



**Cyfoeth
Naturiol
Cymru
Natural
Resources
Wales**



**Bryniau Clwyd a
Dyffryn Dyfrdwy**
Clwydian Range
and Dee Valley

Ardal o Harddwch Naturiol Eithriadol
Area of Outstanding Natural Beauty



Llywodraeth Cymru
Welsh Government

Clwydian Range and Dee Valley AONB

Landscape and Nature Recovery in a Changing Climate

Landscape and Nature Recovery in a Changing Climate

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Landscape and Nature Recovery in a Changing Climate

Introduction

The effects of climate change are increasingly being experienced within the Clwydian Range & Dee Valley Area of Outstanding Natural Beauty (AONB). In 2019 both Wrexham and Denbighshire County Councils declared a climate change and ecological emergency. The impact of changes may be short lived or long lasting for future generations. Our communities, landscapes, and ecological networks will need to adapt to cope and thrive.

This plan explores the landscapes of the AONB and identifies the key climate change risks, challenges, and potential mitigation and adaptation actions by landscape character type. It also includes opportunities to support nature and increase ecological resilience.

By using a landscape perspective, it helps us to recognise and relate to potential changes where we live and work. This plan provides a basis for community, stakeholder and cross sector action on landscape change that contributes to the sustainable management of natural resources (SMNR). The objective of SMNR is to enhance the resilience of ecosystems, which are fundamental to achieving sustainable development and our wellbeing goals. The intention is that it will encourage the right adaptation and mitigation measures in the right places. This will have benefits for natural beauty, biodiversity, cultural heritage and wellbeing in a designated landscape.

The Management Plan for the Clwydian Range & Dee Valley AONB provides the 5-year strategy for the AONB. This plan suggests actions for the next decade. It is expected that it will be reviewed alongside the Clwydian Range & Dee Valley AONB management plan and would be updated in 2030.

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Clwydian Range & Dee Valley AONB Landscape and special qualities

The combination of features, habitats and landscapes and how they interact and function together makes the Clwydian Range & Dee Valley AONB special. The links between landscapes are important for adapting to the impacts of climate change as well as building Resilient Ecological Networks.

The special qualities and features that are key to the AONB have been carefully considered within this plan, they include:

Special qualities	Features
Landscape character and quality	Tranquillity Remoteness and wildness, space and freedom
Habitats and wildlife	Heather moorland and rolling ridges Broadleaved woodlands and veteran trees River valleys and the River Dee Limestone grasslands, cliffs and screes
Historic environment	Historic settlements and archaeology Industrial features and the World Heritage Site Historic defence features Small historic features Traditional boundaries
Access, recreation and tourism	Iconic visitor and cultural attractions The Offa's Dyke National Trail and promoted routes
Culture and people	The built environment People and communities

The AONB is in the process of becoming a 'Dark Skies Park' which will add to the special landscape character and quality of the AONB and will also benefit nature and wellbeing.

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Landscape types within the AONB

LANDMAP is an all-Wales landscape resource where landscape characteristics, qualities and influences on the landscape are recorded and evaluated into a nationally consistent data set. The landscape types in this plan are based upon quality assured LANDMAP Visual & Sensory evidence.

The range of LANDMAP Visual & Sensory landscape types that are represented in the AONB have been grouped into six landscape types defined by their predominant land use, character and landscape qualities as follows:

Upland moorland	20-50% moorland and scree
Upland wooded and Lowland wooded	20-50% wooded
Upland open and Lowland open	>50% grassland, <20% wooded, few hedgerow trees
Developed	built land, quarries and communities

At this strategic level each landscape type will include a range of landscape characteristics and features. For example, woodlands will be present in upland open and lowland open landscapes, but the predominant land use and characteristic is a grassland landscape with less than 20% woodland. Management may change current landscape character to such an extent that an area may transition towards a different landscape type in the future, this may be in response to sustainable land management choices and the climate and nature emergency.

Figure 1 shows the current distribution of the six landscape types in the AONB and figure 2 the percentage of each landscape type. Figure 3 shows the relative landscape importance of each landscape type sourced from the LANDMAP Visual & Sensory evaluation.

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Visualising future landscapes

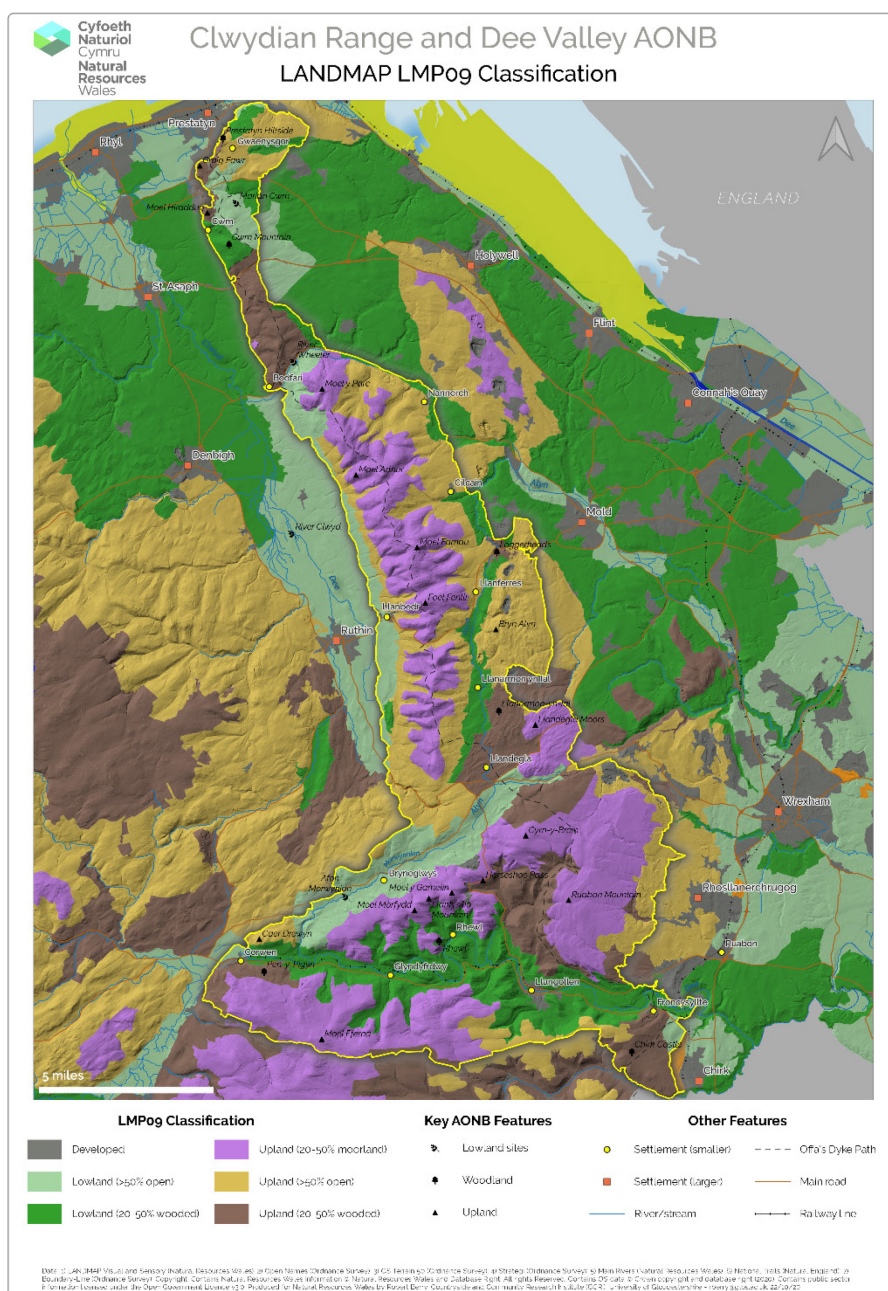
Landscape character can provide an important communication tool to raise awareness and understanding of the risks and opportunities of climate change as people relate to landscapes as places to live, work and enjoy.

The six landscape type narratives describe the key landscape characteristics and qualities, the key objectives to conserve and enhance the landscape, and explain potential landscape changes and opportunities if we are to adapt to climate change, contribute to achieving carbon net zero and deliver resilient ecological networks to benefit local communities and the wider public.

The visualisations depict a desirable future AONB landscape, a landscape that is adapting to climate change, incorporating measures to mitigate climate change, supporting nature recovery and conserving the natural beauty and special qualities of the AONB.

The visualisations represent the six landscape types within the AONB and care has been taken to draw characteristics and features from a variety of places.

Figure 1 Clwydian Range & Dee Valley AONB Landscape Types



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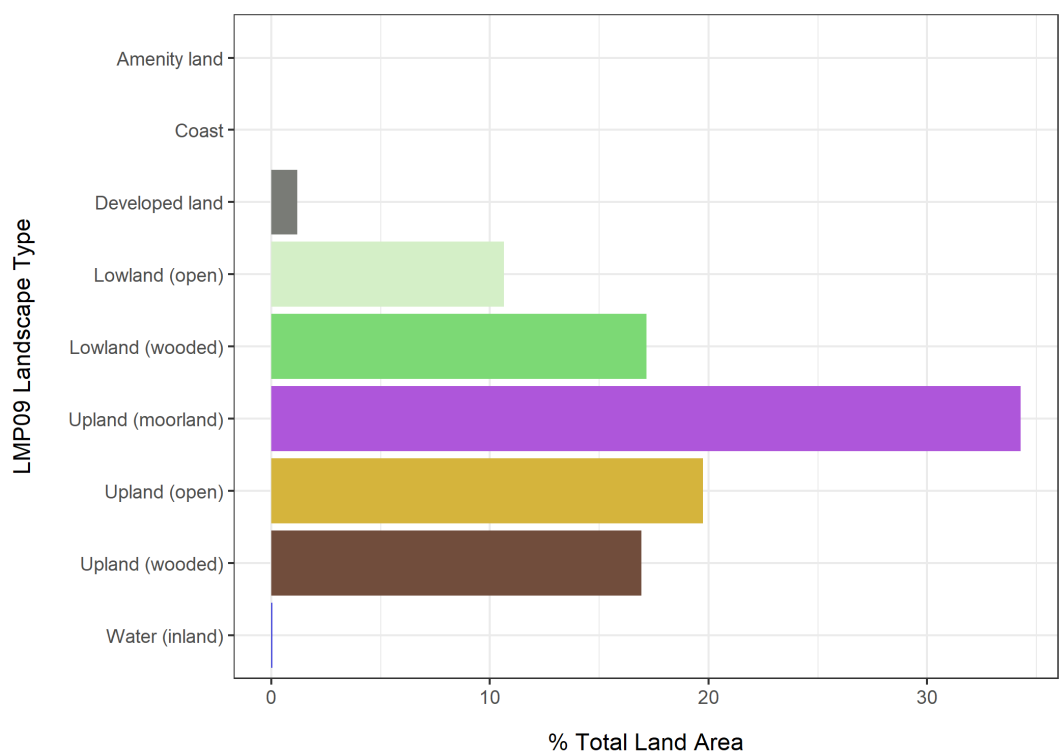


Figure 2 Percentage cover of landscape types within the AONB

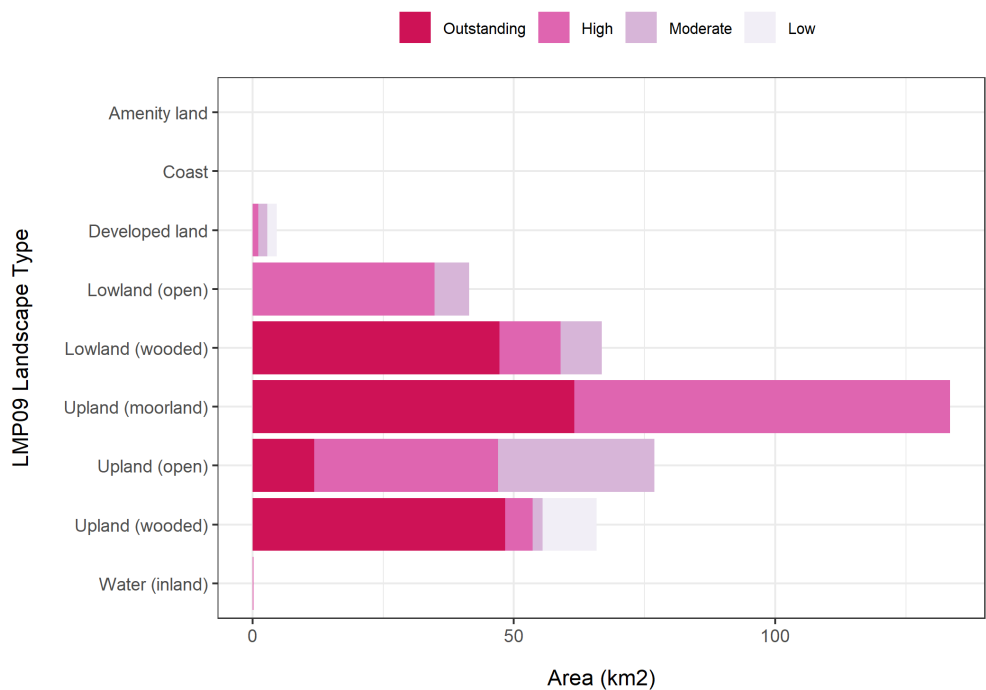


Figure 3 LANDMAP Visual & Sensory evaluation of landscape types values within Clwydian Range & Dee Valley AONB

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LANDMAP landscape evaluations identify landscape importance ranging from outstanding (nationally important), high (regionally or of county importance), moderate (locally important) or low (of little importance) in the context of the national LANDMAP dataset.

Nature recovery and resilient ecological networks

Maintaining and enhancing Resilient Ecological Networks (RENs) are a policy priority in Wales. Restoring the condition and diversity of ecological networks, making them bigger and better connected can improve their ability to resist, recover and adapt to pressures and demands including climate change.

Ecosystem resilience is the capacity of ecosystems to deal with disturbances, either by resisting them, recovering from them, or adapting to them, whilst retaining their ability to deliver services and benefits now and in the future.

Linking protected sites with landscape features and mosaics that are valuable to resilient ecological networks benefits both biodiversity and natural beauty. Nature based solutions to climate change adaptation and mitigation can contribute to ecological recovery.

This plan links opportunities for nature recovery with landscape adaptation and mitigation to respond to the loss of biodiversity and nature emergency.

A changing climate

Flooding and drought events, more frequent extreme weather, wildfires, pests and diseases affecting tree cover, changes in land use suitability and challenges for habitats and species are examples of how the landscape may change in the short and long term.

Climate change adaptation is the management adjustment to the anticipated risks and impacts arising from climate change.

Mitigation is taking actions to limit climate change and its effects, usually by reducing greenhouse gas emissions and increasing carbon absorption such as by planting trees and restoring peatland.

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The changing climate will directly and indirectly impact on the landscapes in which we live, work and experience life, with implications for landscape character, local distinctiveness and quality. Landscape change may be evident from mitigation measures, such as renewable energy generation, water resource management and adaptation through the planned expansion of woodland.

The climate change risks and impacts in this plan are based upon the Met Office UK Climate Projections 18 (UKCP18). This plan can help us to be prepared by encouraging proactive adaptation and mitigation actions that can also deliver better outcomes for landscapes and resilient ecological networks.

Users and uses

The plan will be available to all. Users are most likely to be land managers and decision makers, agri-environment and woodland planners, public bodies and local communities. The mitigation and adaptation actions suggested are intended to be feasible, appropriate and effective at helping our landscape cope with climate change.

Land managers and public bodies can use this document to help shape their land management plans, to identify appropriate mitigation and adaptation actions they can take to manage the impacts of climate change on their land and to explore the future risks they may have to deal with, encouraging pre-emptive measures to manage these.

Agri-environment and woodland planners may use this document to identify opportunities for woodland creation that will maximise climate change mitigation and adaptation potential whilst contributing to the sustainable management of natural resources.

Local communities and other interested parties may use this plan to inform their community projects and plans, to bolster the climate change conversation locally and to create a solutions focussed approach to living and prospering in a changing climate.

This plan can help inform more detailed, place based local assessments where they are required.

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Upland Moorland

34% of the Clwydian Range & Dee Valley AONB is an upland moorland landscape type comprising of areas that have 20-50% moorland cover and are associated with upland plateaus, hillsides, scarp slopes and scree.

All upland moorland in the AONB is of outstanding value (nationally important) or high value (regionally important) in LANDMAP Visual & Sensory. Landscape characteristics and qualities are strongly associated with tranquillity and dark night skies, remoteness, wildness and extensive views.

The Special Qualities of the AONB associated with upland moorland include landscape character and quality, the historic environment, its habitats and wildlife and access, recreation and tourism.

The peaks of Moel Famau, Moel y Parc, Moel Arthur and Moel Fenlli, dominate the Clwydian Range whilst Moel Gamelin and Moel Morfydd are the dominant features of the Llantysilio ridge to the South.

Stunning, far-reaching views over the Dee Valley to the South, the Vale of Clwyd and the Cheshire and Flintshire plains to the North with viewpoints and visitor areas at the Horseshoe Pass and Moel Famau.

The upland moorland landscape attracts locals and tourists to its iconic visitor and cultural attractions including Offa's Dyke National Trail, promoted routes and open access areas.

The upland areas of the AONB are characterised by the dramatic high moorland ridges of the Clwydian Range and Llantysilio Mountain with their shallow peaty soils over Silurian shales. The underlying carboniferous limestone is exposed dramatically along the Eglwyseg escarpment at its Western edge continuing northwards towards the coast with exposures at Bryn Alyn, Loggerheads, Graig Fawr and Prestatyn Hillside.

The extensive moorland plateaus of Cyn y Brain, Ruabon Mountain and Llandegla moors to the East are almost totally devoid of settlement. They are crossed by a single road providing a sense of hidden wilderness and remoteness despite their proximity to nearby

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urban areas to the east and surrounding pastoral farmland. Here the peaty soils are generally deeper and wetter with significant areas of blanket bog.

The heather moorland includes a mosaic of heather, bilberry, grassland and gorse, which creates a varied colour pattern in the landscape throughout the year and contributes to its outstanding beauty. There are 3,000 acres of heather moorland of international importance for conservation within the AONB.

The historic environment is evident in this landscape, in the form of historic defences, small historic features and traditional boundaries. The ridges are interspersed by a chain of Iron Age Hillforts reflecting a sense of frontier and generations of human occupation.

Open heather-clad hills are bounded by drystone walls and small fields, trees and hedgerows along steep valley sides. Predominant boundaries associated with upland moorland range from stone walls (6%), mixed (7%) and fences with/without trees (10%). 11% is open with no boundaries, contributing to the sense of remoteness in the landscape.

Upland moorland connects to upland wooded and upland open landscapes, with good connectivity with ffridd. Where upland moorland borders lowland wooded and lowland open landscapes, it provides a contrasting backdrop to the lowland valleys and mosaic landscapes.

Key priorities and challenges

- Conserve and enhance the special qualities and outstanding and high upland moorland landscape characteristics and qualities.
- Improve habitat condition and reverse habitat decline.
- Manage moorland to minimise peat drying out benefiting carbon storage, habitat biodiversity and historic landscape character.
- The challenges to the diversity, extent and condition of the habitats associated with upland moorland include climate change, past and current management practices, overgrazing and nitrogen deposition.

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A changing climate

Climate change is likely to cause significant changes to upland moorland, caused by hotter, drier summers altering surface water conditions and leading to changes in plant communities. Warmer mean temperatures are also likely to increase the length of the growing season and potentially increase threats from invasive species.

Hotter, drier conditions increase the risk of wildfires, the 2018 wildfire caused catastrophic damage to 250 hectares on Llantysilio Mountain. Managing moorland to reduce the risks climate change poses, benefits the peat habitats and species, nearby communities and reduces pressures on emergency services.

Although upland moorland is not at risk from flooding there is a risk of erosion from heavy rainfall events, it has an important role in regulating the flow of water to more vulnerable lowland areas. Rainfall in areas such as the Jubilee Tower on Moel Famau makes its way down to settlements such as Ruthin. Slowing water flow in the uplands can help reduce the impact of extreme weather events contributing to lowland flooding in communities.

Mitigation within upland moorland landscapes

Mitigate by:

- protecting peaty soils as a long-term sink for greenhouse gases;
- restoring poor condition peaty soils so they don't release carbon;
- reducing cattle and sheep and their associated methane emissions;
- tree planting and natural regeneration in appropriate locations to sequester carbon, in accordance with the UK Forestry Standard;
- renewable development in appropriate locations, not compromising the setting of the designated landscape and special quality views to iconic visitor and cultural attractions.

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Adaptation within upland moorland landscapes

Risk: Peaty soils drying out from reduced summer rainfall causing changes in upland vegetation.

Adapt by:

- maintaining peaty soils for carbon capture and regulating the flow of water off the hills;
- damming man-made grips and ditches to retain moisture and promote sphagnum growth;
- where appropriate, restoring afforested peaty soils to open habitat for biodiversity, landscape and climate benefits;
- reporting archaeological exposures to Clwyd Powys Archaeological Trust.

Risk: Trees, grasses and shrubby vegetation may encroach on moorland in warmer conditions.

Adapt by:

- controlling natural regeneration of scrub and purple moor grass by cutting and grazing to create optimal conditions for heather and key habitats, to enhance moorland as a special landscape quality and minimise risk from wildfires;
- restoring degraded moorland and expanding habitat mosaics, connecting with ecological networks to increase resilience to change and conserve variations in texture, colour and biodiversity.

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Risk: Upland streams and water may increase in temperature and dry up in summer.

Adapt by:

- fencing off streams to increase semi-natural vegetation benefiting water infiltration and flow regulation, reducing erosion and sediments entering the watercourse;
- planting broadleaves, where appropriate, for a range of benefits including shade to reduce thermal stress on salmonid populations from rising freshwater temperatures;
- carefully constructing leaky woody debris dams and pools as part of natural flood management and to slow summer water loss, offering potential refuge areas for aquatic species and maintaining pools as a feature in the landscape;
- supplying alternative sources to water stock, especially upland cattle, for when streams dry up.

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Upland wooded

17% of the Clwydian Range & Dee Valley AONB is an upland wooded landscape type, a landscape that is a mix of open agricultural fields and substantial woods associated with hillsides, scarp slopes and plateau. This landscape has more woodland than the upland open landscape type, woodland cover is likely to be between, or exceed, 20-50%.

54 km² of upland wooded is of outstanding value (nationally important) or high value (regionally important) in LANDMAP Visual & Sensory, 10km² have a low value evaluation.

Woodland is mainly associated with the valley sides and hilltops providing a strong landscape element and sense of enclosure to the lower adjacent land and framing views from the higher ground. Woodlands on the Ancient Woodland Inventory are mostly concentrated in narrow valleys.

Upland mixed ash woodlands and upland oak woodlands are UK priority habitats and of Local Biodiversity Action Plan significance occurring in places such as Pen y Pigyn Wood near Corwen. The Gorsedd stone circle was erected within the sessile oak ancient woodland of Pen y Pigyn for the National Victory Eisteddfod 1919.

Some of the large estates in the AONB have plantations that date back to the 18th-19th centuries. The 20th century afforested areas comprise large blocks of conifer, often angular in design. They contrast with deciduous woodland, adjacent moorland and upland grassland.

Seasonal colour and texture are apparent in areas of older woodland and in recently introduced broadleaved species and where larch is still present. Evergreen conifers continue to dominate close to the key population centres of the Dee Valley such as Llangollen.

The agricultural landscape has predominantly become enclosed farmland since the 18th century Enclosure Acts, while a small proportion remains unenclosed. The landscape is characterised by high levels of sheep stock and minimal arable cultivation. Surviving patches of semi-natural grazing land is intermixed with enclosed farmland. Over half is associated with managed hedges with trees and a quarter with stone walls.

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The use of farms and dwellings associated with the movement of stock into higher pastures during summer (hafod) and down to sheltered grassland during winter (hendre) are evident, particularly by the summer houses for shepherds that remained to look after the upland flock.

Low levels of dispersed settlement characterise this landscape, mostly as small-scale farmsteads and linear settlements that developed to serve the cattle rearing and sheep-grazing economies.

Key priorities and challenges

- Conserve and enhance the extent and condition of broadleaved woodlands and priority woodland habitats as a special feature of the AONB.
- Increase trees in the landscape, reinforcing its wooded and enclosed character.
- Modify conifer plantations increasing the proportion of broadleaves, encouraging better adaptation, connectivity and integration in the landscape.
- The challenges to the diversity, extent and condition of the habitats associated with upland wooded landscapes include climate change, pollution, land use change, insufficient management, pests and diseases.

A changing climate

Significant effects caused by climate change are likely to be changing weather patterns affecting woodland composition, condition and tree species suitability. Warmer mean temperatures are also likely to increase the length of the growing season and potentially increase threats from invasive species. Increased risks from extreme weather, with hotter, drier conditions increasing the risk of wildfire events. More frequent storms with stronger winds pose a windfall threat to standing dead wood, ageing trees and trees of ill health.

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Mitigation within upland wooded landscapes

Mitigate by:

- restoring ancient woodlands and manage existing woodlands, hedgerows and coppice to sequester carbon and reduce downstream flooding;
- increasing planting and natural regeneration of primarily native resilient trees and woodland in accordance with the UK Forestry Standard. Use habitat network maps to guide where new woodland creation can provide the greatest benefit for resilience and nature recovery;
- introducing silvopasture systems combining shrubs, trees and grasses to improve carbon sequestration compared to pasture, a more enclosed and textured landscape character would arise;
- micro-hydro systems may be appropriate where they can be integrated and do not impact adversely on ecosystems.

Adaptation within upland wooded landscapes

Risk: Pests and diseases from overall increase in average temperature are likely to increase with species such as ash, oak, larch and spruce already affected.

Adapt by:

- taking all precautions to ensure that new woodland planting does not bring the risk of new strains of disease, particularly to upland mixed ash woodlands and upland oak woodlands which are significant within the AONB. Climatic conditions are likely to remain favourable for broadleaved species, oak and ash suitability will remain high. Natural regeneration within existing woodland has genetic diversity benefits and reduces risks of introducing new strains of pests and diseases;
- introducing drought and disease resistant tree species to sustain continuous broadleaf woodland cover and increase adaptation potential to a wide range of climatic conditions, pathogens and pest species. Refer to the Forest Resilience Good Practice Guide on Improving the tree species diversity of Welsh woodlands;

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- increasing native broadleaves within existing conifer and mixed woodlands, adding habitat diversity and adapting straight woodland edges through additional planting to UK Forestry Standard and guidelines for landscape.

Risk: More frequent storms with high winds may work against successful tree growth at higher elevations and in exposed locations.

Adapt by:

- locating new woodlands away from exposed and south/south west facing slopes where increased stress from low or infrequent rainfall or from wetter winters and waterlogging unfavourable to root growth may exacerbate windthrow risk;
- retaining and planting trees and hedges with resilient species to provide shelter for livestock against storm and heat events.

Risk: Interacting risks challenging the restoration of broadleaved woodland, and its connectivity across the landscape, to favourable condition.

Adapt by:

- fencing overgrazed woodlands with habitat interest to reduce stress and encourage an understorey, which may alter in response to changes in temperature and moisture;
- allowing natural regeneration of species that may survive and resist disease. Plant small numbers of trees to encourage birds to perch and drop seeds;
- conserving hedges with trees to contribute to landscape connectivity and character, carbon storage and ecological networks by gapping up hedgerows, reducing the frequency (<3 years) and height (>2m) of hedgerow trimming and retaining vegetation buffers to reduce stress and increase biodiversity enhancing their quality and extent.

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Risk: Drought conditions from hotter drier summers causing tree stress and overall increase in average temperature changing species.

Adapt by:

- reducing Sitka spruce as a more susceptible species on well drained and south-facing slopes and replacing with a wider variety of species, generally reducing conifer monocultures and favouring deciduous species to reverse the decline of semi-natural woodlands;
- reducing fire risk by including firebreaks, new woodland planting should have designed-in fire risk mitigation especially close to built up areas;
- increasing shrub species such as hazel, hawthorn and elder to support oak-associated biodiversity and adapt to oak decline.

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Upland open

20% of the Clwydian Range & Dee Valley AONB is an upland open landscape associated with upland valleys, hillsides, lower plateau and scarp slopes with open grazing being more than 50% of the land use.

47km² of upland open is of outstanding value (nationally important) or high value (regionally important) in LANDMAP Visual & Sensory. 30km² are evaluated as being of moderate value reflecting their local importance. Open, panoramic landscapes with extensive views and dark night skies are a key quality. Remnant hedge banks and old stone walls are present on the lower steep slopes of the central Clwydian Range and Llantysilio Mountain as evidence of past enclosures.

The upland grassland areas of the AONB are influenced by its underlying geology. The acid grassland areas associated with the Silurian shales of the central Clwydian Range, Llantysilio and North Berwyn are important transitions between the upland moorland and the lowland wooded or lowland open landscapes. The upland limestone grasslands are a distinctive characteristic of the carboniferous limestone ridges and plateaus of the eastern edge of the Clwydian Range & Dee Valley including Prestatyn Hillside, Bryn Alyn, Moel Findeg and the Panorama.

Rugged, scattered limestone outcrops, screes and pavements are a special quality of the AONB. Many of these limestone grassland areas are notified as Sites of Special Scientific Interest and are nationally significant for their plant communities. Mature, wind-sculpted hawthorns often cling to rocky areas adding to a sense of exposure and wildness.

Marginal areas of semi-natural vegetation provide an important transitional habitat between the uplands and the more intensively farmed lowlands, they are important for ecological connectivity and regulating the flow of water into water networks. The moorland slopes of Moel Famau, Moel Arthur and Penycloddiau give way to a patchwork of rough grassland interspersed with trees and small woodlands in steep valleys in contrast to the more arable and productive Vale of Clwyd.

This upland margin, or ffridd, is characterised by its agricultural function of rough, less intensive grazing influenced by both altitude and geology. The long history of relatively

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low intensity management has led to these grassland areas often being made up of a complex mosaic of vegetation, containing pockets of heath, acid grassland with small stands of birch and rowan in amongst areas of gorse and bracken. This mosaic makes them important areas for ecological connectivity with species such as stonechat, tree pipit and yellow-hammer favouring these habitats and the moorland edge above. In Spring and Summer, the tiny delicate flowers of species such as tormentil, heath bedstraw and harebell bring flashes of colour to this landscape. In the Dee Valley these marginal grassland slopes include the smaller hills of Dinas Brân, Caer Drewyn and Velvet Hill which sit between the Dee and the surrounding higher ridges of Llantysilio, North Berwyn and Esclusham.

This predominantly open character type also includes three large woodland blocks and numerous smaller woodlands, approximately half are recorded on the Ancient Woodland Inventory as ancient woodland sites. These woodlands form part of a significant primary habitat network, important for native woodland biodiversity and resilience.

In some areas, particularly around Moel Famau, these upland grasslands have been extended onto moorland slopes through agricultural improvement during the 1970s and 1980s, creating harder more incongruous boundaries across larger expanses and are more intensively grazed.

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Key priorities and challenges

- Restore and reconnect limestone grassland, a special quality of the AONB, with key habitats and networks.
- Conserve and enhance the outstanding and high landscape characteristics and qualities.
- Enhance moderate landscapes to strengthen landscape character, integrity and sense of place.
- Increase the amount and diversity of ffridd, carefully manage sustainable mixed grazing.
- The challenges to the diversity, extent and condition of the habitats associated with upland open include climate change, air pollution, land use change, insufficient management, agricultural intensification and unmanaged access.

A changing climate

Significant effects caused by climate change are likely to be changing weather patterns altering hydrology and grassland dieback caused by extreme drying. Under management may increase fuel loading with an increased fire risk.

Mitigation within upland open landscapes

Mitigate by:

- reducing cattle and sheep to livestock units that reflect sustainable agriculture and reduce emissions;
- gapping up hedgerows and planting trees, in accordance with the UK Forestry standard where appropriate to sequester carbon and restore ancient woodlands;
- reverting more fields to ffridd grassland;
- wind and solar energy developments outside of the AONB, and other smaller scale sources of renewable energy within the AONB, should be located and designed to minimise landscape and visual impacts. Micro-hydro systems may be appropriate where they can be integrated and do not impact adversely on ecosystems.

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Adaptation within upland open landscapes

Risk: A longer growing season may benefit grassland and mixed farming.

Adapt by:

- reverting more intensive pastures to fridd grassland for livestock;
- retaining existing fridd as an edge and connecting habitat balancing grazing to enhance habitat and landscape mosaics;
- supporting the restoration of mixed farming where appropriate to enhance sward diversity and landscape texture.

Risk: Tree, hedgerow and vegetation stress from hotter, drier summers and increasing pests and diseases.

Adapt by:

- gapping up hedgerows, reducing the frequency (<3 years) and height (>2m) of hedgerow trimming and retaining vegetation buffers to reduce stress and increase biodiversity thereby enhancing the quality and extent of hedgerows, their contribution to landscape character, carbon storage and ecological networks;
- planting small woodlands in accordance with the UK Forestry Standard, such as in extensive areas of improved grassland if appropriate, with diverse tree species increasing adaptation potential to a wide range of climatic conditions, pathogens and pest species. Refer to the Forest Resilience Good Practice Guide on improving the tree species diversity of Welsh woodlands;
- introducing silvopasture systems by integrating livestock with tree planting;
- fencing overgrazed woodlands with habitat interest to reduce stress, encourage an understorey and allow natural regeneration for genetic diversity benefits and reducing risks of new pests and diseases;
- increasing sward diversity in pastoral grasslands helps improve resilience to drought and heat.

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Risk: Summer rainfall patterns affecting local conditions, from less surface water to increased temperatures and risk of flooding in upland valleys.

Adapt by:

- fencing off streams in places to increase semi-natural vegetation benefiting water infiltration and flow regulation, reducing erosion and sediments entering the watercourse;
- creating riparian woodland 20+ metres wide for a range of benefits including providing a dappled (~50%) shade over the water to help reduce thermal stress on salmonid populations from rising freshwater temperatures;
- carefully constructing leaky woody debris dams and pools as part of natural flood management and to slow summer water loss, offering potential refuge areas for aquatic species and maintaining pools as a feature in the landscape.

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Lowland wooded

17% of the Clwydian Range & Dee Valley AONB is described as a lowland wooded landscape comprising of valleys, river valleys and farmland mosaics. Some places are densely wooded in character, with a mix of coniferous and deciduous plantations, in contrast to places that are characterised by open valley grazing. It is a tranquil, rural landscape.

59km² lowland wooded is of outstanding value (nationally important) or high value (regionally important) in LANDMAP Visual & Sensory. 8km² are evaluated as being of moderate value reflecting their local importance.

The field pattern is predominantly small to medium scale, regularly shaped with boundaries defined by stone walls or hedgerows, many with hedgerow trees, extending up the hillsides. The combination of hedges and small woodlands contribute to the strong sense of woodland cover totalling 56km². Broadleaved woodlands and veteran trees are a special quality of the AONB.

The semi wooded valleys of the River Wheeler near Bodfari, the River Alyn from Bryneglwys to Cilcain and the River Dee valley in the South have a strong sense of place enhanced by the valley landform.

The River Wheeler is a narrow minor river valley that dissects the hills and drains into the Vale of Clwyd. The River Alyn starts off in the foothills of the Morwynion Valley, a gentle intervening vale then descends into a narrow-incised valley near Loggerheads. The distinctive River Dee originates from the upland areas of Llantysilio and Eglwyseg Mountains to the north and Y Berwyn to the south, deeply cut in its narrowest areas it descends to form a major river valley. All three rivers and the numerous small streams sourced from upland wooded valleys are important river habitats.

Soils are predominantly poorly drained and seasonally wet. Silty soils overlay the sandstones and shales, areas of more freely draining loams and deep loams are associated with the gravel deposits. Floodplains have developed from the alluvium, gravels and terraces in the lower part of the rivers, contrasting with incised valleys and gently undulating valley floors.

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This landscape type is most at risk of flooding, particularly along the Dee River, Wheeler and Alyn Rivers where there are areas associated with 'flood zone 3'. Flood zone 3 is the area at risk from a 1 in 100 chance or greater of a river flooding event happening in any given year (or a 1 in 200 chance of flooding by sea). Overall, it affects 6km² but due to the linear ecological of the rivers, tributaries and watercourses the adjacent areas affected extend over many kilometres in length if not breadth and include settlements and towns such as Llangollen and Corwen.

Settlement is strongly related to both topography and the historic transport network. The historic and popular tourist town of Corwen is located by the River Dee at a historic crossing point and the iconic Pontcysyllte Aqueduct and Canal World Heritage Site extends across the Dee Valley.

The often abruptly changing and dramatic landscape character is evident to travellers by road, rail and canal along the important transport corridors and 'gateways' to upland Wales from England's lowlands, including along the Thomas Telford London to Holyhead road.

Key priorities and challenges

- Conserve and enhance the outstanding and high value landscape characteristics and qualities including the broadleaved woodlands and veteran trees, a special quality of the AONB.
- Enhance moderate landscapes to strengthen the wooded, hedgerow and farmland mosaic character.
- Increase woodland planting benefitting carbon sequestration and contributing to natural flood management, link habitat networks to rivers.
- Manage sustainable agriculture for a changing climate, a Less is More approach and farming with nature.
- Settlement or development expansion should avoid areas vulnerable to flooding and be linked to sustainable and active travel opportunities.
- The challenges to the diversity, extent and condition of the habitats associated with lowland wooded include climate change, air, land and water pollution, pests and diseases, agricultural intensification, built development and competing land uses.

Landscape and Nature Recovery in a Changing Climate

A changing climate

Significant effects caused by climate change are likely to be changing weather patterns affecting woodland composition, condition and tree species suitability. Warmer mean temperatures are also likely to increase the length of the growing season and potentially increase threats from invasive species. Increased risks from extreme weather, with hotter, drier conditions increasing the risk of wildfire events. Changing weather patterns will increase the risk of flooding as well as increased pressure on water resources from prolonged dry weather.

Mitigation within lowland wooded landscapes

Mitigate by:

- conserving important carbon stocks in woodlands, wet woodlands and hedgerows;
- increasing carbon sequestration by new planting and promoting natural regeneration in accordance with the UK Forestry Standard. Using habitat network maps to guide where new woodland creation can provide the greatest benefit for resilience and nature recovery;
- managing farmland to promote healthy soils by reducing ploughing and avoiding overgrazing to benefit soil organic carbon (SOC) stored and increase resilience to floods and drought;
- converting some areas from silage towards less intensive wet pasture or species rich meadows benefitting wildlife and soil health;
- reducing the use of diesel and electricity on farms. Rebalance energy and fuel usage to favour appropriate renewable energy, whilst conserving the character of traditional and historic buildings;
- balancing livestock numbers with the amount of grass/crops that can be naturally grown without further inputs, reducing the end weight of cows and increasing calf and lamb rearing could reduce the carbon footprint of livestock;

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- decreasing the use of synthetic fertilisers to reduce greenhouse gases, benefit ecology in and around watercourses and improve water quality. Prepare Nutrient Management Plans contributing to climate smart, sustainable agriculture. Cover slurry storage units (using dark colours) to reduce methane emissions.

Landscape and Nature Recovery in a Changing Climate

Adaptation within lowland wooded landscapes

Risk: Hedgerows and their species composition are adversely affected by hotter drier summers and pests and disease. Gaps and losses contribute to a decline in the historic fieldscape and ecological network as fences may replace hedgerows.

Adapt by:

- conserving and restoring hedgerows by gapping up with more resilient and diverse plants, reducing the frequency (<3 years) and height (>2m) of hedgerow trimming. Retaining vegetation buffers to reduce stress and increase biodiversity;
- protecting new hedgerow growth to ensure long term shelter for livestock against storm and heat events.

Risk: Woodlands and trees are adversely affected by hotter drier summers, pests, disease and an overall increase in average temperature. Oak and ash may be particularly affected although their climatic suitability remains high.

Adapt by:

- taking all precautions to ensure that new woodland planting does not bring the risk of new strains of disease, particularly to the broadleaved woodlands and veteran trees that are a special quality of the AONB. Natural regeneration within existing woodland has genetic diversity benefits and reduces risks of introducing new strains of pests and diseases;
- introducing drought and disease resistant tree species to sustain continuous broadleaf woodland cover and increase adaptation potential to a wide range of climatic conditions, pathogens and pest species. Refer to the Forest Resilience Good Practice Guide on Improving the tree species diversity of Welsh woodlands. Encourage natural selection through natural regeneration;
- reducing fire risk by including sensitively designed firebreaks in larger areas of new woodland planting and existing woodlands.

Landscape and Nature Recovery in a Changing Climate

Risk: Warmer, wetter winters may lead to increased soil waterlogging, surface water flow, higher river levels and more frequent flooding.

Adapt by:

- using natural landscape features to store and slow down the flow of water as part of natural flood management to mitigate the impacts of smaller, more frequent floods;
- creating riparian woodland 20+ metres wide providing a dappled (~50%) shade over the water and increasing semi-natural vegetation along watercourses and upper slopes to slow fast runoff and smooth out flows;
- allowing land to hold excess water and increasing wet woodland (willow and alder) to smooth flows during intense storms;
- fencing off sections of watercourses. Re-naturalising watercourses and adding leaky woody debris dams in streams. This will also benefit watercourses in drier conditions and during low flows.

Landscape and Nature Recovery in a Changing Climate

Lowland open

11% of the Clwydian Range & Dee Valley AONB is described as a lowland open landscape, a pastoral landscape of farms and fields with fewer hedgerow trees and a lower proportion of woodland (<20%) than in the lowland wooded landscape type. The landscape is dominated by grassland as a land use, although the boundaries are mainly hedges or hedges with trees it retains a sense of openness.

35km² of the lowland open landscape is of high value (regionally important) in LANDMAP Visual & Sensory. 7km² is evaluated as being of moderate value reflecting their local importance.

Whilst the lowland habitats physically within the AONB are of limited extent and may appear fragmented their continuation outside the AONB into the surrounding landscape increases their resilience.

Lowland open and lowland wooded landscapes often adjoin each other, the transition between open and wooded landscapes can be distinct or gradual. Increases in tree and woodland cover in the adjoining landscapes are likely to integrate well, the area around Bodfari is a good example.

The River Alyn flows from an open landscape that transitions into a narrower and more enclosed landscape through farmland with wooded banks before reaching Loggerheads and the Alyn Valley. This lowland landscape type has 2km² within flood zone 3, indicating a 1% (1 in 100) chance or greater of a flood happening in any given year, most likely linked to the Rivers Wheeler, Alyn and Morwynion.

Landscape and Nature Recovery in a Changing Climate

Key priorities and challenges

- Conserve and enhance the outstanding and high landscape characteristics and qualities.
- Enhance moderate landscapes by strengthening hedgerows, habitat mosaics and enhancing linkages between watercourses and wildlife corridors.
- Manage sustainable agriculture for a changing climate, a Less is More approach and farming with nature.
- Increase tree cover in the landscape, as hedgerow trees, parkland trees, shelterbelts, agroforestry and woodlands to provide shelter for stock and increase carbon sequestration.
- Use landscape diversity and pattern as a framework for integrating new forms of crops and agri-related structures such as poly tunnels and new large farm buildings.
- Settlement or development expansion should avoid areas vulnerable to flooding and be linked to sustainable and active travel opportunities. The challenges to the diversity, extent and condition of the habitats associated with lowland open include climate change, air, land and water pollution, pests and diseases, agricultural intensification, built development and competing land uses.

A changing climate

Significant effects caused by climate change are likely to be changing weather patterns resulting in increased pressure on water resources from prolonged dry weather and grassland dieback caused by extreme drying. Wetter conditions may lead to increased soil waterlogging and water course overtopping. Diverse hedgerow and trees species will aid resilience to pests and diseases.

Landscape and Nature Recovery in a Changing Climate

Mitigation within lowland open landscapes

Mitigate by:

- manage important carbon stocks in trees, woodlands and hedgerows, increase carbon sequestration by planting new woodlands and promoting natural regeneration in accordance with the UK Forestry Standard;
- manage farmland to promote healthy soils by reducing ploughing and avoiding overgrazing to benefit soil organic carbon stored and increase resilience to wetter winters and drier summer droughts;
- convert some areas from silage towards less intensive pasture or species rich meadows benefitting wildlife and soil health;
- reduce the use of diesel and electricity on farms. Rebalance energy and fuel usage to favour appropriate renewable energy, whilst conserving the character of traditional and historic buildings;
- balancing livestock numbers with the amount of grass or crops that can be naturally grown, considering rotational grazing with possibly increased paddocks;
- manage slurry spreading and storage to reduce farm emissions, visual intrusion and environmental harm. Decrease use of synthetic fertilisers to reduce greenhouse gases to benefit nature in and around watercourses and improve water quality. Prepare Nutrient Management Plans contributing to climate smart, sustainable agriculture;
- reducing the end weight of cows and increasing calf and lamb rearing could reduce the carbon footprint of livestock. Cover slurry units (using dark colours) to reduce methane emissions.

Landscape and Nature Recovery in a Changing Climate

Adaptation within lowland open landscapes

Risk: Hedgerows and their species composition are adversely affected by hotter drier summers and pests and disease. Gaps and losses contribute to a decline in the historic fieldscape and Resilient Ecological Network as fences may replace hedgerows, reinstatement of hedgerows along fence lines to improve landscape and ecological resilience.

Adapt by:

- managing and restoring hedgerows by gapping up with more resilient and diverse plants, reducing the frequency (<3 years) and height (>2m) of hedgerow trimming. Retaining vegetation buffers to reduce stress and increase biodiversity;
- planting new hedgerows and encouraging hedgerow trees in this more open landscape, protecting new tree and hedgerow growth to ensure long term shelter for livestock against storm and heat events;
- new buried archaeological remains may be revealed by soil parching, report to the relevant Welsh archaeological trust.

Landscape and Nature Recovery in a Changing Climate

Risk: The lower proportion of woodland and trees in this landscape type may mean the adverse effects of hotter drier summers, pests and disease and an overall increase in average temperature will be more conspicuous.

Adapt by:

- taking all precautions to ensure that new woodland planting does not bring the risk of new strains of disease, particularly to the existing broadleaved woodlands and veteran trees that are a special quality of the AONB. Natural regeneration within existing woodland has genetic diversity benefits and reduces risks of introducing new strains of pests and diseases;
- introducing more hedgerow and parkland trees, planning for long term parkland tree replacement;
- introducing drought and disease resistant tree species to sustain continuous and diverse broadleaf woodland cover and increase adaptation potential to a wide range of climatic conditions, pathogens and pest species. Refer to the Forest Resilience Good Practice Guide on Improving the tree species diversity of Welsh woodlands. Encourage natural selection through natural regeneration;
- reducing fire risk by including sensitively designed firebreaks in larger areas of new woodland planting.

Landscape and Nature Recovery in a Changing Climate

Risk: Warmer, wetter winters may lead to increased soil waterlogging of lowland farmland, surface water flow and river overtopping.

Adapt by:

- increasing trees and bankside vegetation to store and slow down the flow of water as part of natural flood management to mitigate the impacts of excess water and watercourse overflows, minimise the risk of erosion and loss of soil and benefit watercourse habitats in drier conditions and during low flows. Riverside trees provide shade and act as a cooling mechanism for fresh water;
- allowing land to hold excess water to smooth flows during intense storms, increasing low intensity pasture; fencing off sections of watercourses to stock to reduce erosion, improve watercourse habitats and encourage alternative water supplies (establish new ponds) reducing pressure on watercourses during low flows.

Landscape and Nature Recovery in a Changing Climate

Developed

Just over 1% (4.6 km²) of the Clwydian Range & Dee Valley AONB is associated with developed land including urban communities, villages, larger rural settlements and quarries. In addition to the AONB population of 19,000, over a million people visit each year. Communities where people live and visit can be guided towards becoming better places for people and nature, as well as adapting sustainably in a changing climate.

The historic environment is a special quality of the AONB and is clearly evident within the developed landscape as historic settlements, historic features and traditional boundaries; industrial features associated with limestone, lead and slate quarrying; the Pontcysyllte Aqueduct and Canal World Heritage Site and the Vale of Llangollen and Eglwyseg Registered Historic Landscape.

Communities

The two principal historic towns, Llangollen and Corwen, retain many historic architectural buildings. The use of locally quarried stone and slate as building materials in Llangollen and Corwen strongly contributes to their historic character and sense of place. Economic decline has resulted in some original stone buildings declining. Rural villages in attractive settings include Nannerch, Cilcain, Llanbedr Dyffryn Clwyd and Froncysyllte. Villages that were built using materials that reflect the underlying geology stand out in the undulating landscape, such as Nannerch, a traditional stone village that is situated on the higher ridges and plateau. Each with strong links to earlier land use and employment in agriculture or the slate quarrying industry, like at Llanbedr Dyffryn Clwyd.

Open spaces and gardens in towns and villages provide an important contrast from the built environment. Linear river and canal corridors through towns, small green spaces and street tree planting are important visually, historically, for nature and our wellbeing.

Busy roads and increased light pollution in and around towns and villages and along their linking transport routes can contribute to a reduction in tranquillity and dark skies. Outside of the AONB urban areas with populations exceeding 10,000 are concentrated around the northern and western boundaries, with significant expansions in recent decades along the A55 corridor. The small market towns of St Asaph, Denbigh and Ruthin have a strong

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interrelationship visibly and physically with the AONB landscapes. Actions within the AONB can be beneficial to communities beyond its boundaries.

Quarries

Evidence of exposed stone quarrying, industrial features and workings may be found across the AONB and in landscapes such as upland moorland. Those areas that are more sizeable such as the slate quarries of the Horseshoe Pass are specifically included here.

An extensive complex of former and current limestone, aggregates and slate quarries punctuate the AONB. Quarrying for building stone and slate has left a distinctive mark on the landscape through disused quarries and locally distinctive stone buildings, slate is the main roofing material in the AONB. The limestone quarried aggregate from the eastern side of the AONB is primarily used for road stone and cement in the building industry. Landscapes from former lead, silver and zinc ore mines lie mainly in the east of the AONB, some are now quarried for stone.

Views of the slate workings of the Horseshoe Pass are prominent from the surrounding areas and for users of the A525, the high sculptural spoil heaps and water filled excavated areas are a distinctly recognisable landscape feature of the AONB. The two small quarry areas on the limestone outcropping on the eastern side of the River Alyn valley are largely concealed by the well vegetated undulating adjacent landform. Relict tips and spoil heaps from deep coal mining and other extraction are also evident in the landscape outside the AONB and are often considered to detract from landscape character, tranquillity and sense of place.

Some workings now have a varied mosaic of scrub and rough pasture, with further potential for managing habitats associated with rock exposures and reclaimed workings.

Landscape and Nature Recovery in a Changing Climate

Key priorities and challenges

- Enhance and expand green infrastructure for multiple benefits.
- Manage surface water through SUDS.
- Increase renewable energy where not adversely affecting the high quality landscapes.
- Improve energy performance and reduce carbon energy use in buildings.
- Encourage public transport and active travel.
- The challenges include changing weather patterns increasing risks to people and property, pollution (health and wellbeing decline), built development and infrastructure (soil sealing, carbon and waste), over exploitation of ecosystems by people living in urban areas, non-native species, pests and disease affecting built structures and health.

A changing climate

Significant effects caused by climate change are likely to be caused by hotter, drier summers and warmer wetter winters with increasing extreme events. Connections between developed areas, communities and the surrounding landscape are compelling.

For example:

- the effects of heavy rainfall events in the AONB uplands can contribute to lowland flooding in communities within and outside of the AONB;
- drifting smoke from upland wildfires may detrimentally affect communities and visibility on roads;
- green infrastructure within settlements contributes to nature networks in the wider landscape.

Considering communities and developed land in the context of their wider surroundings can contribute to more effective adaptation and increased resilience.

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Mitigation within developed landscapes

Mitigate by:

- increase the number and extent of green roofs and walls to manage rainwater, control pollution, insulate buildings and provide habitats for wildlife;
- increase deciduous tree planting, especially street trees, to shade buildings to prevent the development of urban heat islands and to contribute to carbon sequestration;
- ensuring infrastructure and routes retain trees and provide sufficient space for roots and crowns;
- reducing carbon use by reducing street lighting to minimum required for safe places and spaces, reducing upward light spill by fitting shielded fixtures, converting to warm tone LED and using controlled lighting. Benefiting wellbeing, visibility of dark skies and nocturnal nature;
- increasing active travel and encouraging reduced car usage by retrofitting convenient and safe cycle and pedestrian routes linked to green infrastructure in existing and expanding settlements;
- increasing renewable energy use for low carbon heating and cooling, improving energy performance in existing and regenerated building stock;
- encouraging new builds to be net zero emissions with character and design a positive addition to the AONB;
- reducing transport emissions through transport decarbonisation and encouraging the use of Ultra Low Emissions Vehicles. Retrofitting charging points in carparks and installing charging points in all new developments;
- fitting solar PV on all suitable roofs to generate low carbon electricity;
- supporting communities, businesses and charities to increase the circular economy by re-use, repair or recycle for 'zero waste';
- utilising curtains, blinds and shutters to reduce heat loss and reduce carbon footprint.

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Adaptation within developed landscapes

Green infrastructure is defined as the network of natural and semi-natural features, green spaces, rivers and lakes that intersperse and connect places. This network is important for connecting our rural upland and lowland landscapes to our local parks, street trees, roadside verges, cemeteries and gardens. Enhancing the network and strengthening connections can help with adaptation and resilience.

Sustainable drainage systems (SUDS) mimic natural drainage by managing surface water run-off as close to source as possible, bringing multiple benefits to communities and nature by reducing storm water surges, controlling pollution, providing habitats for wildlife and making urban areas more attractive. Enhancing green infrastructure and introducing more SUDS will be important in developed landscapes.

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Risk: Warmer mean temperatures and hotter summers affecting wellbeing, trees and vegetation.

Adapt by:

- identifying opportunities where green infrastructure provision in and around developed areas can benefit nature and its resilience, restore links to adjacent landscapes and benefit mental and physical wellbeing whilst helping to regulate microclimates and heat island effects;
- planting more trees in parks, open spaces, streets and gardens, cemeteries, allotments and roadside verges to supplement existing, possibly ageing, tree populations and strengthening the green infrastructure network;
- increasing diversity of tree species to build resilience to pests and diseases and potential declining quality or loss of species;
- monitoring the health of trees and vegetation in streets and open spaces to identify stress and trends in pests and diseases. Manage and water the most important trees to ensure their survival;
- increasing species attractive to pollinators in all green spaces, convert some close mown grass in amenity and public building areas to wildflower meadows and cut green spaces and verges less often to be more pollinator friendly;
- encouraging communities to make their gardens better connected for nature (e.g. Hedgehog Highways) reducing isolation and improving genetic diversity.

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Risk: Hotter drier summers and reduced rainfall impacting on water availability.

Adapt by:

- capturing rainwater from buildings and infrastructure into SUDS features and slowing the release of water, aiding infiltration;
- increasing water management at the property level by installing water butts linked to property gutters, sheds and greenhouses to adapt the source of water used in the garden from mains water to water butts;
- increasing awareness about stopping water leakages and using grey water recycling.

Risk: Wetter winters, excess water and flooding during winter months.

Adapt by:

- increasing SUDS schemes to manage water quality, improve biodiversity and amenity value. Capturing rain where it falls, holding back and slowing the release of rainwater, reducing surface water flooding and increasing infiltration and discharge to watercourses, attenuation basins, retention ponds and swales;
- including permeable paving, kerb inlets and permeable tree grills to cope with storm water in areas of higher footfall;
- increasing trees, water sensitive planting areas and raingarden planters linked to overflows to slow water discharge to sewers, minimise pollutants from housing, industry and infrastructure entering groundwater, rivers and habitats;
- avoiding property development in flood risk areas and installing property level flood protection in existing at risk properties to increase resilience.

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Risk: Increased recurrence and severity of extreme events and storm damage.

Adapt by:

- historic structures are likely to be impacted by more severe weather conditions affecting building fabric from wetting/drying, freeze/thaw, storm damage, pests and fungal infestations of buildings;
- adapt by continuous maintenance and enlarging gutter capacity when replacing;
- designing and reprofiling unstable slopes vulnerable to slippage, including spoil heaps, to be resilient to more intense storms and rainfall;
- installing water management systems and establish vegetation if appropriate to reduce the potential risk of increased pollution from higher levels of run-off during periods of intense rainfall.

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