

Adaptation Sub-Group of the Climate Change Commission for Wales Report from the Natural Environment Working Group report

Integrating Adaptation into Management of the Natural Environment

Overview

The Adaptation Sub-group of the Commission has agreed that working groups should report on the current state of knowledge in relation to adaptation in specific sectors. Adaptation in this context is understood to mean adjustment to actual or expected climate change, or its effects, with the objective of reducing species, habitat, ecosystem and societal vulnerability to adverse impacts.

This report from the Natural Environment Working Group provides a summary of the current position regarding research and work completed or underway on adaptation to climate change impacts affecting the natural environment in Wales. The natural environment is defined here as all aspects of the Welsh environment except for the built environment. The built environment, including the historic environment, is being covered by the Built Environment Working Group. The current knowledge base and situation is considered in relation to terrestrial, freshwater, coastal and marine ecosystems along with landscape. Related policy areas such as spatial planning and RDP are also considered in relation to their role in delivering adaptation.

This paper is not intended to provide an exhaustive review of relevant work but does provide the necessary overview to identify issues that should be examined at the Welsh level, so that the Adaptation sub-group can consider further action in relation to them.

Recently, it has been suggested that the paper might provide input to the forthcoming WAG Climate Change Adaptation Action Plan. A series of recommendations, many relevant to the Action Plan, are identified within the document and collated at the end.

The imperative for adaptation in the natural environment

Global climate by 2100 is projected to be at least as warm as it has been at any time during the last few thousand years – it is necessary to go back more than ten million years to find global mean temperatures more than 2°C higher than now. Current biodiversity has survived temperature variations of 5°C between glacial and inter-glacial periods. A further rapid increase of up to 5°C beyond this range will pose immense problems for species and their ability to adapt or disperse. These problems will be exacerbated by the current *rate* of increase of warming due to greenhouse gases – very likely unprecedented in at least the last 10,000 years.

Such challenges are being faced at a time when the natural world is already experiencing a geologically unprecedented rate loss of species, driven in part by habitat destruction and fragmentation. Habitat fragmentation is a fundamental threat to the adaptive capacity of the natural world.

UKCIP02 projects that average daily temperatures across Wales will rise by up to 2°C by the 2020s, 3°C by the 2050s and 5°C by the 2080s, subject to the extent of global greenhouse gas emissions through the century. These are high-end temperature levels, but it is suggested that a precautionary adaptation strategy should assume that these are more likely to be realised than lower levels, not least in view of the continuing inadequacy of the international emission reduction response to date. Wetter winters and drier summers along with greater frequency and intensity of extreme events are also projected. The Pitt Review emphasized that climate change has the potential to cause more extreme scenarios than considered hitherto.

A range of impact assessments across sectors suggest that failure to adapt to climatic changes is likely to result in severe flooding episodes, water supply shortages, crop failures, widespread biodiversity losses with consequent substantial economic and social costs. We will never have a comprehensive knowledge of future impacts so have to act on the basis of the best available evidence. In this period of rapid climatic change and uncertainty of impacts, we have to act under the *precautionary principle*. Hence, **it is essential that adaptation measures be mainstreamed into all policies and measures relating to the management of the natural environment (Recommendation 1)**. This applies equally to WAG, government agencies and NGOs. Even with adaptation, it will inevitably be impossible to retain all natural and historic environmental features in their current state or location. Hence, **all environmental recording or monitoring schemes should include assessment of climate change impacts so as to enhance our understanding of scale and trajectory of environmental change (Recommendation 2)**.

Projecting climate change impacts and the role of the new probabilistic UKCIP08 scenarios

The new UKCIP08 scenarios will for the first time identify the probability of specific climatic changes occurring in Wales as a whole and also for each 25-km square. However, it is not so easy to project how these changes will impact on natural systems and biodiversity receptors due to the number of variables and their interactions, e.g. how will warmer and wetter winters combined with sea level rise and greater storminess affect a dune ecosystem. With this in mind, **based on the better understanding of potential climatic impacts provided by UKCIP08 for localities and Wales as a whole, there is a case for UKCIP08 outputs being considered in the development of all future guidance relating to land and sea management decisions (Recommendation 3)**.

There is a need for an integrated vulnerability assessment of the impacts on both protected sites and the wider countryside, including non-climatic factors such as socio-economic factors, to focus adaptation activity and ensure that it addresses the relevant threats (Recommendation 4). CCW is beginning to address this requirement.

Given the uncertainty in the degree of climatic impacts and availability of probabilistic UKCIP08 scenarios, there is a research need to assess what level of probability that site-specific and more general adaptation measures should be based on. In other words, whether the most likely degree of impact should be managed for or whether a precautionary approach should be taken assuming a more extreme impact (Recommendation 5).

All Local Authorities should consider the impacts of climate change using UKCIP08 outputs and incorporate adaptation at the community level through Community Strategies and Local Service Boards through strategic planning mechanisms such as LDPs (Recommendation 6). In relation to this need WLGA, CCW, EAW and UKCIP are working over the next 3-years with four Welsh authorities on the *Changing Climate, Changing Places* project. Using existing impacts data, it will explore the scope of climatic impacts and risks to authority services and the local people, environment and economy in order to ensure adaptation is integrated into local decision-making. Subsequently it is hoped that LAs can adopt the approaches developed during this project more widely across Wales.

While UKCIP08 will enable better quantification of the effects of climate change it is important to recognise that research suggests that changes in land use and management practices will remain critical to the state of the natural environment in the future (just as they were during the 20th Century). Projecting such socio-economic changes requires evaluation at a national level of for example, how farmers will use their land under a changed climate and socio-economic conditions. Research to date shows that it is very difficult to predict future land-use choices but **there is a research need to develop a series of possible land use futures building upon the work of *Sustainable Farming and Environment – Action Towards 2020* (Recommendation 7).** This may be partly addressed by forthcoming work of the UK Government Foresight Programme on Land Use Futures.

An Integrated Cross-Sectoral Approach to Adaptation

Biodiversity conservation and environmental protection have in the past been largely addressed in isolation from, or at least *post-hoc* with respect to other related sectors and policies. It is vital if we are to achieve an integrated cross-sectoral approach to adaptation for the natural environment that adaptation is considered in the context of all related policies. Particularly relevant WAG policy documents include:

- *One Wales* (June 2007) – *Section 8 A Sustainable Environment* is mainly focussed on climate change mitigation rather than adaptation, and with little mention of the natural environment.
- *The Environment Strategy for Wales* (May 2006) – includes Action 33, to set priorities for landscape-scale projects in order to build up the resilience of biodiversity to adapt to climate change, including habitat restoration and review of the support mechanisms; Outcome 8 – Wales has improved resilience to the impacts of climate change, with a clear flexible programme of measures in place; Outcome 19 – the loss of biodiversity has been halted.
- *Planning Policy Wales (2002, revised consolidated version due 2009)* - sets out the land use planning policies of WAG. It is supplemented by a series of Technical Advice Notes (TANs). Planning policy provides a framework for local planning authorities to prepare unitary development plans (UDPs) and may influence individual planning applications. Interim guidance relating to climate change issues has been issued.
- *Responding to our changing climate* (February 2007) – consultation document for a draft climate change adaptation action plan for Wales: including sections on water resources, flooding, biodiversity and land management.
- *People, Places, Futures - The Wales Spatial Plan* (update February 2008) – includes a section *Valuing our Environment*, together with six area framework strategies, each of which includes – or should include - climate change adaptation priorities.
- *Rural Development Plan Axis 2 review consultation* – this importantly proposes a far more integrated approach to environmental management with water resource, carbon and biodiversity management being addressed as a whole, which is to be welcomed. However, there are major scientific issues to be overcome in terms of assessing the effectiveness of water resource and carbon management for auditing purposes within future agri-environment schemes. Additionally, other approaches to adaptation are not adequately addressed, although this perhaps reflects limited experience of implementing many facets of adaptation.

It is very noticeable that with the exception of the draft adaptation action plan the above documents give more space to climate change mitigation measures than to adaptation. It is important that in any revision of policies consideration is given to the need for climate change adaptation. The EU Green paper on climate change adaptation covered the importance of adaptation in the natural environment and a White paper is expected in 2009. The White paper could help provide support and guidance to raise the profile of adaptation action.

In line with this need for cross-policy integration, this report recommends that **the Welsh adaptation strategy and action plan must be consistent with, indeed driven by, the principles of sustainable development, including:**

- **Living within environmental limits**
- **Using sound science responsibly (Recommendation 8).**

Living within environmental limits involves not only conserving biodiversity for its intrinsic value, but also highlights the need to protect ecosystem goods and services that contribute to sustainable living. Environmental limits are the level beyond which the environment is unable to accommodate a particular activity or range of activities without sustaining unacceptable or irreversible degradation. Using sound science responsibly involves applying the *precautionary principle* and is of fundamental importance in ensuring that biodiversity is properly protected through adaptation to address likely climate change impacts: the science of climate change is key to an informed understanding of likely impacts and the adaptation responses.

The integration of adaptation in all policies should be mainstreamed through a more explicit inclusion of adaptation within the review of the WAG Sustainable Development Strategy and the associated WAG Policy Integration Tool (Recommendation 9). It is important that the tool or other approaches fully integrate consideration of climate change to ensure that policies:

- Facilitate efforts to increase resilience to climate change impacts;
- Avoid mal-adaptation or reducing the ability of the environment to adapt to impacts;
- Do not lock society into trends or behaviour that will be unsustainable in future.

A joint CCW and Environment Agency project (see case study below) identified the need for climate-proofing of all policies or strategies for the natural environment resource management whenever they are developed or reviewed.

There is a need for adaptation measures to be integrated more generally within all large development projects both public and private. Such integration is a novel challenge that may require a novel solution to ensure it is met. Overseeing consideration of adaptation across all policies, plans and large development proposals would help ensure integration of climate change adaptation and mitigation measures within all major developments. At present with no simple chain of responsibility for this agenda there is a risk that consideration of adaptation is left to others. **It is recommended that the current remits of statutory bodies and policies to address adaptation are evaluated for gaps that may lead to a lack of coordinated action and to take remedial action if necessary (Recommendation 10).**

Successful adaptation will require action at a large scale, working within appropriate 'natural' units such as catchments or coastal cells. **Planning adaptation at a landscape scale will require effective partnerships at local, regional and national level, and often the development of appropriate**

mechanisms to enable cooperation between landowners in a similar way to Catchment Sensitive Farming (Recommendation 11).

The Stern report identified at the macro-economic scale that adaptation now, to avoid costs arising from future impacts, is a cost effective approach. It also recognised the central importance of the natural environment for societal adaptation and the contribution that land-use reform can make to emissions. **There is a research requirement to assess both the likely costs of a failure to adapt and the costs of adaptation, including the cost-benefits of different adaptation options so as to prioritise adaptation actions given resource limitations, although this approach cannot override the statutory requirements to manage (and adapt) within our protected areas such as SACs/SPAs (Recommendation 12).**

Financial constraints are one of the main barriers to adaptation, particularly as short-term planning and financial budgeting in both the public and private sector leads to other issues taking priority for funding. There is a need to identify appropriate financial mechanisms to fund adaptation (Recommendation 13).

Case study - Adapting Natural Resource protection policies to climate change

The Environment Agency, CCW and University of Bangor have undertaken research indicating that current natural resource protection policies must be adapted to allow for the effects of climate change. Projected climate and socio-economic scenarios for 2020 and 2050 were used to investigate how six natural resource policies, strategies and plans would affect a case study area in the River Usk Catchment. The initiatives chosen for analysis were:

- *Sites of Special Scientific Interest (SSSI)*
- *Welsh agri-environment schemes (Tir Gofal)*
- *Woodlands Strategy*
- *Biomass Action Plan*
- *Catchment Abstraction Management Strategies (CAMS)*
- *Catchment Flood Management Plans (CFMP),*

These measures were chosen to cover a wide spectrum of natural resource protection policies addressing nature conservation, water resource management, flood protection and economic use of the countryside. For each of these initiatives, the vulnerability of key components of each policy to climate change was assessed. The overall policy vulnerability was then considered as the sum of its key components, so that if one or more component had a high probability of failure, then the overall policy was considered to be vulnerable.

The study found that current SSSI policy is not flexible enough for future conditions of climate change. In particular, the way the policy considers Britain's wildlife will need to change as species disperse in response to climate and

communities currently protected by SSSI change in nature. Welsh agri-environment policies, which have regular reviews of management practices and payments, are well suited to adapt to changing climatic and socio-economic conditions and may help enhance the performance of other policies. The success of the Woodland Strategy for Wales depends on the future demand for timber products, the world price for timber and future levels of environmental awareness. Where new woodland is developed, this could enhance biodiversity, however, conflicts may arise between new woodlands managed for timber and biodiversity conservation. The Biomass Action Plan depends on viable markets for biomass products, to encourage investment by farmers to help meet climate policy targets. Environmental problems associated with wide scale planting of commercial biomass crops may be exacerbated under climate change, however, strategic landscape planting of biomass could potentially support the woodland strategy, conservation policy and water resource planning.

CAMS is only one part of the overall UK water resource planning framework, and in itself is a flexible policy which should reduce its vulnerability to climate change. However, the policy faces a serious challenge in balancing social and environmental demands on water resources in a changed climate of decreased rainfall. Only if water demand is managed can the ecological aspirations of CAMS and wider water resource planning be met. Time-limiting of licences and moving towards market mechanisms for water rights with options such as reverse auctions to cost-effectively meet environment requirements are possibilities currently being considered for managing water resources.

CFMP policy is flexible, with regular reviews of activities, but, it has a high risk of failure due to uncertainty in predicting the likely frequency, magnitude and social and economic impact of future floods. CFMP could potentially interact with other land use policies, such as developing woodlands in key places to increase infiltration of water and reduce flood risks.

*The study concludes that the vulnerability of existing natural resource protection policies should be further explored and all new policies should explicitly consider climate change adaptation, incorporating greater flexibility in delivery. A key recommendation is that **all resource protection policies should be assessed for climate change risks and managed as a coherent whole, to offer a 'joined-up' approach to managing the countryside (Recommendation 14).***

Principles for adaptation in the natural environment

The conservation of natural resources is now more important than ever, particularly due to population growth, increasing resource use (as exemplified by the growth of the Welsh ecological footprint) and the compounding effect of climate change impacts and other stress factors such as air pollution.

The principles for conserving terrestrial biodiversity under a changing climate identified by the UK Biodiversity Partnership should guide the conservation of the natural environment more widely including the freshwater and marine environment (Recommendation 15). They identify a need for all those involved in implementing biodiversity conservation to:

- i) conserve existing natural resources and high-quality environments because protected sites are, and will remain, strongholds for wildlife in a changing environment;**
- ii) reduce other sources of harm not linked to climate, such as pollution and inappropriate management; and**
- iii) making sound decisions based on analysis, including thoroughly analysing the relevant drivers of change, and adapting conservation priorities in response to climate change.**

A range of actions for implementing each of the principles within Local Biodiversity Action Plans and similar local action is suggested in the report. These three principles largely require us to do better what we do already: climate change is just another driver for these activities. (<http://www.ukbap.org.uk/Library/BRIG/CBCCGuidance.pdf>)

The other principles require a more integrated landscape-scale approach to biodiversity conservation, to deliver less fragmented habitats along with greater focus on habitat heterogeneity. The remaining principles are:

- iv) developing ecologically resilient and varied landscapes, through conserving and enhancing local variation within sites and habitats, combined with making space for the natural development of rivers and coasts;**
- v) establishing ecological networks through habitat protection, restoration and creation; and**
- vi) integrating adaptation and mitigation measures into conservation management, planning and practice.**

Consideration of the MONARCH study and similar work, such as the recently published 'Climatic Atlas for European Birds', highlights the limited understanding of relationships between species, habitats and climatic parameters at present. There is also a paucity of practical examples of adaptation projects – nevertheless several case studies are included in this paper to illustrate on-going work. Many assessments have evaluated the need for further research or policy development to deliver adaptation for wildlife (e.g. EPBRS and UK BRAG), but this should not act as a barrier to the need to apply existing knowledge (such as the BAP Guidelines) at the landscape-scale.

In implementing the UK Biodiversity Partnership principles, we should assess their effectiveness to refine them and improve future adaptation

action. Their implementation and monitoring within an exemplar Welsh LBAP area has already been identified as an important step in demonstrating their value. (Recommendation 16).

There is a need for conservation organisations to collaboratively develop a series of ‘exemplar’ on the ground adaptation projects within Wales to demonstrate the potential for adaptation, and crucially assess its costs and benefits along with the practicalities of implementation, thereby acting as beacon projects to inform others (Recommendation 17). There are a number of projects that may be able to contribute to this, including the Anglesey Fens LIFE+ project, the GLAMBAG ecological connectivity in SE Wales project and the integrated rural development project in the Cambrian Mountains.

Another key principle for adaptation in the natural environment should be to ensure functional resilience within ecosystems to ensure that they continue to deliver vital goods and services, for example to deliver flood management, water supply, agricultural and forestry production, biodiversity and recreation. Land use adaptation measures that simultaneously enhance the adaptive capacity of ecosystem services are a vital component of our response. Such measures can only be developed through integration of land-use policy agendas, as outlined above.

Accommodating dispersal of species within our countryside

There is already clear evidence that species are responding to the accelerated rate of climate change over recent decades. Among the responses is a northward or altitudinal expansion in range by more mobile species; however, many others have failed to show significant movement, because of their poor dispersal capacity or the lack of suitable habitat at the edge of range. The climate space envelope projections - for species of conservation interest provided by MONARCH - point to the potential for substantial changes in the geographical area that is climatically suitable for a wide array of species from a variety of taxa. While the impact of potential changes for each individual species is uncertain, overall it is clear that:

- Any loss or shift in suitable climate space will be more severe, and increase the risk of species being lost in all or part of their range, unless major cuts are made in greenhouse gas emissions.
- There is an urgent need for adaptation measures to be developed and implemented at the earliest opportunity, to maintain and enhance habitat or ecosystem resilience while accommodating changes, such as in species distributions.
- The substantial uncertainty inherent within such projections means that the response of individual species will undoubtedly produce surprises, so biodiversity conservation must be flexible and adaptive.

Owing to extensive habitat fragmentation of many habitats in Wales, particularly in the lowlands, climate change will almost certainly have an exaggerated impact. **Ecological connectivity should be improved through targeted restoration of semi-natural habitat as it has the potential to make the natural environment, particularly severely fragmented lowland habitats, more resilient to climate change impacts (Recommendation 18).** It is important to recognise the importance of connectivity-enhancing green infrastructure in urban landscapes too. Additional benefits of green spaces and corridors in urban areas include cooling urban areas (reducing the heat island effect), contributing to sustainable urban drainage, as well as improving recreation opportunities. The concept can be applied at varying scales from neighbourhood to town/city or region.

A number of components may contribute to ecological connectivity. *Habitat connectivity* describes the spatial or functional inter-linkages between core areas of suitable habitat. It is often focused on the establishment or maintenance of corridors or stepping stones of similar habitat to link core areas, although consideration should be given to the capacity of other habitats to act as conduits for dispersal. *Landscape permeability* is the capacity for dispersal of biodiversity across the wider landscape, because within a heterogeneous landscape species movement between areas of suitable habitat will be constrained by their varying ability to disperse across other habitats via a multitude of routes. **Adaptation measures are required at a variety of scales, promoting the enhancement of heterogeneity in habitat and micro-climate on individual sites by site managers will be equally important as improving connectivity at the landscape-scale (Recommendation 19).**

Recent research has used habitat maps and computer modelling to understand the current ecological connectivity of Wales. These results have been used to identify areas of land that are likely to provide ecological connectivity between protected sites or other areas of semi-natural habitat. Currently this work is being developed further to consider the feasibility of implementing improvements to connectivity within the SE Wales Spatial Plan region. A current Defra review of the evidence base for habitat connectivity improving the dispersal capacity has been inconclusive largely due to the inadequacies of existing experimental evidence and lack of monitoring. **It is vital that all efforts to improve ecological connectivity and habitat/micro-climate heterogeneity should be monitored for their effectiveness (Recommendation 20).**

Wales' natural environment delivers multiple benefits for society - so-called ecosystem goods and services. These include food production, fresh water, flood control and carbon storage. The ability to limit climate change impacts while continuing to supply other ecosystem goods and services is in itself an important ecosystem service that should be valued and enhanced. Priority should be given to land use adaptation measures that simultaneously enhance the adaptive capacity of the environment while benefiting other ecosystem goods and

services. For example blocking drainage in upland catchments should enhance in the long-term soil carbon storage (see case study below), while simultaneously increasing the ability of the catchment to accommodate future extreme precipitation events. This integrated ecosystem approach is in contrast to traditional "hard" solutions such as downstream flood defences, that while enhancing adaptive capacity in some respects may harm the provision of other ecosystem good and services.

Research into valuing the ecosystem goods and services of natural assets and sites including their full social and environmental benefits is needed to accord due consideration to natural assets in integrated landscape-scale adaptation projects (Recommendation 21). The Welsh Sustainable Development Scheme requires taking account of the full range of costs and benefits when making plans and decisions, including those which cannot easily be valued in money terms. Such a valuation will also be central to delivering the ambitious reform agenda outlined in the current WAG consultation on Axis II of EU CAP.

Adaptation Case Study – Berwyn Mountains Blanket bog restoration project

Wales has a significant resource of peat soils including around 70,000 hectares of blanket bog. A large quantity of carbon is locked up in these bogs, which are in danger of drying out which could lead to the release of large amounts of carbon to the atmosphere. A project in the Berwyn/Migneint area in North Wales is undertaking restoration of blanket bog, blocking drains, removing invasive non-native species and providing a sustained improvement in the condition of the blanket bog. These actions will contribute to making the two Special Areas of Conservation (SACs) on which the project works, more resilient to climate change and protect the peat soils on which they are based. The improved habitat condition also benefits a wide range of species that rely on this habitat. Such projects aim to contribute to both mitigation and adaptation. Further details can be found at: <http://www.blanketbogswales.org/default.aspx?pageID=4>

Other similar projects are taking place elsewhere in Wales, notably the Montgomery Wildlife Trust's Pumlumon project and BBNPA's Waun Fignen Felen project.

(<http://www.montwt.co.uk/pumlumon.html>)

(<http://www.breconbeacons.org/search?SearchableText=waun+fignen+felen>)

The Wales Spatial Plan (WSP) - What Role?

Integrated spatial planning is required to facilitate adaptation to climate change and to allocate space for essential land use change and relocation of both developments and natural habitats away from areas of risk. It would be sensible that the existing framework of the Wales Spatial Plan (WSP) is used to this end. At present the WSP does not adequately consider climate change adaptation

and mitigation or facilitate the allocation of space for future land uses. During 2008, the WSP is moving into its 'delivery phase'. **Consideration should be given to including the recommendations of this and other adaptation sub-group reports into the programme of actions for delivery through each of the Wales Spatial Plan Area Strategies (Recommendation 22).** It is currently proposed by WAG that each area should have *inter alia* an Environment Project Manager, to be responsible for leading an Environment Sub-Group, which will be responsible for 'refining and delivering' the environmental and climate change outcomes and priorities of the area strategy. The WSP and its Area Sub-Groups should take account of the climatic implications arising from UKCIP08. Climate change adaptation is already recognised as falling within the scope of the WSP area process. However, clarification is needed concerning resourcing and organisational responsibilities, especially with regard to local authorities, CCW and EAW. Clearly, principal responsibilities will rest with the relevant public bodies. There is also significant risk of the current WSP approach leading to silo-treatment of adaptation and wider climate change issues, at the expense of the required mainstreaming across all aspects of WSP

WAG should set out in the respective remit letters of Welsh public bodies, such as the National Parks, CCW and EAW, what will be required from them in terms of climate change adaptation actions. The spatial coherence of action could be delivered in many cases through enhanced engagement with the WSP groups (Recommendation 23). WSP Areas are also expected to play a crucial role in delivering the Environment Strategy and Climate Change Strategy adaptation policy actions.

Local Authority Planning and Local Development Plans

The natural environment is affected directly and indirectly by development, requiring local planning authorities to anticipate this in their Local Development Plans. The "Planning for Climate Change" agenda builds a better role for local planning authorities but needs to anticipate the impacts of development on Wales' natural environment in a changing climate. **Planning policy guidance should require Local Authorities to promote local action improving community energy and food security through local community development projects and small infrastructure improvements that can also benefit the natural environment and biodiversity conservation (Recommendation 24).** Food production, renewable energy generation and biodiversity conservation can all be enhanced together as a co-product of sustainable developments (indeed the revised final draft of TAN 5 requires biodiversity enhancements wherever and whenever possible with development) and there are increasing opportunities for local income generation from local food and energy schemes that can be reinvested in all these measures. For example, Brecon Beacons National Park Authority has recently calculated that it is technically feasible and - provided the right planning applications come forward with the right investment - highly probable, that a handful of private or

community-owned combined heat and power plants could generate up to 5.35 megawatts of electricity, enough to supply 6490, or 63.5%, of the Park's households, generating additional income of about £4,686,600 per year from the value of the energy sold. In addition, it is technically feasible to generate 244 kilowatts of hydro-electricity to supply 405, or 2.7%, of the Park's households, generating additional income of about £213,744. Similar calculations have been done for the output and value of micro-wind turbines. This provides income generation as well as energy and similar achievements are possible for food. By facilitating and *enabling* this sort of civic engagement in these essential commodities, Government and LAs can create a window of opportunity for engagement with and investment in biodiversity conservation too. Furthermore, schemes such as village, farm and moorland-based HEP schemes also entail biodiversity conservation and water conservation whereby a key objective is the restoration of moorland vegetation (for example by grip blocking) to retain the water supply to drive the turbines year round. In this example, biodiversity conservation is achieved effectively as a bi-product of improved energy security and income generation. A more secure discharge for downstream flows will also occur, potentially improving water availability in periods of drought, for water supply and the water environment lower down the catchment. This being said, such hydropower schemes need to be carefully considered on a case by case basis to ensure that such synergies are present, especially when located in National Parks and designated sites.

Currently, Section 106 Agreements under the Town and Country Planning Act, 1990, provide a means for local planning authorities to provide for community infrastructure needs. The Community Infrastructure Levy within the Planning Bill for England and Wales will also potentially provide local planning authorities with the tools to guarantee that new developments are tied to solving community infrastructure needs. **Planning guidance should encourage Local Authorities to include biodiversity conservation, local grazing schemes, renewable energy infrastructure and local food production in Section 106 agreements or in future the Community Infrastructure Levy (Recommendation 25).** This sort of guidance could usefully be incorporated into the Planning for Climate Change agenda.

<http://www.communities.gov.uk/publications/planningandbuilding/infrastructurelevyguidance>

Understanding the scope of marine climate change impacts

A Defra report states "Climate Change appears almost certain to result in significant long term changes in marine and coastal environments including increased sea temperatures, sea level rise and ocean acidification, and as such probably poses the biggest single threat to maritime ecosystems" (Defra, 2005). Marine air and sea surface temperatures have been rising at a similar rate to

land air temperature. In addition, sea level rise will lead to more pressure on coastal space. Surface seawater has already increased in acidity by 0.1 pH units due to the oceans absorbing carbon dioxide. Future acidification could bring about widespread and significant changes to marine ecosystems. In particular, evidence suggests increased acidity will hinder the ability of marine organisms, including plankton, corals, crustaceans and molluscs, to make calcium carbonate shells and plates.

The precise effects on maritime biodiversity are impossible to predict but in general terms we are likely to see widespread changes to the distribution of species and habitats. For example, we may see an advance of southern species into Welsh waters and the retreat of northern species. The MarClim project (<http://www.mba.ac.uk/marclim>) showed that the toothed topshell, *Osilinus lineatus*, previously lost from parts of the North Wales coast by the cold winter of 1962/63 has re-established on the Llyn Peninsula in response to a warming climate. Observed impacts on marine food chains have already been reported. A plankton regime shift linked to changes in sea temperature has had knock-on effects, as seen through the recent large-scale breeding seabird failures in the North Sea, thought to be due to a shortage of their sand-eel prey, in turn linked to the change in plankton community, although this effect may be compounded by fishery pressure.

Climate change impacts in the marine environment are less well quantified and understood than in the terrestrial environment thereby undermining the potential for adaptation. The Marine Climate Change Impacts Partnership (MCCIP) aims to develop a long-term multidisciplinary approach to understanding and communicating the implications of climate change on our seas. It has developed Annual Report Cards summarising existing and future impacts on marine ecosystems, indicating the level of confidence in these projections <http://www.mccip.org.uk/arc/2007/default.htm>.

MCCIP has helped fill a gap on marine climate change impacts. The new UKCIP08 scenarios will include marine scenarios for the first time. **There is a research need to utilise new marine UKCIP08 scenario outputs to examine the potential scope of impacts on marine biodiversity so as to allow better consideration of climate change impacts in marine conservation management (Recommendation 26).**

The role of Marine Protected Areas and the ecosystem approach in marine adaptation

There is good evidence that marine ecosystems, e.g. coral reefs that retain high diversity and structural components recover more rapidly and fully from climatic impacts than degraded ones. Many biodiversity strategies recognise the need to improve the resilience of biodiversity and ecosystems by protecting adequate and appropriate space; limiting non-climate related stresses; and using adaptive management based on ongoing monitoring in a similar way to in terrestrial

systems. The IUCN has recognised that marine protected areas have a vital role to play in enabling marine biodiversity to become more resilient and adapt to a changing climate.

<http://cms.iucn.org/where/global/index.cfm?uNewsID=100>

CCW has advised WAG that there is a need for highly protected marine reserves (HPMRs) in Welsh waters, as part of an ecosystem-based approach to managing Wales's seas. HPMRs are expected to enable marine habitats to recover and thrive and thereby to increase the resilience of the wider marine protected area network (Dernie et al 2006). CCW is currently undertaking a project to develop a process for selecting HPMRs. A number of other necessary elements of marine management have been identified, principally marine planning, a suite of marine ecosystem objectives, improved management of marine SACs and SPAs and managed realignment of the coast. These measures, being in accordance to the UKBAP guidelines outlined above, should simultaneously enhance the adaptive capacity of the marine environment

The Joint parliamentary Committee's scrutiny of the Marine Bill said the proposed Marine Conservation Zones (MCZs) are essential for the UK commitment to sustainable development and to OSPAR's work to determine an ecologically coherent network of Marine Protected Areas, with one objective being recovery and restoration. The Committee recommended designating MCZ's on a precautionary basis, for example to support an effective MPA network under a scenario of climate change. While not endorsing the 30% figure of the Royal Commission, all parties agree that this is the kind of proportion of our seas that should become MCZs.

The Government response (available as is the Committee's report on <http://www.defra.gov.uk/marine/legislation/index.htm>) agrees with conferring a duty on the Secretary of State and Welsh Ministers to designate MCZs in order to contribute to an ecologically coherent network of sites, which will include highly protected sites (HPMRs). WAG is working with CCW to establish a partnership project for the identification of potential sites within Welsh territorial seas. While non-statutory, this project should ensure that stakeholders have a genuine and effective opportunity to engage in the shaping of the MPA network and build consensus on the most suitable configuration of sites to recommend for designation as MCZs. Any orders necessary for the protection of an MCZ in Wales will be made by Welsh Ministers. The government sees a protracted timescale, with the first report to the Welsh Assembly due by 2012. However, as we don't depend on the new Marine Management Organisation, it should be possible to expedite matters sooner in Wales.

It is important that Marine Protected Areas, including Highly Protected Marine Reserves, are established promptly by WAG and CCW as they have a valuable contribution to make to adaptation in the marine environment.

Their contribution to climate change adaptation should be considered during their selection process (Recommendation 27).

Climate change and its implications put high pressure on the use and development of marine resources. **Climate change and its impacts on marine and coastal ecosystems and species must be a key consideration in marine spatial planning, its implementation and monitoring. Coastal and marine planning should apply an ecosystem-based approach (Recommendation 28).**

HABMAP, a seabed-mapping joint Wales/Ireland InterReg project covering the southern part of the Irish Sea has produced high-resolution seabed habitat maps using data collation and predictive modelling methods that are able to incorporate consideration of future climate change impacts. These maps have a wide range of uses, including strategic planning (incorporating Marine Spatial Planning), informing survey requirements for EIAs, identifying potential areas for habitat restoration and informing the selection of a coherent network of protected sites. Such resources could play a valuable role in considering the potential for adaptation measures in the marine environment around the Welsh coast.

http://www.walescoastalpartnership.org.uk/images_client/resource/HABMAP%20summary%20Sept07.doc; <http://www.habmap.org/>.

The UK Seamap project undertook broader-scale habitat mapping for the whole of UK waters <http://www.jncc.gov.uk/page-2117>.

Managing erosion and flooding impacts and risk on the coast

The effects of climate change will be felt particularly quickly and significantly along our coastline. The coast is home to valued features of the natural and historic environment, as well as communities. It is also disproportionately important for public access and recreation. The increased level of flooding and erosion risk under climate change means it will not be possible to provide protection for all vulnerable sites. Hard defences can also damage natural processes governing coastal features such as sand dunes. In the longer term it will be necessary to adapt to coastal change through an approach that works with these natural processes. In some cases, the most cost-effective and sustainable adaptation option will be to relocate people, buildings and wildlife habitats away from risk areas. **Compensatory coastal habitat should be created, where managed retreat is the most cost effective and sustainable coastal defence solution, to prevent the decline in extent of coastal habitats. This could be beneficial economically where those habitats can themselves provide or contribute to coastal defence (Recommendation 29).**

At present there is an incomplete picture of the level of coastal risk. The National Trust has completed a risk assessment for the coast it owns— more than one fifth of the Welsh coast. This indicates which locations are vulnerable to erosion or

flooding and identifies designated sites and habitats at risk. **There is a research need to evaluate the current rate and extent of coastal erosion along with future vulnerability to erosion or flooding along the entire Welsh coast. Such an assessment would feed in to the development of Shoreline Management Plans. (Recommendation 30).** A similar approach to that taken in the National Trust's Shifting Shores project could be taken.

http://www.nationaltrust.org.uk/main/shifting_shores_brochure_final-2.pdf

Making the most of Wales Coast, the ICZM Strategy for Wales is an important tool that can help integrate coastal policies and activities, encouraging a long-term view that works with natural processes. It could also help integrate policies, tools and adaptation approaches across the land and sea border. **There is a need to ensure climate change adaptation is a priority in the future development and implementation of Integrated Coastal Zone Management strategy (Recommendation 31).**

There is often public hostility to managed-retreat projects owing to the perception of accepting defeat and because individuals stand to lose homes and/or livelihoods. In considering realignment of the coast, the issues of equity and sustainability enter as well as cost-effectiveness. The important role of the new Shoreline Management Plans, not only in addressing issues arising from the coastal change pressures, but particularly in building communication with coastal communities and promoting public awareness of these issues and the difficult decisions ahead are important. **A communication and community engagement programme should be developed by those involved in implementing ICZM so as to fully involve the public in decision-making on managing coastal change (Recommendation 32).**

Case Study Coastal Adaptation– Cemlyn Bay

Cemlyn Bay on Anglesey is a brackish lagoon and basin retained by a shingle bar owned by the National Trust. The lagoon and bar are managed by the Wildlife Trust as a nature reserve and are designated as part of an Area of Outstanding Natural Beauty, SSSI, and SAC. The lagoon supports diverse species, several specific to lagoons. The site is best known as an internationally important seabird colony, including breeding Common and Arctic terns.

The ridge separating the lagoon from the sea changes with the action of tide and weather. The water level and salinity of the lagoon is monitored to maintain the ideal habitat for terns and other wildlife. A sluice system manages water levels to benefit the bird population.

Cemlyn falls within a zone at very high risk of erosion that is defined as between 100 and 200m inland from the current shoreline by the National Trust's Coastal Risk Assessment. It is also in an area at risk of tidal flooding. As sea levels rise the shingle bar will be breached -as already happens in storm periods- resulting

in salt water inundation of the lagoon affecting the habitat conditions which wildlife depend on.

The National Trust's policy for management of important conservation sites is to work with natural processes where possible, and to accommodate the dynamic nature of the coast. Where coastal change results in the loss of habitats the expectation is that they will be replaced at alternative sites. Through computer modelling the Trust are exploring options for future management, particularly potential changes to water salinity levels following flooding. It is crucial to better understand how the site may change in future so we can work with partners to develop a new vision for the site. Stakeholders will develop an adaptation strategy for this site, including actions for the medium and long term.

Adaptation in relation to the freshwater ecosystem

The principles outlined above for adaptation in the terrestrial natural environment will be applied to freshwater. A dominant principle is that of reducing existing pressures, for example on water resources or from pollution. This will increase species' resistance and resilience to change. We need to make the best use of the evidence base and available guidance (including UKCIP) to help us identify what adaptation actions will be needed. We also need to adopt an adaptive management approach, as outlined by the UKBAP guidelines so that we remain flexible to new information and unforeseen changes.

The current implementation of River Basin Planning, under the Water Framework Directive, provides an integrated approach to reducing pressures on the freshwater, estuarine and coastal environments. The aims are to ensure no deterioration and good ecological status of catchments. River basin planning can be seen as a key means of delivering climate change adaptation, since it:

- Takes an integrated landscape scale approach with planning at the catchment scale;
- Reduces existing non-climate pressures taking a risk based approach;
- Manages emerging pressures (including mitigation and adaptation actions of other sectors) to ensure no deterioration in ecological status;
- Takes an adaptive management approach with plans being revised every six years.

This landscape scale approach is reflected in the Environment Agency's Catchment Flood Management Plans (CFMPs) and Catchment Abstraction Management Strategies (CAMs). As an influential regulator, it is working to help minimise the impacts of the mitigation and adaptation of other sectors on wildlife. For example, it is helping develop guidelines to minimise the environmental impacts of hydropower. CFMPs and CAMs were identified by the EA / CCW report *Adapting Natural Resource protection policies to climate change report* as offering a tangible way forward to deliver natural environment adaptation

measures. **CFMPS and CAMS should be fully supported to provide powerful examples of cross-agency working to deliver enhanced resilience in the aquatic environment** (Recommendation 33).

Compared with many other areas of the UK, the rate of runoff from land in Wales is relatively high and the contribution of groundwater to base river flows relatively low. This means that river flows are very high at times of heavy rain and very low during periods of prolonged dry weather. It is likely that climate change will exacerbate this pattern. We anticipate that there will be a change in the balance of annual precipitation, with less falling in summer and more in winter, falling in more concentrated, heavier downfalls. This has serious implications for both flood risk management and the management of abstraction. With the current system for managing water resources, it is predicted that there will be an overall loss of water from Wales' supplies each year because once the river systems and reservoirs are full each winter, the rest will run downstream in rivers to the sea. In winter, therefore, there will be increasing scour of the river bed, leading to loss of habitat and washout of organisms. In summer, hotter temperatures will lead to increased demand for water and this will increase pressure on rivers, groundwater and reservoirs already suffering the direct impacts of drought. The impact on freshwater organisms will be compounded by faster warming of rivers and lakes as the temperature rises.

The challenge, therefore, is to devise a holistic approach to managing freshwaters that:

- reduces the risk of flooding of sensitive (primarily built-up) areas;
- increases winter storage capacity for release and abstraction in the drier summers;
- ensures continuity of water supply; and
- protects biodiversity by giving it the means and space to adapt.

A strategic approach is emerging, based on learning the lessons that we have already been taught, particularly in relation to flooding. To help avert catastrophic flooding, Wales should undertake an ecosystem response to climate change at the largest appropriate scale. This will involve restoring the bogs, moors, wet woodlands and fens within the uplands and floodplains of Wales. These restored areas will act as a sponge to absorb the rainfall, or as basins to store it in areas away from populated land. In both cases there will be significant benefits for biodiversity. It will not be sustainable to defend all land and properties from flooding, so society will need to adapt to living with floods. Silver linings should not be ignored: for example making space for floodwaters in rural areas and towns provides open spaces for people to enjoy.

Recommendation 27 from the 2008 Pitt Review ("Learning Lessons from the 2007 floods"), "DEFRA, the Environment Agency and Natural England should work with partners to establish a programme through Catchment Flood

Management Plans and Shoreline Management Plans to achieve greater working with natural processes" can apply equally to Wales. **The use of CFMPs and SMPs to achieve an inter-agency programme working with natural processes could form a valuable contribution to implementing adaptation in Wales (Recommendation 34)**, a wetter country with a higher per capita resource of coastline, floodplain, moorland, uplands and semi-natural river systems.

Areas of Wales are already susceptible to water shortages and non-mains supplies to rural areas dried up in the hot dry summer of 2006. The Water Resources Strategy for Wales, due to be published in 2009, will set out the future pressures for water resources in Wales as well as how we can adapt to and mitigate against these. Parts of Wales, for example the River Dee system, are likely to be deficient in water supplies within 50 years. Wales is more dependent than elsewhere in the UK on surface water storage and summer droughts will potentially have greater effects. Farmers, for example, already have to move livestock off traditional upland pastures during dry summers to areas with natural water retention capacity.

As well as the incidental benefits associated with managing flood risk and water resources noted above, there will need to be direct intervention to protect Wales' precious biodiversity. Salmon and trout are of high socio-economic value to Wales and are sensitive to high temperatures and low flow. Evidence indicates that particular land management activities could reduce the direct impacts of climate change on these fish. For example, allowing trees to re-establish on river banks, will provide shade and reduce summer stream temperatures. These relatively simple measures would also benefit sensitive invertebrates, improve bank side habitat and reduce weed growth where this is a problem. In other words there are direct and assured benefits beyond "simply" adapting to climate change. The approach may need to be applied selectively so as not to add to flood risk or water resource pressures.

Improving access to all possible habitats within a species natural range will assist adaptation. The impact of dams and weirs in preventing access to headwaters for migratory fish may be critical as headwater areas will be cooler and increase the chances of lifecycle completion. Removing such obstacles to migration or installing fish passes will be an important intervention in allowing migratory fish to adapt to climate change. Such action will need to be appropriately reconciled with increased demands on catchments to provide hydroelectricity.

Floods and droughts can permanently change the nature of lakes and watercourses and the species and habitats they support. For landlocked species such as char and gwyniad already under risk of extinction, there is nowhere to go and intervention through translocation, genetic banking and captive breeding may be required.

Invasive non-native species are likely to become an increasing problem in a changing climate and they are a particular problem in the aquatic environment. We need to make the best use of existing resources by taking concerted risk-based approach across all partners. We will do this under the action plan to support the “Invasive non-native species framework strategy for Great Britain”.

The role of land management and agriculture in adaptation

The agriculture and land management sector, representing farmers, land managers and associated businesses, can play an important role in the response to climate change. The National Farmers' Union (NFU), the Country Land and Business Association (CLA) and the Agricultural Industries Confederation (AIC) launched a joint Climate Change Task Force in January 2007, to present a united stance against the serious threat that climate change poses to agricultural production and the rural sector. The task force recognizes the role played by agriculture and rural land use in the wider context of global sustainable development. Given that we all depend upon large areas of the land for our food and, increasingly, for other renewable resources, we must accept our responsibility to use our finite resources wisely, and to mitigate unwanted impacts on air quality, soil, water, habitats and wildlife. The report arising from the task force largely focuses on reducing the carbon or environmental footprint rather than on adaptation.

http://www.cla.org.uk/Policy_Work/Policy_Reports/Environment/Climate_Change/8941.htm/

The report, *Sustainable Farming and Environment – Action Towards 2020*, produced by an independent task and finish group for WAG, identified a number of potential climate change actions for both government and the wider farming and rural community. These include ensuring climate change is a major priority in land management schemes under the Rural Development Plan, establishing good practice guidelines for carbon soil management and aiming towards carbon neutrality for Welsh agriculture by 2020.

<http://new.wales.gov.uk/topics/environmentcountryside/farmingandcountryside/farming/sustainablefarming2020/?lang=en>

The agricultural sector will need to adapt to both its role in delivering adaptation for biodiversity and flood alleviation through agri-environment schemes and the potential localisation of supply for some goods, including biomass and some foods, driven by climate change mitigation and security of supply concerns.

The role of the RDP and agri-environment schemes in adaptation

The majority of the countryside is made up of farmland that does not enjoy any special protection. This wider countryside will be crucial in the process of adaptation to climate change. Some straightforward approaches can be taken to make the countryside more hospitable to wildlife, by increasing the numbers of

hedges, ponds, water-filled ditches, patches of woodland, scrub and field margins managed for biodiversity. Agri-environment schemes are perfectly placed to deliver these features within the farmed landscape. Focusing resources geographically and implementing the appropriate management prescriptions to benefit species will be essential. Land managers must be given the appropriate support by advisors to allow best value in achieving adaptation through agri-environment schemes.

Climate change is an important theme in the Rural Development Plan for Wales 2007-2013. Both mitigation and adaptation to climate change are being considered in the current review of RDP land management schemes. While integrating both climate change mitigation and adaptation in the RDP is an important goal, it must be recognised that there is not the evidence currently to underpin a significant investment in carbon management through the RDP while adaptation measures for biodiversity conservation, such as reducing other sources of harm are tried and tested practice that should not become secondary to new measures of uncertain value. There remains a need to develop the scientific evidence and practical experience of management practices to underpin the incorporation of adaptation (and mitigation) measures in the RDP and agri-environment schemes.

<http://new.wales.gov.uk/topics/environmentcountryside/farmingandcountryside/ruraldevelopment/20072013ruraldevelopmentplan/?lang=en>

Climate change adaptation should be a key element in the development of agri-environment schemes emerging from the current WAG review of Axis 2. Many actions to deal with increased flood risk, reduce rainwater run-off and conserve water resources can also deliver benefits for biodiversity and mitigation (carbon conservation). Wherever possible agri-environment action should make the most of these 'win-win' opportunities (Recommendation 35).

There are disincentives within the current single farm payment and agri-environment schemes for tree planting and the creation of other marginal habitats for biodiversity that need to be removed. Excluding woodland areas and even grazed woodland and scrub from payment areas discourages some adaptation measures (Recommendation 36).

As rural development funds are limited, it will be a challenge to ensure that these adaptation measures are adopted on a large enough scale to make an impact.. The need to make the most of limited funding makes an integrated approach all the more important.

The WAG Agricultural strategy review needs to consider the potential role for adaptation in the sector: currently the focus is on its mitigation role. Incorporating landscape-scale measures that can deliver win-wins for farmers and adaptation is vital. For example, woodland planting could

provide benefits in terms of connectivity, flood management but also reduce erosion and provide livestock shelter (Recommendation 37).

The importance of adapting animal husbandry and land management practices

Climate change is likely to have an effect upon livestock appetite and health, although larger ruminants are better able to tolerate greater climatic changes. High temperatures increase the risk of heat stress by 20% for ewes and 60% for lambs (Defra Research Project CC0315). Increased temperatures may also lead to a decrease in reproductive capacity, which tends to decline at elevated temperatures. Clearly this is something that could impact upon livestock numbers. An increase in extreme weather events may lead to a lack of grazing and therefore an increased need for supplementary feeding. It will be important that the farming industry rapidly identifies and adapts to such changes.

Farmers will need to consider more carefully how they might get water to their stock in a period of drought. **On-farm storage of rainwater, through small-scale reservoirs or rainwater harvesting, may offer one important adaptation approach. Where these are justified they should be sited and constructed in a way that would deliver environmental benefits (Recommendation 38).**

This is already allowed and is being promoted in the Water Resources Strategy as small-scale storage reservoirs for farmers. Funding mechanisms exist in England, which may need to be considered for Wales where appropriate. The Environment Agency has prepared guidance on developing small-scale storage reservoirs for agriculture and will work with:

- a) WAG so that assessments can be made for potential future funding for areas where pressures on water resources are greatest;
- b) Planning authorities so that they are aware of the importance of storage reservoirs in the context of a twin track approach as an effective way of managing water resources.

The farming industry should consider the practical implications of changes to livestock and crop production required as a consequence of climatic changes, such as changes to sowing, breeding and shearing patterns that may become necessary in future (Recommendation 39).

Milder winters may result in an increase in pathogen and fly problems if diseases and/or disease vectors successfully over winter. Bluetongue disease is one example of this. In 2007, bluetongue reached the UK from the near continent, and, in 2008, a bluetongue restricted zone was declared in South East Wales. Bluetongue is a non-contagious viral disease of ruminants spread by mosquitoes. Originally a disease of southern Africa, it has been steadily

spreading northwards since the late 1990s. It is thought that this spread is at least in part due to global warming, which has allowed the survival of both the virus and vector during milder winters, with the disease now found well to the north and west of its historical distribution.

Farmers and government must maintain a high level of vigilance against the increasing threat posed by the incursion of exotic diseases and pests. It must be recognised that despite our best efforts some diseases will from time to time arrive in this country, and could even become established in a worst-case scenario. Contingency measures for such scenarios should be in place as a rapid response will reduce the risk of their proliferation (Recommendation 40).

Higher temperatures can have a serious impact upon housed livestock, and investment may be needed in improved ventilation and cooling, although this is expensive, not only to install but also to run. Poultry flocks are especially vulnerable due to the narrow range of temperatures that they are able to tolerate. Outdoor raised livestock may need larger areas in which to shelter from weather extremes. However, warmer temperatures in winter may mean that livestock housing periods can be decreased, reducing feeding and bedding costs, and in addition lambing and calving could also start earlier in response to warmer temperatures.

Farmers will need to assess the greater need for ventilation of livestock sheds and milking parlours to adapt to higher temperatures, as well as a greater requirement for outdoor shelter and shade (Recommendation 41).

Adaptation measures for woodlands and trees

Ongoing work aims to better understand the impacts of climate change on the suitability of tree species in Wales, using various UKCIP02 scenarios. This work reported in summer 2008, with these results being used to update guidance to woodland owners and managers (<http://www.forestry.gov.uk/fr/INFD-7FXBYQ>). Some tree species are expected to be severely impacted by climate change under high emission scenarios. The research reinforces the fact that **there should be action to enhance species diversity at an individual woodland and landscape level to enhance resilience to climate change (Recommendation 42).**

In terms of woodland biodiversity, there has been joint work by FC Wales and CCW to explore the role of habitat networks based on the principle of ecological rather than physical habitat connectivity. This is being applied to a certain extent in targeting woodland creation and management, but not yet in wider agri-environment scheme targeting. Further work is required to better understand the balance between improving resilience for native woodland biodiversity, and the

negative impact of facilitating the dispersal of non-native species such as rhododendron, grey squirrels and deer.

Woodland and trees can help us to cope better with the effects of a changing climate. The role that strategically sited woodland or trees can play in both increasing the soil percolation of water is now better understood. However, further work is required to assess the effectiveness of such planting, as we are a long way from the continental situation, where land management in the upper catchment or floodplain woodland along the catchment are viewed effectively as 'engineering solutions' to water management, and funded accordingly. These issues and relevant recommendations are discussed in the RDP and agri-environment section of this report.

Research by Manchester University has recently suggested that increasing urban tree cover to 10% would keep summer temperatures pegged at 2008 levels, rather than their projected rise of 4°C by 2080. This is on top of the more obvious benefits that trees can have on improving the environmental quality of the urban environment. **Urban woodland and individual trees can play a valuable cooling and shading role in adapting to the greater frequency of heat waves in urban areas. This needs to be better communicated to those planning our town and city landscapes (Recommendation 43).**

Case Study - The Pontbren project

The Nant Pontbren is a headwater tributary of the River Severn in Montgomeryshire, Mid-Wales. A large proportion of the catchment, over 1000 ha, is farmed by the "Pontbren group"; a consortium of ten hill farming families. The group aims to provide a sustainable approach to farming and has been diversifying their farming practices in recent years. Part of the group's management strategy has been to fence off small strips of land and plant them with trees, providing shelter for animals. This has provided an ideal opportunity to investigate the impacts of grazing and tree planting on the soil and flood risk.

The Pontbren farmers noticed that these strips of trees were reducing the amount of water flowing over the land. In conjunction with Coed Cymru a preliminary study was established, supported by WAG and CCW. The work, by CEH and University of Bangor, has shown some startling results. The condition of the soil in areas planted with trees had changed dramatically, allowing water to percolate into the soil at a rate over sixty times greater than neighbouring grassland. This showed that small strips of trees could help reduce the flood risk.

Pontbren has become the UK focus for research into upland land use and flooding with support obtained from the Flood Risk Management Research Consortium (FRMRC) and Forestry Commission; and addition of Imperial College London to the team. . The current experimental work includes:

- *Experiments to investigate the effects of different land use treatments (grazing, no grazing, tree planting);*
- *Studies on two hill slopes to evaluate surface and subsurface runoff processes, the effects of agricultural drainage, and the effects of tree shelter belts;*
- *Monitoring of flows in a network of drains, ditches, small and large streams to understand how the hydrological response of hillslopes comes together to generate river flows.*

Soils

The WAG Soils Strategy highlights the need to protect our soil resource as part of the delivery of a sustainable future for Wales. Soils deliver a range of vital functions for human activities including food production, support for ecosystems and habitats, and environmental services. These services include a vital role in the carbon cycle, stabilising and degrading contaminants, and providing clean water. Soils will be expected to deliver greater food output to satisfy increasing global demands and decreases in productivity elsewhere. The European Commission has expressed concern that soils in Europe are being degraded by a host of human activities, including inappropriate agricultural and forestry practices.

In Wales, we need to not only protect the soil resource but plan how to adapt to future pressures on soils. Climate change is expected to have significant direct effects in terms of loss of soil carbon and damage to soil structure. Heavy rainfall events, which are projected to become more commonplace, as well as periods of drought, will heighten the risk of severe soil erosion. Both off-road vehicles and the use of footpaths by walkers may locally compound soil erosion problems. As well as leading to losses of soil, particulate pollution of waterways on account of increased soil run-off will become a greater threat.

The Welsh Assembly Government has issued a consultation entitled *The Welsh Soils Action Plan*, which examines some of the issues identified above. It can be found using the link below:

<http://new.wales.gov.uk/consultations/currentconsultation/envandcouncurrcons/130308welshsoilsactionplan/?lang=en>

Our ability to adapt to climate change impacts such as flooding and biodiversity changes will depend heavily on soil management. The use of measures to increase the organic content in soils will not only contribute to mitigation but enhance soil structure to give improved water retention and so reduce the threat of drought. As mentioned earlier, **agri-environment schemes can support soil management and carbon conservation by preventing overgrazing particularly on upland organic and peat soils. Encouragement of organic farming, promoting landspreading of biowastes, and introduction of biochar technology can also play a role. While these are often seen as**

mitigation measures it is important to recognise that they can contribute to adaptation too (Recommendation 44).

Farmers will need to consider how they might adapt their current farming practices to respond to soils impacts, particularly erosion, for example through simple measures like contour ploughing to reduce soil erosion losses. Higher soil temperatures are likely to lead to longer growing seasons, with grass normally only growing when temperatures are above 6°C. It may be extended by between 40 and 100 days by 2080. Farming practices will need to change in order to take best advantage of this shift, including the ability to grow different varieties or novel crops. On the other hand, for the first time, during summer 2007, WAG suspended temporarily the cross-compliance requirement prohibiting the use of mechanical equipment on waterlogged soil, due to the exceptionally wet weather that we had seen during the summer. This may become a more common occurrence if as projected heavy rainfall events increase in frequency so farming practice will need to adapt to these changes too.

The impacts of climate change on vulnerability to soil erosion should be fully considered by all farmers and land managers as well as in all relevant policy guidance owing to the threat of resource loss, diffuse pollution and deterioration in soil structure and condition (Recommendation 45).

Landscape

The Welsh landscape has been shaped by climatic changes in the past, such as the 'Little Ice Age' between 1590 and 1890 that resulted in abandonment of marginal land, and will certainly be changed by future climatic changes. Agricultural land use is a dominant factor influencing the shape of the landscape. Any change to a longer growing and grazing season might be expected to result in extensions to the ranges of crops potentially leading to the ploughing of currently pastoral areas. The dramatic changes in acreages of crops sown in southern England over the last few decades could well occur in Wales as a result of climate change.

Many of the issues referred to elsewhere in this paper in relation to aspects such as spatial planning, agriculture and woodlands are highly relevant to the landscape but there has been little exploration of the implications of climate change for landscape explicitly. However, the European Landscape Convention (ELC) is a new instrument devoted exclusively to the protection, management and planning of all landscapes in Europe. It could perhaps help address the desire to consider adaptation at the landscape-scale as it encourages a joined up approach through policy and planning in all areas of land-use, development and management, including the recognition of landscape in law. The Convention promotes landscape protection, management and planning so could further an integrated approach to the management of the natural heritage including adaptation in Wales, though the Convention does not specifically refer to climate

change. Member countries undertake to integrate landscape into their spatial and town planning policies. The revision of Planning Policy Wales due in 2009 should reflect the integrated approach set out in the ELC. The Landscape Institute has published a climate change position statement that sets out the need for landscape architects to play a holistic role in addressing adaptation within development projects.

Case Study – The role of National Parks in developing adaptation

Wales' three National Parks occupy 20% of Wales and the five Areas of Outstanding Natural Beauty (AONBs) an additional 5%. They include Wales' highest and lowest, wettest and driest, warmest and coldest localities and are geographically spread across Wales. They include highly popular locations as well as Wales' least populated landscapes and some of the most economically deprived communities in rural Wales.

This means that they are likely to experience the largest ecological and economic range of climate change impacts in Wales. They will require significant investment in skills and adaptive capacity for the people who live and work there to mitigate and adapt. Their landscape character, demography and main economic activities are all especially vulnerable to climate change impacts. Their extent also means they provide Wales with large, relatively continuous landscapes and seascapes in which to play a lead role in demonstrating the value of adaptation through landscape management. They can also provide a barometer for change elsewhere.

As IUCN Category V landscapes their management is achieved through supporting the interaction between people and the environment, rather than just by direct intervention within protected areas. This approach offers more scope than elsewhere in Wales to develop both economic and ecological resilience together because a wide range of people will be involved at all stages of developing adaptation responses. This approach is consistent with WAG's National Parks Policy Statement for the Parks to play a lead role in developing cutting edge solutions to sustainable rural development and this can be extended to the AONBs too. NPs and AONBs are ideally designed to develop, innovate, experiment and implement adaptation responses to climate change.

All 3 National Park Authorities are currently developing their National Park Management Plans (NPMPs) and also their Local Development Plans (LDPs), which are their principal policy mechanisms for practical adaptation responses. The NPMPs are the governing plans not just for the NPAs but also for all statutory bodies for their operations within NPs. Climate change is a strong cross-cutting theme in all of the plans. The LDPs will address climate change through spatial planning and development control and will be looking to include radical departures from traditional planning. Already the Parks are achieving integrated solutions to planning, energy and biodiversity conservation, for

example through the development of small-scale hydroelectric projects that can also enhance biodiversity and water conservation.

The NPAs are in a good position, given that they attract large numbers of visitors from all over Wales and the UK, to contribute to a programme of building public awareness and demonstration of good practice for adaptation.

Historic Landscapes

Since June 2007, the Historic Environment Group (HEG) have been considering the range of physical, chemical and biological changes likely to affect historic assets, including landscapes, as a result of climate change. The group has looked at how changes should be dealt with, monitored and reported on at a national level plus recommendations on the need for more policy guidance. HEG member organisations will be working in partnership on this issue, aiming to share best practice through building up an information bank of case studies that demonstrate positive and negative evidence of climate change impact. It is hoped that a consistent set of messages will emerge and demonstrate good practice in adaptation work across Wales.

Group members have used predictive modelling and created images to highlight different levels of likely impact depending on climate conditions. **There is a need to further develop modelling of climate change impacts on historic landscapes and archaeological features to identify adaptation best practice (Recommendation 46).** This approach will be developed as an HEG-led initiative to demonstrate and quantify climate change impacts on the historic environment in Wales.

Summary of recommendations

1. It is essential that adaptation measures be mainstreamed into all policies and measures relating to the management of the natural environment.
2. All environmental recording or monitoring schemes should include assessment of climate change impacts so as to enhance our understanding of scale and trajectory of environmental change.
3. Based on the better understanding of potential climatic impacts provided by UKCIP08 for localities and Wales as a whole, there is a case for UKCIP08 outputs being considered in the development of all future guidance relating to land and sea management decisions.
4. There is a need for an integrated vulnerability assessment of the impacts on both protected sites and the wider countryside, including non-climatic factors such as socio-economic factors, to focus adaptation activity and ensure that it addresses the relevant threats.
5. Given the uncertainty in the degree of climatic impacts and availability of probabilistic UKCIP08 scenarios, there is a research need to assess what level of probability that site-specific and more general adaptation measures should be

based on. In other words, whether the most likely degree of impact should be managed for or whether a precautionary approach should be taken assuming a more extreme impact.

6. All Local Authorities should consider the impacts of climate change using UKCIP08 outputs and incorporate adaptation at the community level through Community Strategies and Local Service Boards through strategic planning mechanisms such as LDPs.

7. There is a research need to develop a series of possible land use futures building upon the work of *Sustainable Farming and Environment – Action Towards 2020*.

8. The Welsh adaptation strategy and action plan must be consistent with, indeed driven by, the principles of sustainable development, including:

- Living within environmental limits
- Using sound science responsibly.

9. The integration of adaptation in all policies should be mainstreamed through a more explicit inclusion of adaptation within the review of the WAG Sustainable Development Strategy and the associated WAG Policy Integration Tool.

10. It is recommended that the current remits of statutory bodies and policies to address adaptation are evaluated for gaps that may lead to a lack of coordinated action and to take remedial action if necessary.

11. Planning adaptation at a landscape scale will require effective partnerships at local, regional and national level, and often the development of appropriate mechanisms to enable cooperation between landowners in a similar way to Catchment Sensitive Farming.

12. There is a research requirement to assess both the likely costs of a failure to adapt and the costs of adaptation, including the cost-benefits of different adaptation options so as to prioritise adaptation actions given resource limitations, although this approach cannot override the statutory requirements to manage (and adapt) within our protected areas such as SACs/SPAs.

13. Financial constraints are one of the main barriers to adaptation, particularly as short-term planning and financial budgeting in both the public and private sector leads to other issues taking priority for funding. There is a need to identify appropriate financial mechanisms to fund adaptation.

14. All resource protection policies should be assessed for climate change risks and managed as a coherent whole, to offer a 'joined-up' approach to managing the countryside.

15. The principles for conserving terrestrial biodiversity under a changing climate identified by the UK Biodiversity Partnership should guide the conservation of the natural environment more widely including the freshwater and marine environment. They identify a need for all those involved in implementing biodiversity conservation to:

- i) conserve existing natural resources and high-quality environments because protected sites are, and will remain, strongholds for wildlife in a changing environment;

- ii) reduce other sources of harm not linked to climate, such as pollution and inappropriate management; and
- iii) making sound decisions based on analysis, including thoroughly analysing the relevant drivers of change, and adapting conservation priorities in response to climate change.
- iv) developing ecologically resilient and varied landscapes, through conserving and enhancing local variation within sites and habitats, combined with making space for the natural development of rivers and coasts;
- v) establishing ecological networks through habitat protection, restoration and creation; and
- vi) integrating adaptation and mitigation measures into conservation management, planning and practice.

16. In implementing the UK Biodiversity Partnership principles, we should assess their effectiveness to refine them and improve future adaptation action. Their implementation and monitoring within an exemplar Welsh LBAP area has already been identified as an important step in demonstrating their value.

17. There is a need for conservation organisations to collaboratively develop a series of 'exemplar' on the ground adaptation projects within Wales to demonstrate the potential for adaptation, and crucially assess its costs and benefits along with the practicalities of implementation, thereby acting as beacon projects to inform others.

18. Ecological connectivity should be improved through targeted restoration of semi-natural habitat as it has the potential to make the natural environment, particularly severely fragmented lowland habitats, more resilient to climate change impacts.

19. Adaptation measures are required at a variety of scales, promoting the enhancement of heterogeneity in habitat and micro-climate on individual sites by site managers will be equally important as improving connectivity at the landscape-scale.

20. It is vital that all efforts to improve ecological connectivity and habitat/micro-climate heterogeneity should be monitored for their effectiveness.

21. Research into valuing the ecosystem goods and services of natural assets and sites including their full social and environmental benefits is needed to accord due consideration to natural assets in integrated landscape-scale adaptation projects.

22. Consideration should be given to including the recommendations of this and other adaptation sub-group reports into the programme of actions for delivery through each of the Wales Spatial Plan Area Strategies.

23. WAG should set out in the respective remit letters of Welsh public bodies, such as the National Parks, CCW and EAW, what will be required from them in terms of climate change adaptation actions. The spatial coherence of action could be delivered in many cases through enhanced engagement with the WSP groups.

24. Planning policy guidance should require Local Authorities to promote local action improving community energy and food security through local community development projects and small infrastructure improvements that can also benefit the natural environment and biodiversity conservation.
25. Planning guidance should encourage Local Authorities to include biodiversity conservation, local grazing schemes, renewable energy infrastructure and local food production in Section 106 agreements or in future the Community Infrastructure Levy.
26. There is a research need to utilise new marine UKCIP08 scenario outputs to examine the potential scope of impacts on marine biodiversity so as to allow better consideration of climate change impacts in marine conservation management.
27. It is important that Marine Protected Areas, including Highly Protected Marine Reserves, are established promptly by WAG and CCW as they have a valuable contribution to make to adaptation in the marine environment. Their contribution to climate change adaptation should be considered during their selection process.
28. Climate change and its impacts on marine and coastal ecosystems and species must be a key consideration in marine spatial planning, its implementation and monitoring. Coastal and marine planning should apply an ecosystem-based approach.
29. Compensatory coastal habitat should be created, where managed retreat is the most cost effective and sustainable coastal defence solution, to prevent the decline in extent of coastal habitats. This could be beneficial economically where those habitats can themselves provide or contribute to coastal defence.
30. There is a research need to evaluate the current rate and extent of coastal erosion along with future vulnerability to erosion or flooding along the entire Welsh coast. Such an assessment would feed in to the development of Shoreline Management Plans.
31. There is a need to ensure climate change adaptation is a priority in the future development and implementation of Integrated Coastal Zone Management strategy.
32. A communication and community engagement programme should be developed by those involved in implementing ICZM so as to fully involve the public in decision-making on managing coastal change.
33. CFMPS and CAMS should be fully supported to provide powerful examples of cross-agency working to deliver enhanced resilience in the aquatic environment.
34. The use of CFMPs and SMPs to achieve an inter-agency programme working with natural processes could form a valuable contribution to implementing adaptation in Wales.
35. Climate change adaptation should be a key element in the development of agri-environment schemes emerging from the current WAG review of Axis 2. Many actions to deal with increased flood risk, reduce rainwater run-off and conserve water resources can also deliver benefits for biodiversity and mitigation

(carbon conservation). Wherever possible agri-environment action should make the most of these 'win-win' opportunities.

36. There are disincentives within the current single farm payment and agri-environment schemes for tree planting and the creation of other marginal habitats for biodiversity that need to be removed. Excluding woodland areas and even grazed woodland and scrub from payment areas discourages some adaptation measures.

37. The WAG Agricultural strategy review needs to consider the potential role for adaptation in the sector: currently the focus is on its mitigation role. Incorporating landscape-scale measures that can deliver win-wins for farmers and adaptation is vital. For example, woodland planting could provide benefits in terms of connectivity, flood management but also reduce erosion and provide livestock shelter.

38. On-farm storage of rainwater, through small-scale reservoirs or rainwater harvesting, may offer one important adaptation approach. Where these are justified they should be sited and constructed in a way that would deliver environmental benefits.

39. The farming industry should consider the practical implications of changes to livestock and crop production required as a consequence of climatic changes, such as changes to sowing, breeding and shearing patterns that may become necessary in future.

40. Farmers and government must maintain a high level of vigilance against the increasing threat posed by the incursion of exotic diseases and pests. It must be recognised that despite our best efforts some diseases will from time to time arrive in this country, and could even become established in a worst-case scenario. Contingency measures for such scenarios should be in place as a rapid response will reduce the risk of their proliferation.

41. Farmers will need to assess the greater need for ventilation of livestock sheds and milking parlours to adapt to higher temperatures, as well as a greater requirement for outdoor shelter and shade.

42. There should be action to enhance species diversity at an individual woodland and landscape level to enhance resilience to climate change.

43. Urban woodland and individual trees can play a valuable cooling and shading role in adapting to the greater frequency of heat waves in urban areas. This should be better communicated to those planning our town and city landscapes.

44. Agri-environment schemes can support soil management and carbon conservation by preventing overgrazing particularly on upland organic and peat soils. Encouragement of organic farming, promoting landspreading of biowastes, and introduction of biochar technology can also play a role. While these are often seen as mitigation measures it is important to recognise that they can contribute to adaptation too.

45. The impacts of climate change on vulnerability to soil erosion should be fully considered by all farmers and land managers as well as in all relevant policy guidance owing to the threat of resource loss, diffuse pollution and deterioration in soil structure and condition.

46. There is a need to further develop modelling of climate change impacts on historic landscapes and archaeological features to identify adaptation best practice.

20 November 2008

ANNEX 1. Key sources of information

It was decided that a comprehensive reference list would not be produced for this report but some of the key sources of information on adaptation utilised in the production of this report are listed below.

- Environmental research and monitoring database by the Environmental Research Funders Forum <http://www.erff.org.uk/>
- Extension to ACCELERATES: climate change impacts and responses on the United Kingdom <http://www.defra.gov.uk/wildlife-countryside/resprog/findings/accelerates/index.htm> (assessment of the vulnerability of European agroecosystems to environmental change in support of the conventions of climate change and biological diversity.)
- Wildlife Trust's approach to management to improve resilience to climate change
[http://www.wildlifetrusts.org/files/uploaded/download.php?filename=A Living Landscape \(full\).pdf](http://www.wildlifetrusts.org/files/uploaded/download.php?filename=A Living Landscape (full).pdf)
- Coed Cadw approach to space for nature
<http://www.woodlandtrust.org.uk/campaigns/publicationsmore/space.pdf>
- MONARCH project and reports
http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=330
- PRINCE project reports
<http://publications.environment-agency.gov.uk/pdf/SCHO0507BMOJ-e-e.pdf>
- Climate proofing rural resource protection policies and strategies in Wales report
<http://publications.environment-agency.gov.uk/epages/eapublications.storefront/49185449004f11fc273fc0a80296061f/Product/View/SCHO0407BMGV&2DE&2DE#>
- MCCIP: <http://www.mccip.org.uk/arc/2007/default.htm>
- ICZM Strategy for Wales: <http://www.mccip.org.uk/arc/2007/default.htm>
- HAPMAP: <http://www.habmap.org/>
- <http://www.nfuonline.com/documents/Policy%20Services/Environment/Climate%20Change/NFU%20Climate%20Change.pdf>
- <http://www.nfuonline.com/x26424.xml>
- Environment Agency (2008) *Climate Change and River Flows in the 2050s*, <http://publications.environment-agency.gov.uk/pdf/SCHO1008BOSS-e-e.pdf>
- Downing, T.E, Butterfield, R.E., Edmonds, B., Knox, J.W., Moss, S., Piper, B.S. and Weatherhead, E.K. (and the CCDeW project team) (2003). *Climate Change and the Demand for Water*, Research Report, Stockholm Environment Institute Oxford Office, Oxford.