Natural England Commissioned Report NECR202c

# Increasing the resilience of the UK's Special Protection Areas to climate change

## Case study: Peak District and South Pennine Moors

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# Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

## Background

Understanding the ecological consequences of climate change for Special Protection Areas (SPAs) is critical if site managers are to develop adaptive management strategies. This series of case studies highlights how current management might be adapted at site level to address future climate change impacts.

The study identifies some of the greatest barriers to delivering adaptive management, which will require a consensus across a wide number of organisations if the priority actions to increase the resilience of SPAs to climate change are to be delivered.

This report is supported by the following:

- NECR202 - Overview and key messages
- NECR202a - Case study: Minsmere-Walberswick
- NECR202b - Case study: North Norfolk Coast and Great Yarmouth North Denes
- NECR202d - Case study: Somerset Levels and Moors
- NECR202e - General adaptive management recommendations

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**Further information**
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## Note

This report has been prepared for Natural England and represents a contribution to the evidence base informing the development of adaptive management strategies for the UK's SPAs in relation to climate change. The report's aim is to outline the potential ecological consequences of climate change for SPAs and to discuss potential adaptive management responses. Current management activities and potential adaptive responses for each SPA case study were informed by the discussion deriving from site workshops where major stakeholders for the SPA were represented. The report makes no specific policy recommendations, and the information contained may not be in agreement with other existing management and/or policy-related documents.

## Stakeholder participation

The workshop was attended by representatives from government, conservation organisations, and water companies, specifically Natural England (Phase II representatives), the National Trust (Peak District Estate and Marsden Moor), RSPB (Dove Stone), Moors for the Future, Peak District National Park, Bradford City Council, United Utilities, and Yorkshire Water.

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# 1. Site summary

**Location:** 53 28 03 N 01 45 51 W

**Area:** 452.7 $km^2$ (Phase I); 209.4 $km^2$ (Phase II)

**Habitat:** Inland waterbody (<1%), Bogs (39%), Heath (34%), Dry grassland (11%), Humid grassland (14%), Broadleaf woodland (<1%), Inland rock (<1%).

**Original citation for qualifying species**[1]**:** Eurasian golden plover (752 pairs), Merlin (77 pairs), Peregrine (16 pairs), Short-eared owl (25 pairs), Dunlin (140 pairs).

**Other species of interest:** Northern lapwing, Common snipe, Eurasian curlew, Common redshank, Common sandpiper, Whinchat, Northern wheatear, Ring ouzel, Twite.

**Notes:** Major urban and industrial centres near to the Peak District Moors provide significant visitor pressure and approximately two-thirds of the moorlands are open to public access. Habitat damage through physical erosion or fire, combined with disturbance of breeding birds, can be significant. Initiatives for sustainable recreation are being developed. Wildlife crime, particularly illegal raptor persecution, continues to be a major issue. Many habitats are sub-optimal (in vegetation terms) as a consequence of historic air pollution, high grazing pressure and wildfire burns, but moorland habitat restoration is being widely implemented, led principally by collaborations between Moors for the Future, conservation organisations, and water companies. Grazing pressure is generally being lowered and appropriate burning or cutting regimes implemented under Environmental Stewardship schemes. Evidence suggests that breeding birds in the south-west of the area may be declining on both open moorland and enclosed rough grazing land, possibly due to general agricultural improvement of the surrounding areas which are used by some species for some of their habitat requirements; e.g. golden plovers feed on in-bye land off the moor. The site has been identified as a Special Area of Conservation (SAC) for habitats such as blanket bog and the area is also managed for its SSSI interest; as such, there will be a need to balance the management of the different interests across the whole site.

# 2. Current management activities

## 2.1. Land ownership and management

Land ownership in the South Pennines is a complex mosaic of large and small landowners (Figure 1). Large parcels of land are owned and/or managed by conservation organisations (the National Trust, RSPB), local city councils, and public utility companies, with much of it grazed by tenant farmers. Other large areas are managed by private estates, primarily for grouse shooting and hill farming, whilst a number of smaller landholdings are also farmed privately within the SPA's boundaries.

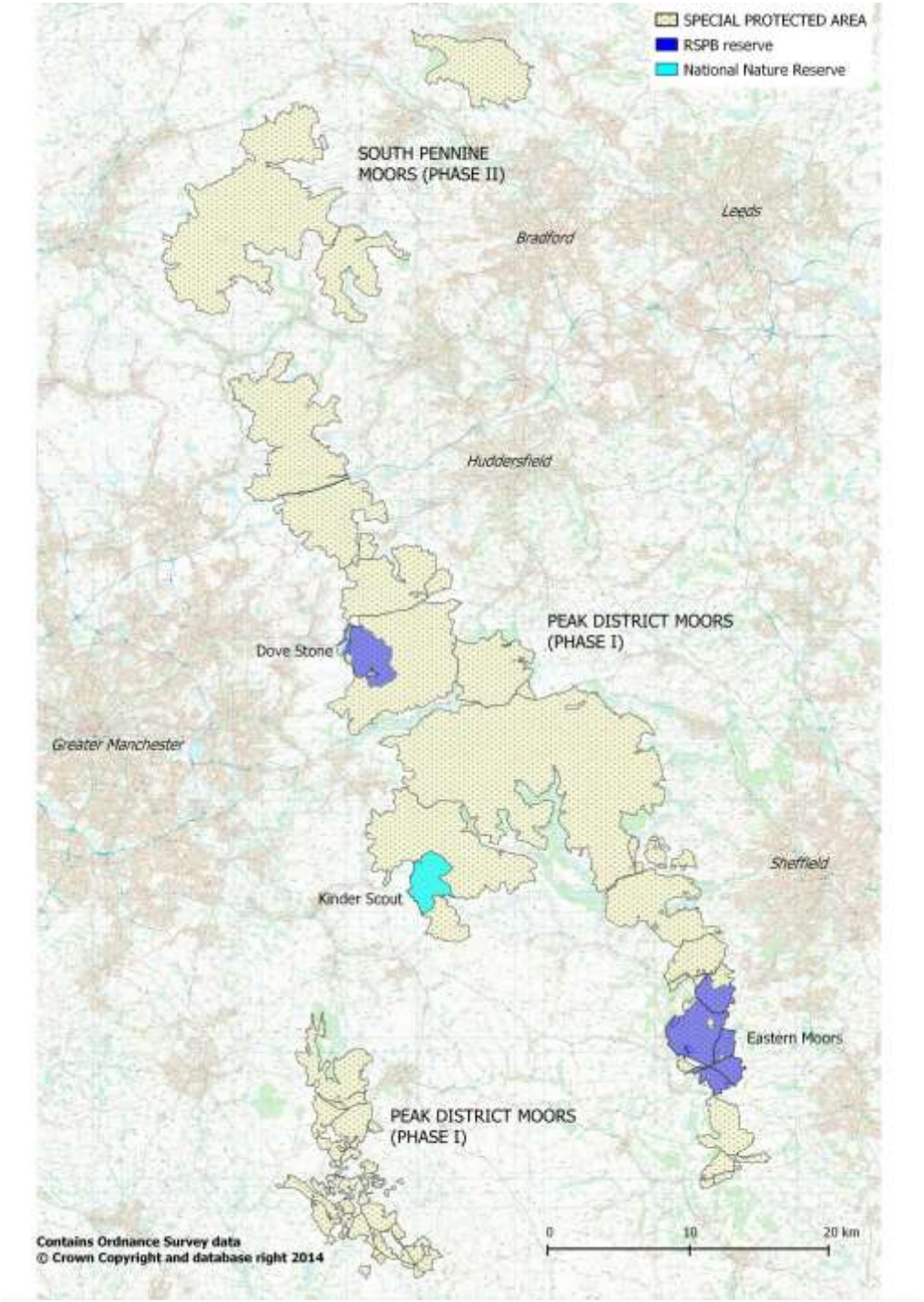



Figure 1. The SPA and surrounding area. National Trust and water company landholdings are not shown.

There are also extensive tracts of common land within the SPA. Historically, the South Pennine moors have been managed primarily for sheep grazing and/or sport shooting, whilst also receiving a high degree of visitor pressure from surrounding conurbations. In recent years, an increasing focus, particularly on land managed for conservation or public utility purposes, has been to restore peatland and increase the overall quality of upland habitat, largely through re-vegetation initiatives and the blocking of drainage ditches and eroding gullies, led primarily by Moors for the Future (MFF). The motivation for this work has been primarily to improve habitat condition of SSSIs within each landholding, and also to improve ecosystem service provision, particularly for water quality and carbon storage. Bird species within the SPA boundaries have largely been regarded as likely to benefit from general overall habitat quality improvement, rather than as a feature that should be specifically targeted for management. There is increasing capacity through MFF's MoorLife project and other initiatives developed by Natural England, the water companies and others for monitoring and research on the biodiversity impacts and outcomes of current management activities as a means of informing future management objectives and strategies.

## 2.2. Peatland and water management

Many of the larger organisations, including National Trust, Moors for the Future, and the water companies are heavily engaged in peatland habitat restoration, including re-vegetating areas of bare peat, and blocking grips and gullies. Grip-blocking has generally been accepted as part of good peatland management by land-owners and tenant farmers. Peatland restoration is viewed as a vital component of maintaining the ecosystem services of carbon capture and of ensuring continued water quality into the future given projected water deficits with climate change. Of particular concern for water companies, and one of the primary drivers of their investment in restoration, is the long term trend of increasing colour (dissolved organic carbon) and strategies to mitigate this. Restoration is likely to benefit biodiversity, including SPA breeding species, with well-developed links between ditch-blocking, water tables and cranefly abundances, and close links between cranefly populations and breeding birds such as golden plover. Anecdotally, bare peat re-vegetation by RSPB and United Utilities has had a positive impact on breeding golden plover at Dove Stone RSPB reserve.

The large number of reservoirs in and around the SPA store water from the catchment, and although much rainfall is still lost as run-off, investment in infrastructure to improve water quality as part of sustainable catchment management programmes will likely also benefit increased water capture and storage capacity. However, there are limitations imposed on water management by the fact that a large portion of the catchment is in private ownership and outside the boundaries of land managed by the water companies. The water companies are removing coniferous plantations in exchange for more biodiverse deciduous woodland and are increasing the extent of deciduous woodland in cloughs and gullies to reduce run-off and erosion as part of their catchment management strategy (e.g. Woodland for Water programme).

## 2.3. Vegetation management

### *Moorland*

Although a traditional component of grouse moor management, heather-burning is widely regarded as likely to damage peatland habitats, with potential impacts on ecosystem service delivery. As a result, Natural England, water companies and conservation organisations are increasingly investigating cutting over burning as part of prescribed moorland management, but an assessment of the impacts of cutting is still in the preliminary stages and requires more research. While it was initially met with resistance, tenants and landowners are generally accepting cutting as an alternative, and it has been adopted by estates as a method to control burns.

A transition from sheep to cattle is generally encouraged as part of current grazing management schemes as cattle are thought to produce more diverse vegetation swards, particularly as a means to open dense *Molinia caerulea* (purple moor-grass) swards. However, cattle-grazing is more challenging economically for hill farmers, requiring the capability to overwinter animals elsewhere, greater cost of feed etc., and so remains difficult to promote. In areas supplying drinking water, there is also a potential link between cattle and the risk of *cryptosporidium* occurrence, leading to water companies preferentially grazing with sheep rather than cattle. A reduction in skilled shepherding and the loss of hefted flocks as a result of the 2001 foot and mouth outbreak are likely factors contributing to sustained high levels of grazing which have impacted heather cover across the South Pennines. There is little direct evidence as yet, however, linking these gradual habitat changes to changes in SPA breeding bird populations. There is a transition in grazing management to reduce the levels of winter-grazing by taking stock off the moor, but limitations include a lack of sufficient off-wintering ground available nearby, in addition to a gap in Higher Level Stewardship (HLS) funding between the cost of off-wintering and the recompense options available. Hill farmers represent an aging demographic, and may have less capacity to move stock into the future. With a certain number of sheep required to make hill grazing economically viable for farmers, and increasing difficulties in meeting those targets associated with an aging demographic means that land managers in the future may be faced with the problem of stocking densities on the moors that are too low to deliver appropriate grazing management schemes. However, farmers that come together as a group may have a greater potential to deliver environmental stewardship management for large areas of moor (through HLS or its successor, Countryside Stewardship).

### *In-bye land*

Surrounding the unenclosed moorland are areas of improved and semi-improved pasture used for grazing cattle and sheep. As well as providing an important breeding habitat for some wader species, they are also used for feeding by some moorland breeding waders, such as curlew and golden plover. The small number of hay meadows remaining provide a seed-rich habitat for Twite. The majority of the key areas of in-bye land used by waders in the Peak District have been identified and are currently under environmental stewardship.

## 2.4. Woodland

Upland conifer plantations are under 25-year forest stewardship plans. Many of the plantations on the fringes of the SPA are not economically viable and some will likely be

turned into deciduous woodland over the next 25 years. However, removal or conversion to deciduous woodland is limited by access and many are owned by small landowners without the capacity to remove them. Planting deciduous woodland is part of the water companies' catchment management programmes, but an increasing extent of woodland comes with an increasing responsibility to manage successional areas and scrub and more discussion is required on how management responsibilities for woodland should be allocated. Although many woodland areas are undesirable from the SPA perspective (they harbour predators of ground nesting birds and may be avoided by breeding waders, raptors and grouse), actively removing them may prove particularly challenging given difficulties with access, and may be undesirable if likely to impact upon water quality through increased soil erosion.

## 2.5. Predator management

Lethal control of foxes, corvids and mustelids is widely undertaken as part of grouse moor management, and has been demonstrated to have a beneficial impact upon breeding wader productivity and populations[2]. The alternative to lethal control, fencing, is generally impractical and expensive over such large areas. At Dove Stone, RSPB staff thought that reducing the number of sheep, particularly lambs, has resulted in a decrease in predators which has benefited golden plover and dunlin.

## 2.6. Human disturbance

With large urban areas in close proximity, visitor access to the South Pennines is high. Paving paths with flagstones has been used to reduce path erosion and disturbance to ground-nesting birds by keeping visitors to designated paths[3]. The Countryside Act stipulates that dogs must be on leads during the nesting season, but this is difficult to enforce and some visitors do not follow this directive. Mountain-bikers generally respect instructions to keep to paths, but off-roading and quad-biking is a significant problem on access land, and resources are insufficient to address this issue in any substantial way.

Wildlife crime, especially raptor persecution, continues to be a problem in the uplands and is likely to be an additional pressure (together with predation and disturbance) on these populations, which will make them less resilient to future climate change.

# 3. UKCP09 Climate Projections

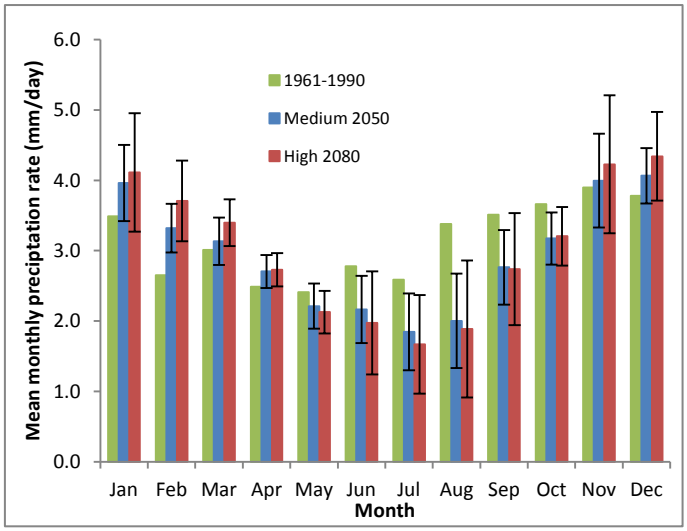
## 3.1. Changes in precipitation and temperature

Using the UKCP09 climate projections online user interface (http://ukclimateprojections-ui.metoffice.gov.uk/), we calculated the mean absolute and projected changes in climate variables (precipitation and maximum mean daily temperature) for the HadRM3 regional climate model 25 x 25 km grid cells for the southern (1275) and northern (1196) extents of the South Pennines under a 2050 medium and a 2080 high emissions scenario (Figure 1). The projections for the southern and northern extents were similar (except for December precipitation, which was predicted to increase by 10-15% more in the north than in the south), and only the southern projections are shown here. The UKCP09 projections predict that the South Pennines will get progressively warmer and wetter in winter, and warmer and drier during the summer, a pattern which mirrors the general trend expected across the UK:

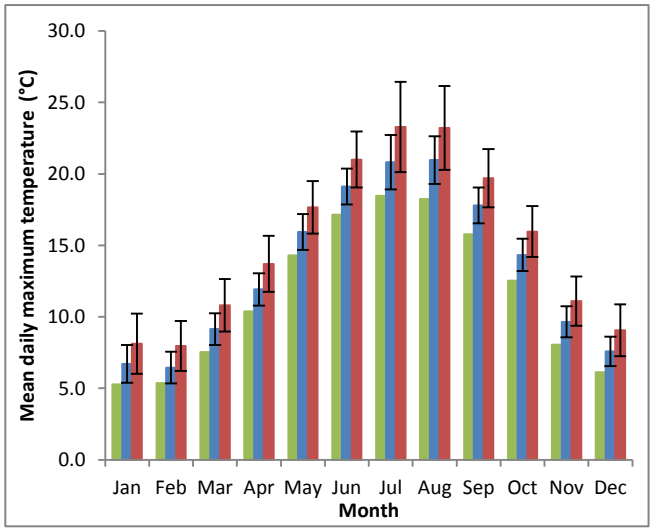
- Precipitation: 10-18% increase during the winter, largest increase in December (in the north) and February (in the south) ; 17-25% decrease during the summer, largest decrease in August;
- Temperature: overall increase year-round of between 2-5°C.

Figure 2. a) Absolute mean monthly precipitation rate (mm/day) and b) mean daily maximum temperature (°C) vs the UKCP09 climate projections for the HadRM3 25 x 25 km grid cell (1275) at the southern extent of the South Pennines SPA. Relative change in c) mean monthly precipitation rate (%) and d) mean daily maximum temperature (°C) for the UKCP09 climate projections for the grid cell at the southern extent of the South Pennines SPA.

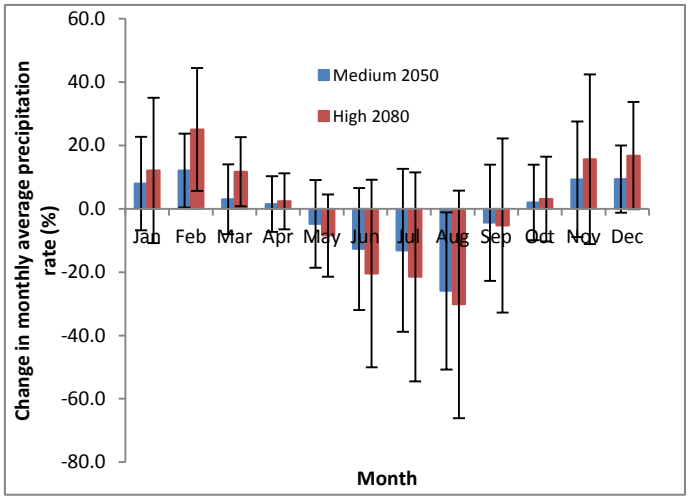
a)



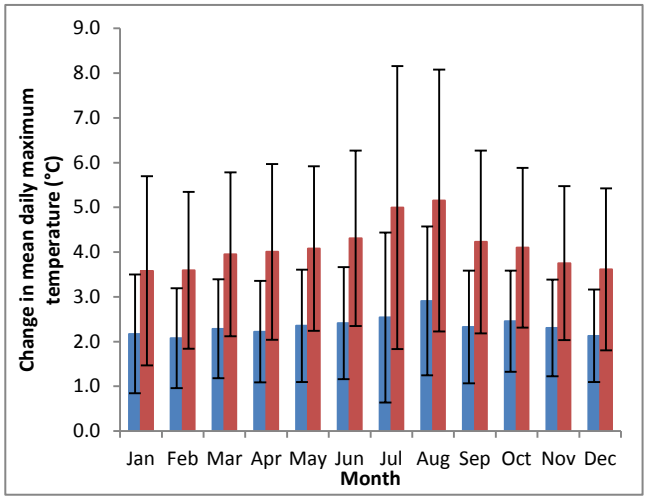

b)



c)


60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
Change in monthly average precipitation rate (%)
Medium 2050
High 2080
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

d)


9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Change in mean daily maximum temperature (°C)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

## 4. Projected climate change impacts and ecological outcomes

The tables below outline the primary impacts (in no particular order) of projected climate change and the potential ecological consequences for the South Pennines SPA.

| Cause | Consequence | Ecological outcomes |
|---|---|---|
| • Reduction in frequency and duration of winter snow. | • Impacts on the timing of spring phenology. | • Reductions in snow cover likely to advance spring breeding of upland birds, leading to increased potential for replacement clutches / nesting attempts;<br>• Potential impacts on upland plants and invertebrates. |
| • Decrease in summer rainfall and increase in summer temperatures and evapotranspiration. | • Increased rate of drawdown in summer;<br>• Drought. | • Loss or reduction in quality of wetland / peatland nesting habitat and foraging habitat and changes in the abundance and composition of prey populations (e.g. terrestrial/aquatic invertebrates such as tipulids and chironomids);<br>• Reduced water quality in rivers due to an increase in nutrient concentration;<br>• Increased risk of wildfire in dry years, leading to large-scale habitat change / loss, as well as potential impacts on breeding attempts. |
| • Warmer temperatures. | • Advance and increase in extent of growing season. | • Changes in vegetation structure, composition, and growth rate, leading to impacts on species requiring short swards;<br>• Potential expansion of scrub and trees into upland areas;<br>• Promotion of dwarf shrubs (especially heather) over bog species;<br>• Increase in plant pathogens and disease;<br>• Altitudinal shifts in ticks and potential increases in strongylosis occurrence may increase disease risk for grouse. |
| • Increase in extreme rainfall events year-round. | • Increased flood risk. | • Increased flood risk for nests during extreme summer rainfall events, particularly for riparian and freshwater nesting species. Increased spring rainfall may affect raptor and grouse productivity;<br>• Increased risk of peatland erosion from unvegetated surfaces. |

## 5. Projected population trends

Population trends under a 2050 medium emissions scenario and a 2080 high emissions scenario were produced only for those species which were modelled as part of the CHAINSPAN report[4]. Population trends were modelled based upon projected changes in summer and winter temperature and precipitation from UKCP09 data. Annex I SPA qualifying species are in **bold underline**, migratory SPA qualifying species are in **bold**, species part of a qualifying assemblage are underlined, and potential Annex I colonists are in *italics*. Vertical arrows represent projected population changes greater than 50%, diagonal arrows changes between 25-50%, and horizontal arrows changes less than 25%. N=non-breeding, PS=spring passage migrant, PA=autumn passage migrant. Red arrows represent those populations which are declining, black arrows represent stable populations, and green arrows represent increasing populations. The outcome from a national risk assessment for these species summarises the likely effects of climate change across the country from high opportunity to high risk. For this, species in *italics* have outputs of particularly low confidence, and projections in **bold** are for species with moderate or good confidence.

| Species | National risk assessment | Model quality | 2050 medium | 2080 high |
|---|---|---|---|---|
| Eurasian curlew | **HIGH RISK** | Poor | ↘ | ↓ |
| **Eurasian golden plover**[5] | *HIGH RISK* | Very poor | → | → |
| Northern lapwing | *HIGH RISK* | Moderate | → | → |
| Common snipe | *HIGH RISK* | Poor | → | → |
| Common redshank | **LTD IMPACT** | Moderate | → | → |
| Common sandpiper | *RISK & OPP* | Very poor | → | → |
| *Dartford warbler* | **HIGH OPP** | Moderate | ↑ | ↑ |
| *Nightjar* | HIGH OPP | Poor | ↑ | ↑ |

[4]Pearce-Higgins *et al.* (2010) *Glob. Ch. Biol. 16:12-23* projects a future population decline in the Peak District using a well-validated model based on a mechanistic understanding of likely impacts.

In addition, populations of a number of other qualifying species also occur in the South Pennines, but were not modelled as part of the CHAINSPAN report, largely due to insufficient data. For all of these species, an indication of their likely sensitivity to climate change can be assessed from a national risk assessment of vulnerability to climate change. Note that for raptors in the uplands, illegal persecution is likely to play a large role in also driving population trends.

| Species | National risk assessment |
|---|---|
| **Short-eared Owl** | HIGH RISK |
| **Dunlin** | HIGH RISK |
| Twite | HIGH RISK |
| **Merlin** | RISK & OPP |
| **Peregrine** | *MED RISK* |
| **Hen Harrier** | HIGH RISK |
| Red grouse | HIGH RISK |
| Black grouse* | *RISK & OPP* |
| Ring ouzel | HIGH RISK |

*Species with potential to re-establish within the SPA

## 6. Potential adaptive management responses

Given the projected climate change impacts likely to influence bird populations (see Section 4) at the South Pennines SPA, we outline some of the key adaptive management measures that could be undertaken to help mitigate the effects of climate change for current (green) and potential (grey) SPA features. The effect size of these measures on the species or species assemblages is denoted by a directional arrow. Orange arrows indicate an effect on the breeding population.

| **Climate impacts:** Decreased summer rainfall and higher temperatures leading to summer drought | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ecological outcomes:** Decline in food resources | | | | | | | | | | | |
| **Measures** | **Merlin** | **Peregrine** | **Short-eared owl** | **Golden plover** | **Dunlin** | **Other breeding waders** | **Twite** | **Ring ouzel** | **Black grouse** | **Nightjar** | **Dartford warbler** |
| Block artificial drains on blanket bog[6,7] | ↗ | | | ↑ | ↑ | | | | | | |
| Re-vegetate areas of eroding peat | ↗ | ↗ | ↗ | ↑↓ | ↗ | | | | | | |
| Provision of a mosaic of open habitats with heterogeneity in vegetation structure | ↗ | ↗ | ↗ | ↑ | ↑ | ↑ | | ↑ | ↑ | ↗ | ↑↓ |
| Remove forestry plantations from blanket bog & adjacent areas[8,9] | ↑ | | ↑ | ↑ | ↑ | ↑ | | | ↑ | | |
| Peatland restoration using *Sphagnum* seeding | ↗ | | | ↗ | ↗ | | | | | | |

| **Climate impacts:** Decreased summer rainfall and higher temperatures leading to summer drought | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ecological outcomes:** Increased risk of wildfire in dry years | | | | | | | | | | | |
| **Measures** | **Merlin** | **Peregrine** | **Short-eared owl** | **Golden plover** | **Dunlin** | **Other breeding waders** | **Twite** | **Ring ouzel** | **Black grouse** | **Nightjar** | **Dartford warbler** |
| Use appropriate grazing and cutting to limit fuel load and create fire breaks | ↑ | ↗ | ↑ | ↑ | ↗ | ↗ | | ↑ | ↑ | ↗ | ↗ |
| Use controlled burning to limit fuel load and create fire breaks | ↑ | ↗ | ↑ | ↑ | ↗ | ↗ | | ↑ | ↑ | ↗ | ↑↓ |
| Control visitor access during sensitive periods | ↗ | | ↗ | ↗ | ↗ | ↗ | | | ↗ | ↗ | ↗ |
| Provision of a mosaic of open habitats with heterogeneity in vegetation structure | ↑ | ↗ | ↑ | ↑ | ↑ | ↑ | | ↑ | ↑ | ↗ | ↑↓ |
| Block artificial drains on blanket bog to raise water table | ↗ | | | ↑ | ↑ | | | | | | |
| Improved fire detection and emergency service response | ↑ | | ↑ | ↑ | ↑ | ↗ | | ↑ | ↑ | ↑ | ↑ |

| **Climate impacts:** Warmer temperatures advancing growing season and increase vegetation growth, exacerbated by $CO_2$ fertilisation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ecological outcomes:** Changes in vegetation structure and composition. Potential expansion of scrub and trees, and promotion of dwarf shrubs over bog species | | | | | | | | | | | |
| **Measures** | **Merlin** | **Peregrine** | **Short-eared owl** | **Golden plover** | **Dunlin** | **Other breeding waders** | **Twite** | **Ring ouzel** | **Black grouse** | **Nightjar** | **Dartford warbler** |
| Use appropriate grazing or cutting regimes to maintain open / heterogeneous structure | ↗ | ↗ | ↗ | ↑ | ↑ | ↑ | | ↑ | ↑ | ↗ | |
| Use controlled burning to maintain open / heterogeneous structure | ↗ | ↗ | ↗ | ↑ | ↑ | ↑ | | ↑ | ↑ | ↗ | |
| Provision of a mosaic of open habitats with heterogeneity in vegetation structure | ↗ | ↗ | ↗ | ↑ | ↑ | ↗ | ↗ | | | ↗ | ↗ |
| Block artificial drains on blanket bog to raise water table | ↗ | | | ↑ | ↑ | | | | | | |
| Vegetation destruction to combat plant disease | ↘ | | ↘ | ↘ | ↘ | | ↘ | ↘ | ↘ | ↘ | ↘ |

| Other compensatory measures not directly related to climate change | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measures** | **Merlin** | **Peregrine** | **Short-eared owl** | **Golden plover** | **Dunlin** | **Other breeding waders** | **Twite** | **Ring ouzel** | **Black grouse** | **Nightjar** | **Dartford warbler** |
| Provide suitable feeding areas on nearby agricultural land (earthworm and tipulid-rich feeding areas for golden plovers & rough grassland for hen harriers and short-eared owl). | ↗ | | | ↑ | | ↑ | ↑ | | | | |
| Prevent illegal killing & disturbance | ↑ | ↑ | ↑ | | | | | | ↑ | | |
| Carry out legal control of generalist predators known to be predating eggs and chicks to boost productivity[10–12] | ↗ | | ↗ | ↑ | ↑ | ↑ | | | ↑ | ↑ | |

# 7. Practical assessment of suggested adaptive management responses

Discussion with representatives responsible for directing and overseeing land management in the South Pennines provided an assessment of the suggested adaptive management measures to improve the SPA's resilience to climate change. Synergies with current management practices were identified, as were constraints associated with implementing suggested measures. The discussion also highlighted some potential areas for future development of adaptive management measures.

Current management activities being undertaken in the South Pennines and strategies for the short-term future present an excellent example of upland habitat restoration to improve overall habitat quality and ecosystem service capacity with respect to carbon capture and water quality, but that also serve to increase the resilience of upland habitats to climate change. Interestingly, the motivation for most or all of this current management activity has been to improve the condition of SSSI features and to promote water quality, but a number of upland breeding SPA features are likely to have also benefitted. Much of the funding has been obtained through sources for habitat restoration and existing biodiversity benefits. Thus, this management which is likely to deliver significant climate change adaptation has not been undertaken specifically for that reason, but yet has occurred as a result of the associated co-benefits it provides.

While many of the represented organisations have been forward-thinking in mapping out a vision of the future for the next 50-70 years and have already begun acting on their strategy for the future, stakeholders who participated in the case study workshop acknowledged that there is little formalisation or coordination on developing a broader vision of the long-term future for upland habitat management objectives. Whilst there was wide agreement about the current focus on habitat restoration and improving SSSI condition, it was felt there was less consistency in views about a future vision for the South Pennines, and how the SPA fits into a national or international vision for biodiversity and ecosystem service delivery as a whole.

Given projected negative impacts of climate change upon many of the current suite of upland bird species, many of the adaptation measures discussed are largely to increase resilience to climate change by countering potential negative effects of rising temperatures, fire risk and drought. However, by focussing on measures to improve habitat condition (peatland restoration, vegetation management), it is likely that these measures will also deliver suitable areas for colonisation by range expanding qualifying species also, such as Dartford warbler and nightjar.

## 7.1. Peatland and water management

Much of the current management being undertaken to improve overall peatland habitat quality has the added benefit of also increasing its resilience to climate change. While re-vegetating blanket bog and blocking drainage channels have immediate benefits for improving habitat quality, blanket bog's water-holding capacity may mean that the resilience of peatland to hot summers and drought is also improved. Such restoration, particularly associated with blocking drainage ditches, will also reduce the impact of wildfire by raising

water levels, and may have some benefits for downstream flood risk, although further research is required to fully assess this.

Although the condition of large areas of land currently under conservation and public utility management have been improved in this way, extensive areas of land, particularly under private ownership, could also be restored to further improve the resilience of the SPA to climate change. However, while Natural England have provided some match funds for restoration as a mechanism for improving habitat condition, there are currently insufficient mechanisms in place to deliver gully-blocking on such an extensive scale. While an effective method is currently in place for blocking large gully systems, there is uncertainty over developing different methods to deliver specific ecosystem services. The ability for small landowners to implement their own grip or gully-blocking is impeded by audit requirements within the EU scheme which requires evidence of spending; this can present a cash flow problem in some areas to achieving completion of the work. Applying monitoring at a wider scale than its current level would improve the quality of feedback on the impacts of peatland restoration management actions for biodiversity and habitat quality, providing data which would help inform future policies. The ecological outcomes of blocking may depend strongly upon the way it is done, such as whether pools are created.

The re-vegetation of eroding areas of bare peat requires stabilisation of the peatland surface before seeding with peatland plant species into a nurse crop. Transplanting dwarf shrubs between sites, such as heather or crowberry, as part of restoring blanket bog's vegetation community may encourage the spread of plant disease such as the *Phytophthora* pathogen. Climate change may exacerbate this risk. Concerns were also expressed about the dieback of crowberry across parts of the Peak District and South Pennines Phase II.

As already outlined, vegetation restoration and grip-blocking has received considerable support from a wide range of stakeholders for reasons of improving habitat condition and improving water quality. To this end, the EU's Water Framework Directive and Environment Agency-designated Safeguard Zones to ensure quality of "raw water" abstracted for drinking water is likely to be a strong driver of continued moorland restoration. It should be noted, however, there are large areas of moorland not covered by these as they don't contain reservoirs. Moorland restoration has been well coordinated for the Peak District through the MFF initiative which has achieved wide support. As a means for undertaking large-scale habitat management and restorative work, MFF has been very successful through bringing together academics, conservation agencies and land owners to deliver a single vision of restoration, a model that could be applied elsewhere. Interestingly, the potential benefit to the SPA of increasing the resilience of vulnerable peatlands to climate change has not been the primary driver of investment in restoration, although it has been viewed as an additional motivating benefit by all organisations. Looking to the future, there is probably less commonality between land owners as to what the ideal end point for such restoration should be. Whilst there is recognition of the value of heterogeneous habitat (see below) to favour a wide range of biodiversity, as well as to limit the risk associated with wildfire, there is a significant practical challenge to maintain this in a landscape where low intensity management options predominate. The value of wet heath habitats was also recognised, but this is a more difficult habitat to restore.

## 7.2. Vegetation management

In response to the potential increased risk of wildfire there is a need to create firebreaks. Cutting is preferred to prescribed burning for this, but more research is needed to assess its impact before it is more broadly adopted for moorland vegetation management. There are logistical constraints to cutting due to the needs for vehicular access which may result in peatland damage, and management must be maintained on a more frequent basis. Some managed burning may therefore be required in some hard to access areas. Ditch blocking to raise water levels may also reduce the risk of wildfire in blanket bog areas. Extensive *Molinia* grassland areas are acknowledged as a significant wildfire risk, but aside from these measures, it is difficult to see how this can be significantly reduced. Strong and effective coordination of fire-response across the emergency services is therefore important so that when fires do occur, they can be dealt with quickly.

Most of the South Pennines is farmed, principally for sheep and cattle grazing. Given the marginal economic nature of such farming with most farmers reliant upon subsidies, such management is increasingly regarded as a conservation tool to deliver appropriate vegetation structure and composition for habitat and biodiversity benefit. Cattle-grazing is increasingly preferred to sheep to promote vegetation heterogeneity, particularly to help break-up *Molinia* swards, although the evidence that this will also have a direct benefit to birds is relatively weak. However, cattle-grazing may also increase the risk of contaminating watercourses with *cryptosporidium* which constrains where it can be safely implemented. Cattle farming is more expensive than sheep due to the greater need for off-wintering locations and fields to grow silage for feed. There is the need to consider the potential consequences of in-bye management decisions on the capacity of the farming system to deliver appropriate, low-intensity grazing management across extensive upland areas. Generally, grazing management in the uplands may become increasingly challenging due to the aging demographic of hill farmers and the economic uncertainties associated with this way of life, which may pose challenges for the ability to manage the vegetation of these areas appropriately in the future. Agglomeration of land holdings is also a risk as farmers gradually retire.

In-bye land is an important habitat used by many of the upland breeding birds for foraging, such as twite, golden plover and curlew, as well as supporting small but locally important breeding wader populations. While such fields are often managed under HLS agreements, they are not currently within the boundaries of the SPA despite being important for qualifying species of the SPA. The continued provision of appropriately managed in-bye areas under HLS and its successors (e.g. Countryside Stewardship) will be an important consideration for the future, and considering potential extensions to the SPA to cover these areas, or a buffering approach to the SPA, may be appropriate. For waders, these fields should be managed to promote soil invertebrate biomass whilst maintaining appropriate swards through grazing[13], whilst for twite, they should be maintained as seed-rich meadows[14]. If livestock are off-wintered locally, then this can have a negative impact upon the quality of in-bye habitat, particularly if converted to intensive silage production. Off-wintering elsewhere is more expensive, and then has implications for the management of other parts of the country.

To conclude, maintaining suitable vegetation conditions in upland areas, which will help increase resilience to climate change, is dependent upon low-intensity grazing management to produce the right outcomes. Achieving this within the constraints of maintaining the quality

of in-bye habitats, a reduction in hill farming expertise (shepherding, hefting, etc.) and the costs of the associated infrastructure, is a challenge. However, without the long-term maintenance of hill farming, it is difficult to see how the required heterogeneity of moorland habitats can be maintained across the SPA for the benefits of existing features, and also for some potential colonists.

## 7.3. Woodland

While plantation removal would benefit many upland-breeding birds known to avoid or be negatively affected by proximity to commercial plantations (e.g. breeding waders, raptors and ring ouzel), there are significant constraints to achieving this. Tree removal on steep slopes is associated with increased risk of soil erosion, with unacceptable water quality consequences downstream for the water companies. Removal is also constrained by extensive private ownership of plantations and practical difficulties associated with access.

At the same time, there is a significant desire for native woodland restoration and re-creation across the SPA, regarded as part of the natural landscape. At present, this is focussed on cloughs and valley sides, and may improve habitat for some species' of conservation concern, but that are not SPA features. Woodland creation should also deliver benefits for improving water quality within catchment areas. For this reason, utility companies have prioritised such planting on steep slopes, as well as replacing commercial plantations with native planting through time. These benefits will need to be weighed against any potential costs to birds that benefit from the retention or creation of more open areas, with overlap between e.g. tree planting and twite breeding habitat (favours open moorland) in some areas. Whilst the negative impacts of non-native conifer planting are well established[10,15], further research is required on the impact of native woodland planting on upland bird populations. Land managers planning regeneration of deciduous woodland in the uplands should carefully consider the impacts on SPA features that prefer open ground with respect to woodland placement and how it can be sympathetically managed such that it impacts minimally on open-ground species.

## 7.4. Predator management

A number of SPA breeding species, particularly the breeding waders, are potentially vulnerable to increasing predator populations, and they may therefore benefit from predator control. Long-term projected impacts of climate change may have significant consequences upon the future viability of the ability of estates to support high density red grouse populations, through impacts on habitat quality, food resources and disease, which in turn could affect the qualifying interest of the SPA. There may be a potential need in future to consider the implementation of predator management for reasons of compensatory adaptation, to boost breeding wader populations that are facing increasingly negative impacts of warming[7]. However, this was recognised as a potentially costly and short-term solution that, depending upon the future magnitude of climate change, may not deliver long-term benefit.

## 7.5. Human disturbance

Increasing visitor pressure in the uplands may be expected with drier, warmer summers. While controlling access is costly, and difficult to implement because of open access rights

across large areas of the Pennines under the CRoW Act, measures such as footpath improvement and public education may have a positive impact on reducing disturbance during sensitive periods and are more feasible and resource-efficient to implement[3,16]. Controlling off-roading and quad-bike activity is more difficult and at present, resources are insufficient to address this fast-growing issue, which is perceived to be a problem in some areas. Increasing numbers of visitors also represent a greater risk of wildfires. Improving detection and response times can contribute towards mitigating the damage caused by wildfire, and trying to influence visitor behaviour is likely to be a more cost-effective and feasible action than restricting access.

A trend towards increasing visitors will be exacerbated by urban growth around the SPA, which may also involve building on in-bye land directly. Compensation provided by housing developers to fund in-bye management is one potential measure to mitigate the effects of increasing development. Participants felt there was considerable potential to promote habitat restoration projects, such as peatland restoration or native woodland expansion, to garner public support for upland conservation efforts and to raise public awareness on the impacts of future climate change and human disturbance.

While there is increasing legislative attention addressing wildlife crime, particularly the illegal persecution of raptors, enforcing legal action against offenders is still resource-limited[17]. Some argue that increasing the resources available for enforcement and prosecution of wildlife crimes would help in reducing this pressure on current SPA features such as merlin, peregrine, and short-eared owl, and may create an environment for the establishment of populations of potential SPA features including hen harrier and goshawk. Reducing the severity of pressures such as illegal persecution on raptors would be likely to increase their resilience to climate change.

## 8. Priority actions to improve resilience

Current management practice, particularly peatland restoration, will continue to benefit both upland habitats and the species that rely on them, and will increase the resilience of upland habitats to climate change. Management strategies for SSSI features, SPA features, and ecosystem services generally align at present with few conflicts of interest and benefit biodiversity as a whole. The current focus on habitat restoration has wide support and will deliver significant adaptive benefit. There is less support for more targeted measures for individual species, such as predator control or forest removal where it was seen to not deliver wider public benefits (e.g. habitat condition, water quality), or indeed to result in dis-benefits for certain habitats or species. Climate change is projected to put increasing pressure on the majority of upland bird species for which the SPA is currently designated. Reducing other pressures on these species, and restoring and improving habitat conditions for these species, particularly re-vegetating and raising water levels on peatland, will maximise their resilience to climate change. With appropriate vegetation management, these areas should also become increasingly important for range expanding heathland species projected to colonise the uplands. Priority measures to improve resilience of the SPA to future climate change are listed below. Those which are **synergistic with current actions**, or least likely to be restricted by other constraints, are in **bold**. Those which have the *greatest potential for conflict* given current management or other interests are in *italics*. Those which ***align with current practice but are restricted by some constraints*** are in ***bold italics***.

| Action | Synergies | Constraints |
|---|---|---|
| **Peatland restoration through re-vegetation of bare peat and blocking grips and gullies** | Widely implemented across the SPA | Plant pathogen transport associated with re-vegetation<br>Long-term funding for maintenance of blocked gullies |
| ***Reduce burning and possibly increase cutting of vegetation to increase heterogeneity and biodiversity*** | Implemented in trials on some moors | Perceived or actual conflicts with grouse management.<br>Quantifying impacts of cutting still in progress (e.g. risk of compaction, increased vehicle access on deep peat areas and associated rutting, erosion etc.). |
| *Transition from sheep- to cattle-grazing where suitable* | Implemented in certain appropriate areas | Economic constraints and suitable only on dry grass moors<br>Limited evidence that this will benefit birds. |
| *Removal of conifer plantations* | Desirable to improve quality for SPA breeding waders and raptors | Conflicts with water companies as associated with soil erosion and affects water quality |
| *Restoration / planting of* | Currently implemented, | Uncertain impacts on open |

| | | |
|---|---|---|
| *deciduous woodland on slopes and gullies, or to replace coniferous plantations* | particularly by water companies to increase water table and improve water quality, and conservation organisations, as part of the natural landscape | country bird species |
| **Improve public education and footpaths to reduce impacts of disturbance** | Currently implemented in certain areas | Limited by large coverage area and available resources |
| ***Increase level of lethal predator control*** | Widely implemented on grouse moors | Resource-limited elsewhere |
| Prevent illegal killing and disturbance to wildlife – particularly raptors | Increasing legislation and legal action against offenders | Lack of enforcement resources |
| Improve monitoring and research on biodiversity impacts and outcomes of current management activities to feedback into informing future management objectives and strategies | Currently implemented at small scales.<br>Possibly facilitated through engagement with citizen science and recreational users of the SPA. | May be resource-limited to apply at a broader landscape scale |

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