Scottish Natural Heritage

Summary of the effects of climate change on landscape and quality of life in Scotland

December 2011
Our nature and landscapes are part of our heritage. Climate change is the single greatest threat to Scotland's nature, and how we choose to respond will affect not only our nature and landscapes, but also our lifestyles, our economy and our culture. By changing how we manage our landscapes, we can significantly improve our response to climate change.

Summary of the effects of climate change on landscape and quality of life in Scotland

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This overview outlines the way the landscape of Scotland could be affected by climate change and describes some of the challenges and opportunities for managing these effects. It summarises research carried out for Scottish Natural Heritage into the effects of climate change on our landscapes and the ways in which they contribute to people’s quality of life.

The research was based on information from the UK Climate Projections 09 climate change projections, focusing on the changes which could take place over the next fifty years. While there is uncertainty about the patterns of climate change, its direct impacts and the way that society responds to it, we can be sure that there will be change and there will be implications for the landscape. This summary is intended to illustrate the kinds of changes that could take place – it is, however, neither a firm prediction nor a description of preferred policy outcomes. There will, of course, be other influences, unrelated to climate change, which could have an equally significant effect on the landscape.
Overview

The research explored how Scottish landscapes will be affected by the direct impacts of changing temperatures, precipitation, weather events and sea level change. There is likely to be a loss of land to the sea, an increase in flooding and changing patterns of natural and semi-natural habitats.

Landscapes will also be affected by our attempts to slow climate change, for example by developing renewable energy or increasing the amount of carbon locked up in soils and vegetation (known as 'climate change mitigation'), and by ways in which we respond to the changing climate in planned and unplanned ways (known as 'climate change adaptation').

The research concluded that the combined effects of these changes are likely to be most noticeable in lowland and coastal areas. These tend to be the more populated parts of Scotland, so the effects of climate change on the landscape are likely to have a disproportionate impact on people. In the uplands, with the exception of developments such as windfarms, landscape change may be more subtle.

The research also found that mitigation and adaptation measures may have a greater influence on the Scottish landscape than the direct effects of climate change. This means there are important opportunities to influence the process of landscape change.

The most significant direct changes include:
- an increase in coastal flooding and erosion, including loss of low lying areas of land to the sea as a result of sea level rise, larger waves and storm surges;
- an increase in river flooding, erosion and slope instability;
- effects of changing patterns of rainfall, increases in storm damage and a potential increase in pests and disease on trees and forests.

Measures designed to mitigate climate change are already influencing landscape change and include:
- windfarm developments, introducing large modern structures into many upland and some lowland and coastal landscapes;
- cultivation and processing of biomass in the form of short rotation coppice and energy crops;
- tidal and marine based renewables;
- micro-renewables;
- carbon storage including woodland expansion and peatland restoration.

Measures to adapt to climate change include:
- engineered responses to the threat of coastal and riparian flooding;
- sustainable flood management responses, including restoring natural floodplains, increasing woodland planting in river catchments, and allowing coastlines to change as sea levels rise;
- changing patterns of woodland and forest management, and the expansion of habitat networks;
- intensification of agricultural production in lowland areas, with changes in crops, new buildings and greater use of irrigation;
- policies designed to steer development away from locations where there is an increased risk of flooding or storm damage;
- expansion of outdoor recreation and tourism, particularly during the summer months.
Impacts of Climate Change on Scottish Landscapes

Climate change is widely accepted as one of the greatest challenges facing us over the coming decades. Changes will result from the direct impacts of changing temperatures, patterns of precipitation, weather events and sea level change. Changes to the landscape will also result from human attempts to slow climate change, for example by developing renewable energy or increasing the amount of carbon locked up in soils and vegetation (referred to as ‘climate change mitigation’), and the way that we respond to the changing climate in planned and unplanned ways (referred to as ‘climate change adaptation’).

Many of these changes have implications for Scottish landscapes. While the landscapes we see today are in part a product of a constantly changing climate, the speed and range of changes we are now experiencing - and are likely to experience in the future - are very different. These changes could alter the character of the landscape, the way in which it is perceived and enjoyed, and the way in which it contributes to our quality of life.

This summary outlines many of the challenges and opportunities that will affect the landscape of Scotland as a result of climate change. It summarises research carried out by Scottish Natural Heritage into the effects of climate change on our landscapes and the ways in which they contribute to people’s quality of life. The research was based on information from the UKCIP02 and UKCIP09 climate change projections, focussing on the changes which could take place over the next fifty years.

While there is uncertainty about the patterns of climate change, the direct impacts and the way that society will respond, we can be sure that there will be change and there will be implications for the landscape. There will, of course, be other influences, unrelated to climate change, which could have an equally significant effect on the landscape.
Direct effects of climate change

The most significant direct changes could include an increase in coastal flooding and erosion, including loss of low-lying areas of land to the sea as a consequence of sea level rise, larger waves and storm surges. There is also likely to be an increase in river flooding, erosion and slope instability. Semi-natural habitats are likely to change as species' favoured conditions move north. This could affect heather moorland, peat bogs, native woodlands and upland plant communities.

There are likely to be direct effects on trees and forests reflecting changing patterns of rainfall, increases in storm damage and a potential increase in pests and disease. This could be most evident in agricultural areas, woodlands, designed landscapes and settlements. The pattern of snowfall and snow lie is likely to change.

Along low-lying sections of coast, or in areas where flooding or land stability are already issues, changes in landscape character could be quite dramatic. However, for the most part these changes will be more gradual and subtle - modifying rather than transforming the landscape.
Climate change mitigation

Measures designed to mitigate climate change are already influencing Scotland’s landscape. Windfarm development is introducing large modern structures into many upland and some lowland landscapes. This trend is likely to continue alongside the upgrading and expansion of the national grid, and the growth of offshore wind energy, particularly along the east coast, the Solway Firth, the coast of Argyll, Islay and Tiree. Other forms of renewable energy technologies are likely to include the cultivation and processing of biomass in the form of short rotation coppice and energy crops. There will also be development of tidal and marine based renewables, and the wider take up of small scale or micro-renewables such as solar panels on buildings. Some of these developments could have a significant effect on the character of the landscape.

Climate change mitigation also includes measures designed to increase carbon storage. There is already an objective to increase the total area under woodland and forests, meaning that many parts of Scotland are likely to see an expansion of productive forests (where trees are planted as a crop) and native or semi-natural woodland. Depending on where such expansion takes place, and how new woodlands are designed; this could either reinforce or change existing landscape character. Other measures could include the restoration of natural upland habitats, for example by reversing drainage of peat bogs, where these contribute to carbon storage. Most of these changes are likely to reinforce and restore landscape character.
Climate change adaptation

Adaptation to climate change is also likely to result in a range of landscape changes. Planned adaptation will include responses to the increased risk of river corridor and coastal flooding. Natural floodplains are likely to be restored and areas of new woodlands established to intercept rainfall and slow the speed of run-off. There will also be demand for engineered flood defences, particularly where settlements, historic sites and properties, infrastructure or more productive farmland are at risk.

Similar responses are likely along the coast, including estuaries and sea lochs. Initiatives which allow the coastline to change as sea levels rise (known as ‘managed realignment’) will help retain valued coastal landscapes and habitats, even though some loss of land will result. Elsewhere, coastal flood defences may be strengthened, in places resulting in the loss of inter-tidal landscapes. Other measures could include the upgrading of infrastructure to make it better able to deal with higher rainfall.

It will also be necessary to alter the way that forests and woodlands are managed. Changing rainfall patterns, temperatures and storminess will be reflected in the use of different tree species and the avoidance of higher and more exposed locations. The wider use of continuous cover forestry (planting and harvesting trees in a way that maintains the forest canopy and promotes a more natural woodland structure) in preference to clear felling (cutting down all the trees in a block and replanting, resulting in even-aged forests). It is likely that the timing of forestry activity may also change reflecting the impact of wetter winters.

The need to help species adapt to climate change is already leading to the development of habitat networks and this could result in a noticeable increase in woodland cover, particularly in more intensively settled and farmed landscapes where there has been significant habitat loss in the past.

Unplanned responses to climate change could result in significant landscape changes in some parts of Scotland. Lowland agricultural landscapes, particularly those which are closest to the main urban centres, are likely to experience the changes as land managers adapt to the changing climate. Farmers may be able to grow a wider variety of crops, but may also need to adapt to drier summers by storing water and making wider use of irrigation, and wetter winters by changing the timing of operations such as ploughing and maintaining permanent ground cover vegetation during the fallow period. There may be a need for new farm buildings as crops change and stock require shelter from winter rain. Field boundary trees may be lost, but new woodlands and habitat networks may be created. The whole sector is also likely to be affected by wider economic trends, including the likelihood that Scotland’s competitive advantage may increase over those areas experiencing more severe climate change. These effects are likely to be most significant along the East coast, where it is likely that existing arable farming activity will intensify. Pastoral areas in the west, together with more fertile Highland glens, could also experience change.

Finally, the changing climate is likely to have an impact on patterns of tourism and recreation, as people adapt to warmer and drier summers. Scotland could see an expansion in recreation activity, particularly in more accessible areas around settlements and in protected landscapes. Conversely, an increase in winter rainfall in many areas and reduction in snow lie could have an impact on winter recreation, reinforcing existing patterns of seasonality. These changes could result in pressure on accessible recreation facilities during the summer, with possible increases in erosion and fire risk, and pressure for tourism related development. People’s experience of Scottish landscapes may also be affected by changing weather patterns and the impacts of direct effects, mitigation measures and adaptation responses.
The implications of change for Scottish landscapes

All these changes could have an influence on the character of the landscape and, importantly, the ways in which it contributes to our quality of life.

Overall, it appears that human mitigation and adaptation measures may have a more significant influence on the character of the Scottish landscape than the direct effects of climate change.

This is an important finding, meaning that there is potential to influence policy and actions on the ground to make sure that the effects on the landscape are taken fully into account.

A further finding is that the combined effect of these direct, mitigation and adaptation changes are likely to be most noticeable in lowland and coastal areas.

This reflects the influence of farming, settlements, transport infrastructure and land use in shaping landscape character, together with the likely impact of changing sea levels. This contrasts with the uplands where landform is a more dominant factor and where, with the exception of developments such as wind farms, change may be more gradual and subtle. Many of these lowland landscapes are undesignated, meaning there are fewer opportunities to influence change. They are also more settled, meaning that the effects will have a disproportionate impact on people.

Although we do not know the exact combination of changes that will affect specific locations, we do know that change is already happening, and without careful planning one of Scotland’s most important environmental assets could experience lasting damage.

In some cases there will be difficult decisions and tradeoffs. However, there will also be opportunities to create new landscapes, habitats and recreational resources.
Rising to the Challenge

Some of the most significant landscape changes will result from the ways in which we mitigate and adapt to climate change. The challenge is to make sure that actions, policies and strategies across all sectors reflect the importance of Scotland’s landscapes. Wherever possible, our responses to climate change should improve the landscape and the benefits it provides to people, by reflecting existing landscape character or creating new, high quality landscapes.

The following pages provide some initial suggestions on how we should aim to embed consideration of the landscape into the way we adapt and mitigate climate change. The list is not exhaustive and will continue to evolve over time.

To realise the opportunities, and also to minimise the impacts of climate change on the landscape we need to:
- work across sectors;
- take a long term perspective;
- take a strategic perspective;
- continue to improve the evidence base;
- communicate and involve.

Perhaps most importantly, we need to adopt an integrated approach to managing climate related landscape change across lowland agricultural, upland and coastal landscapes. We need to start taking action now to ensure we are able to adapt to changes that are likely to occur in the future. At the same time, we need to recognise that climate change is one amongst a number of factors influencing the landscape, and in many areas, wider economic and social trends may be just as important.

The following sections describe how key policy sectors can help ensure Scotland’s landscape resource is reflected in decisions about how we respond to the challenges presented by climate change.
Flooding and water resources

Potential effects
Rivers and lochs are likely to be affected by changes in patterns of rainfall and possible increases in the intensity of rainfall events. This could result in changing patterns of erosion and deposition, alterations in river courses and more frequent flood events and landslides.

Human responses to these changes may have even more profound implications on the landscape.

River catchments are likely to see measures to slow the speed of run-off. This could include woodland expansion and the restoration of natural floodplains and upland peatbogs in areas upstream of settlements and other areas vulnerable to flooding.

In some cases responses will take the form of engineered flood defences to protect towns, villages and other important assets.

Existing drainage infrastructure may need to be upgraded to cope with larger flood flows.

Some areas may see an overall decrease in rainfall, making droughts more frequent. This is likely to affect rivers, wetlands and lochs and could create pressure for additional or expanded reservoirs. In other parts of Scotland there may be pressure to develop water capture, storage and export infrastructure, particularly if other parts of the UK experience even more serious reductions in rainfall.

Priorities
The priority in this sector is to develop a strategic and long term approach to flood defence which reflects the importance of conserving and enhancing the landscape and townscape resource. Key elements should include:

- avoiding development in locations which could be at increased risk of flooding in the future (not just those currently at risk);
- adopting sustainable flood management measures including moorland management, woodland expansion, restoration of natural floodplains and Sustainable Drainage Systems. Most of these measures will help reinforce landscape character, though many have a long lead in time, suggesting that action is needed now;
- focusing engineered flood defence works in those locations where lives or properties are at risk and where there is no sustainable alternative. Careful design of such schemes is essential to avoid impacts on the landscape and townscape.

In the longer term Scotland could become an exporter of water to drier parts of the UK. Careful planning of water infrastructure is needed, particularly where it would affect more remote upland areas.

Partners
Key partners in this sector include the Scottish Environment Protection Agency (SEPA), the River Basin Management Plan Area Advisory Groups, local planning authorities, Forestry Commission Scotland, the National Union of Farmers (Scotland) and the Scottish Rural Property and Business Association.
Figure 1

Mapping based on UKCP09 Climate Change Scenario data
Figure 2

* Change distribution based on comparison of areas of woodland and trees from the National Inventory of Woodland and Trees with climate change variable P1: Average change in winter precipitation and W1: average wind speed change in winter

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Agriculture

Potential effects

Agriculture could experience a range of changes, many of which would be driven by wider economic influences and increased competitive advantage over areas where the effects of climate change are more severe.

- Agriculture may become more intensive in areas that are currently most productive (particularly along the east coast). In these areas there may be changes in crops, the requirement for new farm buildings, the loss of traditional landscape features including field boundaries and trees, and more evident use of irrigation infrastructure and on-farm water storage;
- Elsewhere it is possible that arable cultivation may expand into lowland pastoral areas, and into the more fertile lower parts of Highland Glens. Dairying, cattle and sheep could move into currently marginal areas;
- There is likely to be some trade-off between a reinvigorated agricultural sector and measures to increase woodland cover;
- Reductions in summer rainfall, and increase in arable cultivation, are likely to result in an increase in on-farm water storage and wider use of irrigation;
- Increases in winter rainfall in some areas are likely to require soil conservation measures and a change in timing of some operations, such as ploughing.

Partners

Key partners in this sector include the Scottish Government, members of the Scottish Rural Development Programme (SRDP) Regional Priorities Advisory Committees (RPACs), the National Union of Farmers (Scotland) and the Scottish Rural Property and Business Association, together with local authorities and environmental agencies.

Priorities

The SRDP has a key role to play in managing the effects of agricultural adaptation to climate change. Its priorities should reflect the influence of climate change on the sector and the potential effects on the natural heritage, including the landscape resource. Each RPAC should ensure that the landscape implications of climate change are reflected in the development of regional priorities, though it may also be necessary to consider more locally targeted incentives. In many cases it will be possible to manage change in a way that reflects an area’s character; though in others there will be a need to plan for more substantial landscape change.

Some actions are required now, for example to ensure that the structure of field boundary trees, shelterbelts and farm woodlands is maintained and where necessary supplemented with more adaptable species. This is preferable to an unplanned response which may happen once loss or damage is already very visible.

Planning authorities should ensure that policies and guidance on the development of new agricultural buildings is relevant and up to date.

While there has been considerable research into the effects of climate change on agriculture, there remains some uncertainty as to how this will play out in different parts of Scotland. Further research is needed to assess the influence of wider economic influences, including the impacts of more severe climate change elsewhere and to explore more precisely how farming in different parts of Scotland will respond to the changing climate.

Information and best practice will help ensure that land managers are assisted in adapting to changing climate and economic conditions in ways which are sensitive to the landscape resource.
Figure 3

- Change distribution based on comparison of more intensive agriculture represented by all farmland except less favoured areas with climate change variables T2: Autumn temperature change, P1: Average change in winter precipitation, and W1: Average wind speed change in the winter climate change variables.

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Figure 4

Potential landscape change due to the cultivation of novel crops

The Minimum/Maximum range is based on the data sets relevant to the change shown.

Change distribution based on comparison of arable farmland areas (including cereals, general cropping, horticulture and mixed farming farm types) with climate change variable T2: Autumn temperature change.

Certainty level: UKCIP02 climate change

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Forestry

Potential effects

Woodland and forests could be affected by a number of changes.

Native woodlands in areas such as Argyll and the Cairngorms could be colonised by other species and damaged by storms. However, the area of woodland is likely to expand in order to contribute to carbon sequestration and flood management strategies. These changes are likely to affect upland glens and, perhaps, some current agricultural areas.

Productive forests are likely to experience changes in species composition, especially in the east where some existing species such as Sitka spruce will be less viable, and management, with increased use of continuous cover cultivation and a move away from higher and more exposed slopes.

Within more agricultural landscapes there could be a change in the pattern of woodland, with an increase in the development of woodland networks and shelterbelts, but a possible loss of individual trees.

Partners

Key partners in this sector include Forestry Commission Scotland, members of the Scottish Rural Development Programme (SRDP) Regional Priorities Advisory Committees (RPACs), private forest owners and forestry sector together with local authorities and environmental agencies and organisations.

Priorities

Climate change is already at the heart of national forestry policy in Scotland. The importance of mitigating climate change is reflected in the objective of expanding woodland cover from 17% to 25% by 2050 as a means of increasing carbon sequestration. This could be achieved through a variety of woodland types, tailored to the character of the local landscape. There is growing support for the development of biomass derived from forest management and crops such as short rotation coppice. Careful siting and design of new woodlands and biomass crops is required to ensure they provide landscape, biodiversity and recreational benefits in addition to their role in supporting climate change mitigation. Woodland and Forestry Strategies, Forest Plans and the administration of woodland grants through the SRDP process have key roles to play. Forestry Commission Scotland guidance will also help ensure new woodlands are well designed.

Equally important are the changes in woodland and forest management that will be necessary as we adapt to the changing climate. There is a need for particularly careful management of our native woodlands to maximise their resilience to drought, storms, flooding and an increase in pests, diseases and competing species. Elsewhere, it may be necessary to change the species composition of productive woodlands, and possibly within farm woods and along field boundaries. Careful choice of species will limit any impacts on the appearance of the landscape. Wetter winters in some areas may mean that the timing of forestry operations is changed and infrastructure such as tracks, culverts and bridges are upgraded. Good design will ensure that landscape impacts are kept to a minimum.
Figure 5

- Change distribution based on comparison of areas of woodland and trees from the National Inventory of Woodland and Trees with climate change variable P2: Average decrease in summer precipitation

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Figure 6

- Change distribution based on comparison of more intensive agriculture, represented by all farmland excluding less favoured areas with climate change variables T1: Average annual temperature increase, P1: Average change in winter precipitation, P2: Average decrease in summer precipitation and W1: average wind speed change in the winter.

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Spatial planning and land use

Potential effects
Climate change could affect settlements in a range of ways:
- potential requirement for upgraded flood defences along river corridors;
- need for wider use of sustainable drainage systems;
- development of habitat networks to help plant and animal species adapt to climate change and the effects of habitat fragmentation;
- open space is likely to come under greater demand for recreation activity;
- urban trees and other vegetation may suffer stress from summer drought and winter water logging;
- building designs, materials and techniques may change to include energy efficiency measures, micro-renewables and features such as green roofs and walls.

Infrastructure is likely to be affected by:
- changing patterns of energy production, including further development of renewable sources such as wind, tidal, wave and biomass energy, and the requirement for upgraded grid connections;
- Transport infrastructure may be upgraded to cope with higher winter rainfall and, in specific locations, an increased risk of landslides and slope instability;
- implications for coastal infrastructure including harbours, ports and ferry terminals, and coastal transport routes;
- increased demand for water elsewhere in the UK could result in the development of reservoirs and aqueducts in southern Scotland.

Priorities
The planning system has a key role to play in addressing many of the challenges of climate change, so it is important that the implications for the climate are fully understood. The planning system could also play a key role in reconciling competing pressures for land (e.g. agricultural intensification, renewable energy development, carbon storage), whilst helping ensure that habitat networks or new greenspaces are provided in the right place and at the right time. There is likely to be a growing emphasis on making sure land uses are co-ordinated and contribute to a range of policy objectives.

Climate change is already being reflected in the planning policy framework. A strategic approach to land allocation helps ensure that new development does not increase the risk of flooding. In part this is about avoiding locations which already flood or which might be at risk of flooding in the future. It is also about preventing development which limits opportunities for sustainable flood management in the future. Wider use of Sustainable Drainage Systems will help ensure that run-off from new development is minimised.

Avoiding areas at risk of flooding could result in settlements expanding into higher and more prominent locations. Landscape and visual analysis will be increasingly important in ensuring that any negative effects are kept to a minimum.

Warmer and drier summers could place greater demands on open spaces in and around our towns and cities. The planning system plays a key role in ensuring that high quality open spaces are provided in the right places and sustained in the longer term. Initiatives such as the Central Scotland...
Green Network, together with Regional and Country Parks, also have a key role to play. Planning also has a role to play in maintaining the quality of townscapes across Scotland. Support for micro-renewables together with a likely increase in the use of air conditioning equipment could slowly transform the appearance of the built environment. Planning policies, guidance and advice should aim to minimise these incremental impacts.

The planning process is also critical in developing Scotland’s renewable energy potential in a way that minimises the impact on the landscape and seascape resource. This requires an approach which directs major developments to those areas which are more able to accommodate schemes, whilst protecting more sensitive and valued landscapes, townscapes and seascapes.
Figure 7

Potential for landscape change through storm damage, pest and disease damage, drought and flood damage and increased use of green and blue infrastructure

The Minimum/Maximum range is based on the data set relevant to the change shown.

Map Scale: 1:3,400,000

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Figure 7

- Change distribution based on comparison of urban and peri-urban areas identified in the Scottish Executive urban-rural classification with climate change variables T2: Autumn temperature change and T4: Change in daily maximum temperature in the summer-autumn.

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Summary of the effects of climate change on landscape and quality of life in Scotland
Figure 8

- Distribution based on areas of coniferous forestry identified from the National Inventory of Woodland and Trees and arable farm type
Biodiversity

Potential effects

The changing climate is likely to affect a wide range of natural and semi-natural habitats.

- Changing rainfall could have mixed effects on peatbogs. Increased winter rainfall could increase the rate of peat formation, but could also lead to an elevated risk of bog-bursts and erosion. Summer drought could also have a negative impact on peatbogs and other wetlands;

- Heather moorlands may also change, partly in direct response to climate changes, and partly because of changes in the way they are managed;

- Upland habitats, particularly those adapted to low temperature environments are likely to be affected by warmer winters;

- Semi-natural woodland habitats are likely to be affected by changing species, changing patterns of pests and disease and an increase in storm damage and stress associated with summer drought;

- Impacts on riverside and coastal habitats as a consequence of increased flood risk and our response to it;

- More habitat enhancements as a consequence of habitat networks and ‘re-wilding’ initiatives;

- Broader effects associated with changes in the area of land that is climatically suitable for particular species and habitats.

Partners

Key partners in this sector include the Scottish Government, Scottish Natural Heritage, local authorities and organisations such as RSPB and the Scottish Wildlife Trust.

Priorities

Although there is growing understanding of the effects of climate change on specific species and habitats, there is currently a lack of information about the landscape scale implications of changing patterns of rainfall, temperature, storminess and sea level rise. A priority should, therefore, be to develop a strategic view of potential habitat change across Scotland, with the aim of informing landscape and other policy sectors.

Many of the adaption responses from other sectors have the potential to benefit Scotland’s biodiversity. These include sustainable flood management which could see moorland habitat restoration, woodland expansion and the recreation of natural floodplains. Many of these measures will also deliver landscape benefits.

The development of habitat networks, reconnecting areas of fragmented habitat, is one of the most important means of helping species adapt to the changing climate. While this will usually contribute to landscape character, care may be required in some areas where features such as woodland or wetlands are introduced into otherwise open landscapes. Similarly, the creation of new coastal wetlands or managed realignment projects should be located and designed in a way that reinforces existing landscape character or creates a new, high quality landscape.
Figure 9

> Change distribution based on comparison of peatland areas identified in the 1990 landcover digital data for Scotland with climate change variable P1: Average change in winter precipitation

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<td>&lt;10</td>
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Figure 10

Change distribution based on comparison of blanket bog and peatland areas identified in the 1990 landcover digital data for Scotland with climate change variables T1: Average annual temperature increase, P1: Average change in winter precipitation, and P2: average decrease in summer precipitation.

<table>
<thead>
<tr>
<th>Certainty level: UKCIP02 climate change</th>
<th>Low</th>
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<td>Certainty level: mapped data</td>
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<td>Timescale of change (years)</td>
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Transport

Potential Effects
In the medium term, the principal pressures on this sector are likely to be associated with increased winter rainfall in some areas and a general increase in the intensity of storms and rainfall events. The impacts could include flooding and land instability along key routes. Responses are likely to include the upgrading of drainage infrastructure, culverts and bridges, together with slope stabilisation works. For the most part, these will be incremental changes, but there is potential to slowly impact on the character of rural landscapes and the way they are experienced, particularly in upland areas. Allowing the expansion of woodland and scrub on steeper, less stable slopes, could provide an alternative to more engineered approaches to slope stabilisation.

In the longer term, rising sea level could have an impact on coastal transport infrastructure, including harbours, ferry terminals, road and rail routes. It is possible that increases in flood defences will be needed in some places, though rerouting be necessary. The implications are likely to be particularly serious in remoter areas and where sea level rise is compounded by exposure to storms and surge tides. This could affect routes on narrow raised beach coasts and where causeways have been constructed linking islands or crossing sea lochs. Responses to these impacts could result in significant local landscape impacts. Some of these will be unavoidable, but good design and scheme mitigation should help keep them to a minimum.

Partners
Key partners in this sector include Transport Scotland, Network Rail, roads authorities and Scottish Natural Heritage.

Priorities
Careful design of upgraded drainage infrastructure will help ensure that the local and wider landscape impacts are kept to a minimum.

Where there are slope stability issues, the use of a range of measures, including tree planting and well designed drainage and debris flow channels and shelters will also help limit the wider landscape impacts.

Sensitive design will also be needed where measures are needed to address coastal flooding and sea level rise where this affects coastal transport routes or harbour infrastructure.
Coasts and seas

Potential effects
Changing sea levels and the increased risk of storm surges are likely to result in an increased risk of flooding in low lying coastal and firth locations. Changes in sea level and storminess could also affect processes of coastal erosion and deposition, with implications for features such as mudflats, sand dunes and beaches.

Measures to allow coastal retreat or flooding (‘managed realignment’) could see more natural coastal landscapes retained, although some areas of existing land will be lost. This may have implications for landscape and historic features and existing land uses such as agriculture. Retaining more natural coastal landscapes may reduce the severity of extreme flood events.

Stronger flood defences are likely to be required to protect coastal towns, villages, infrastructure and better farmland. The design of these structures could have a major impact on the landscape and could result in the loss of intertidal features and processes as they are ‘squeezed’ between the rising water level and immovable defences. Harder flood defences also require greater maintenance and can result in severe impacts if they fail.

Other types of adaptation may include the development of coastal habitat networks, linking surviving fragments of habitats to increase plants’ and animals’ resilience to climate change.

It is likely that coasts and seas will be subject to further expansion of renewable energy. This could include additional on and off-shore wind farms, the development of tidal barrages in key estuaries and the deployment of wave and tidal stream technologies. It is possible that the development of carbon capture, transport and storage infrastructure will have implications for coastal landscapes.

Priorities
Plans and strategies for the coast, estuaries and seas should reflect both the need to respond to climate change, and the importance of taking landscapes and seascapes fully into account.

Avoiding building in low-lying coastal areas will reduce the need for future flood defences and will help retain natural coastal landscapes; this includes a healthy safety margin so that developments are not overtaken by climate change.

Managed realignment can help retain natural coastal landscapes, create important wetland habitats, provide opportunities for informal recreation and help reduce the risk of flooding elsewhere. The design of engineered flood defences should be designed in a way that reinforces the character of the built environment and that sits comfortably in the wider landscape.

One of the risks is that we take an incremental and uncoordinated approach to adaptation and mitigation. This could result in a gradual, but significant impact on the character and quality of coastal landscapes. A strategic approach will help identify sections of coastline, estuaries and areas of sea where there should be an emphasis on solutions which have minimum effects on landscapes and seascapes.

It is important that our responses to climate change are properly informed by an understanding of coastal landscapes, and their sensitivity and resilience to change. Techniques of coastal and seascape assessment mean there is an opportunity to inform coastal adaptation strategies and coastal and marine renewable energy policies.

It will also be important to monitor the changing coastal landscape and seascapes so the effects of climate change and implications for our quality of life are properly understood.

Partners
Key partners in this sector include Marine Scotland, Scottish Environment Protection Agency, local planning authorities and Scottish Natural Heritage.
Figure 11

- Estimate of sea level change (cm) around the Scottish coast between 2000 and 2080. The estimate takes the global mean sea level change projection from IPCC AR4 and subtracts the GIA component (isostatic rebound) based on Shennan and Horton (2002) and Smith et al. (2008). These estimates assume that IPCC scenario SRES A1B will apply.
- Data source: SNIFFER FRM 10 Coastal Flooding in Scotland a Scoping Study

Certainty level: Uncertain (high number of variables)

Timescale of change (years) | <10 | 10–100 | 100+ |
Figure 12

- Surge hazard assessment based on analytical consideration of potential for wind set-up of surges in inlets around the Scottish coast. The greatest uncertainty is associated with the south west coastal areas due to the hydrodynamic complexities of the Irish Sea.

Data source: SNIFFER FRM 10 Coastal Flooding in Scotland a Scoping Study

Certainty level: Uncertain (high number of variables)

Timescale of change (years)
Recreation and tourism

Potential effects
Warmer, drier summers could make many parts of Scotland more attractive for recreation and tourism. This could bring benefits for local communities and economies, but could also increase demand for additional tourism developments, including caravan sites, campsites, hotels and visitor attractions and put unsustainable pressure on fragile infrastructure.

Increasing numbers of visitors could weaken the sense of remoteness currently experienced in parts of Scotland.

In and around towns and cities, growing levels of outdoor recreation and warmer, drier summers could increase the stress on open spaces.

Recreation could be affected by milder, and in some areas, wetter winters. Reduction in snowfall and more rapid snowmelt could affect activities such as skiing, as well as changing people’s experience of the winter landscape – particularly in valued Highland landscapes. Where rainfall increases erosion, damage to paths and open spaces could increase.

Partners
Key partners in this sector include local planning authorities, access authorities and access forums, Visit Scotland, Scottish Natural Heritage, Forestry Commission Scotland, Greenspace Scotland, sportScotland and sports representative groups.

Priorities
Careful planning and design of new tourism and recreation developments will help ensure that they respect the character of the landscape, protecting the resource upon which the sector depends. Early diversification will help areas dependent on winter sports develop alternative sources of income.

Access strategies and recreation management plans should consider the effects of increased numbers of visitors on the way that people experience and enjoy the landscape, particularly in more remote areas.

The impacts of recreation activity in areas experiencing summer drought or winter waterlogging should be monitored and wherever possible managed.
Figure 13

Change distribution based on comparison of all areas except those classed as remote in the Scottish Executive urban-rural classification and climate change variables T1: Average annual temperature increase, T2: Autumn temperature change, T3: Increased difference between summer-winter temperature, P2: Average decrease in summer precipitation, C1: Increased cloud cover, SN1: Change in snowfall, T4: Change in daily maximum temperature in summer-autumn

Certainty level: UKCIP02 climate change
- Low
- Med
- High

Certainty level: mapped data
- Low
- Med
- High

Timescale of change (years)
- <10
- 10-100
- 100+
Potential for landscape change through increased demand and use of greenspace in urban and peri-urban areas

Minimum
Maximum

The Minimum/Maximum range is based on the data set's relevant to the change shown.

Figure 14

- Change distribution based on comparison of urban and peri-urban areas identified in the Scottish Executive rural-urban classification with climate change variables T2: Autumn temperature change, T4: Change in daily maximum temperature in summer-autumn

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**Historic environment**

**Potential effects**

Climate change could present particular challenges for Scotland’s historic environment and the contribution that it makes to the wider landscape.

Woodlands in designed landscapes and specimen trees could be affected by changing rainfall patterns and higher temperatures.

Historic sites in coastal locations could be affected by sea level rise, while many sites and historic buildings could be affected by a combination of wetter winters and increased visitor pressure in the summer. Archaeological sites preserved in peat and other wetland environments may suffer more rapid decay as a result of drying and erosion. Agricultural intensification and expansion into currently marginal areas will increase pressure on sites and monuments in farming areas. Assets in floodplain and riverside locations will be at risk from flooding and erosion, and also the need to construct new defences for settlement and infrastructure.

Mitigation measures, particularly renewable energy generation and woodland expansion, are likely to have an impact on how assets relate to, and can be understood, in the wider landscape. The ‘setting’ of many sites is as integral to their importance as their physical attributes, therefore careful planning of development will be critical in preserving these values.

Some of these impacts will be difficult to avoid, others will require careful management to minimise loss and damage.

**Priorities**

The timescales for restoring or replacing historic woodlands, avenues and specimen trees is long, so it is vital that the implications of climate change are considered now. Positive management of existing trees will increase their resilience to changes in the climate or patterns of disease and pests. It may also be appropriate to implement a planned programme of replacement. Careful choice of species will be required to maintain the overall character of the woodland in question, whilst taking account of future climatic conditions.

It is likely that some of the greatest challenges will face historic landscapes in coastal locations and a prioritised programme of protection will be needed to conserve the most important sites. Elsewhere, careful recording should be carried out before sites or landscapes are lost.

Many planned and unplanned adaptation responses could have implications for the historic dimension of the landscape. It is therefore important that woodland expansion initiatives, or incentives relating to agricultural change, are considered in terms of their implications for the historic environment, and the contribution it makes to the wider landscape.

Similarly, the adaptation of buildings to cope with higher temperatures, more intense rainfall or to provide locally generated heat and power, should be carried out in ways that conserve their historic character and significance.

**Partners**

Key partners in this sector include Historic Scotland, council archaeology services, National Trust for Scotland, Royal Commission on the Ancient and Historical Monuments of Scotland, Association of Local Government Archaeological Officers: Scotland and the UK Department of Culture, Media and Sport (for World Heritage Sites)
Geographic summaries
This National Summary is accompanied by a series of 14 geographic summaries, covering groupings of local authorities. These summaries, which can be downloaded from the SNH website cover the following areas:

- Aberdeen and Aberdeenshire
- Argyll and Bute
- Ayrshire
- Dumfries and Galloway
- Tayplan area
- Edinburgh and South East Scotland
- Falkirk, Stirling and Clackmannanshire
- Glasgow and the Clyde Valley
- Highland and Moray
- Orkney
- Shetland
- Western Isles
- Loch Lomond and the Trossachs National Park
- Cairngorms National Park

For further information or advice, please contact:

E: landscape@snh.gov.uk
W: www.snh.org.uk