Natural England Commissioned Report NECR202a

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

Case study: Minsmere-Walberswick

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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
- NECR202b - Case study: North Norfolk Coast and Great Yarmouth North Denes
- NECR202c - Case study: Peak District and South Pennine Moors
- NECR202d - Case study: Somerset Levels and Moors
- NECR202e - General adaptive management recommendations

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Further information
This report can be downloaded from the Natural England website: **www.gov.uk/government/organisations/natural-england**. For information on Natural England publications contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

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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

This workshop was attended by representatives from the RSPB (Minsmere, Dingle Marshes), Natural England (Suffolk Coast National Nature Reserve), and Suffolk Wildlife Trust (Dingle Marshes).

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1. Site summary

Location: 52 18 55 N   01 38 02 E

Area: 20.2 km^2

Habitat: heath and scrub (23%), broad-leaved deciduous woodland (16%), marshes and fens (15%), estuaries and mudflats (14%), salt marshes (8%), improved grassland (7%), coniferous woodland (5%), inland water bodies (4%), sand (3%), shingle (3%), arable land (2%).

Original citation for qualifying species[1]: *during the breeding season*: Avocet (91 pairs), Bittern (7 individuals), Little Tern (28 pairs), Marsh Harrier (16 pairs), Nightjar (24 pairs), Woodlark (20 pairs); *over winter*: Avocet (278 individuals), Bittern (14 individuals), Hen Harrier (15 individuals).

Climate change adaptive management is considered for the following species groups (both current and potential SPA features):

- Terns (breeding);
- Gulls (breeding);
- Waders using freshwater wetlands or grassland (non-breeding);
- Bivalve-feeding species (non-breeding);
- Waders using predominantly intertidal or estuarine habitat (non-breeding, also breeding redshank and ringed plover);
- Avocet (breeding and non-breeding) and potentially black-winged stilt (breeding);
- Open-water waterbirds (non-breeding);
- Waterbirds using saltmarsh or freshwater wetlands (breeding and non-breeding); and
- Heathland species (breeding).

Notes: Minsmere-Walberswick is located on the Suffolk coast south of Southwold in eastern England. It comprises two large marshes, the tidal Blyth estuary and associated habitats. This composite coastal site contains a complex mosaic of habitats, notably areas of marsh with dykes, extensive reedbeds, mud-flats, lagoons, shingle, woodland and areas of lowland heath. It supports the largest continuous stand of Common Reed *Phragmites australis* in England and Wales and demonstrates the nationally rare transition in grazing marsh ditch plants from brackish to freshwater. There are nationally important numbers of breeding and wintering birds. In particular, the reedbeds are of major importance for breeding Bittern *Botaurus stellaris* and Marsh Harrier *Circus aeruginosus*. A range of breeding waders (e.g. Avocets *Recurvirostra avosetta*) and heathland birds occur in other areas of the SPA. The shingle beaches support breeding Little Tern *Sterna albifrons*, which feed substantially outside the SPA in adjacent marine waters. The site is also important for wintering Bitterns and raptors.

Much of the land is managed by conservation organisations and positively by private landowners through environmental stewardship schemes. The coastal zone is going to respond to and be changed by natural processes, and this is being addressed in the Shoreline Management Plan (SMP). Alternative sites for freshwater reedbed and wet grassland creation are being sought to help offset the possible future losses.

2. Current management activities

2.1. Land ownership and management

Natural England and conservation organisations (National Trust, RSPB, and Suffolk Wildlife Trust) manage the majority of land within the SPA, together with some private landowners (Figure 1). There is a high level of cooperation and coordination between organisations in developing and implementing within-reserve management plans that improve the overall quality of the SPA at both a site-specific scale and from a regional perspective within the network of reserves along the Suffolk Coast (Figure 2). Adaptive management is already being implemented across the SPA, and current management strategies are becoming more dynamic in nature in response to increasing environmental unpredictability. There is a strong recognition that change is inevitable at the site, and land managers are already implementing measures that will allow the site to better accommodate change.

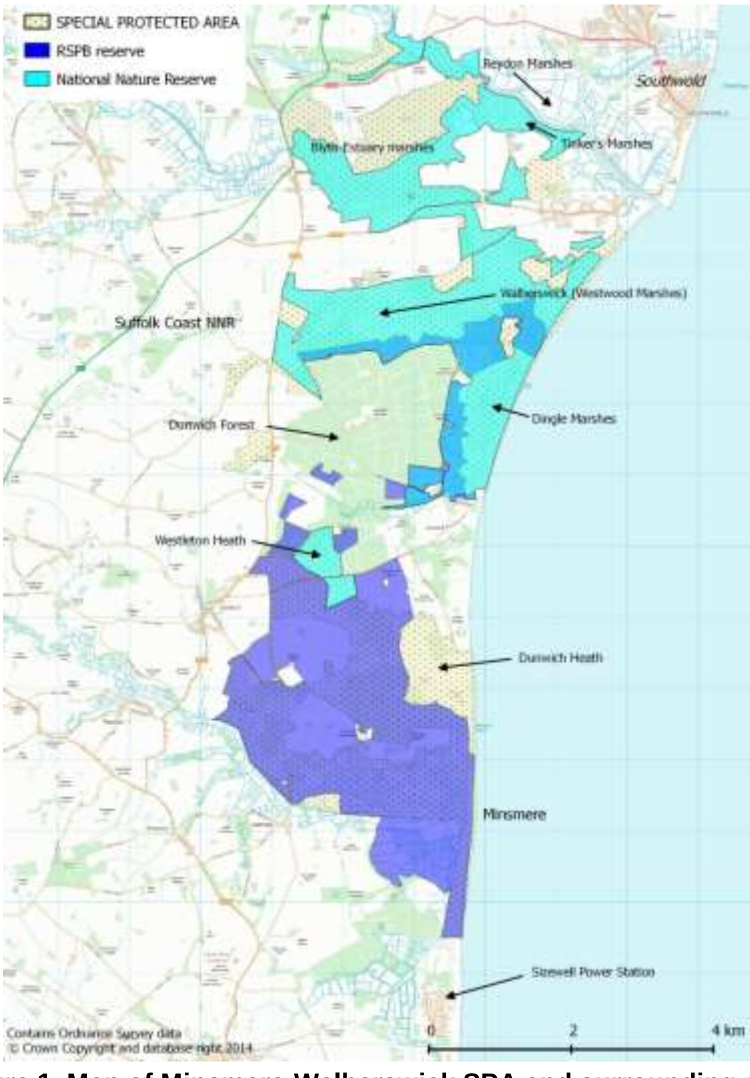

Figure 1. Map of Minsmere-Walberswick SPA and surrounding area.

Figure 2. Network of protected areas along the Suffolk Coast.

2.2. Water management

Management of saline and freshwater within the SPA is viewed as a dynamic and constantly-evolving process, and is moving towards being less prescriptive in nature and instead being more responsive and flexible according to changing conditions. A natural shingle ridge and beach barrier provide the primary protection for the SPA's freshwater wetlands and coastal grazing marshes from the sea, and its low, broad profile greatly decreases wave energy. Breeding terns and ringed plovers use the shingle frontage as nesting habitat. Management of the shingle barrier and other structures varies along the coast. At Dingle Marshes, the shingle ridge was regularly built up by bulldozer, but this has now ceased leading to regular overtopping and the shingle ridge adopting a flatter more natural profile, and naturally rolling back by 1-3m/yr. In contrast, recent work at Minsmere by the Environment Agency (EA) has strengthened the North Marsh wall.

At Minsmere, fluvial flooding on brackish habitats drains through the EA's gravity-draining sluice, but there have been recent difficulties in evacuating winter and early-spring freshwater flooding through this structure which impacts maintenance of brackish invertebrate populations. Whilst a current sluiceworks project at Minsmere has improved the ability to move saline water into these brackish habitats, this remains difficult in wet winters. Heavy rain during the breeding season may also lead to flooding and loss of nests, which again, despite work undertaken by the EA, cannot be eliminated completely. Water levels in freshwater habitats are held as high as possible early in the season to increase resilience to summer drawdown and to encourage reedbed-nesting species to nest high and reduce the risk of nest loss as a consequence of an extreme summer rainfall event raising water levels. Freshwater management at Minsmere is constrained by the inability to independently manage water infrastructure, which remains the responsibility of the EA. Increasingly variable water levels (both floods and droughts) have resulted in a more dynamic approach to the management of lowland wet grassland areas on the South Levels, but does not seem to have detrimentally affected breeding waders (see vegetation management section below).

At Dingle Marshes, the Dunwich River running north through the site serves as the natural barrier between brackish and freshwater habitats. Through negotiations with the EA, the river was diverted by 700 m to reduce the amount of salt- and freshwater flooding on the site as a result of storm surges and natural migration of the shingle, which caused it to block the river mouth. Saltmarsh vegetation is gradually spreading inland as the site is regularly inundated with saltwater and so is becoming increasingly brackish, but freshwater interest will continue to be maintained, as the fresh and fresh-salt gradation are important features of the site. These include saline lagoons used by breeding little tern, ringed plover and avocet at Walberswick, which are of high importance for their invertebrate interest. At Dunwich Forest, the retreat of coastal freshwater marsh is constrained by the forest boundary and higher topography only 500 m from the frontage, and there is less ability for the fresh-salt boundary to move inland here as compared to the neighbouring Westwood Marshes to the north, which extend several kilometres further inland. Here, the banked defences were overtopped in the December 2013 storm surge event, and there is acceptance of likely change leading to the reedbed becoming increasingly brackish. At Dingle Marshes, water movement is largely a result of percolation through the shingle bank, and is subject to a high degree of natural variation.

Further north, the Blyth estuary freshwater marshes (Tinker's and Reydon Marshes, although only Tinker's is within the SPA boundaries) are currently protected by seawalls maintained by the EA on both the north and south banks of the Blyth River between the river mouth and the inner estuary. However, the preferred management policy for the inner Blyth estuary as laid out in the Shoreline Management Plan for the Suffolk Coast (http://www.suffolksmp2.org.uk/) is to withdraw maintenance of the defences protecting the south bank marshes and manage retreat, but to maintain the north bank defences. Currently, Tinker's Marshes acts as a floodwater storage area, which is likely a contributing factor to its freshwater habitat interest, but in the long-term may be converted into intertidal habitat if the flood defences fail.

Nutrient enrichment due to the presence of surrounding pig farms has impacted water quality in the past, both as run-off into freshwater habitats but also run-off on heathlands.

2.3. Vegetation management

Freshwater reedbed

A Department of Energy grant is providing funding to mechanically harvest rush and reed for biofuel, with the intent of producing a commercially saleable product and also providing required reedbed management. At present, this strategy is proving more effective than traditional cutting with brush-cutters. Ideally, all harvesting is completed by late January.

Coastal grazing marsh

Grazing marshes are generally managed under Higher Level Stewardship, mainly for winter waterbirds with some management for breeding waders. Grazing management is mainly provided by cattle owned by local farmers, but Dartmoor ponies in Dunwich Forest have the opportunity to move out of the northern end of the forest and onto Dingle Marshes. Increased winter and early spring vegetation growth has created some difficulties in providing suitable vegetation heights for breeding waders due to higher late-winter water levels restricting the level of grazing management that has been possible early in the spring. As a result of more variable water levels in recent years, at Minsmere, a more dynamic approach to the prescriptions for breeding waders has been adopted, and does not appear to have reduced the breeding wader interest.

Forest

While not within the SPA's boundaries at present, Dunwich Forest is gradually being developed over the next 40 years from a conifer plantation to a mixture of semi-natural habitats including lowland heath, wet woodland and some broad leaved woodland. Developing habitats within Dunwich Forest will transition into existing adjoining reedbeds, marshes, and heathland that are currently encompassed by the SPA, and current and potential SPA features, particularly those associated with heathland will likely benefit.

Heathland and grassland

On heathlands at the northern end of the SPA, Natural England is moderating the level of current grazing by reducing the number of sheep, with the result that heather growth has been positively impacted. At Minsmere, high numbers of deer have had a significant impact on reducing heathland shrub species such as heather and gorse, and numbers of shrub-preferring species such as nightjar have subsequently declined in areas with high levels of deer grazing. Stone-curlew, in contrast, have greatly benefitted from the high levels of deer grazing. Minsmere implemented a deer control programme in the winter of 2013-14, but it is too early to judge its impact. It is likely that deer can provide a beneficial level of natural grazing on heathland and dry grassland if numbers are carefully controlled such that the appropriate level of grazing is achieved.

On Dunwich Heath, heather is managed through rotational winter cutting to provide an age mosaic, and is intermixed with western gorse. Common gorse is cut on a shorter rotation to provide valuable feeding and roosting habitats. The whole site is now under one HLS agreement, which includes 32 hectares of former arable/pig farm. This area is managed to attract woodlark, skylark and stone curlew. Some fields have been seeded with an acid grassland mix, while other areas are simply grazed/cut each year. The whole area is heavily rabbit grazed. In addition, the northern headlands have been seeded with heather cuttings and a heather headland is beginning to establish. Despite higher levels of visitor disturbance on Dunwich Heath, deer grazing is an issue. The rate of heather re-growth following cutting in high disturbance areas is generally greater than in low disturbance areas, and in some of these areas, cut areas are held at the pioneer stage for many years due to grazing pressure. However, deer spend most of their time grazing during the evening when disturbance is at a minimum and are also developing a high degree of tolerance in response to disturbance, often at surprisingly short distances providing dogs are kept under close control. Some deer have been displaced from Minsmere onto Dunwich Heath following the implementation of the new culling programme. Numbers of deer are increasing each year on the heath, but whether adjacent culling at Minsmere will reduce (through an overall population reduction) or increase (through displacement) grazing pressure in the long-term on Dunwich Heath is unknown.

Nutrient enrichment from run-off from nearby pig units and soil blowing off nearby agricultural land during dry summer conditions has resulted in increased vegetation growth and may be affecting conservation interest of species associated with nutrient-poor conditions.

All organisations maintain fire-breaks on heathland, but depend largely on the fire service to respond to wildfires. Some species, including invertebrates and reptiles, may benefit from some level of controlled burning, and some areas that have accidentally burned on Minsmere have regenerated into high quality heather habitat.

2.4. Predator control

Predator management on shingle beaches depends largely on electric fencing, while on grazing marsh, lethal fox control is more common (though is resource-dependent). Minsmere's saline lagoons are protected by an electric fence but this is aging and is regularly breached by ground predators (a replacement is planned). Large gulls are also controlled on saline lagoons, and are becoming increasingly problematic. Predator management for nesting stone-curlews is highly resource-intensive and likely unsustainable if the population continues to grow, as every nest is fenced and lethal control is undertaken.

2.5. Human disturbance

Visitor disturbance, particularly those visitors with dogs, has been an issue on short grass heaths for breeding nightjar and woodlark[2,3]. Restricting access to key areas has been more effective than requesting that dogs be kept on leads. The presence of lambing sheep provides a strong incentive for visitors to keep their dogs on leads, and while this strategy was discovered accidentally at Walberswick reserve in 2013, it will be implemented again in 2014. However, on some heaths visitor disturbance has likely had a beneficial impact by reducing over-grazing by deer (but see above commentary on deer at Dunwich Heath). At Minsmere, nightjar populations in areas where visitors have been excluded have declined, but have remained stable or increased on neighbouring Dunwich Heath which sees high levels of visitor numbers. Visitor disturbance was problematic when little terns were breeding on the shingle beach, even with fencing.

2.6. Connectivity across and outside of the SPA

There is a high degree of functional integration between the sites of the SPAs, with the same individuals using different locations depending upon conditions. For example, there has been a significant exchange of breeding avocet between Minsmere and Tinkers' Marshes, and black-headed gulls between the Blyth estuary and Minsmere. Further afield, this SPA is closely linked to neighbouring SPAs, such as the Alde-Ore and Sandlings SPAs to the south, and Benacre to Easton Bavents in the north (Figure 2). To the south, the further development of Sizewell Power Station will lead to an artificial bulge in the coastline, which may have implications for coastal erosion further north and south.

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 cell (1555) centred on Minsmere-Walberswick under a 2050 medium and a 2080 high emissions scenario (Figure 1). The UKCP09 projections predict that Minsmere-Walberswick will get progressively wetter in winter, and warmer and drier during the summer, a pattern which mirrors the general trend expected across the UK.

- Precipitation: 15-28% increase during the winter, largest increase in February; 17-25% decrease during the summer, largest decrease in August.
- Temperature: overall increase year-round of between 2-5°C.

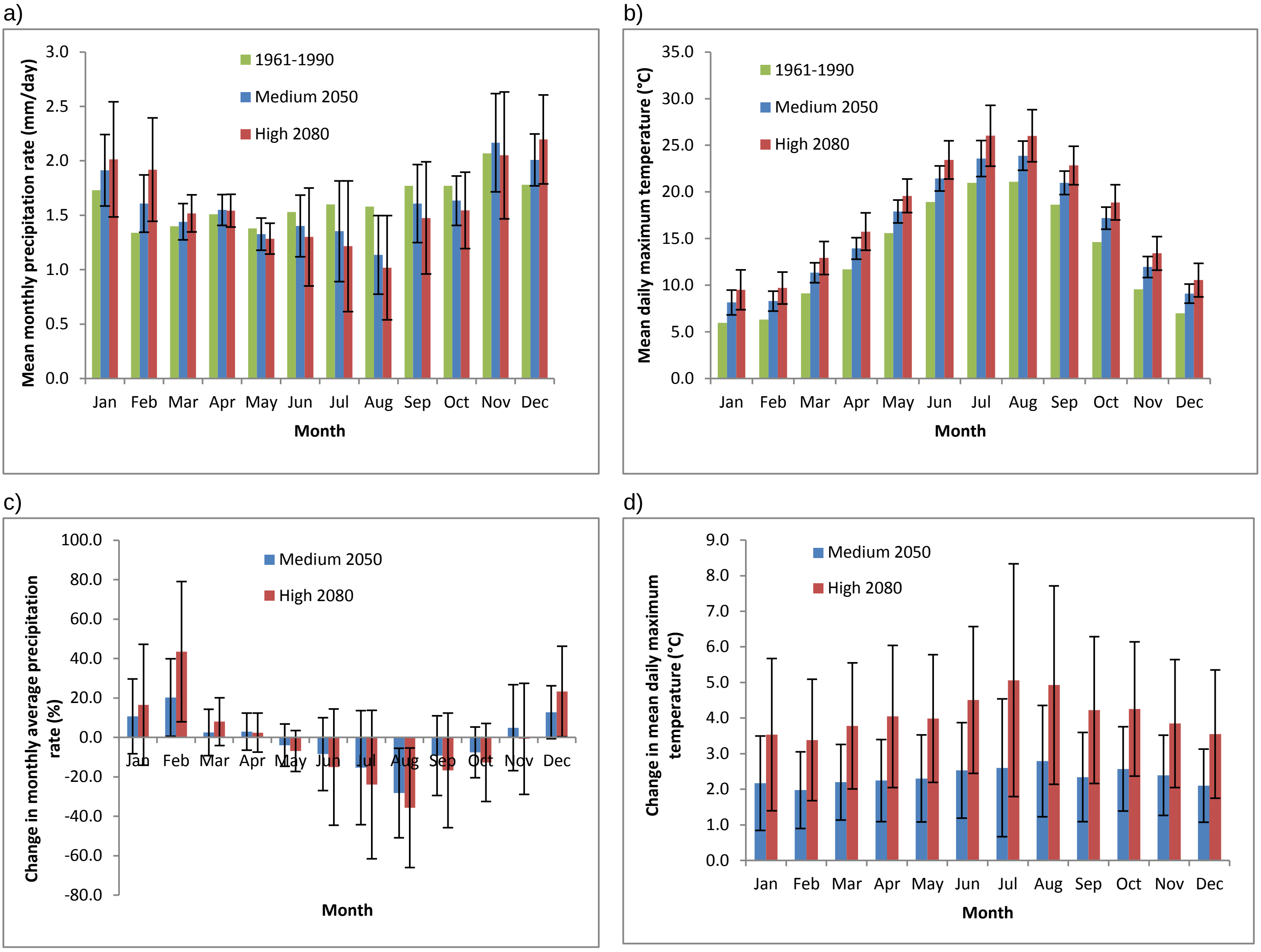

Figure 3. a) Absolute mean monthly precipitation rate (mm/day) and b) mean daily maximum temperature (°C) vs the UKCP09 climate projections for the HadRM3 25 x 25 km grid cell (1555) centred on Minsmere-Walberswick SPA. Relative change in c) mean monthly precipitation rate (%) and d) mean daily maximum temperature (°C) for the UKCP09 climate projections for the same grid cell. Climate values for 2050 medium emissions and 2080 high emissions scenarios were produced from the mean ± SD of 10,000 model projections.

3.2. Sea level rise

The Suffolk coast is vulnerable to coastal flooding as a result of sea level rise and storm surges. Relative sea levels on the coast are predicted to rise by between 23-74 cm under a medium emissions scenario and by 26-90 cm under a high emissions scenario by 2100. More difficult to predict is the frequency and extent to which storms and tidal surges will impact the Suffolk coast, as there is considerable uncertainty in generating predictions of increased frequency and intensity of storms affecting the UK coast[4].

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 habitats of Minsmere-Walberswick SPA.

Intertidal, saltmarshes, shingle beaches		
Cause	**Consequence**	**Ecological outcomes**
• Sea level rise; • Increased risk of storms and storm surges.	• Loss of intertidal mud and saltmarsh through coastal squeeze; • Re-profiling and/or loss of shingle beaches and sand dunes; • Greater frequency of coastal flooding.	• Long-term loss and/or reduction in quality of foraging, roosting, and breeding habitat (but perhaps a short-term gain); • Changes in biomass and species composition of benthic invertebrate prey through direct responses to steepening mudflat profile, changes in sedimentation, and intrusion of saline water upstream in estuaries; • May create / renew some early succession shingle areas that could benefit breeding terns / plovers.

Coastal grazing marshes		
Cause	**Consequence**	**Ecological outcomes**
• Sea level rise; • Increased risk of storms and storm surges.	• Greater frequency of coastal flooding; • Reduced drainage capacity.	• Long-term loss and/or short-term reduction in quality of foraging, roosting, and breeding habitat; • Potential impacts on invertebrate populations.
• Increased spring and summer temperatures.	• Changes in vegetation composition, structure, and growth patterns on saltmarsh and coastal grazing marshes.	• Change in habitat suitability for marsh feeding or -nesting species.
• Increased summer temperatures and evapotranspiration and decreased summer rainfall.	• Increased rate of drawdown.	• Reduction in quality of foraging and nesting habitat, including impacts on invertebrate populations; • Reduced water quality due to an increase in nutrient concentration and eutrophication.
• Increased extreme rainfall events year-round.	• Increased flood risk.	• Change in foraging habitat quality; • Increased flood risk for nests during extreme summer rainfall events[5].

Saline lagoons		
Cause	**Consequence**	**Ecological outcomes**
• Sea level rise; • Increased risk of storms and storm surges.	• Greater frequency of flooding and loss of existing habitat, but with possible evolution of new habitat; • Reduced drainage capacity.	• Long-term loss and/or reduction in quality of foraging, roosting, and breeding habitat.
• Increased winter rainfall.	• Higher water levels and lower salinities in winter.	• Change in quality of foraging habitat; • Changes in the abundance, composition, and accessibility of invertebrate fauna.
• Increased summer temperatures and evapotranspiration and decreased summer rainfall.	• Increased rate of drawdown; • Higher salinities.	• Change in quality of foraging habitat; • Changes in the abundance, composition, and accessibility of invertebrate fauna.
• Increased extreme rainfall events year-round.	• Increased flood risk.	• Change in foraging habitat quality; • Increased flood risk for nests during extreme summer rainfall events[5].

Freshwater reedbeds		
Cause	**Consequence**	**Ecological outcomes**
• Sea level rise; • Increased risk of storms and storm surges.	• Greater frequency of coastal flooding; • Eventual loss of coastal freshwater wetlands; • Reduced drainage capacity.	• Reduction in freshwater wetland prey and habitat quality;
• Increased summer temperatures and evapotranspiration and decreased summer rainfall.	• Increased rate of drawdown.	• Reduction in quality of foraging habitat; • Reduced water quality due to an increase in nutrient concentration and eutrophication.
• Increase in extreme rainfall events year-round.	• Increased flood risk.	• Loss or reduction in foraging habitat quality; • Increased flood risk for nests during extreme summer rainfall events[5].

Heathland and dry grassland		
Cause	**Consequence**	**Ecological outcomes**
• Increased temperatures year-round.	• Increased rate of nitrogen cycling; • Changes in vegetation composition, structure, and growth; • Increased growth of competitive grasses over dwarf shrubs; • Increased growth of tall wavy hair-grass *Deschampsia flexuosa;* • Increased susceptibility of heather to pests.	• Reduced habitat suitability for species requiring heather or a short sward.
• Increased summer temperatures and decreased rainfall.	• Drought; • Increased risk of wildfire; • Decrease in extent of heather-dominated heathland; • Shorter sward height, increased annual plant cover, decreased perennial plant cover.	• Decreased habitat suitability for species preferring heather; • Increased habitat suitability for species preferring short sward.
• Increased severe rainfall events.	• Increased run-off from surrounding agricultural land and greater rate of nitrogen deposition.	• Nutrient enrichment and increased vegetation growth of certain species.

5. Projected population trends

Population trends under a 2050 medium emissions scenario and a 2080 high emissions scenario were produced only for those species (mainly waterbirds) which were modelled at the site as part of the CHAINSPAN report[6]. 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.

Group	Species	Season	National risk assessment	Model quality	2050 medium	2080 high
Terns	Common Tern	B	*LTD IMPACT*	very poor	→	→
	Sandwich tern	PA	*HIGH RISK*	poor	↗	↘
	Little Tern	B	*MED OPP*	moderate	↑	↑
Breeding gulls	Lesser Black-backed Gull	B	HIGH OPP	very poor	→	→
	Black-headed Gull	B	MED OPP	poor	↑	↘
	Herring Gull	B	MED OPP	poor	↑	→
	Great Black-backed Gull	*B*	**LTD IMPACT**	*moderate*	↑	↑
Freshwater grassland waders	Golden plover	N	HIGH OPP	moderate	↘	↘
	Curlew	N	HIGH OPP	moderate	→	↓
	Lapwing	N	*MED RISK*	good	→	→
	Black-tailed Godwit	PA	HIGH OPP	very poor	→	→
	Black-tailed Godwit	N	HIGH OPP	poor	↑	↑
	Snipe	N	HIGH OPP	moderate	↑	↑
Bivalve feeding waders	Knot	N	LTD IMPACT	moderate	↓	↓
	Oystercatcher	N	*MED RISK*	moderate	→	↓
Intertidal waterbirds	Redshank	N	LTD IMPACT	moderate	→	↘
	Ringed Plover	PS	*MED OPP*	moderate	→	↘
	Greenshank	N	HIGH OPP	moderate	→	→
	Greenshank	PA	HIGH OPP	very poor	→	→
	Grey Plover	N	HIGH OPP	moderate	→	→
	Ruff	PA	*MED OPP*	very poor	→	→
	Whimbrel	PA	LTD IMPACT	poor	→	→
	Avocet	N	**HIGH OPP**	moderate	→	↑
	Redshank	PA	LTD IMPACT	poor	↗	→
	Shelduck	N	HIGH OPP	poor	↗	↗
	Dunlin	N	*MED OPP*	poor	↑	↑
	Ringed Plover	N	*MED OPP*	moderate	↑	↑
	Ringed Plover	PA	*MED OPP*	moderate	↑	↑
	Whimbrel	PS	LTD IMPACT	poor	↑	↑

Open-water waterbirds	Goldeneye	N	*RISK & OPP*	moderate	↓	↓
	Great Crested Grebe	N	*MED RISK*	moderate	↓	↓
	Tufted duck	N	*MED RISK*	moderate	↘	↓
	Great Crested Grebe	PA	*MED RISK*	moderate	↘	→
	Red-throated Diver	N	HIGH OPP	moderate	→	↓
	Cormorant	N	*MED RISK*	very poor	→	→
	Pochard	N	HIGH RISK	very poor	→	→
Saltmarsh or freshwater waterbirds	Whooper Swan	N	*MED RISK*	poor	↓	↓
	Wigeon	N	*MED RISK*	poor	↘	↘
	Mallard	N	HIGH RISK	good	↘	↓
	Pintail	N	LTD IMPACT	poor	→	↓
	Gadwall	N	*MED RISK*	very poor	→	→
	Bewick's Swan	N	*MED RISK*	very poor	→	→
	Bittern	B	**LTD IMPACT**	very poor	→	→
	Little Grebe	N	*MED RISK*	very poor	→	→
	Shoveler	N	HIGH OPP	very poor	→	→
	Coot	N	*MED RISK*	good	→	↑
	Little Egret	PA	**HIGH OPP**	moderate	↑	↑
	Teal	N	HIGH OPP	poor	↑	↑
Heathland / grassland	**Nightjar**	B	HIGH OPP	poor	↗	↑
	Woodlark	B	HIGH OPP	moderate	↑	↑
	Dartford Warbler	B	**HIGH OPP**	moderate	↑	↑

In addition, populations of a number of other qualifying species also occur at Minsmere-Walberswick, but were not modelled as part of the CHAINSPAN report, largely due to insufficient data. Population projections for breeding avocet were not modelled as part of CHAINSPAN. This species depends strongly on saline lagoon habitats in the breeding season. Populations for several freshwater colonists species were also not modelled. These include little egret, spoonbill, purple heron, great white egret, night-heron, and glossy ibis. 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.

Species	National risk assessment
Avocet (B)	*HIGH OPP*
Marsh Harrier (B)	*HIGH OPP*
Bittern (N)	**LTD IMPACT**
Hen Harrier (N)	HIGH RISK
Stone Curlew (B)	HIGH OPP
Little Egret (B)	**HIGH OPP**

6. Potential adaptive management responses

Given the projected climate change impacts likely to influence bird populations (see Section 4) at Minsmere-Walberswick 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, blue arrows the non-breeding population (winter and passage).

On the following sheets, terns include: common, sandwich, and little tern (but might also be applied to Arctic tern). Breeding gulls include: lesser black-backed gull, black-headed gull, and herring gull (but might also be applied to Mediterranean gull and great black-backed gull). Wader species that frequently also forage on freshwater & brackish wetlands (in addition to using intertidal areas to varying degrees) include: golden plover, lapwing, black-tailed godwit, curlew. Nesting redshank will use these habitats as well. Species that feed on bivalves include: oystercatcher & knot. Predominantly intertidal/estuarine wader species (that will also use freshwater & brackish wetlands to varying degrees) include: redshank, ringed plover, greenshank, grey plover, ruff, whimbrel, non-breeding avocet, dunlin, and shelduck. Open-water waterbirds include: goldeneye, great crested grebe, tufted duck, red-throated diver, cormorant, and pochard. Saltmarsh or freshwater waterbirds include: whooper swan, wigeon, mallard, pintail, gadwall, Bewick’s swan, bittern, little grebe, shoveler, coot, little egret, and teal.

6.1. Intertidal, saltmarshes, and shingle beaches

Climate impacts: sea level rise, increased storm surges										
Ecological outcomes: loss of habitat through coastal squeeze										
Measures	**Breeding terns / ringed plover**	**Freshwater grassland waders**	**Species that feed on bivalves**	**Intertidal species (inc ringed plover)**	**Breeding gulls**	**Avocet**	**Open-water waterbirds**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Create new intertidal, saltmarsh, and shingle habitat through managed realignment and regulated tidal exchange[7,8]	↑	↑	↑	↑↑	↑	↑↑		↑	↑↑	↑
Increase topographic variation to ensure a range of suitable areas for roosting/nesting at different tidal heights & future sea levels: 1) Create high-tide roosting or shingle nesting islands[9], 2) maximise the variation in elevation of higher areas, 3) create nest rafts	↑*	↑	↑	↑↑	↑	↑↑				↑

* New nesting habitat should be provided near existing colonies

Other compensatory measures not directly related to climate change										
Measures	**Breeding terns**	**Freshwater grassland waders**	**Species that feed on bivalves**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Open-water waterbirds**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Reduce unsustainable fisheries (either fish or shellfish)[10]	↑		↑				↑			
Reduce human disturbance[11,12]	↑	↗	↗	↗↗	↑	↑		↗	↗↑	↑

Other compensatory measures not directly related to climate change										
Measures	**Breeding terns**	**Freshwater grassland waders**	**Species that feed on bivalves**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Open-water waterbirds**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Reduce predation by corvids, foxes, mustelids through electric fencing and/or lethal control	↑			↑	↑	↑		↑	↑	↑
Reduce predation by raptors and gulls through diversionary feeding / management	↑			↗		↗				↗
Careful siting of renewable energy schemes to reduce displacement due to disturbance / collision risk	↑	↑	↑	↑↑	↑	↑	↑	↑		↑

6.2. Coastal grazing marsh

Climate impacts: sea level rise, increased storm surges

Ecological outcomes: loss of habitat through coastal flooding

Measures	Breeding terns	Freshwater grassland waders	Intertidal waterbirds	Breeding gulls	Avocet	Saltmarsh or freshwater waterbirds	Little egret, spoonbill	Black-winged stilt
Maintenance of sea-defences to ensure managed retreat	↗[a]	↑↑[b]	↑↑[c,d]	↗[a]	↑	↑↓ (FW or salt respect'y)	↑↑	↗
Develop infrastructure to increase control over water levels and ability to adjust inputs of fresh and sea water		↑↑[b]	↑↑[c]		↑	↑↑	↑↑	↗

[a]Shingle sea defences provide nesting habitat, [b]nesting lapwing, [c]nesting redshank, [d]shingle sea defences also provide ringed plover nesting habitat

Climate impacts: increased year-round temperatures								
Ecological outcomes: change in vegetation composition, structure, and growth								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Manage vegetation through low levels of grazing, cutting; high levels of grazing may reduce resilience to erosion and coastal squeeze; heterogeneous vegetation height for both foraging and nesting		↑↑*	↑↑**		↑	↑↑	↑↑	

*Nesting lapwing, **nesting redshank

Climate impacts: Decreased summer rainfall and higher temperatures leading to summer drought								
Ecological outcomes: Reduction in habitat quality								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Develop infrastructure to increase control over water levels		↑*	↑**		↑	↑	↑	
Maximise efficiency of water use on site through appropriate site design, enhanced winter water storage, rotational flooding		↑*	↑**		↑	↑	↑	
Secure new or additional water sources externally		↑*	↑**		↑	↑	↑	

*Nesting lapwing, **nesting redshank

Climate impacts: Extreme spring and summer rainfall leading to flooding								
Ecological outcomes: Decline in food resources, loss of breeding attempts								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Create heterogeneous habitat by increasing topographic variation such that suitable seasonal and permanent wet areas of variable depth are present over a proportion of site		↑*	↑**		↑	↑	↑	
Development of appropriate water infrastructure to be able to remove excess floodwater or move to other areas		↑*	↑**		↑	↑	↑	

*Nesting lapwing,**nesting redshank

Other compensatory measures not directly related to climate change								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Reduce human disturbance[11,12]		↑*	↑**		↑	↑	↑	
Reduce predation by corvids, foxes, mustelids through electric fencing and/or lethal control		↑*	↑**		↑	↑	↑	

*Nesting lapwing,**nesting redshank

6.3. Saline lagoons

Climate impacts: increased winter rainfall, increased summer temperatures and decreased summer rainfall								
Ecological outcomes: change in water levels and salinities leading to changes in abundance and composition of prey								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Increase control over water levels & salinity through adjusting inputs of freshwater and sea water (where possible)		↑	↑↑		↑	↗↘*	↑↓↑↓**	↑

*Certain seed species are less sensitive to salinity requirements
**Fish species differ in their salinity requirements

Other compensatory measures not directly related to climate change								
Measures	**Breeding terns**	**Freshwater grassland waders**	**Intertidal waterbirds**	**Breeding gulls**	**Avocet**	**Saltmarsh or freshwater waterbirds**	**Little egret, spoonbill**	**Black-winged stilt**
Reduce human disturbance[11,12]	↑	↗	↗↑	↑	↑	↗	↑	↑
Reduce loss of habitat due to other land use pressures eg. Development	↑	↑	↑↑	↑	↑	↑	↑	↑
Reduce predation by corvids/foxes through electric fencing and/or lethal control	↑		↑*	↑	↑		↑	↑
Reduce predation by raptors through diversionary feeding / management	↑		↑*		↗			↗

*Nesting ringed plover

6.4. Freshwater reedbeds

Climate impacts: coastal flooding and saline incursion			
Ecological outcomes: habitat loss, decrease in habitat and prey quality, increased flood risk for nests			
Measures	**Bittern**	**Marsh harrier**	**Little egret, spoonbill, purple heron, great white egret, night-heron, glossy ibis**
Wetland re-creation less than 5-10 km from existing wetlands in areas with water security and with low risk of coastal flooding (may not be possible due to lack of suitable sites in coastal Suffolk; much compensatory habitat will be further away)[13]	↑↑	↑↑	↑↑
Maintenance of sea-defences to ensure managed retreat	↑↑	↑↑	↑↑

Climate impacts: Decreased summer rainfall and higher temperatures leading to summer drought			
Ecological outcomes: Decline in food resources, changes in vegetation structure, eutrophication and evaporation of shallow wetlands			
Measures	**Bittern**	**Marsh harrier**	**Little egret, spoonbill, purple heron, great white egret, night-heron, glossy ibis**
Minimise water loss through larger sites	↑↑	↗↗	↑↑
Maximise efficiency of water use on site through appropriate site design, enhanced winter water storage, rotational flooding	↑↑	↗↗	↑↑
Secure new or additional water sources externally	↑↑	↑↑	↑↑
Reduce nutrient enrichment by improving water quality and reducing run-off within the catchment	↑↑	↑↑	↑↑

Climate impacts: Extreme spring and summer rainfall leading to flooding			
Ecological outcomes: Decline in food resources, loss of breeding attempts			
Measures	**Bittern**	**Marsh harrier**	**Little egret, spoonbill, purple heron, great white egret, night-heron, glossy ibis**
Create heterogeneous habitat by increasing topographic variation such that suitable seasonal and permanent wet areas of variable depth are present over a proportion of site	↑	↗	↑
Development of appropriate water infrastructure to be able to remove excess floodwater or move to other areas	↑	↗	↑

Other compensatory measures not directly related to climate change			
Measures	**Bittern**	**Marsh harrier**	**Little egret, spoonbill, purple heron, great white egret, night-heron, glossy ibis**
Reduce predation by foxes and corvids through non-lethal and/or lethal control, or buffer edge effects by enlarging wetland habitat by restoring adjacent grassland & arable land[14–16]	↑	↑	↑
Reduce human disturbance[11,12]	↑	↑	↑

6.5. Heathland and grassland

Climate impacts: increased year-round temperatures					
Ecological outcomes: change in vegetation – increased growth of tall competitive grasses, decrease in extent of heather					
Measures	**Nightjar**	**Woodlark**	**Stone-curlew**	**Dartford warbler**	**Red-backed shrike**
Increase resistance of dwarf-shrub vegetation to becoming outcompeted by grasses through turf stripping or prescribed burning[17–19]	↑	↗↘*	↗↘*	↑	↑
Reduce dominance of wavy hair-grass on short grasslands through prescribed burning and grazing[2,20]		↑	↑	↓**	↑

*Short grassland and/or disturbed ground preferred, so burning/grazing may provide short-term benefit depending on extent
** Burning can reduce scrub habitat quality

Climate impacts: increased summer temperatures and decreased rainfall leading to drought					
Ecological outcomes: increased wildlife risk, decreased suitability of heather habitat, increase in extent of habitats with short sward, reducing quality of foraging habitat					
Measures	**Nightjar**	**Woodlark**	**Stone-curlew**	**Dartford warbler**	**Red-backed shrike**
Create more firebreaks and increase fire precautions	↑	↑↓*		↑	

* Burning creates suitable short grassland habitat

Other compensatory measures not directly related to climate change					
Measures	**Nightjar**	**Woodlark**	**Stone-curlew**	**Dartford warbler**	**Red-backed shrike**
Maintain a range of different successional stages	↑	↑	↑	↑	↑
Maintain areas of early successional stages in forestry plantations	↑	↑			
Minimise levels of human disturbance[2,3,19,21]	↑	↑	↑	↑	↑
Reduce predation by foxes and corvids through non-lethal and/or lethal control	↑		↑		↑
Increase site size and reduce fragmentation through habitat re-creation on ex-arable land, former mineral extraction sites, by removing conifer plantations from afforested heathland/grassland[22]	↑	↑	↑	↑	↑

7. Practical assessment of suggested adaptive management responses

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

Of particular note from this workshop was the degree to which land managers for the SPA were already incorporating prospective climate change into their current and future management strategies. Site managers were highly aware of the need for a more dynamic and responsive, less prescriptive approach that could change and evolve according to both short- and long-term variability and uncertainty in environmental conditions. Managers highlighted the fact that birds seemed to respond well to dynamic year-to-year conditions by moving within the SPA or surrounding region accordingly. Existing heterogeneity within the SPA likely allows for this to happen and highlights the importance of maintaining a high level of habitat heterogeneity to accommodate future change. Also of note was the level to which this type of flexible management philosophy has been discussed as an approach to management at the landscape scale along the entire Suffolk Coast, and managers are well aware of the importance of managing the site as part of a connected network with neighbouring protected areas and reserves (e.g. Benacre to Easton Bavents SPA, North Warren RSPB reserve, the Alde-Ore Estuary, and Sandlings SPA).

7.1. Water management

This section of coastline is under increasing pressure from rising sea-levels and storm surges. Management decisions in response to this will not only shape the future of the coastline, but also of the freshwater habitats behind. While the general policy for this section of coast is for limited intervention and the natural evolution of the shingle ridge (rather than managed realignment, *per se*), due to desire to protect the freshwater reedbed at Minsmere in the absence of adequate compensatory habitat elsewhere, the North Wall defence protecting the Scrape and main freshwater reedbed has been strengthened against saline incursions. A less interventionist approach of natural (rather than managed) realignment has been adopted by the EA (with support from Suffolk Wildlife Trust, RSPB, and Natural England) at Dingle Marshes, where the shingle defences are no-longer being artificially maintained, resulting in a landward retreat. This may result in a squeeze of the currently important saline lagoons between the shingle defence and the Dunwich River, depending upon natural processes and any future changes to that water course. Eventually, these lagoons should redevelop naturally, depending on how far they are pushed back. At present, banks around the Blyth are designed to facilitate flooding of the grazing marshes at high water levels. There may be a case for some managed realignment here, as part of restoring the system to that of a more natural estuary, although based on previous experience this could be met with significant local resistance and would need to be balanced against other demands.

In brief, future management at Minsmere-Walberswick will depend largely on the natural movement and/or degradation of shingle barriers and seawalls over time, as the SMP policy for this section of coast is largely one of limited intervention and a reduction in the maintenance of sea-defences. In the long-term, site managers recognise that freshwater reedbed and coastal grazing marshes inland of these defences are likely to have a limited lifespan, and as the shingle frontage rolls back and seawalls are left to degrade, these habitats will become increasingly brackish in nature, transitioning to saltmarsh and saline lagoons. This is particularly the case for certain areas of the SPA, including Tinker's Marshes, Dingle Marshes, and the North Marsh at Minsmere.

Part of the constraint around the potential for managed realignment or retreat is the habitat, topography and land management inland of the SPA. For example, the inland retreat of Dingle Marshes is constrained by the proximity of the elevated ground of Dunwich Forest to the coastal frontage. Elsewhere, agricultural land and transport infrastructure are likely to be considerations for defence, preventing the migration of freshwater habitats inland.

An additional strategy being considered to increase resilience of the SPA to inundation is to increase topographical variation. This is currently already being applied to freshwater reedbed habitats. For example, management has built up parts of the reedbeds on Westwood Marshes and North Marsh which will increase the resilience of this habitat to flood events. As and when these habitats transition from freshwater to brackish conditions, this topographical heterogeneity will then deliver greater resilience of that habitat as well, for exampling by creating islands and saline lagoons to be used by breeding avocets. There is the potential to undertake such management now in parts of Minsmere and Dingle Marshes. However, in some areas, such as southern parts of Minsmere, this option is constrained by the need to protect archaeological features.

The maintenance of appropriate water levels in freshwater wetland habitats will become increasingly difficult with projected increases in rainfall and subsequent flooding due to insufficient water control infrastructure to remove excess floodwaters. Evacuation of freshwater flooding during the winter is also a problem in brackish habitats, and at present, the EA's sluice at Minsmere will likely be unable to cope with removing an increased level of fluvial floodwater. Improving water control infrastructure at all sites within the SPA will not only provide the ability to more effectively move freshwater, it will also improve the ability to respond to more frequent saline inundation in the event of storm surges and to quickly evacuate saltwater from freshwater habitats. However, with rising sea levels, it may become increasing difficult to adequately sluice-drain either fresh or saline floodwater from habitats behind sea defences due to tide lock.

Early season water levels are already kept high in wetlands, which increases resilience to summer drought. Maintaining high water levels in spring will also reduce the risk of nest loss to flooding by an extreme rainfall event later in the season by encouraging wetland-nesting species to nest at higher elevation. Where there is sufficient compartmentalisation, rotational flooding may help make the best use of water resources, by ensuring at least one compartment remains wet in dry years, and *vice versa*. For some sites, such as Dingle Marshes, this may require the construction of such compartments across the site, and improvements in freshwater infrastructure.

While sites within the SPA rely on holding winter water levels high to provide water through the summer, reservoirs and designated winter water storage areas have been less considered as a measure to improve resilience to dry summer conditions. There are few opportunities on site for creating water storage areas (options include Tinkers' Marsh and Westwood Marshes), although this would need to be balanced against the value of the existing habitat. Again, the construction of a greater number of independent compartments for water management may help in this regard. The construction of water storage reservoirs off-site is also a possibility but would likely require extensive cooperation with local farmers, who would also benefit from this in the summer. This option would be expensive. Farmers to the north at Benacre have created reservoirs and summer abstraction is proving effective. Abstraction is more of an issue on Minsmere-Walberswick due to issues with water quality as a result of nutrient enrichment from run-off from surrounding pig units. Southwold is installing a water main to avoid abstracting water from the SPA, which should improve water security for the future.

Within sites, the approach to water management may need to become increasingly flexible to adapt to changing conditions. The current philosophy recognises that in the future, there will potentially be a high degree of annual variation in water levels, and that habitats will naturally respond to this variation and should be managed in a way that is sympathetic to their natural response. For example, reedbed should be allowed to spread in wet years, whereas in dry years, managers may take the opportunity to cut it back. The expectation is that birds will respond to this dynamism in their habitats, and that existing heterogeneity will buffer year-to-year habitat variability by providing suitable habitat elsewhere within the site. In order for this approach to work, sites will need to be sufficiently large for such 'natural' processes to operate effectively, whilst also being sufficiently heterogeneous that there will remain suitable conditions for most species somewhere on site, even in extreme years. In the context of an SPA network, a relatively high degree of connectivity to other protected areas and reserves within the surrounding landscape will also make this management approach more achievable, by providing birds with the opportunity to find suitable habitat within the region, even if it is not available at a particular site. Thus, a heterogeneity of approaches and habitats both within the SPA and across neighbouring SPAs may deliver significant resilience to future climate change, but may require effective coordination and communication of activities across and between sites.

7.2. Habitat compensation

There are few local options to compensate for the projected loss of freshwater habitats at Minsmere-Walberswick due to likely conflict with the need to maintain arable agricultural use inland. Creating new wetlands in more sustainable locations, including maybe away from the Suffolk Coast e.g. on the fens around the Ouse and Nene Washes, may be the most sustainable option, but adequate habitat compensation on the fens will still be constrained by competing agricultural interests, and of course, are a long way from this SPA. There may be potential for small wetland "stepping stones" to be developed along the Waveney Valley and other river systems, although the development of freshwater habitats along the Blyth River is a more tenuous option due to the risk of tidal incursion and the uncertain form of the Blyth Estuary in the future. However, certain reedbed species (e.g. marsh harrier, bittern) are less reliant on stepping stones and depend more on suitably large areas of appropriate habitat. Thus, the present conservation focus for reedbeds and other freshwater habitats is to increase their resilience to climate change as a means of buying time until suitable habitat compensation has been undertaken elsewhere.

7.3. Vegetation management

Freshwater reedbed

Current management to harvest rush and reed for biofuel may provide an economically sustainable and more efficient method of managing reedbed. However, mechanical harvesting may be constrained in future by increased winter rainfall and high water levels, as harvesters are only able to work in dry conditions and are limited even in dry winters. Thus, as outlined, a more flexible approach may be needed.

Coastal grazing marsh

In the long-term, it is recognised that this habitat will be increasingly lost as the maintenance of sea defences ceases. It is likely these habitats will be best protected around Westwood Marshes and Minsmere; at Dingle Marshes there is a trade-off between the loss of this habitat against the need to manage the migration of shingle inland. Around the Blyth, it may be possible to delay the loss of some areas of these habitats by lowering some of the sea-walls close to the estuary, thus widening the area of inundation during flood events and dissipating energy. The installation of pipes in the walls may also reduce the risk of a breach during flood events, thus increasing the longevity of grazing marsh habitats but with more frequent flood events. The Blyth Estuary is subject to many different interests and is under its own management plan; securing the agreement of all interests for a long-term strategy is much more difficult and contentious than within conservation organisation-managed freehold.

Increased flexibility within the Higher Level Stewardship programme prescriptions for grazing management would improve the programme's ability to handle the dynamic nature of changing conditions, while also improving funding security for landowners. Conservation organisations are highly reliant on farmers to provide grazing stock, but implementing appropriate levels of grazing management may become increasingly difficult as a result of uncertainty in the economic sustainability of grazing and the increasing age demographic of graziers. Projected future conditions (wetter winters, drier summers) will only increase the economic uncertainty of grazing. Increased winter and early spring temperatures that result in greater vegetation growth, together with high early spring water levels may make delivering suitable grazing management for breeding waders increasingly difficult under current HLS prescriptions. However, the development of a New Environmental Land Management Scheme (NELMS) may provide the opportunity to develop a system that is better able to accommodate uncertainty and variability in conditions. Turning stock out to graze will be constrained by high early season water levels, and pushing back the timing of grazing will increasingly conflict with the nesting season. On the other hand, high spring water levels are beneficial as they will make habitats more resilient to increased summer drawdown under drier condition. Delivering appropriate management will depend on balancing vegetation management and holding sufficient water through the summer. Interestingly, in this context, a shift at Minsmere to a more dynamic and flexible approach to prescriptions does not appear to have significantly impacted on conditions for breeding waders, as reported by reserve staff. Achieving such flexibility is possible on a nature reserve, but more difficult for private landowners requiring derogation under HLS.

Heathland and grassland

Given projected improvements in the climatic suitability of this site for a number of breeding heathland species, the maintenance, improvement of quality and extension of heathland habitats will be important adaptive responses to climate change. At present, whilst climate change will impact vegetation growth on heathland and grassland, grazing deer and nutrient enrichment from run-off from surrounding pig units may have an even greater impact on vegetation in these habitats. There is currently considerable uncertainty about the likely impact that climate warming will have on nutrient cycling in heathland habits, which may then interact with this problem of nutrient enrichment. A programme recently implemented at Minsmere to control deer may prove effective if it reduces grazing to a beneficial level and allows for the recovery of shrub-dominated heathland.

Projected increases in summer drought conditions are likely to increase the frequency and risk of wildfire, to which the SPA is vulnerable. Whilst it will be important to maintain firebreaks and increase fire precautions, it is likely that fires will happen, and therefore improving local resources available for wildfire response is also important. This could reduce the need for conservation organisations to rely on the fire service and may also improve wildfire risk management by shortening response times.

Maintaining cooperation and coordination across the conservation organisations to ensure a range of different successional stages will continue to benefit heathland management and the development of new heathland habitat in Dunwich Forest as it is gradually felled. The Dunwich Forest area is likely to provide the best opportunity to increase the extent of heathland habitat around the SPA, and indeed, this is one of the objectives of a partnership between Suffolk Wildlife Trust, the RSPB, and the Forestry Commission. The conversion of arable habitats to heathland is another possibility, as has been demonstrated at Minsmere.

It is likely that any future expansion of stone curlew populations will be supported outside of the SPA, as there is minimal room for expansion of the population within the SPA's current boundaries. The opportunities for a successful expansion will depend on appropriate management (fencing and predator control), but given likely resourcing limitations in the extent to which such management may be possible outside of the SPA, this may ultimately constrain the ability of this stone curlew population to successfully expand, without more extensive protection outside the SPA's boundaries. Habitat in nearby Sandlings SPA may provide the best opportunity for stone curlew expansion.

7.4. Predator control

Surrounding shooting estates and released pheasants attract foxes to the local area, while pig units attract corvids and gulls. The gradual felling of Dunwich Forest over the next 30-40 years may diminish its role as a fox reservoir. Fox management generally relies on electric fences with a certain amount of lethal control. A higher level of wardening and lethal control would improve predator management, and therefore breeding wader and other interests, but is constrained by limited resources.

Herring and lesser black-backed gulls are increasingly an issue for smaller nesting waterbirds at Minsmere, and are controlled; however, future changes in populations of these species associated with climate change may exacerbate the problem of gull predation and present the eventual problem of a possible conflict between protection and control of conservation-priority gull species, which are declining rapidly at “natural” coastal sites along the Suffolk Coast.

7.5. Human disturbance

A proposal to expand Sizewell nuclear power station, located 2 km to the south of the SPA, by building a new power station next to the current Sizewell B station may potentially have a large impact on Minsmere-Walberswick (http://sizewell.edfenergyconsultation.info/). Infrastructure options to support the development may include new roads, new rail lines, a temporary jetty for sea freight delivery, and housing for 3000-4000 construction workers. Local hydrology may be impacted by water engineers, and water quality may be affected, particularly if works-associated water needs to drain through the same EA-operated sluice as is used for managing water levels at Minsmere. In addition to local impacts on the SPA itself, the proposed project is of a scale that it may impact on the functional connectivity of coastal reserves, particularly connectivity between Minsmere-Walberswick and areas to the south such as the Alde-Ore and Deben Estuaries and Sandlings SPA.

The success of beach-nesting species such as terns and ringed plover is influenced by disturbance and interactions with predation, and will depend on implementing both fencing (used in the past, but not very effective) combined with active wardening to reduce the impact of visitors. Increasing numbers of visitors to coastal areas and the popularity of heathland for walking means that visitors and dogs may continue to cause disturbance to nesting heathland species such as nightjar and woodlark. Natural England’s four-year programme (2012-2016) to legally dedicate public access rights on freehold areas of their National Nature Reserves may increase visitor pressure and potential disturbance to breeding birds. Public access rights came into effect on Westleton Heath in February 2014, while access rights in NE-freehold areas of Suffolk Coast NNR will not come into effect until September 2015 or later. The effects of this should be monitored. There are also constraints on what can be achieved on the coast due to the coastal footpath, although in some areas, the creation of a surfaced path landward of the breeding colonies may direct visitors away from sensitive areas[23]. Controlling access to particular areas at certain times of year may present a partial solution. Natural England’s use of lambing sheep to provide incentive for visitors to keep their dogs on leads will also contribute to reducing disturbance. Mountain-biking may become an increasing problem on the SPA’s heathland, and while controlling access to a small area is one potential solution, there is no management plan yet in place to address this issue. Current management of visitor disturbance is constrained by insufficient resources, and reducing the impact of disturbance in the future will depend on an increase in resource availability, particularly given likely increases in visitor access.

8. Priority actions to improve resilience

The greatest challenges for future management at Minsmere-Walberswick include management of the transition between salt and freshwater habitats given projected sea level rise, associated coastal erosion, and potential increases in storm surge frequency, as well as increasing summer drought and heavy winter rainfall which will pose a challenge for water management in both brackish and freshwater habitats. There are significant opportunities to improve and extend heathland habitats important for colonising and expanding species, particularly in Dunwich Forest and through the conversion of arable habitats. Current management is largely adaptive in nature and measures are in place to increase resilience of habitats such as freshwater wetlands in the short-term and to accommodate change in the longer-term, while considering that adequate compensatory freshwater habitat creation is an essential adaptive action. Climate change projections are for increases in breeding terns, some gulls, and over-wintering and passage waders, while projections for wintering waterbirds are show declines for some species with others remaining relatively "stable"; however, the potential for beach- and heath-breeding species to benefit from improving climatic conditions will be limited unless disturbance and predation can be properly controlled. Priority responses 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 are the *most constrained* are in *italics* and the primary constraints identified. Those which are ***synergistic with current management but that may be constrained*** in the future are in ***bold italics***.

Action	Synergies	Constraints
Cooperate with the Environment Agency on the natural and managed realignment of shingle barrier and hard defences, strengthening defences where necessary for the short-term	Part of current management	Will be at the long-term expense of freshwater habitats in favour of brackish / saline habitats, but should be used to buy time for compensatory freshwater habitat creation elsewhere
Provide heterogeneous habitat and topographic variation at the site- and landscape-level	Currently implemented for freshwater (reedbed) habitats and for planned transition from freshwater to brackish habitats	Little opportunity for expansion beyond current reserve boundaries, and may conflict with archaeological interest.
Improve water control infrastructure to better manage freshwater flooding and saline inundation	Some improvements within reserves	Often dependent upon infrastructure managed by EA.
Increase compartmentalisation of wetlands to improve ability to manage water levels.	May allow some storage of winter floodwater on site to increase resilience to summer drawdown, as well as managing flood risk.	Capacity may be constrained by land area,

Reduce visitor and dog disturbance by restricting access during sensitive periods, or using wardening or other disincentives	Controlled access to some areas of heathland Presence of lambing sheep incentivizes dog owners to use leads	Conflicts over access rights and increasing visitor numbers to coastal and heathland areas, lack of adequate management resources
Control numbers of deer to reduce grazing pressure on heathland	Implemented on Minsmere Visitor disturbance may reduce deer on popular heaths (e.g. Dunwich Heath)	
Increase flexibility of environmental stewardship and designations to improve ability to respond to dynamic conditions	Delivery of greater biodiversity benefits through well-designed and targeted agreements	Limited by current prescriptions of HLS programme and features of designated sites
Extend heathland areas	Part of a Living Landscape/Futurescapes partnership between Suffolk Wildlife Trust, the RSPB, and the Forestry Commission for Dunwich Forest. Will increase habitat area for species likely to increase in response to climate change.	
Compensatory freshwater habitat creation inland to offset coastal losses		Likely to be constrained by agricultural interests. Unlikely to be possible close to the SPA.

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