophys. Res. 115

[41] Tang, Q., Zhang, X., Yang, X. and Francis, J.A. (2013) Cold winter extremes in northern continents linked to Arctic sea ice loss. Environ. Res. Lett. 8. Online: http://iopscience.iop.org/1748-9326/8/1/014036/pdf/1748-9326_8_1_014036.pdf

[42] Petoukhov, V., and Semenov, V.A. (2010) A link between reduced Barents-Kara sea ice and cold winter extremes over northern continents, J. Geophys. Res. 115(D21). http://onlinelibrary.wiley.com/doi/10.1029/2009JD013568/abstract

[43] Overland, J.E., Francis, J.A., Hanna, E. and Wang, M. (2012) The recent shift in early summer Arctic atmospheric circulation. Geophysical research letters 39(10). Online: http://onlinelibrary.wiley.com/doi/10.1029/2012GL053268/abstract

[44] Liua, J. Curry, J.A., Wang, H., Song, M. and Horton, R.M. (2012) Impacts of declining Arctic sea ice on winter snowfall. PNAS 109(11): 4074-4079. Online: http://www.pnas.org/content/109/11/4074

[45] http://www.guardian.co.uk/environment/2012/oct/10/global-warming-washout-summer?CMP=twt_gu

[46] Overland, J.E., Francis, J.A., Hanna, E. and Wang, M. (2012) The recent shift in early summer Arctic atmospheric circulation. Geophysical research letters 39(10). Online: http://onlinelibrary.wiley.com/doi/10.1029/2012GL053268/abstract

[47] Met Office (2012) Declining sea ice. Online at: http://www.metoffice.gov.uk/research/news/sea-ice

[48] IPCC (2007) Summary for Policymakers – http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spm.html

[49] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[50] Francis, J.A. and Vavrus, S.J. (2012) Evidence linking Arctic amplification to extreme weather in mid-latitudes. Geophysical Research Letters 39(6). Online: http://onlinelibrary.wiley.com/doi/10.1029/2012GL051000/abstract

[51] http://ukclimateprojections.defra.gov.uk/media.jsp?mediaid=87844&filetype=pdf

[52] Coumou, D. and Rahmstorf, S. (2012) A decade of weather extremes. Nature Climate Change 2: 491-496

[53] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[54] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[55] Willis, R. (2008) *Low-carbon Lake District: responding to climate change in the National Park*. UK: Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0017/170342/low_carbon_lake_district_report_16_june_2008.pdf

[56] Lake District Partnership Plan. Online: http://www.lakedistrict.gov.uk/aboutus/partnership/ldnppmanagementplan

[57] Climate UK (2012) A summary of climate change risks for North West England. Online: http://www.climatechangenorthwest.co.uk/sites/default/files/00112a%20CCRA%20NW%20Pack.pdf

[58] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[59] Climate UK (2012) A summary of climate change risks for North West England. Online: http://www.climatechangenorthwest.co.uk/sites/default/files/00112a%20CCRA%20NW%20Pack.pdf

[60] Natural England (2011) Climate change vulnerability in Cumbria map. Online: http://www.naturalengland.org.uk/Images/cumbria-vulnerbility_tcm6-26379.pdf

[61] Joseph Rowntree Foundation (2011) What is pluvial flooding. Online: http://www.jrf.org.uk/blog/2011/11/pluvial-flooding

[62] Cumbria Strategic Partnership (2010) Cumbria Local Climate Impacts Profile: A portrait of the impacts of extreme weather events on local services, communities, economy and natural environment in Cumbria

[63] Taylor, A. (2010) 'Impacts of November 2009 flooding on the Tourism industry (and assistance provided by Cumbria Tourism to mitigate the negative effects and publicise the fact that 'Cumbria is open for business')', 21 May 2010

[64] Cumbria County Council (2012) November 2009 floods: economic impact. Online: http://www.cumbria.gov.uk/floods/damageanalysis/economicimpact.asp

[65] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[66] http://www.guardian.co.uk/environment/2009/nov/20/cumbria-floods-search-missing-policeman

[67] Jacobs (2007) Lake District National Park flood risk assessment. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0020/173054/the_lake_district_national_park_flood_risk_assessment_document.pdf

[68] Jacobs (2007) Lake District National Park flood risk assessment. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0020/173054/the_lake_district_national_park_flood_risk_assessment_document.pdf

[69] Environment Agency. Online: http://www.environment-agency.gov.uk/homeandleisure/31662.aspx

[70] Whittle *et al.* (2010) *After the Rain – learning the lessons from flood recovery in Hull*, final project report for „Flood, Vulnerability and Urban Resilience: a real-time study of local recovery following the floods of June 2007 in Hull" , Lancaster University, Lancaster UK. Online: http://eprints.lancs.ac.uk/31798/1/AFTER_THE_RAIN_FULL_REPORT.pdf

[71] Lindley S., O'Neill J., Kandeh J., Lawson N., Christian R. and O'Neill M. (2011) Climate

Change, Justice and Vulnerability. Joseph Rowntree Foundation. Online:

http://www.jrf.org.uk/sites/files/jrf/climate-change-social-vulnerability-full.pdf

[72] http://www.defra.gov.uk/environment/flooding/funding-outcomes-insurance/insurance/

[73] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[74] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District.

[75] Carroll, Z.L., Reynolds, B., Emmett, B.A., Sinclair, F.L. and Ruiz de Ona, C. 2004. The effect of stocking density on soil in upland Wales. CCW Contract Science Report No 630.

[76] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[77] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[78] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[79] Climate UK (2012) A summary of climate change risks for North West England. Online: http://www.climatechangenorthwest.co.uk/sites/default/files/00112a%20CCRA%20NW%20Pack.pdf

[80] George, G., Hurley, M. and Hewitt, D. (2007) The impact of climate change on the physical characteristics of the larger lakes in the English Lake District. *Freshwater Biology* **52**: 1647-1666

[81] *BBC* (2010) 'Cumbria Great North Swim cancelled over safety fears', 3 September 2010. Available online at: http://www.bbc.co.uk/news/uk-england-cumbria-11175208

[82] Cumbria Tourism (2010) Cumbria Tourism Award Winners 2010. Available online at: http://blog.golakes.co.uk/cumbria-tourism-awards-2010/

[83] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[84] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[85] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[86] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[87] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[88] Climate UK (2012) A summary of climate change risks for North West England. Online: http://www.climatechangenorthwest.co.uk/sites/default/files/00112a%20CCRA%20NW%20Pack.pdf

[89] (reference … Purse, B.V., Mellor, P.S., Rogers, D.J., Samuel, A.R., Mertens, P.P.C. and Baylis, M. (2005) Climate Change and the Recent Emergence of Bluetongue in Europe. *Nature Reviews Microbiology* **3**: 171-181)

[90] CCRA evidence report

[91] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[92] http://www.bbc.co.uk/news/uk-21933135?awesm=awe.sm_t0QSW

[93] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[94] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[95] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[96] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[97] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[98] Willis, R. (2008) *Low-carbon Lake District: responding to climate change in the National Park*. UK: Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0017/170342/low_carbon_lake_district_report_16_june_2008.pdf

[99] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[100] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[101] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[102] Holman, I.P., Loveland, P.J., Nicholls, R.J., Shackley, S., Berry, P.M., Rounsevell, M.D.A., Audsley, E., Harrison, P.A. & Wood, R. (2002) *REGIS - Regional Climate Change Impact Response Studies in East Anglia and North West England.*UK: Defra

[103] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[104] Willis, R. (2008) *Low-carbon Lake District: responding to climate change in the National Park*. UK: Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0017/170342/low_carbon_lake_district_report_16_june_2008.pdf

[105] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[106] *BBC* (2002) 'New hope in midge battle', 13 May 2002. Available online at: http://news.bbc.co.uk/1/hi/scotland/1984277.stm

[107] Woods, J. (2006). 'Don't let the midges bug you'. *The Telegraph*, 7 August 2006. Available online at: http://www.telegraph.co.uk/health/3342310/Dont-let-the-midges-bug-you.html

[108] Scott, D. and McBoyle, G. (2001) Using a 'tourism climate index' to examine the implications of climate change for climate as a natural resource for tourism. A. Matzarakis and C. de Freitas (eds) *Proceedings of the First International Workshop on Climate, Tourism and Recreation*. 5-10 October 2001, International Society of Biometeorology, Commission on Climate, Tourism and Recreation, Greece.

[109] Amelung, B. and Viner, D. (2006) The sustainability of tourism in the Mediterranean. Exploring the future with the Tourism Climatic Index. *Special Issue Journal of Sustainable Tourism: Climate Change and Tourism* **14 (4)**: 349-366

[110] ANPA (2012) Natural Parks: Britain's breathing spaces. Available online at: http://www.nationalparks.gov.uk/learningabout/ourchallenges/tourism/impactsoftourism.htm#thepositive

[111] ANPA (2012) Natural Parks: Britain's breathing spaces. Available online at: http://www.nationalparks.gov.uk/learningabout/ourchallenges/tourism/impactsoftourism.htm#thepositive

[112] Becken, S. and Hay, J.E. (2007) *Tourism and Climate Change: Risks and Opportunities*. UK: Channel View Publications

[113] Hind, D.W.G. and Mitchell, J.P. (2004) *Sustainable Tourism in the English Lake District*. Sunderland, Great Britain: Business Education Publishers Limited

[114] Bell, S.; Tyrväinen, L.; Sievänen, T.; Pröbstl, U. and Simpson, M. (2007) Outdoor recreation and nature tourism: a European perspective. *Living Reviews in Landscape Research* **1 (2)**: 1-46

[115] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District.

[116] Lindley S., O'Neill J., Kandeh J., Lawson N., Christian R. and O'Neill M. (2011) Climate

Change, Justice and Vulnerability. Joseph Rowntree Foundation. Online:

http://www.jrf.org.uk/sites/files/jrf/climate-change-social-vulnerability-full.pdf

[117] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[118] Changeworks (2008) *Energy Heritage: a guide to improving energy efficiency in traditional and historic homes.* Edinburgh: Changeworks

[119] Defra (2012) Climate Change Risk Assessment. Online: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

[120] http://www.lakeswhs.co.uk/documents/LakeDistrictWHS_NomDom_Public.pdf pp.158-67

[121] http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf:

[122] http://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf. Th

[123] IPCC (2013) Activities: Fifth Assessment Report. Online at: http://www.ipcc.ch/activities/activities.shtml#.USz2c3mj79Z

[124] http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf

[125] UKCP09. Online: http://ukclimateprojections.defra.gov.uk/21749

[126] http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf

[127] http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf

[128] Cumbria Strategic Partnership (2010) Cumbria Local Climate Impacts Profile: A portrait of the impacts of extreme weather events on local services, communities, economy and natural environment in Cumbria. Online: http://www.cumbriastrategicpartnership.org.uk/eLibrary/Content/Internet/536/4042394623.pdf

[129] http://www.cumbria.gov.uk/planning-environment/cumbrialocalresilienceforum/aboutus.asp

[130] http://trust.edenriverstrust.org.uk/art-autumn-seminar.html

[131] http://www.alfa-project.eu/en/about/welcome/

[132] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[133] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[134] http://www.forestry.gov.uk/pdf/FCGL007.pdf/$FILE/FCGL007.pdf

[135] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[136] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[137] http://www.forestry.gov.uk/carboncode

[138] http://www.forestry.gov.uk/england-wpc

[139] http://www.rspb.org.uk/Images/gripblocking_england_tcm9-207527.pdf

[140] http://www.iucn-uk-peatlandprogramme.org/sites/all/files/Review%20Peatland%20Hydrology,%20June%202011%20Draft_0.pdf

[141] http://www.iucn-uk-peatlandprogramme.org/sites/all/files/Review%20Peatland%20Hydrology,%20June%202011%20Draft_0.pdf

[142] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[143] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[144] Low Carbon Lake District (2012) Adapting to climate change in the Lake District National Park. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0016/233611/Climate-Change-Adaptation-Report-20-Jan-2012.pdf

[145] http://www.waterwise.org.uk/pages/quick-tips.html

[146] Forest Research (2013) Opportunity Mapping for Woodland Creation to Reduce Diffuse Sediment and Phosphate Pollution in the Lake District

[147] http://www.iucn-uk-peatlandprogramme.org/sites/all/files/Review%20Peatland%20Hydrology,%20June%202011%20Draft_0.pdf

[148] http://www.bassenthwaite-lake.co.uk/uploader/pdf/BLRP%20Business%20Plan%202009-10%20final.pdf

[149] http://www.nurturelakeland.org/love-your-lakes/

[150] http://www.windermere-reflections.org.uk/

[151] http://www.lancs.ac.uk/fass/projects/loweswater/articles/AAB%20Norton%20et%20al%202011.pdf

[152] http://www.bassenthwaite-reflections.co.uk/

[153] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[154] http://ec.europa.eu/agriculture/cap-post-2013/index_en.htm

[155] http://www.scrt.co.uk/cfinns/welcome

[156] http://www.bassenthwaite-reflections.co.uk/

[157] http://www.windermere-reflections.org.uk/about-us/

[158] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[159] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[160] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[161] http://jncc.defra.gov.uk/page-5718

[162] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[163] Scott, D., Amelung, B., Becken, S., Ceron, J-P., Dubois, G., Gössling, S., Peeters, P. and Simpson, M.C. (2008) *Climate Change and Tourism: Responding to Global Challenges*. United Nations World Tourism Organization (UNWTO), United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO), UNWTO: Madrid, Spain

[164] http://www.nurturelakeland.org/love-your-lakes/

[165] Henley Centre (2005), *Paper 2: Demand for outdoor recreation. A report for Natural England's outdoor recreation strategy*, London: Henley Centre/Headlight Vision.

[166] http://www.transitionnetwork.org/

[167] http://slacc.org.uk/

[168] http://www.penrithact.org.uk/

[169] http://transitionnorthwest.ning.com/

[170] Jacobs (2007) Lake District National Park flood risk assessment. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0020/173054/the_lake_district_national_park_flood_risk_assessment_document.pdf

[171] Jacobs (2007) Lake District National Park flood risk assessment. Online: http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0020/173054/the_lake_district_national_park_flood_risk_assessment_document.pdf

[172] Changeworks (2008) *Energy Heritage: a guide to improving energy efficiency in traditional and historic homes.* Edinburgh: Changeworks

[173] English Heritage (2008) Energy Conservation in Traditional Buildings Online: http://www.climatechangeandyourhome.org.uk/live/content_pdfs/94.pdf

[174] http://www.cumbriagreenbuild.org.uk/

[175] http://www.lakedistrict.gov.uk/caringfor/partnership/carbonbudget

[176] http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0007/273292/A-Carbon-Budget-for-the-LDNP.pdf

[177] http://www.lakedistrict.gov.uk/caringfor/projects/carbon

[178] Natural England (2009) Character Area Climate Change Project NE115R. *Responding to the impacts of climate change on the natural environment: the Cumbrian High Fells*. Available online at: http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx

[179] Mitchell, D. (2008a) A note on rising food prices: policy research working paper 4682. World Bank Development Prospects Group. Online: http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2008/07/28/000020439_20080728103002/Rendered/PDF/WP4682.pdf

[180] http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0007/273292/A-Carbon-Budget-for-the-LDNP.pdf

[181] Commission for Rural Communities (2010) High Ground, high potential- a future for England's upland communities. Executive summary, p.9

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