Ecology for the National Adaptation Programme for Climate Change

Short talk presentations: New research results and adaptation case studies

Climate Change Ecology Special Interest Group

4 May 2017

BRITISH ECOLOGICAL SOCIETY

britishecologicalsociety.org
@BritishEcolSoc

Introduction and context setting for the day

Mike Morecroft, Natural England &
Olly Watts, RSPB

Ecology for the National Adaptation Programme for Climate Change

Mike Morecroft,
Natural England, BES Climate Change Ecology Group

Thanks to

- Vicky Fowler, University of Exeter
- Natasha Hunston, Defra
- Katherine Maltby, BAS
- Camilla Morrison-Bell, BES
- Andy Neale, Natural England
- James Pearce-Higgins, BTO,
- Dornford Rugg, Defra
- Olly Watts, RSPB

British Ecological Society for funding

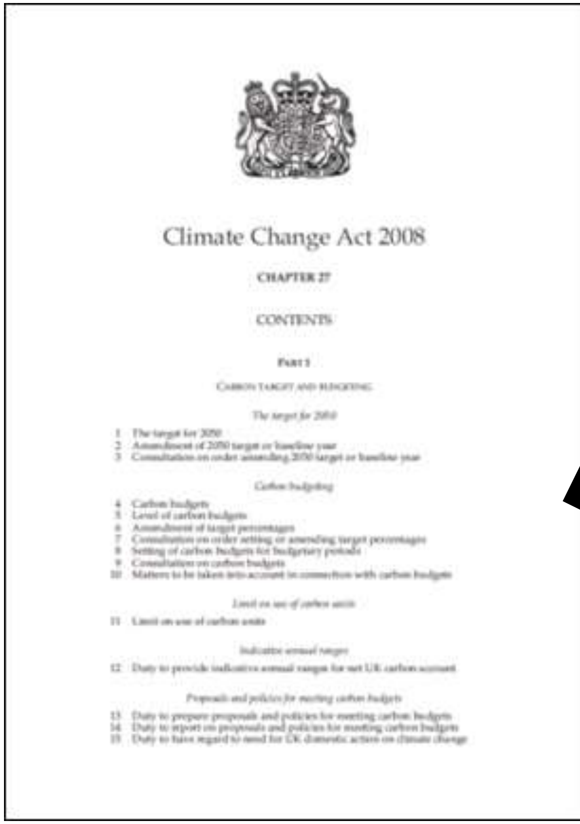
Adaptation is ….

adjustment in natural or human systems

.....

which moderates harm or exploits beneficial opportunities

Statutory Adaptation Planning



Climate Change Act 2008

CHAPTER 27

CONTENTS

PART 1

CARBON TARGET AND BUDGETING

The target for 2050

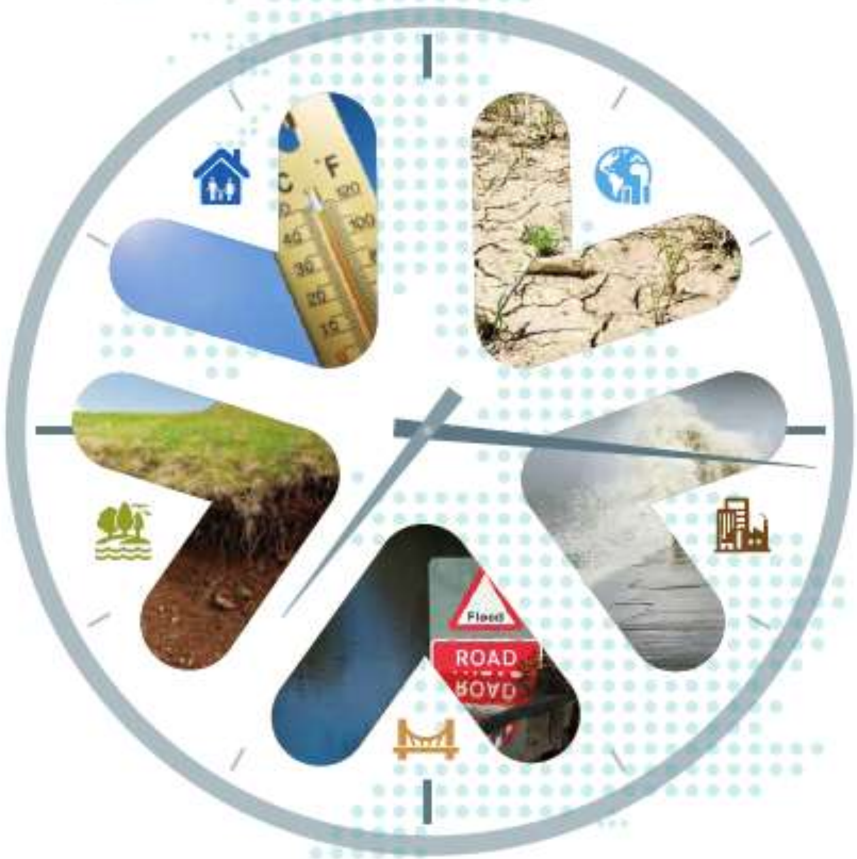
?

Committee on
Climate Change

UK 2017 | Climate Change Risk Assessment

UK Climate Change Risk Assessment 2017

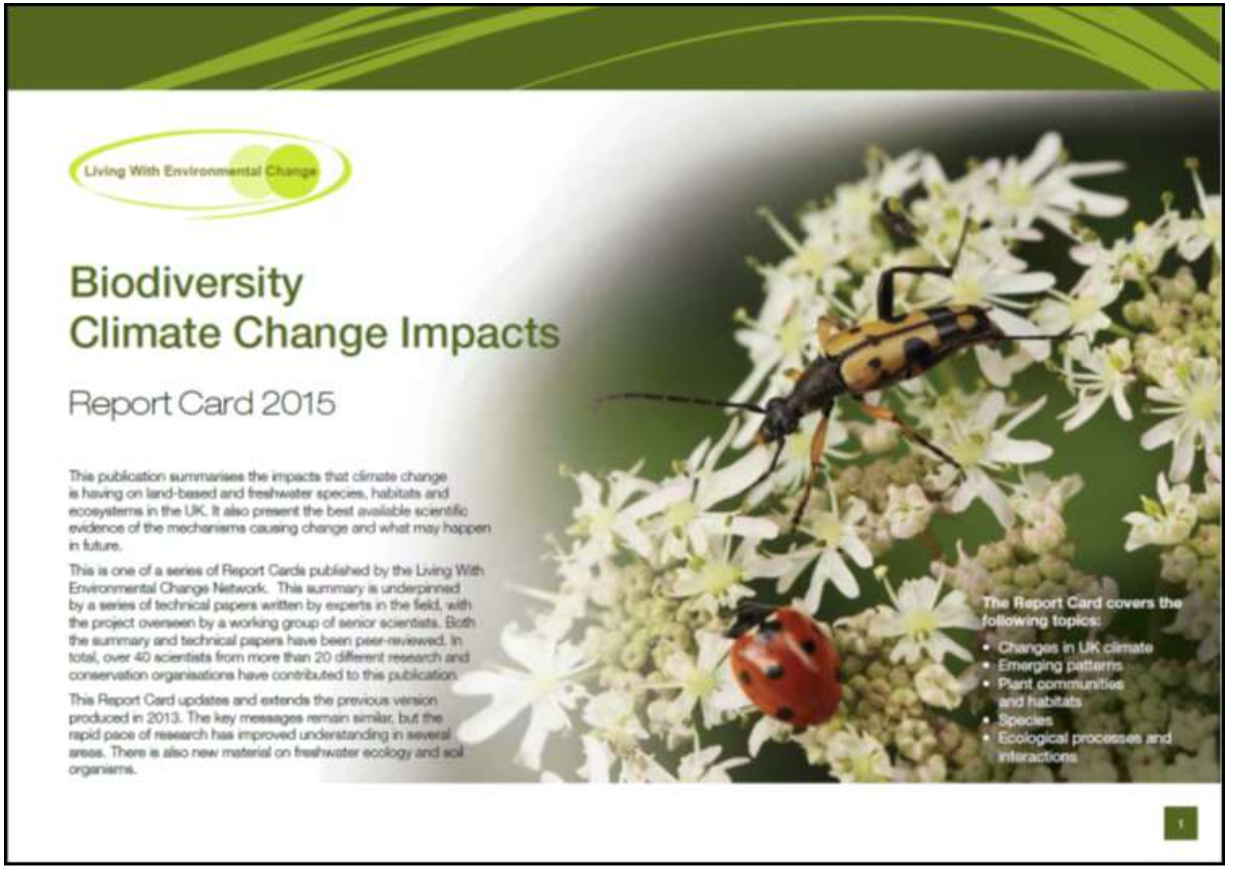
Synthesis report: priorities for the next fi e years



The UK CCRA 2017 Evidence Report

- 3 years
- c80 authors
- >2,000 pages
- 6,000 review comments
- 6 priority areas

There is strong evidence that climate change is affecting UK biodiversity. *Impacts are expected to increase as the magnitude of climate change increases.*



Living With Environmental Change

Biodiversity
Climate Change Impacts

Report Card 2015

This publication summarises the impacts that climate change is having on land-based and freshwater species, habitats and ecosystems in the UK. It also present the best available scientific evidence of the mechanisms causing change and what may happen in future.

This is one of a series of Report Cards published by the Living With Environmental Change Network. This summary is underpinned by a series of technical papers written by experts in the field, with the project overseen by a working group of senior scientists. Both the summary and technical papers have been peer-reviewed. In total, over 40 scientists from more than 20 different research and conservation organisations have contributed to this publication.

This Report Card updates and extends the previous version produced in 2013. The key messages remain similar, but the rapid pace of research has improved understanding in several areas. There is also new material on freshwater ecology and soil organisms.

The Report Card covers the following topics:

- Changes in UK climate
- Emerging patterns
- Plant communities and habitats
- Species
- Ecological processes and interactions

1

Six priority areas

Committee on Climate Change

Priority area	Action
Flooding and coastal change risks to communities, businesses and infrastructure (Ch3, Ch4 **Ch5**, Ch6)	MORE ACTION NEEDED
Risks to health, wellbeing and productivity from high temperatures (**Ch5**, Ch6)	
Risk of shortages in the public water supply, and for agriculture, energy generation and industry (Ch3, **Ch4**, Ch5, Ch6)	
Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity (**Ch3**)	
Risks to domestic and international food production and trade (Ch3, Ch6, **Ch7**)	
New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals (Ch3, **Ch5**, Ch7)	RESEARCH PRIORITY

NOW ------------------------------> FUTURE

RISK MAGNITUDE: LOW | MEDIUM | HIGH

Source: ASC (2016) *UK CCRA 2017 – Synthesis Report*

Climate change risks and opportunities for the natural environment

Natural Assets

Terrestrial (3.2)

Ne1: Risks to species and habitats due to inability to respond to changing climatic conditions

Ne2: Opportunities from new species colonisations

Soils and Land (3.3)

Ne3: Risks and opportunities from changes in agricultural and forestry productivity and land suitability

Ne 4: Risks to soils from seasonal aridity and wetness

Ne8: Risks of land management practices exacerbating flood risk

Ne10: Risks to agriculture, forestry, wildlife and heritage from change in frequency and/or magnitude of extreme weather and wildfire events

Freshwater (3.4)

Ne6: Risks to agriculture and wildlife from water scarcity and flooding

Ne7: Risks to freshwater species from higher water temperatures

Coasts (3.5)

Ne11: Risks to aquifers, agricultural land and habitats from salt water intrusion

Ne12: Risks to habitats and heritage in the coastal zone from sea-level rise; and loss of natural flood protection

Marine (3.6)

Ne13: Risks to, and opportunities for, marine species, fisheries and marine heritage from ocean acidification and higher water temperatures

Cross-cutting Issues (3.7)

Pests and Diseases (3.7.1)

Ne9: Risks to agriculture, forestry, landscapes and wildlife from pests, pathogens and invasive species

Natural Carbon Stores (3.7.2)

Ne5: Risks to natural carbon stores and carbon sequestration

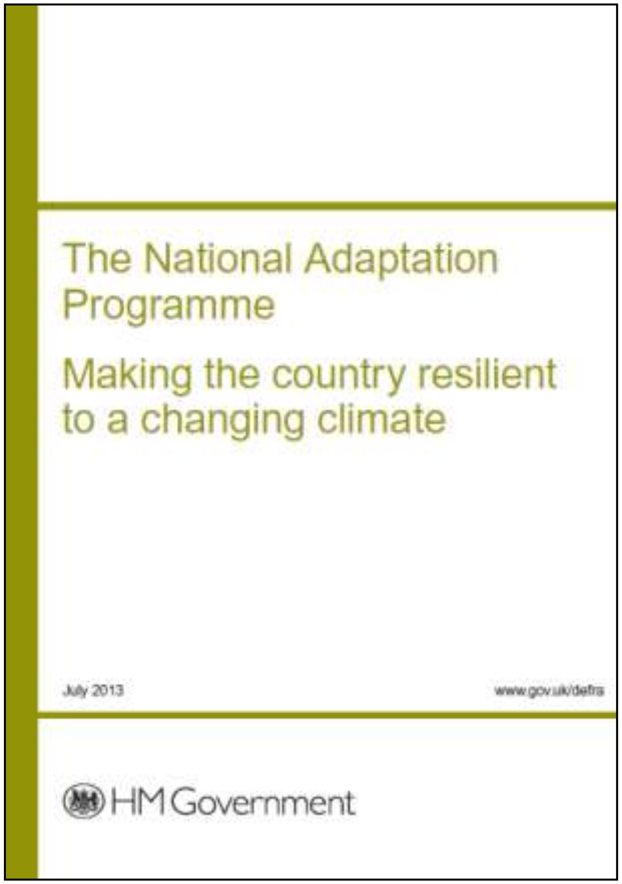
Landscape and Sense of Place (3.7.3)

Ne14: Risks and opportunities from changes in landscape character

Note: Numbers denote the sections of Chapter 3 which discuss the issues presented.

more action needed • sustain current action • research priority • watching brief

NAP 2013 Natural environment theme


The National Adaptation Programme

Making the country resilient to a changing climate

July 2013

www.gov.uk/defra

HM Government

- Building ecological resilience
- Preparing for and accommodating inevitable change
- Valuing the wider adaptation benefits the natural environment can deliver
- Improving the evidence base

Risks and responses – a complex issue……

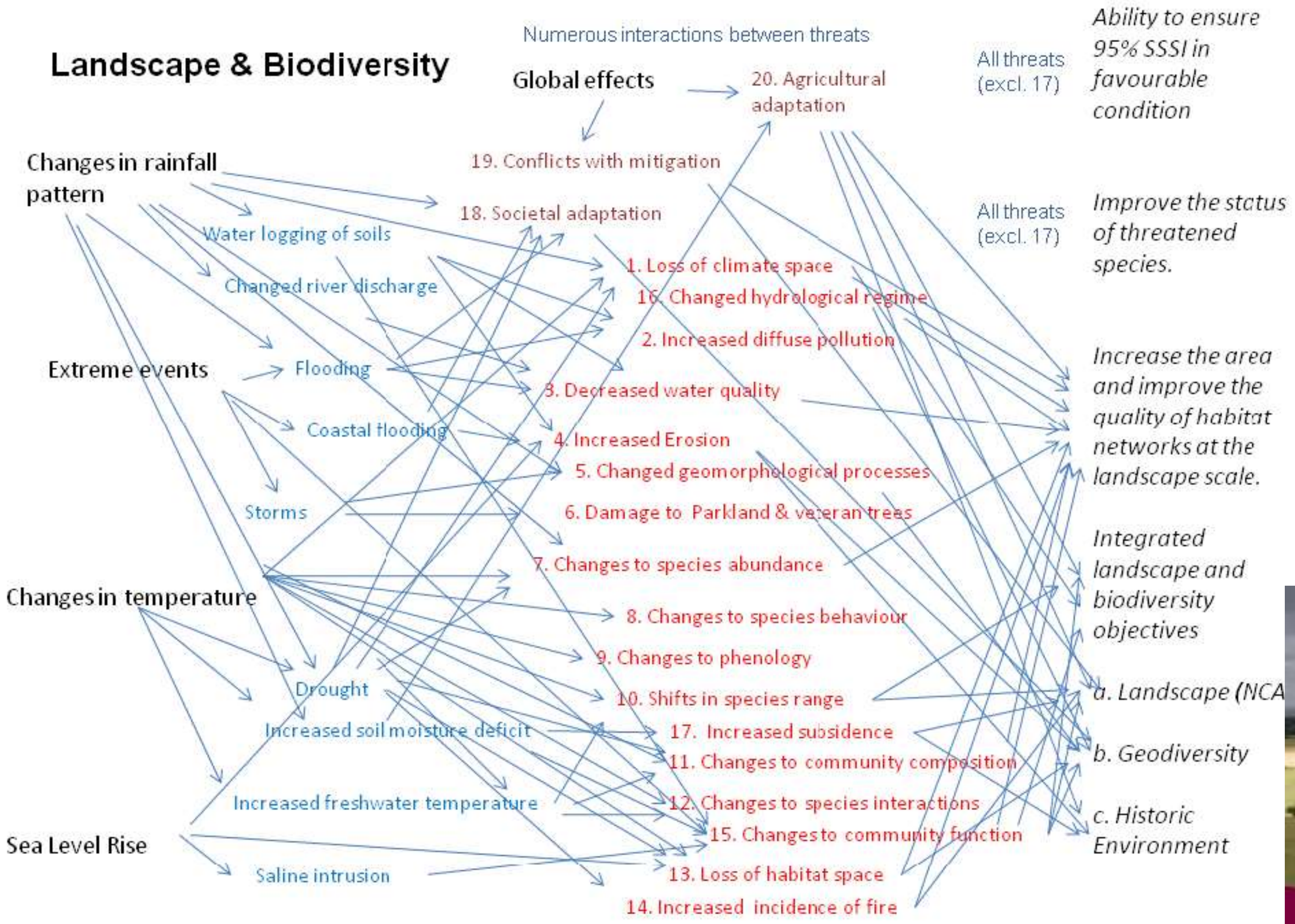


Figure A Threat analysis - Landscape and Biodiversity

What's new since 2013

- Better evidence of the interactions between climate change and land use
- Increasing understanding of the role of microclimate and refugia
- Growing understanding of evolutionary responses to climate change
- New interest in ecosystem based adaptation especially natural flood management
- Growing experience of adaptation
- ………….

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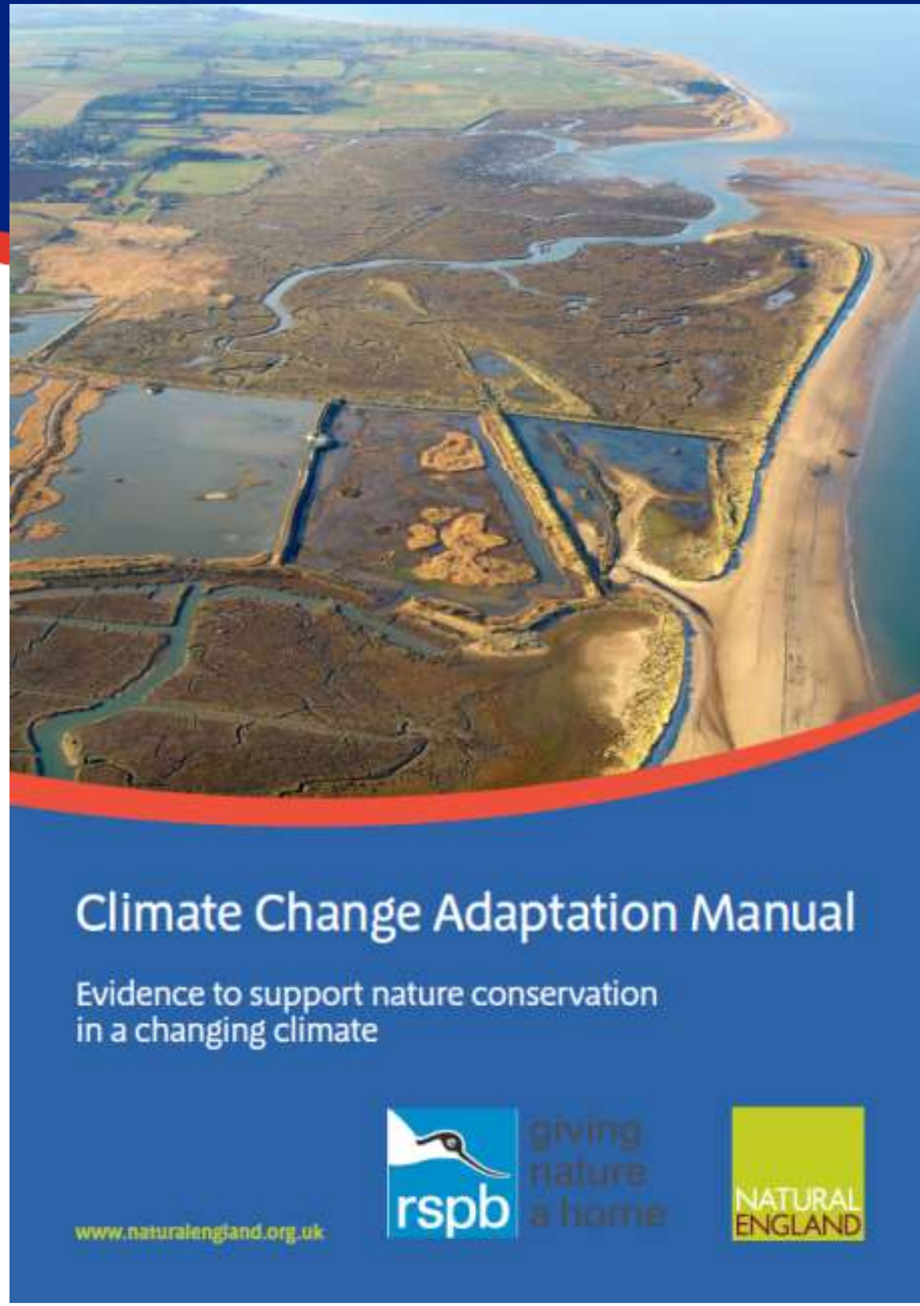


www.naturalengland.org.uk/publications

Ecology for the National Adaptation Programme for Climate Change

Aims

- Review recent developments in the science and practice
- Draw together key messages to inform adaptation to priority risks identified in the Climate Change Risk Assessment
- Promote knowledge exchange between scientists, practitioners and policy makers
- Identify evidence and knowledge gaps

Adaptation principles for the natural environment

Olly Watts, RSPB

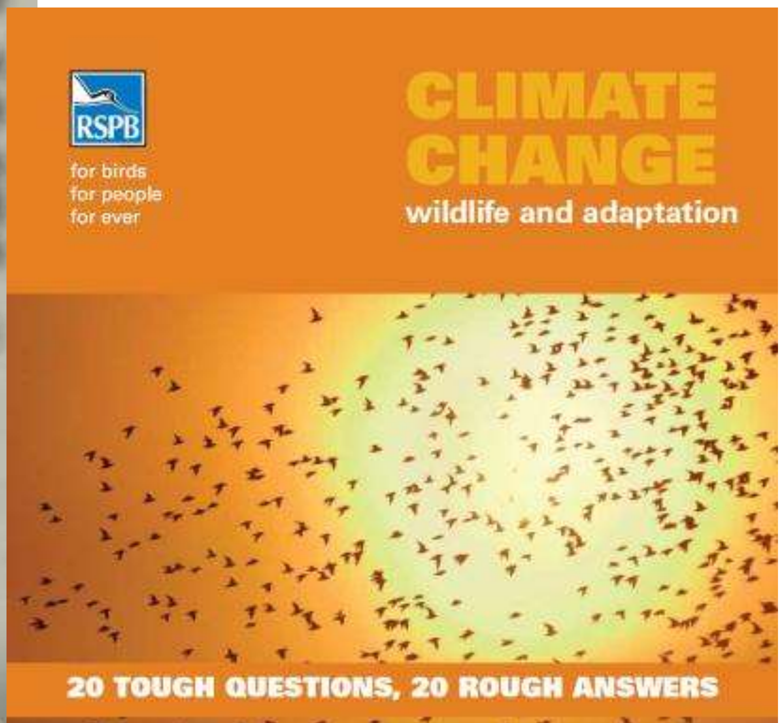
rspb giving nature a home

Adaptation principles for the natural environment

Olly Watts

RSPB Senior Climate Change Policy Officer

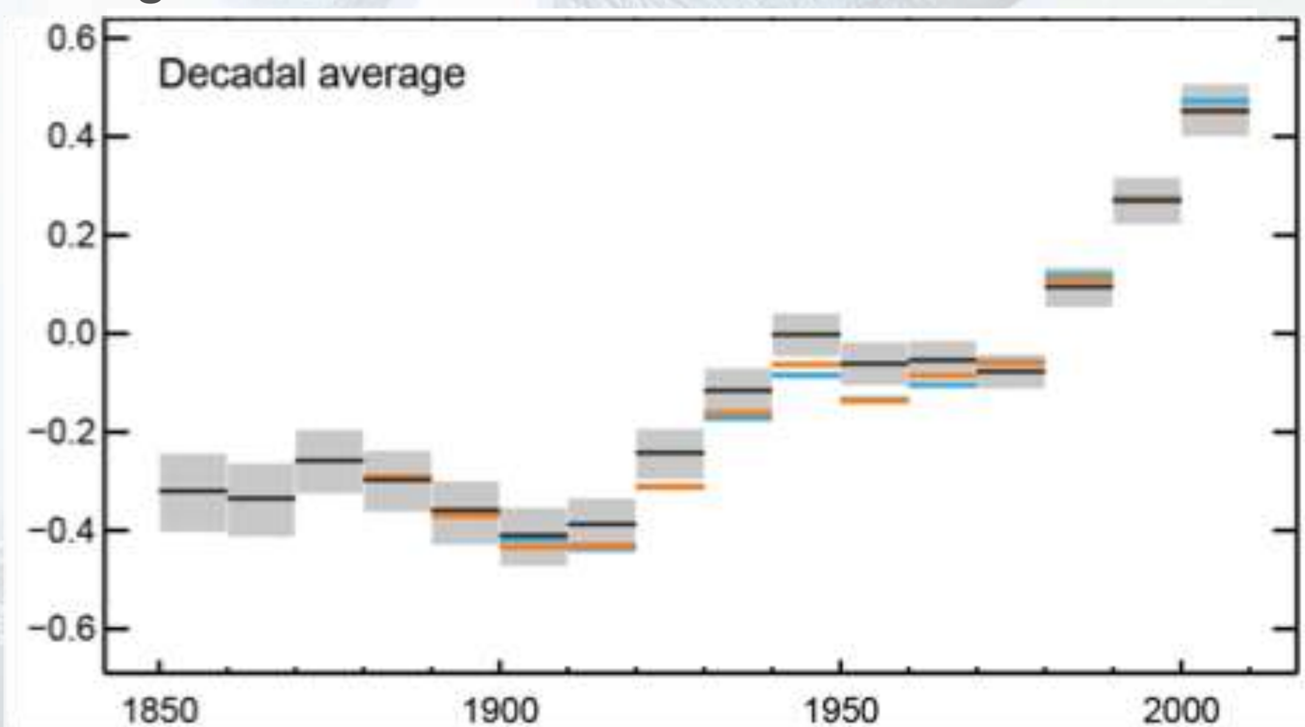
Twenty Tough Questions: Nature policy for climate change



- **Raised issues to define conservation policy and action several years ago**
- **Species important focus**
- **Resilience and accommodation**
- **Protected areas remain important**
- **Wildlife laws still relevant**
- **More land for wildlife - landscape scale developing**
- **Ecosystem based adaptation and ecosystem services**
- **Integrating uncertainty**

Temperatures continue to rise

Each of the past 3 decades has been successively warmer than the preceding decades since 1850



Globally averaged combined land and ocean surface temperatures

AR5 WGI SPM

0.85°C above pre-industrial average global temperature

Climate trends Scotland since 1961

Average annual change observed in Scotland since 1961 (Scotland's Climate Trends Handbook, Sniffer 2014).

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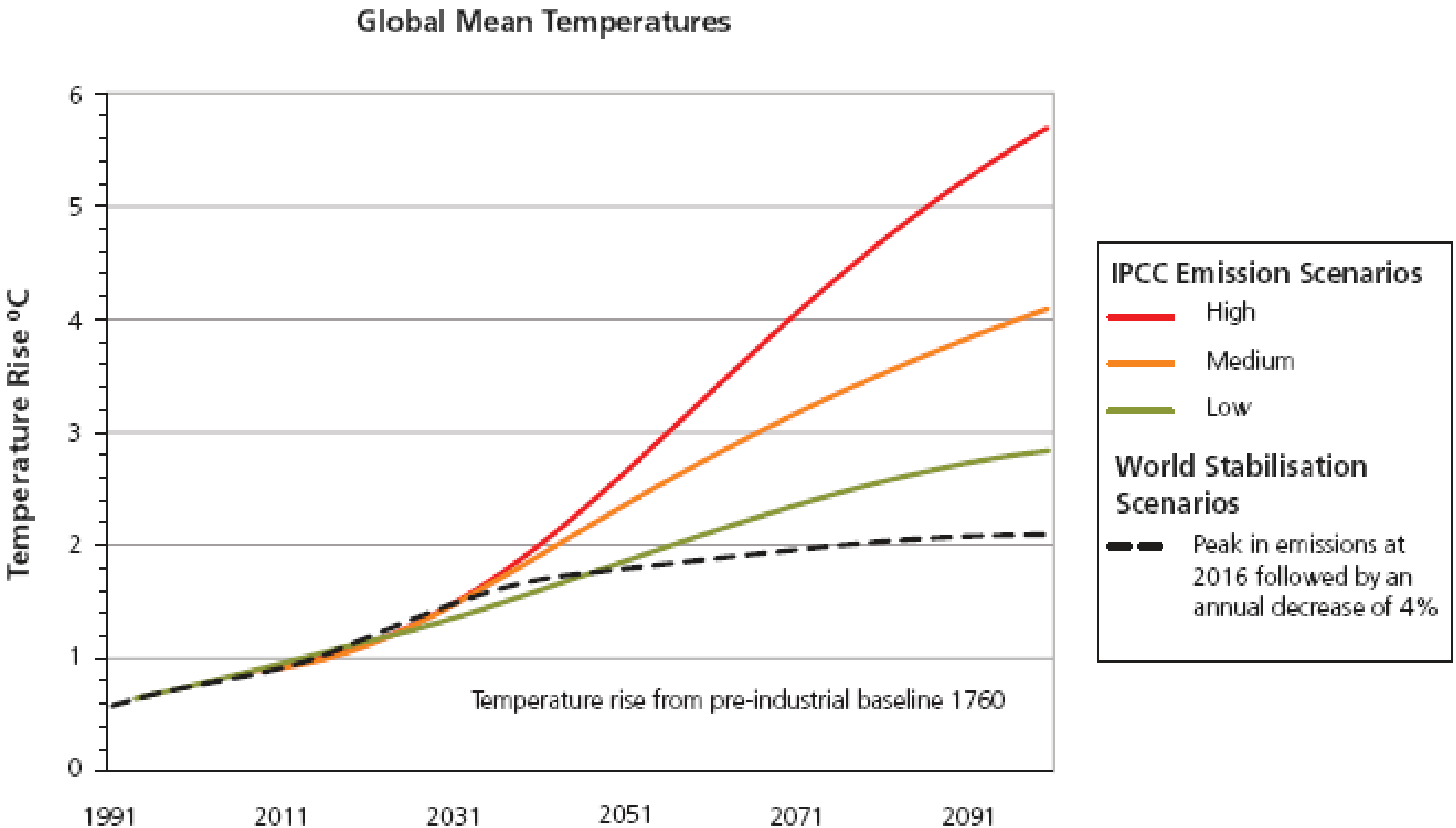
Two Celsius within 25 years



Developing appropriate language for adaptation

- Frame in terms of 2°C and 4°C worlds
- Vulnerability more appropriate than risk
- Journey not a destination
- Embracing uncertainty

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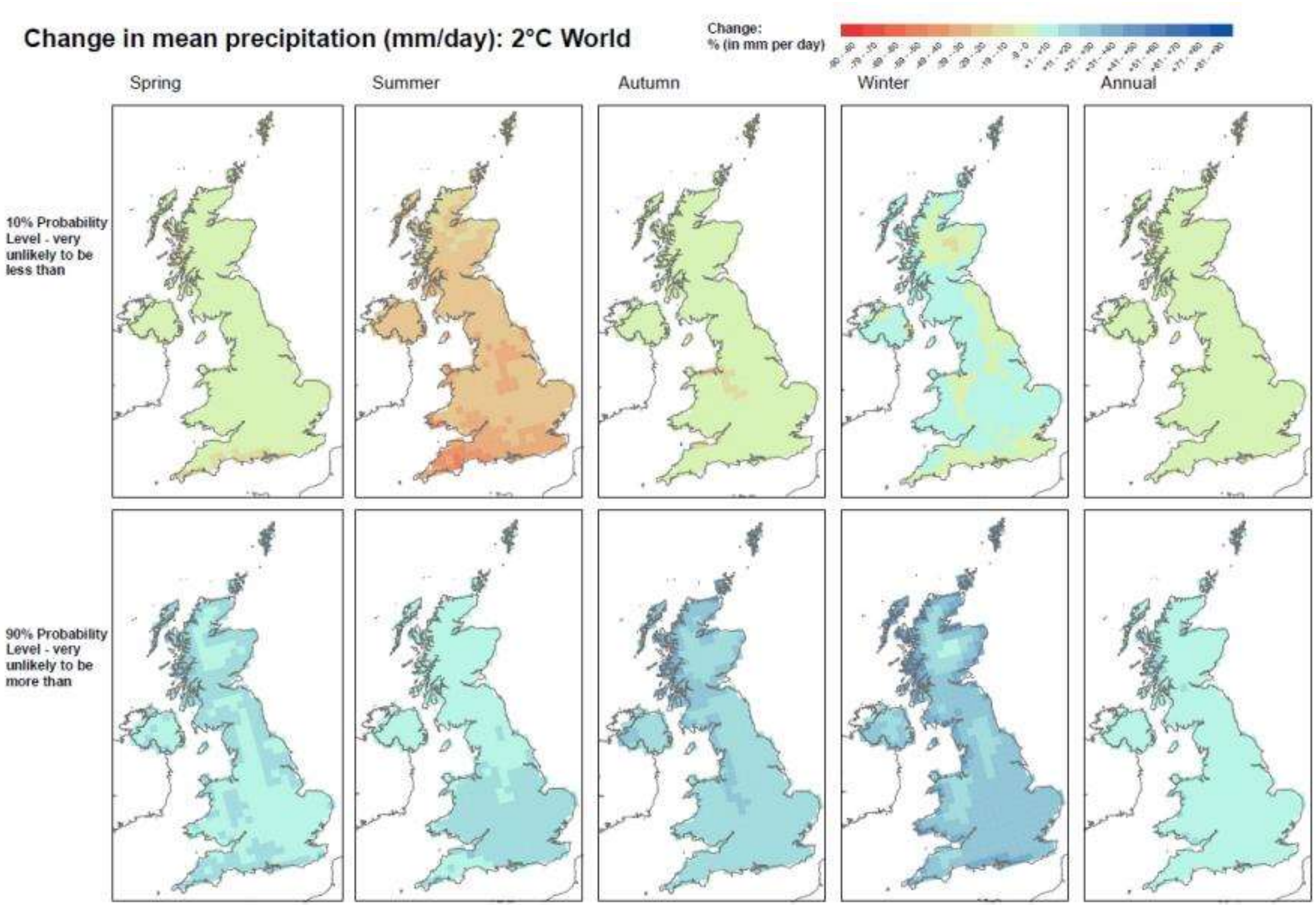
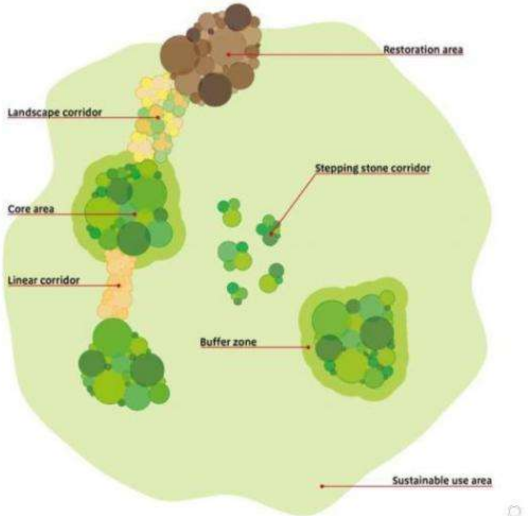
UKCP09 Climate projections - precipitation



Two broad, complementary adaptation strategies

- **Maintain and increase resilience**
  - Strengthening wildlife where it is today
- **Accommodate change**
  - Plan and act for changes in
    - the location and abundance of biodiversity
    - inevitable change in habitats
- **Transformation?**



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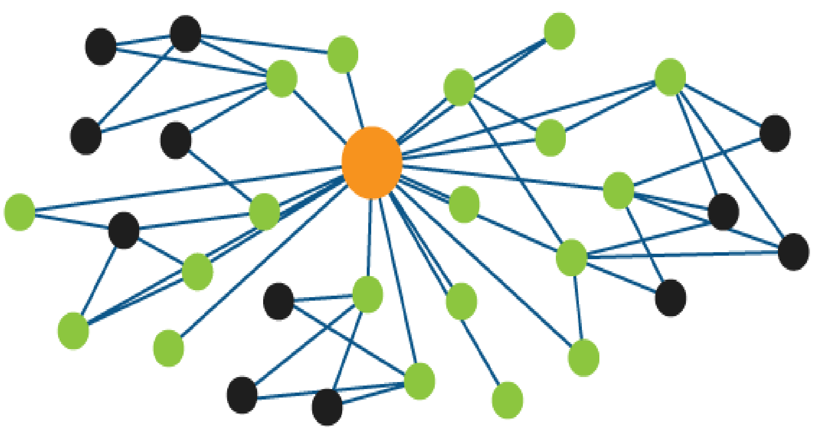
Adaptation over two broad time scales..

Short lead-in time/
short-term impacts
e.g. grazing management
annual control of water levels
Incremental change

Long lead-in time/long-term impacts
eg habitat creation, woodland management, ensuring long-term water supply
Step-change

... and at three spatial scales

- **Specific local needs for biodiversity and habitat**
- **Wider perspective, with neighbouring areas**
- **Strategic regional / country / biogeographic**



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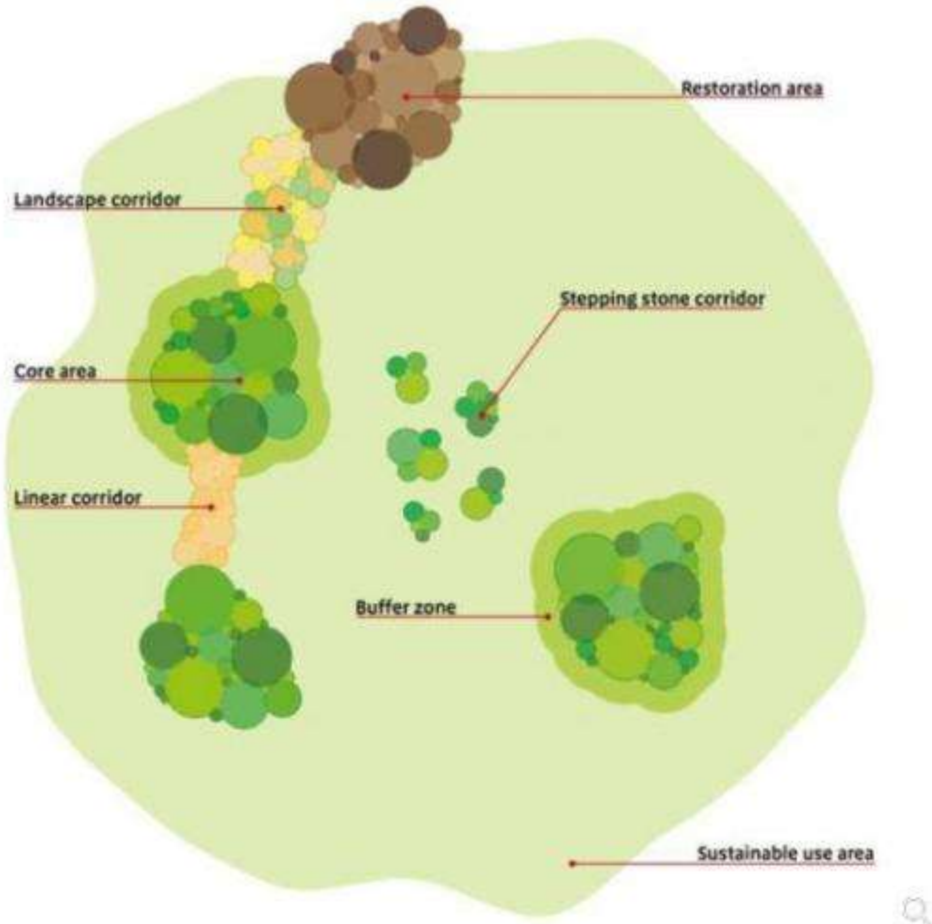
Lawton's nature sites principles



- Bigger
- Better
- More
- More connected

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RSPB nature reserves policies

Defend coastal sites until sufficient replacement habitat has been created

Create new areas of habitat

Translocate some immobile spp

Developing site management




Climate change influences those around us, with implications for our interests

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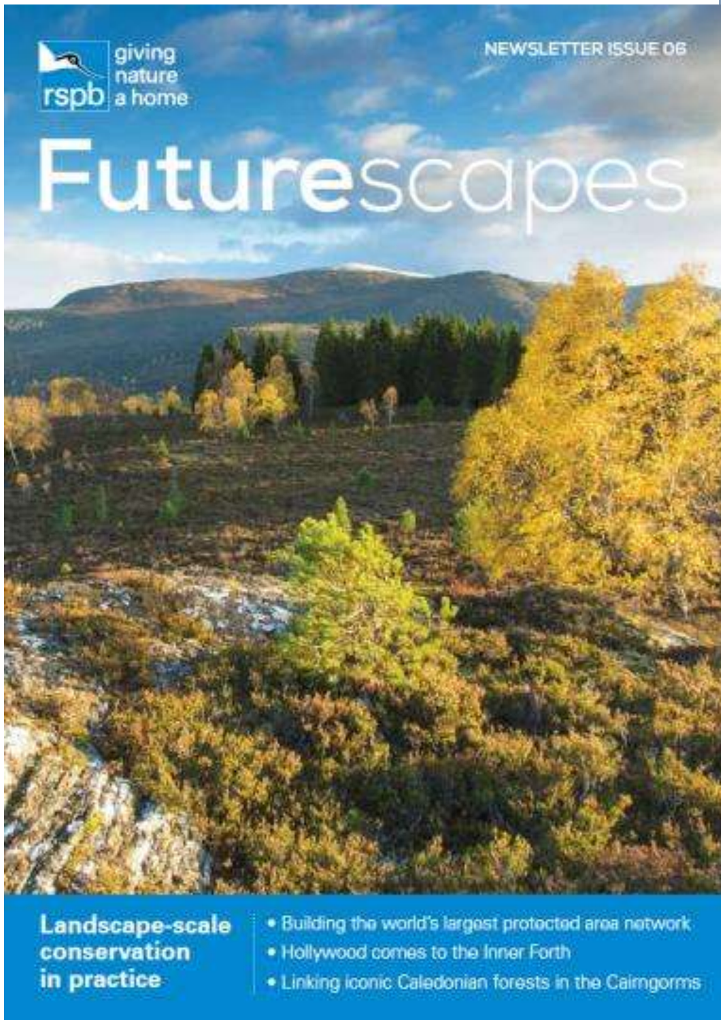
Landscape scale



Cross-sectoral and multi-functional adaptation

- **Nature Based Solutions for adaptation in other sectors**
  - **water management, trees for shade etc**
  - **rural and urban**

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Adaptation for ecosystem services

- **Climate vulnerable ecosystem services?**
- **Maintain, enhance, develop**

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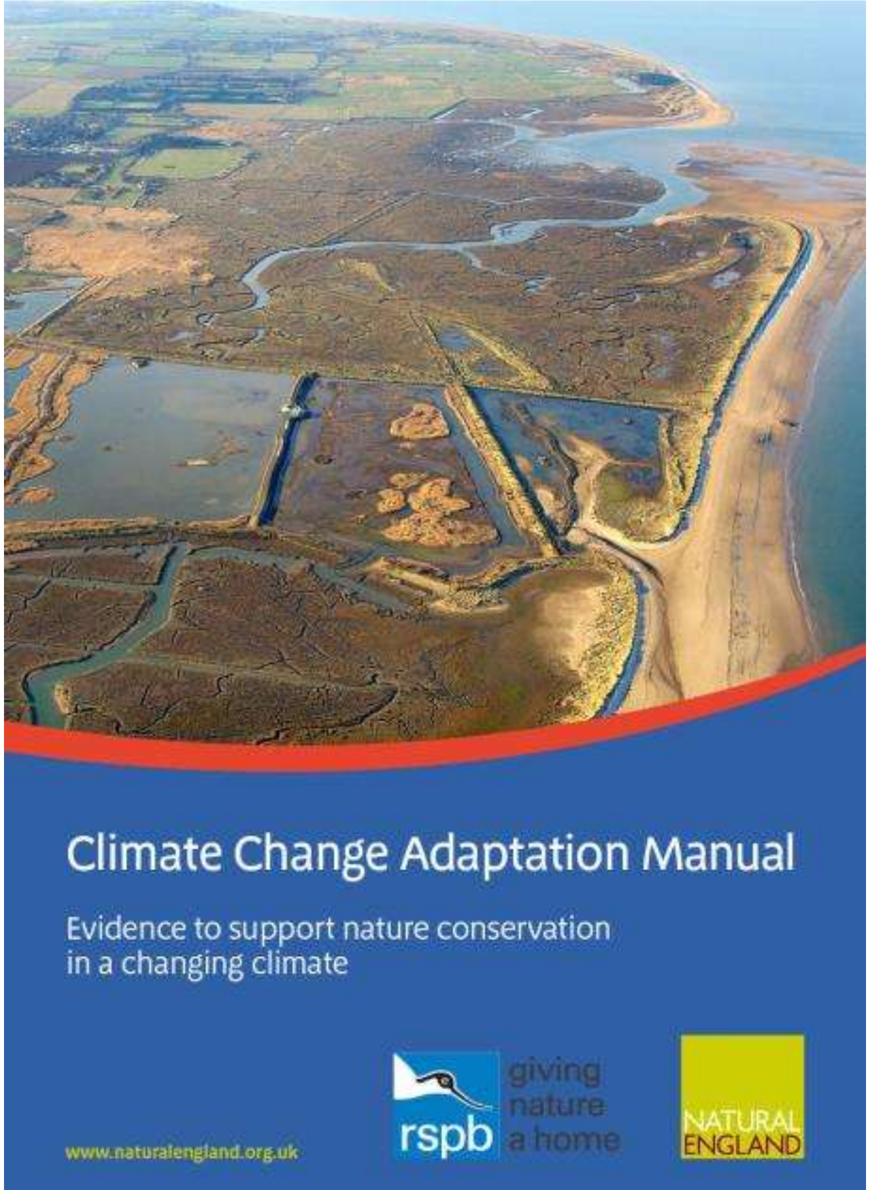
Knowledge: science and experts



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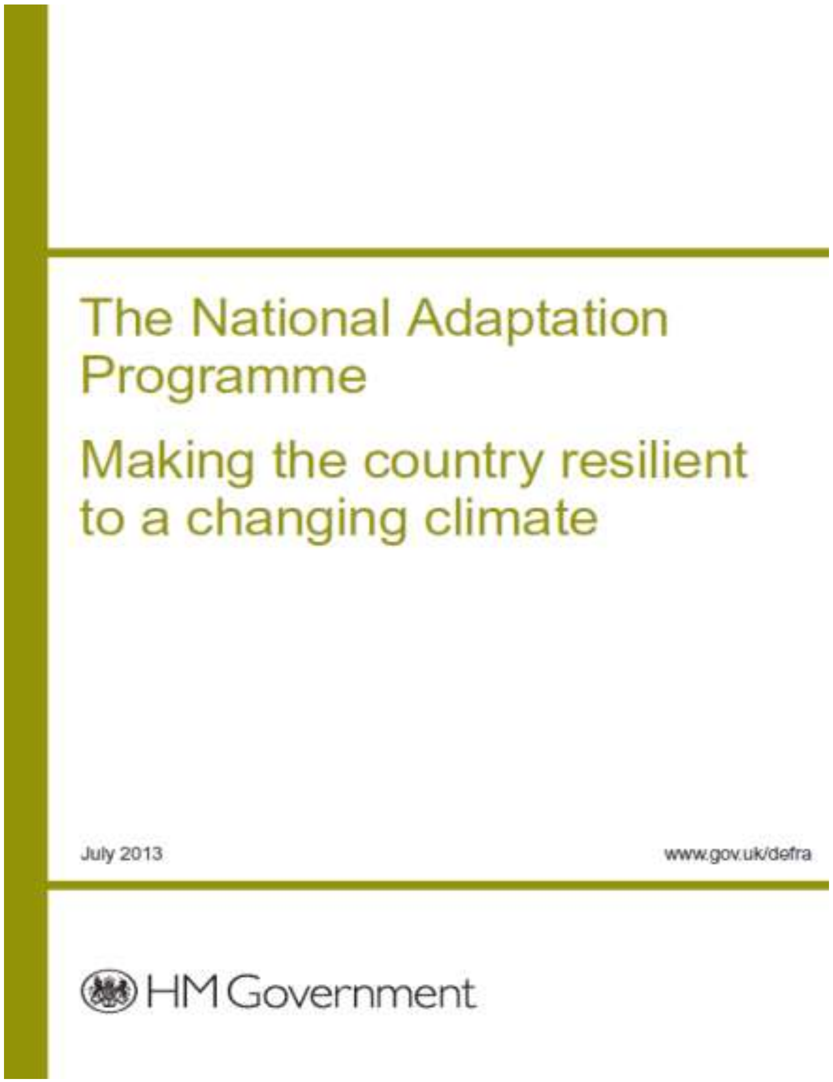
Actions!


The National Adaptation Programme

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HM Government

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- Valuing wider adaptation benefits of the natural environment
- Improving the evidence base

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Adaptating to climate change on Natural England's National Nature Reserves

Simon Duffield, Natural England

Embedding Climate Change Adaptation in National Nature Reserves

Simon Duffield,

Natural England

The challenge

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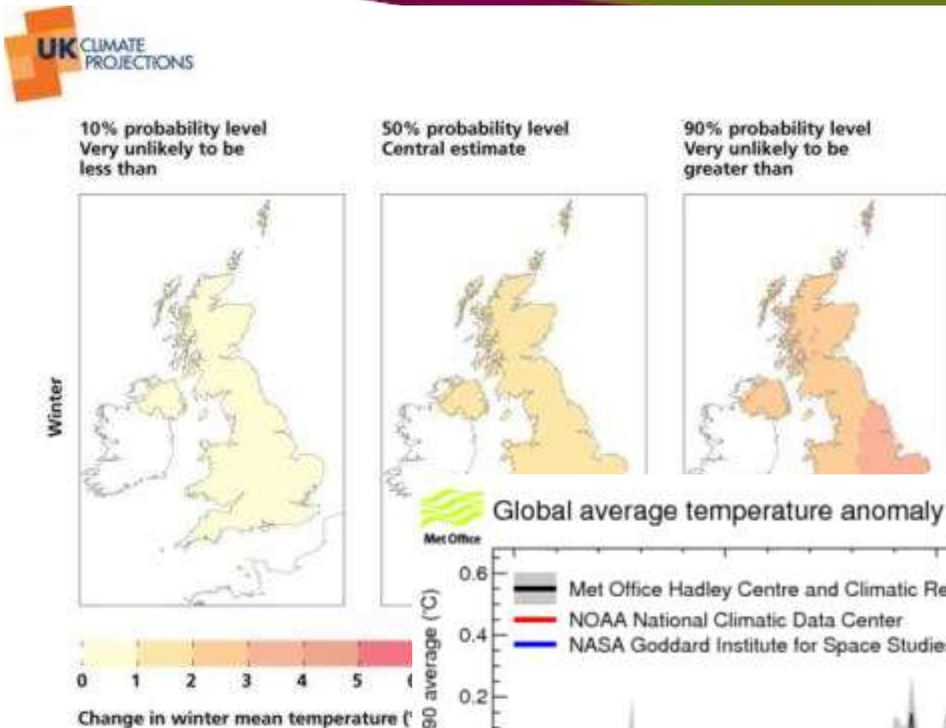
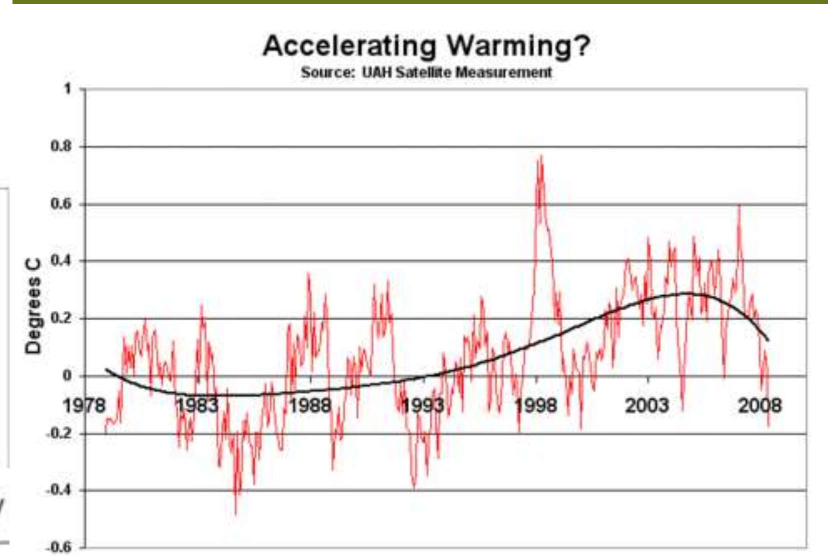
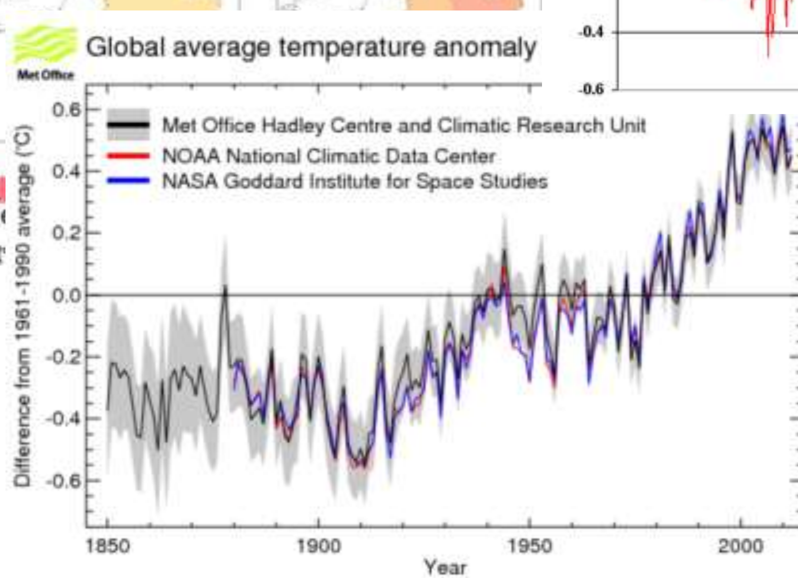




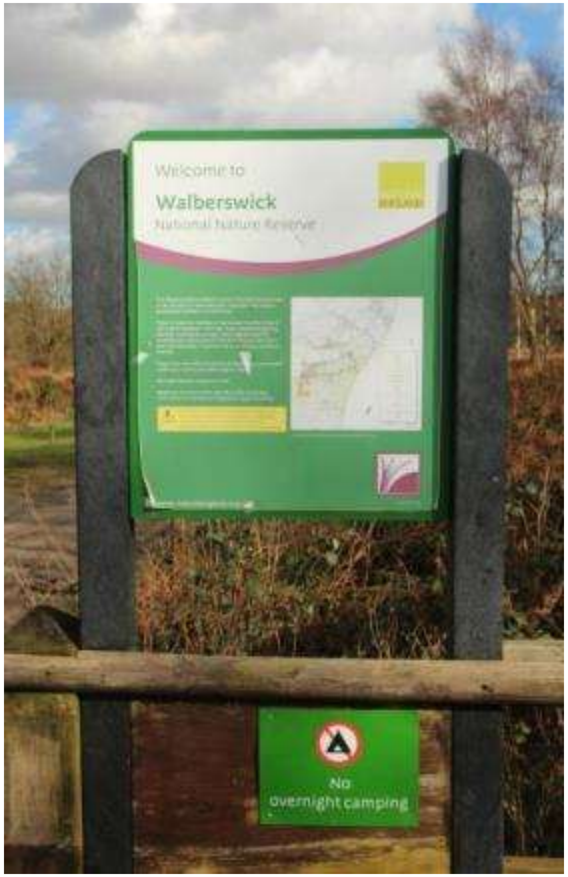


The challenge

Pragmatic
Hands off
Timely

The embedding process

1. Projected Climate Change
2. Impacts
3. Vulnerability Assessment
4. Responses



Focus on vulnerability

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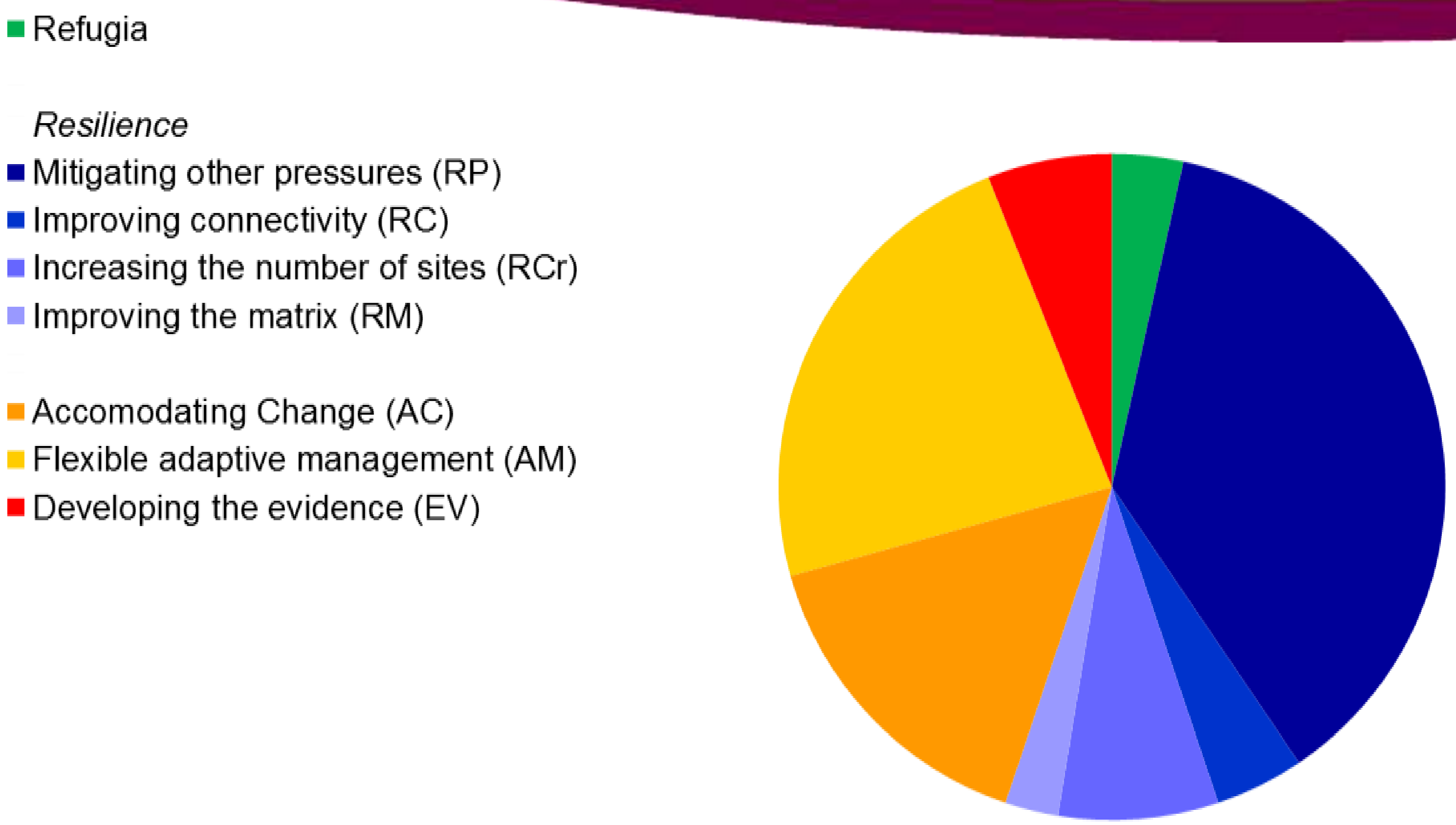
	Vulnerability		
NNR	High	Medium	Low
Aqualate	70%	14%	13%
Stiperstones	100%	19%	0%
Teesmouth	100%	100%	10%
Chippenham	75%	7%	0%
Martin Down	n/a	100%	17%

Features with actions identified

Responses


Refugia
Resilience
Mitigating other pressures (RP)
Improving connectivity (RC)
Increasing the number of sites (RCr)
Improving the matrix (RM)
Accomodating Change (AC)
Flexible adaptive management (AM)
Developing the evidence (EV)

Summary

Positives:
It works

Limitations:
Site based
Current features cf future ones

Actions:
Moderation between site managers
Additional guidance on species
Complete the adaptive management cycle

Finding a home for climate refugees: birds and butterflies in Europe and the UK

Chris Thomas, University of York

Finding a home for climate refugees

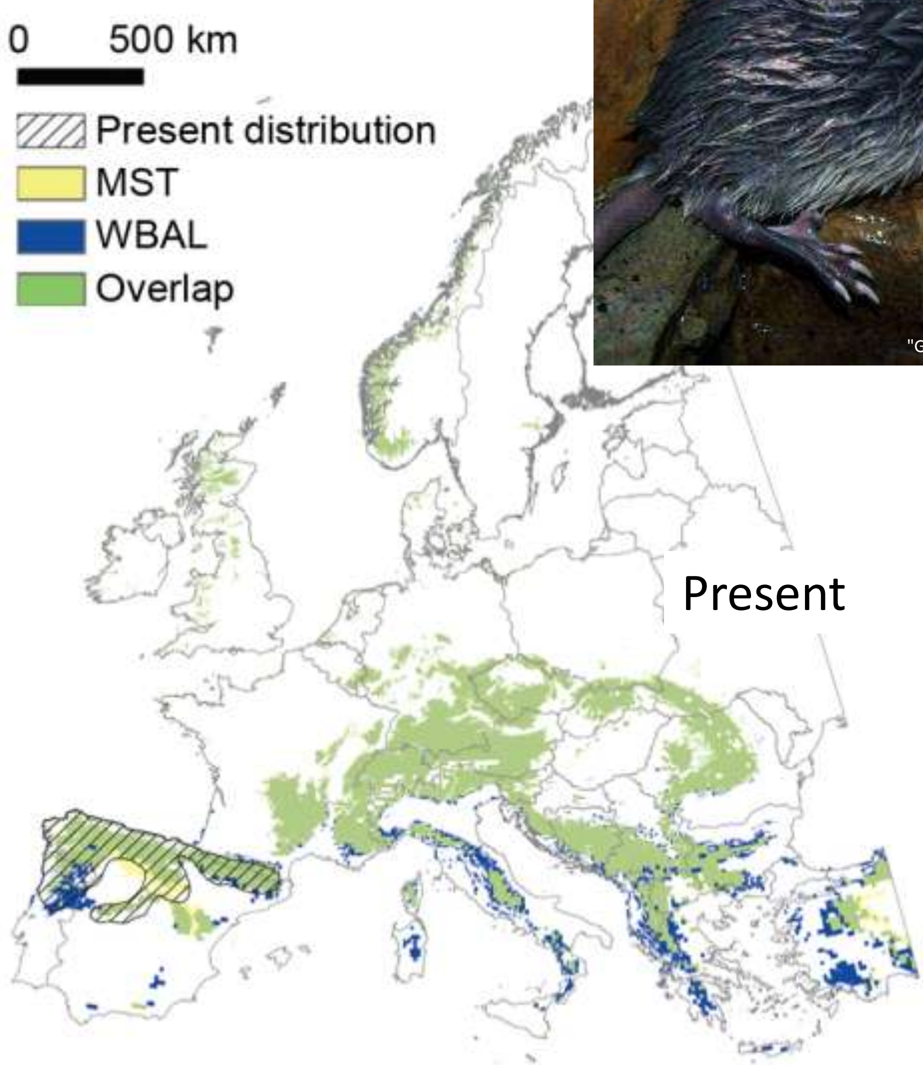
Birds and butterflies in Europe and the UK

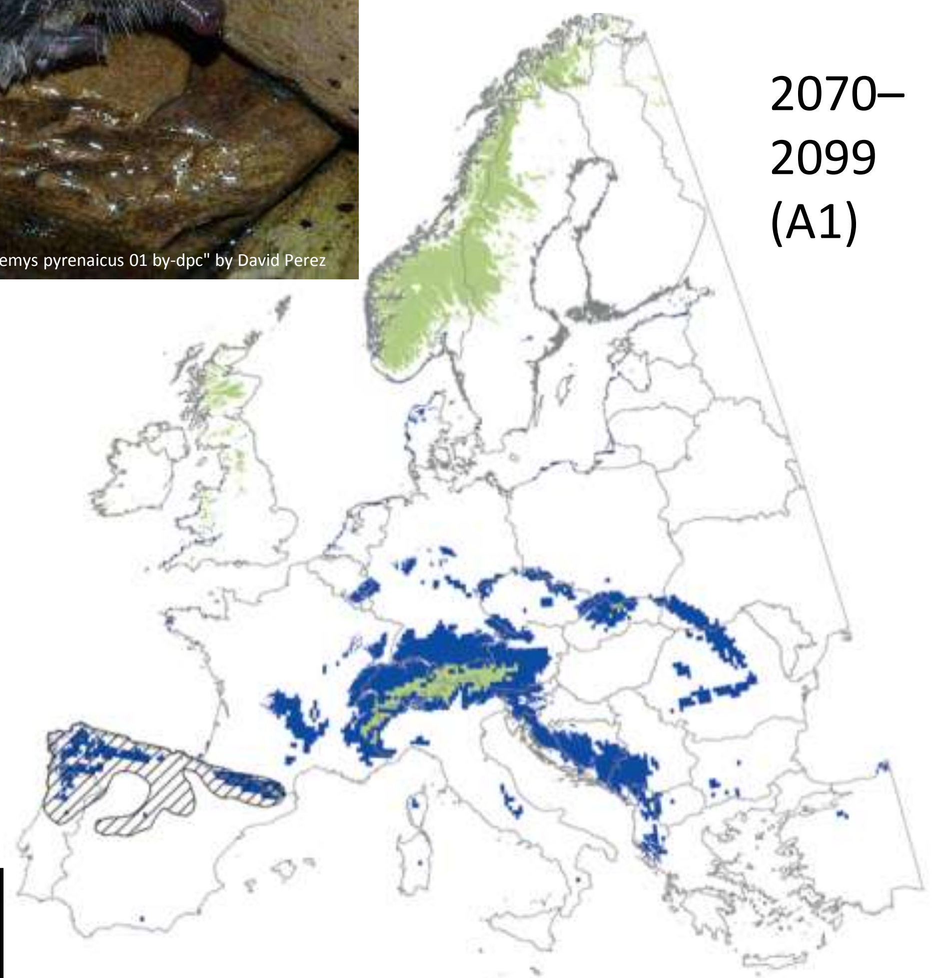
- Which species are at risk of global extinction?
- How can we help?
  - *in situ* (refugia, overlap zones)
  - *ex situ* (holding, gene banks)
  - *trans situ* (joined up, translocation)

Chris Thomas, Chris Wheatley & Colin Beale
chris.thomas@york.ac.uk

Photo: A. Hiley

Present and future potential distribution of the Pyrenean Desman, *Galemys pyrenaicus*, in Europe





Morueta-Holme N, Fløjgaard C, Svenning JC (2010) PLoS ONE 5(4): e10360

BEWARE – provisional numbers!

	Birds (346 species)		Butterflies (377 spp)	
% range overlap*	Lo	Hi	Lo	Hi
0%	14 (4%)	56 (16%)	47 (12%)	178 (47%)
>0, <25%	5 (1%)	36 (10%)	21 (6%)	53 (14%)
25-50%	29 (8%)	57 (16%)	53 (14%)	56 (15%)
>50%	298 (86%)	197 (57%)	256 (68%)	90 (24%)

* Projected overlap between current modelled and future ranges

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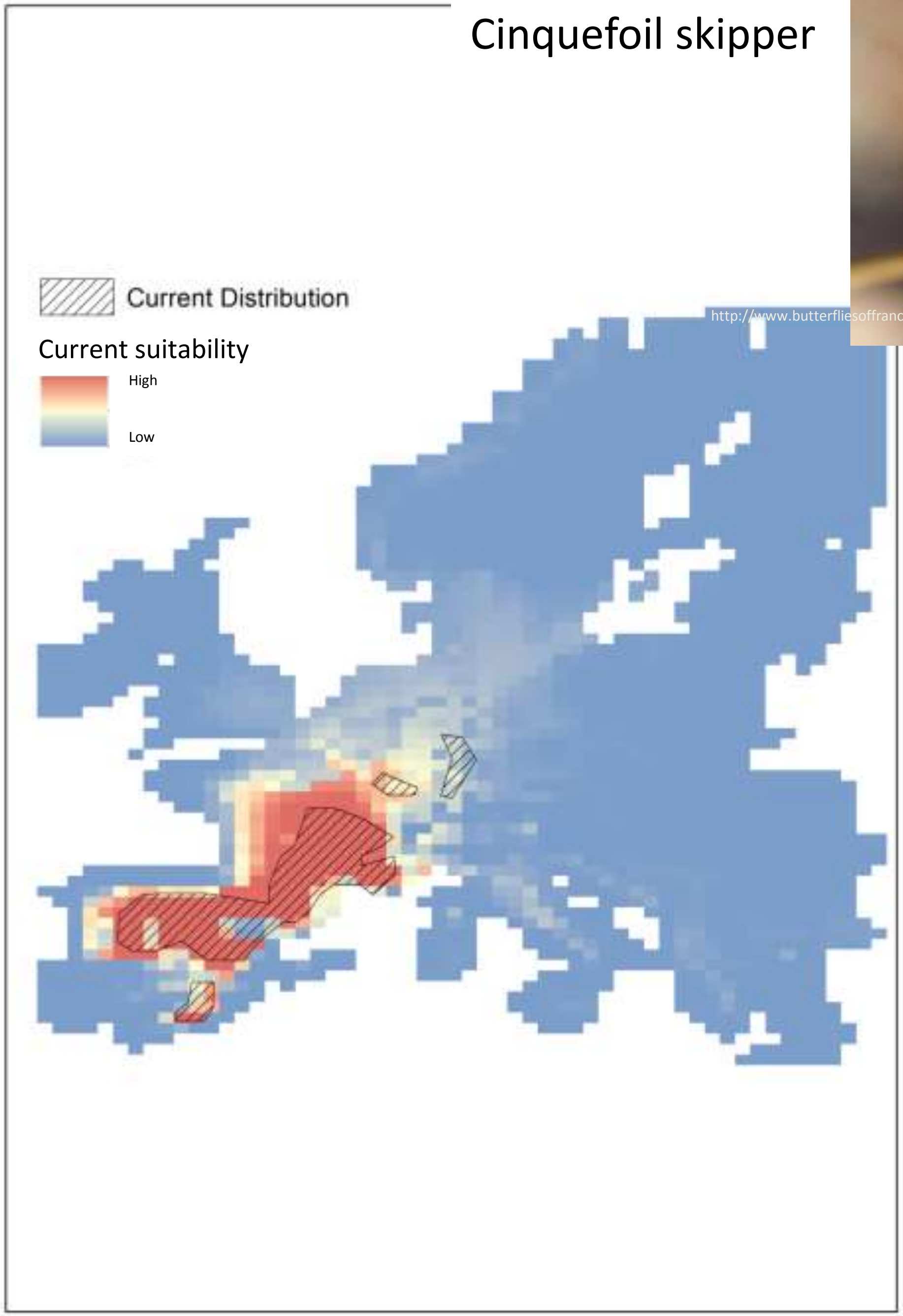
>50%	298 (86%)	197 [illegible]7%)	256 (68%)	90 (24%)

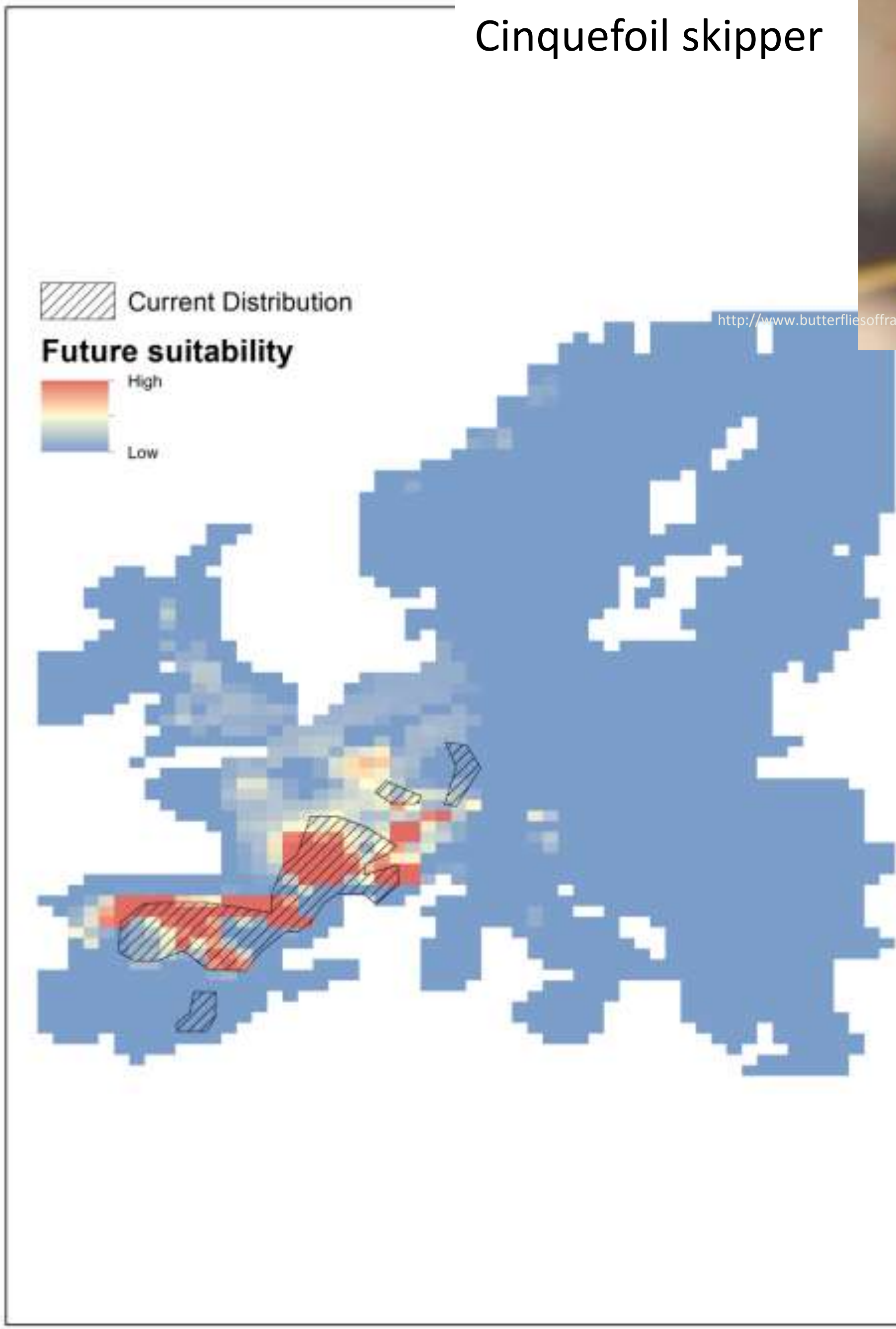
* Projected overlap between current modelled and future ranges

14 birds and 47 butterflies for which *trans situ* solutions should already be planned

Cinquefoil skipper



Cinquefoil skipper



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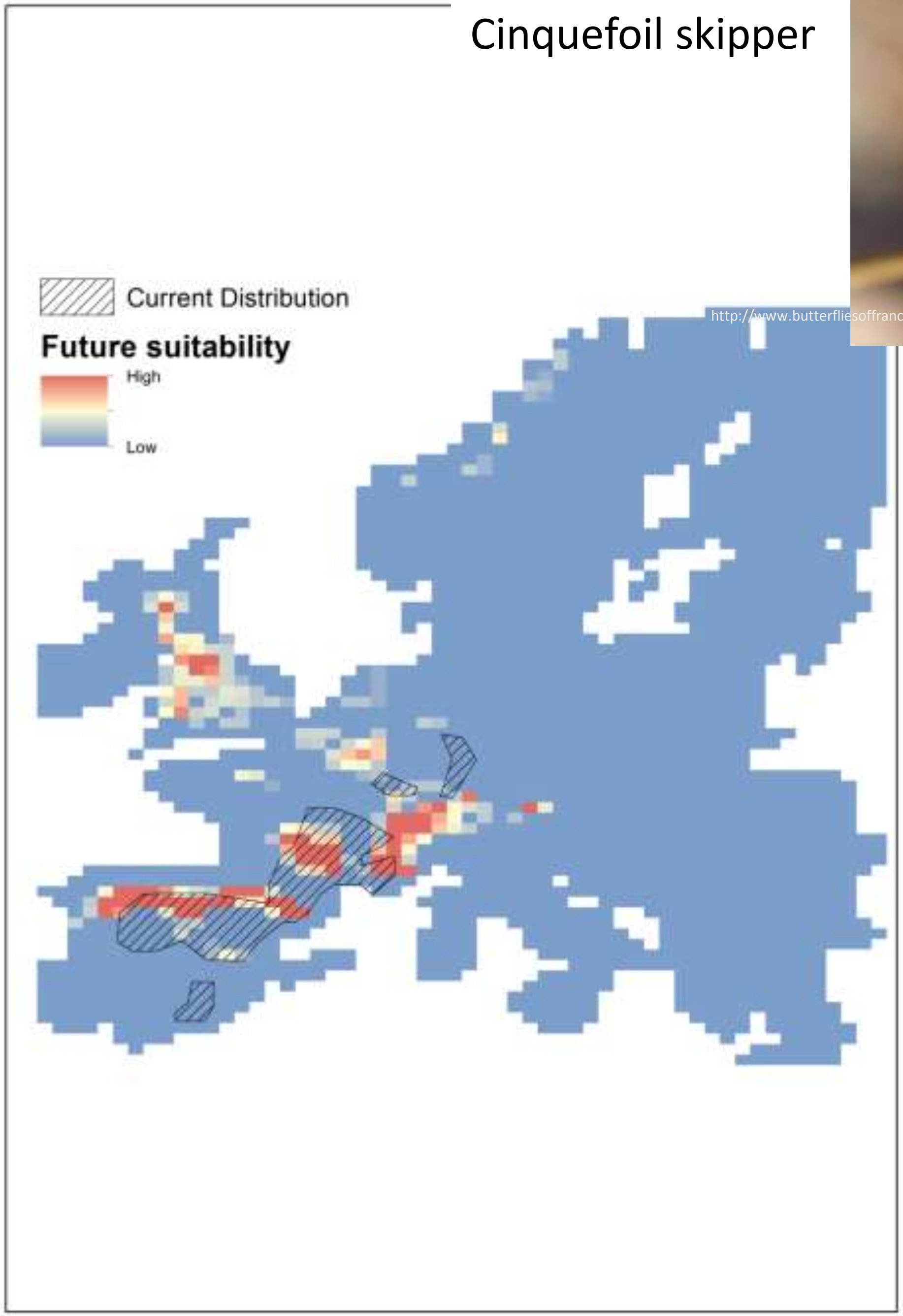

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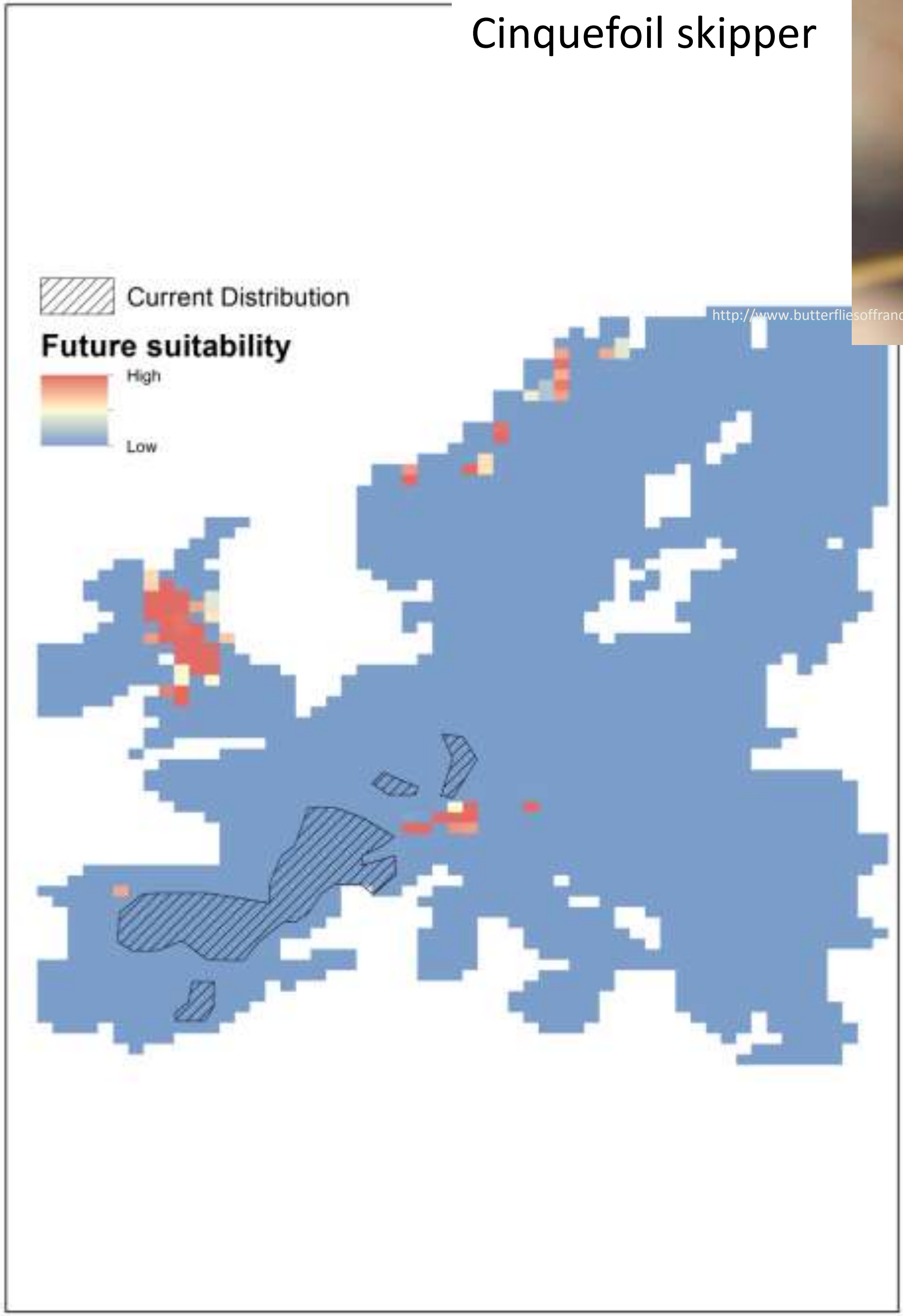

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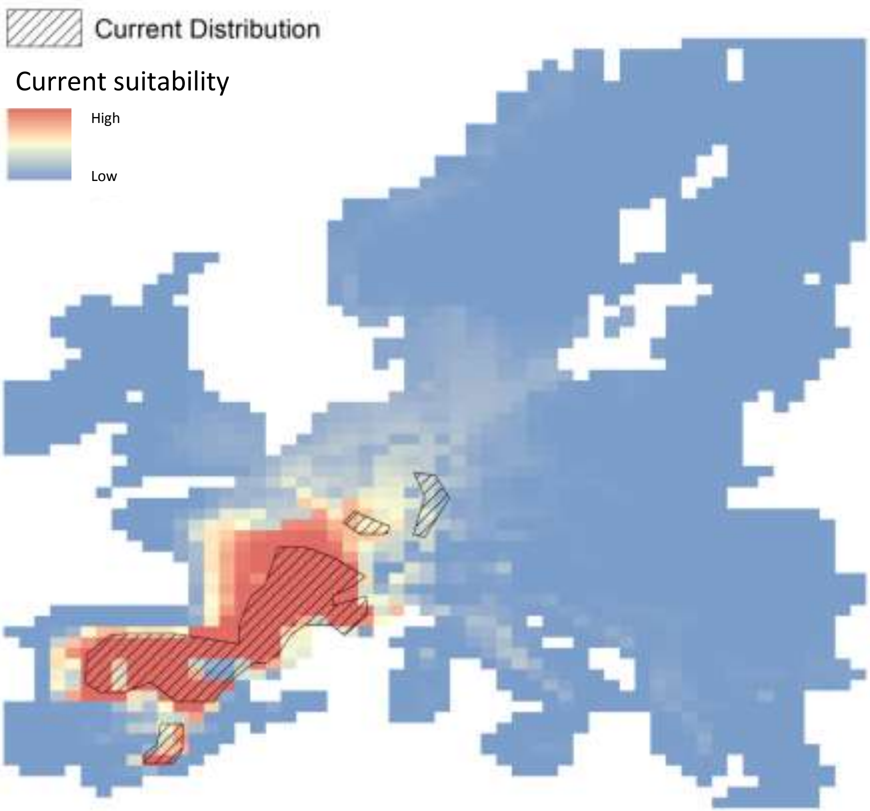
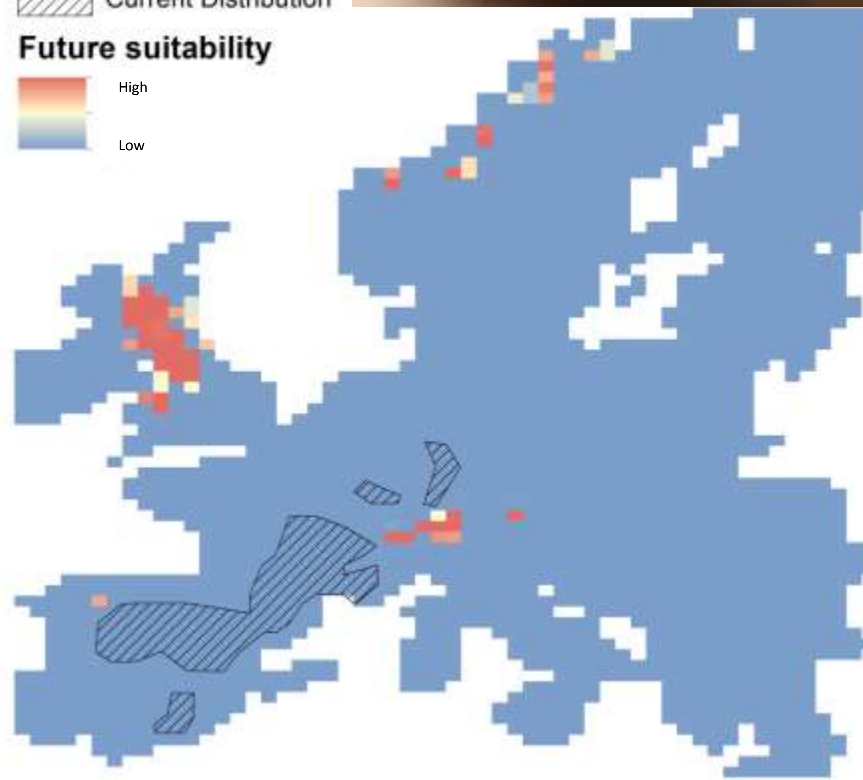


Pyrgus cirsii, present-day



Pyrgus cirsii, RCP8.5, 2080-2100

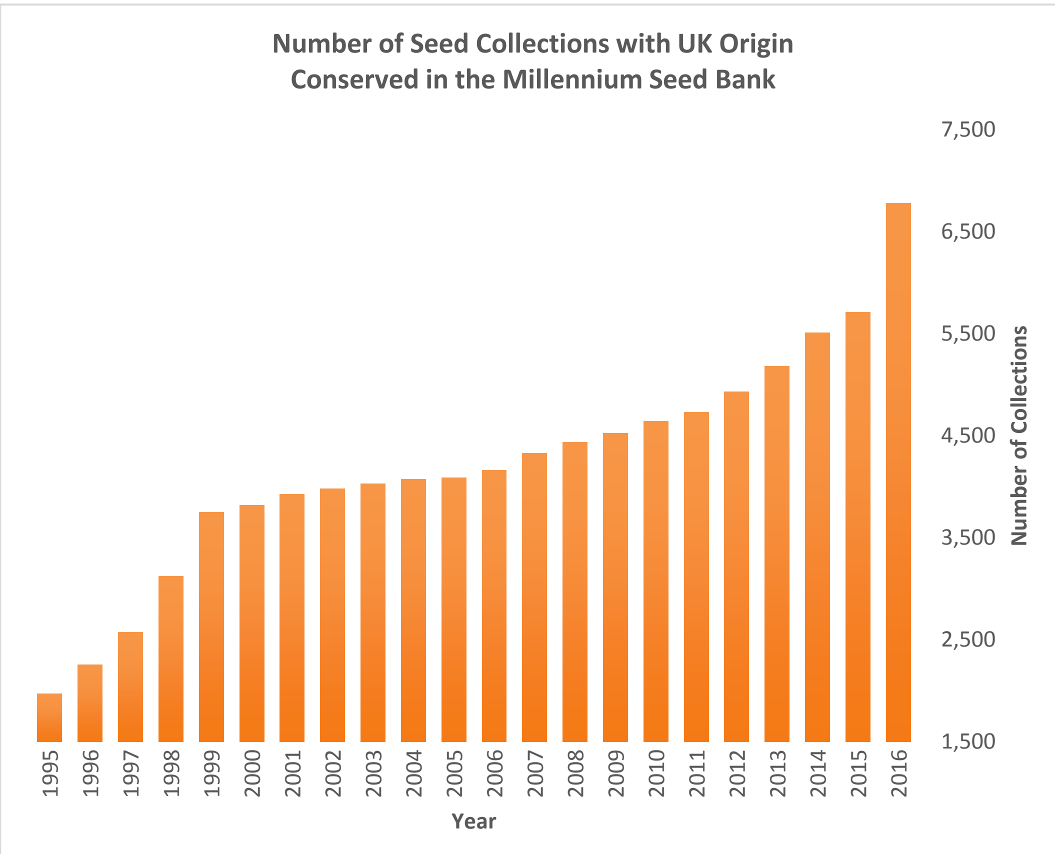
Seed Banking for Climate Change Adaptation

Clare Trivedi, Royal Botanic Gardens Kew

Royal Botanic Gardens Kew

Millennium Seed Bank UK Conservation Programme: our contribution to Climate Change Adaptation

Clare Trivedi
UK Conservation Partnerships Co-ordinator
c.Trivedi@kew.org



The Millennium Seed Bank holds almost 7000 seed collections of UK origin.

96% of the UK native orthodox flora

87% of the 279 threatened UK species

These collections provide a vital back up in case of loss of populations in the wild due to climate change

Royal Botanic Gardens Kew

As appropriate sites or conditions are re-created populations that have been lost are re-introduced from MSB seed collections.

For example:
Ranunculus ophioglossifolius

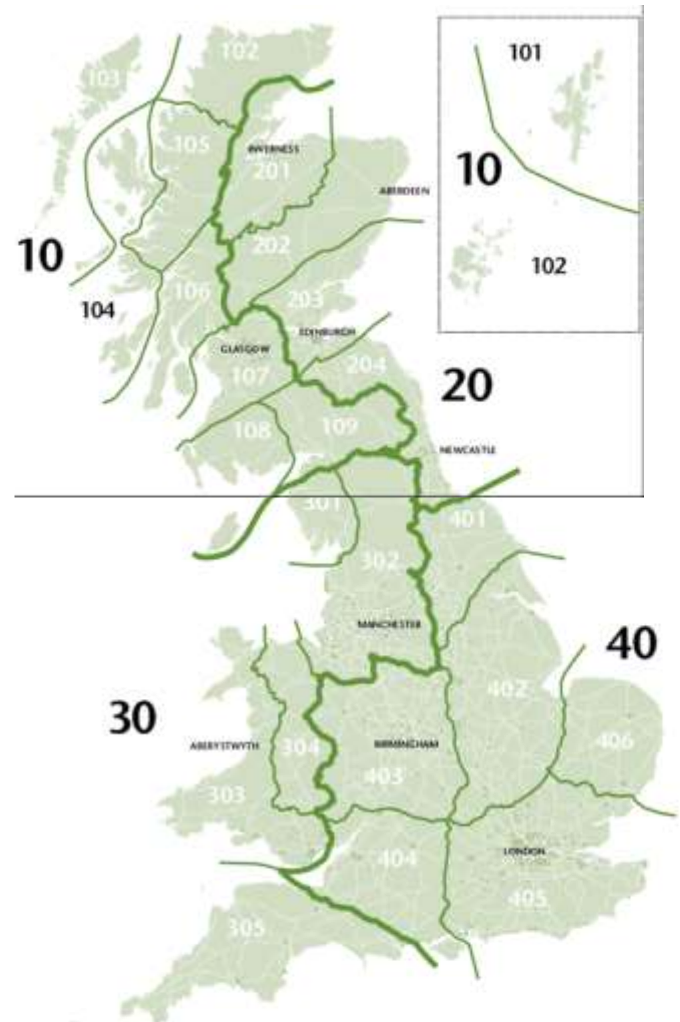
- Schedule 8, VU.
- Kew developed propagation protocols.
- Bulked up seed banked in the MSB.
- Propagated and supplied plug plants.

Royal Botanic Gardens Kew

The UK National Tree Seed Project has seed banked collections from every seed zone in which a species occurs.

Conservation and use of the full diversity of our forest genetic resources could be vital for planting resilient woodlands.

The collections may enable comparative studies on the distribution of traits relevant to climate change adaptation, and may inform better decision making on sourcing of planting material for forestry.



We support the creation and restoration of resilient habitats through:

Supply of high quality, known provenance, planting material

Provision of scientific and technical advice in collection, storage, germination propagation and appropriate use of UK native species

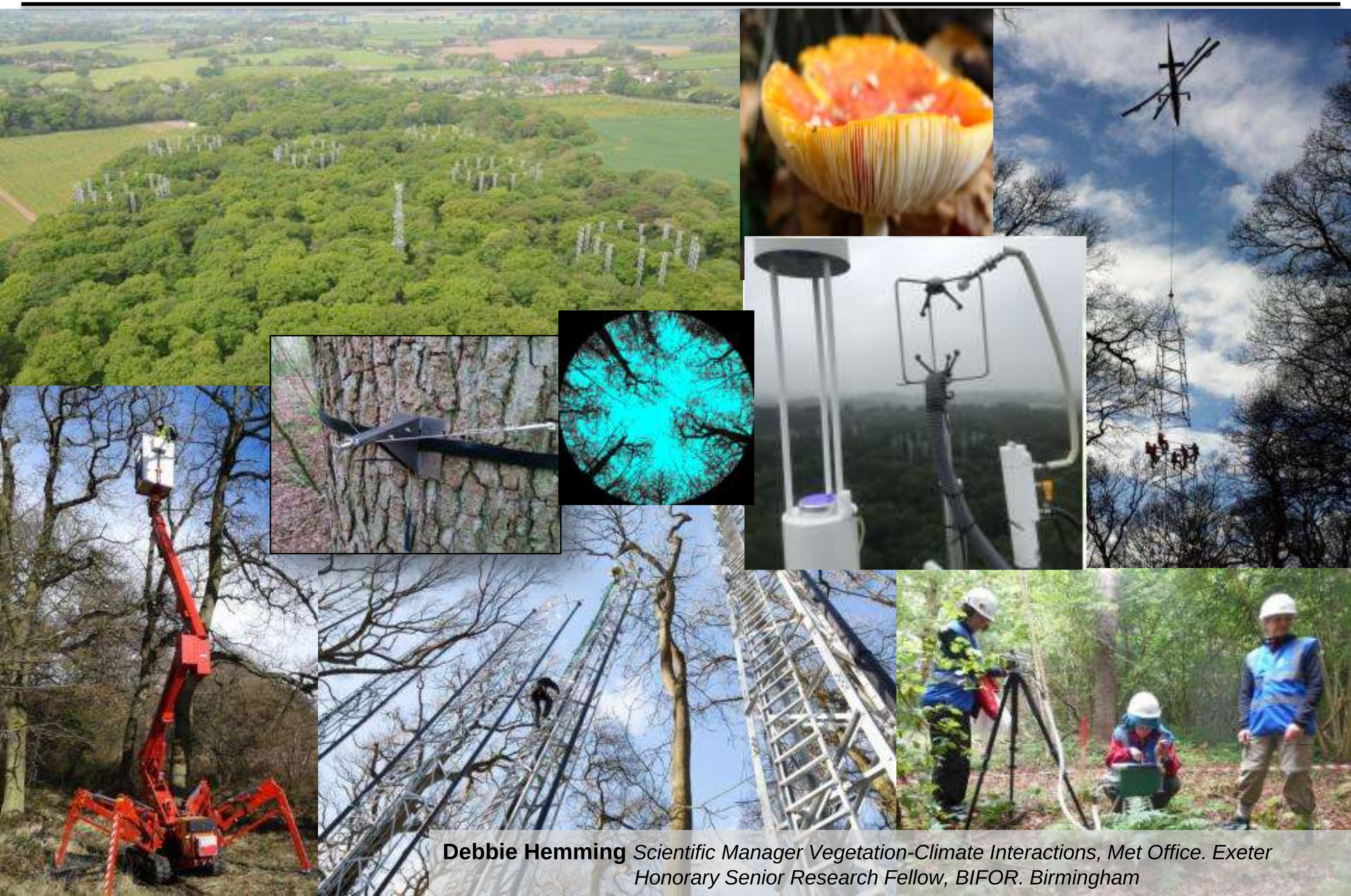
Birmingham Institute of Forest Research (BIFoR)-free-air CO2 enrichment (FACE) facility

Debbie Hemming, Met Office Hadley Centre

Met Office Hadley Centre

BIFOR-FACE – 10 year elevated CO_2 experiment in a mature UK woodland

UNIVERSITY OF BIRMINGHAM | BIFOR



Debbie Hemming *Scientific Manager Vegetation-Climate Interactions, Met Office. Exeter*
Honorary Senior Research Fellow, BIFOR. Birmingham

Location of ‘Mill Haft’ – BIFoR-FACE woodland

Fundamental challenges to be addressed

BIFoR aims to be an internationally leading Institute that will address two fundamental and interrelated challenges:

- The impact of climate and environmental change on woodlands

- The resilience of trees to invasive pests and diseases

See BIFOR web site for details:
http://www.birmingham.ac.uk/research/activity/bifor/face/index.aspx

Acknowledgements & Newsletter

Rob MacKenzie & now Michael Tausz
BIFOR Director

Rick Thomas
BIFOR fluxes, UAVs

Kristine Crous & David Ellsworth
EucFACE Hawksbury Inst. U W Sidney

Liz Hamilton
BIFOR &
U Worcester soils

Neil Loader
U Swansea
Tree ring isotopes

Phil Blaen
BIFOR Hydrologist

Alex 'the squirrel' Poynter
BIFOR Ecologist

Ian Boomer
U Bham Isotope legend

Kadmiel Maseyk
Open U, plant physiology

Climate adaptation in marine protected areas

Brian Huntley, Durham University

Climatic disequilibrium threatens conservation priority forests

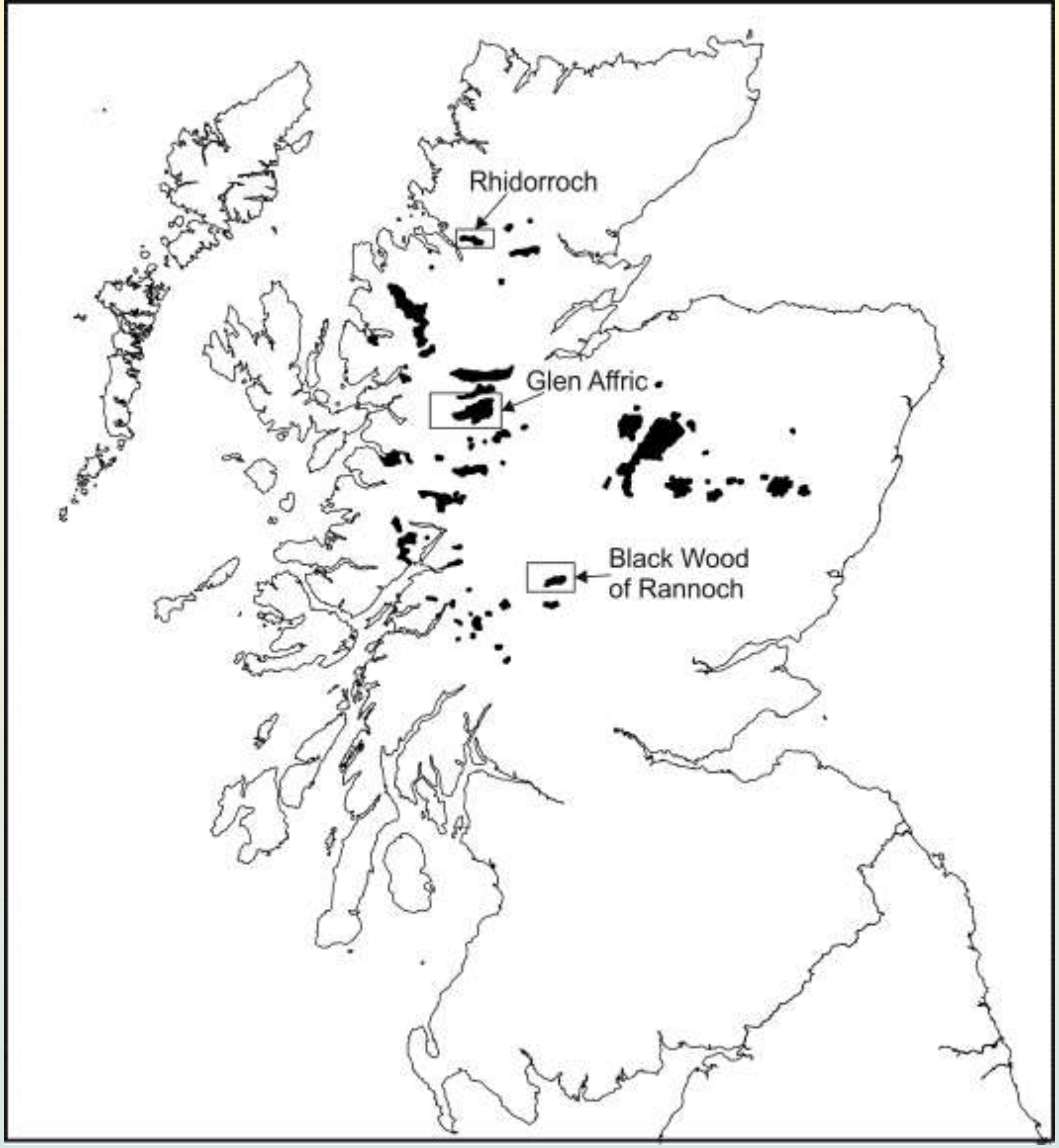
Brian Huntley,

Judy R.M. Allen, Jonathan Bennie,
Yvonne C. Collingham, Paul A. Miller &
Andrew J. Suggitt

Huntley, B., Allen, J.R.M., Bennie, J., Collingham, Y.C., Miller, P.A. & Suggitt, A.J. (2017) Climatic disequilibrium threatens conservation priority forests. *Conservation Letters.*

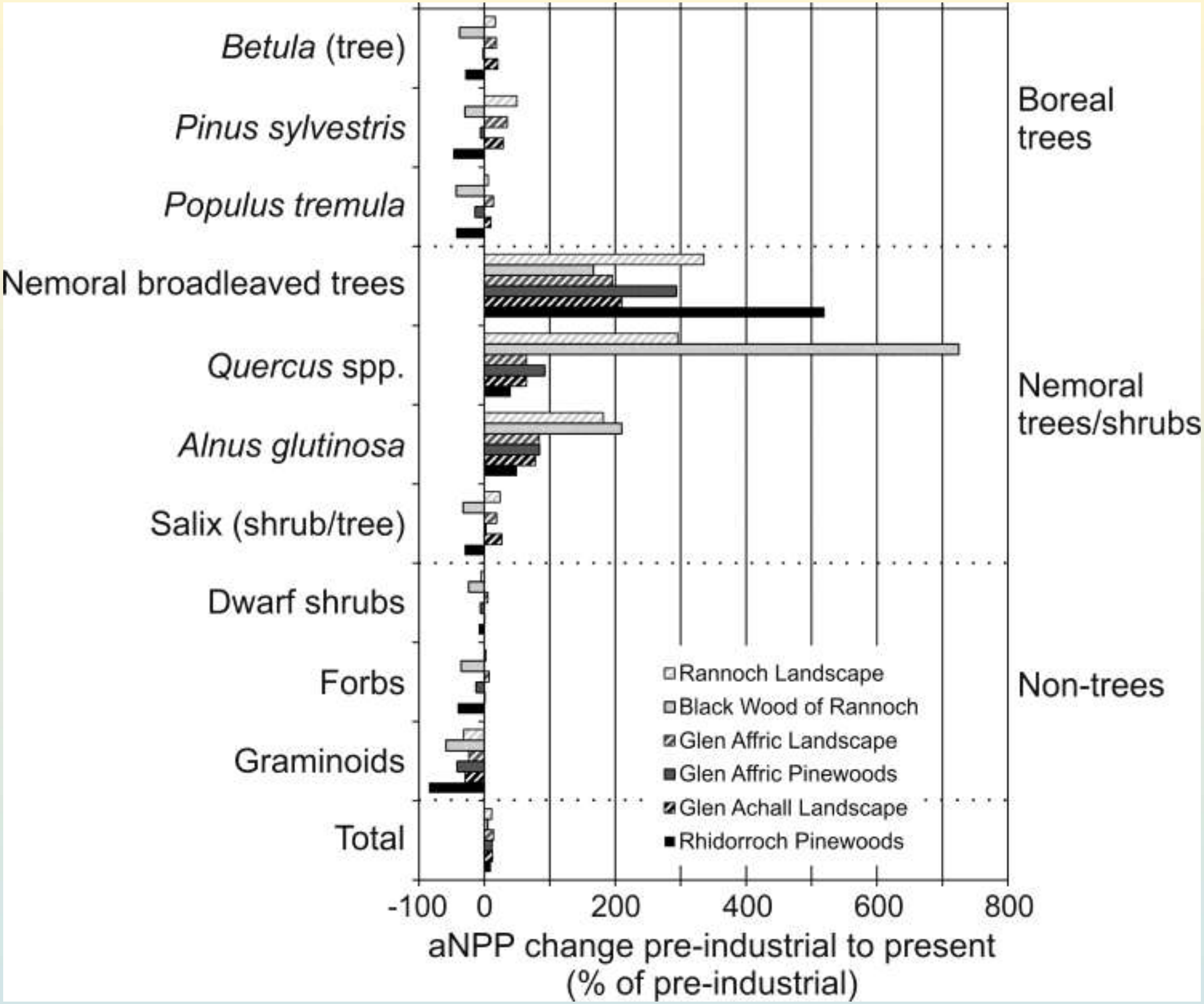
Durham University

Department of Biosciences



Remaining fragments of Caledonian pinewoods

Three study landscapes indicated: Glen Achall, with the Rhidorroch SAC; Glen Affric; and Rannoch, with the Black Wood of Rannoch SAC.



Durham University

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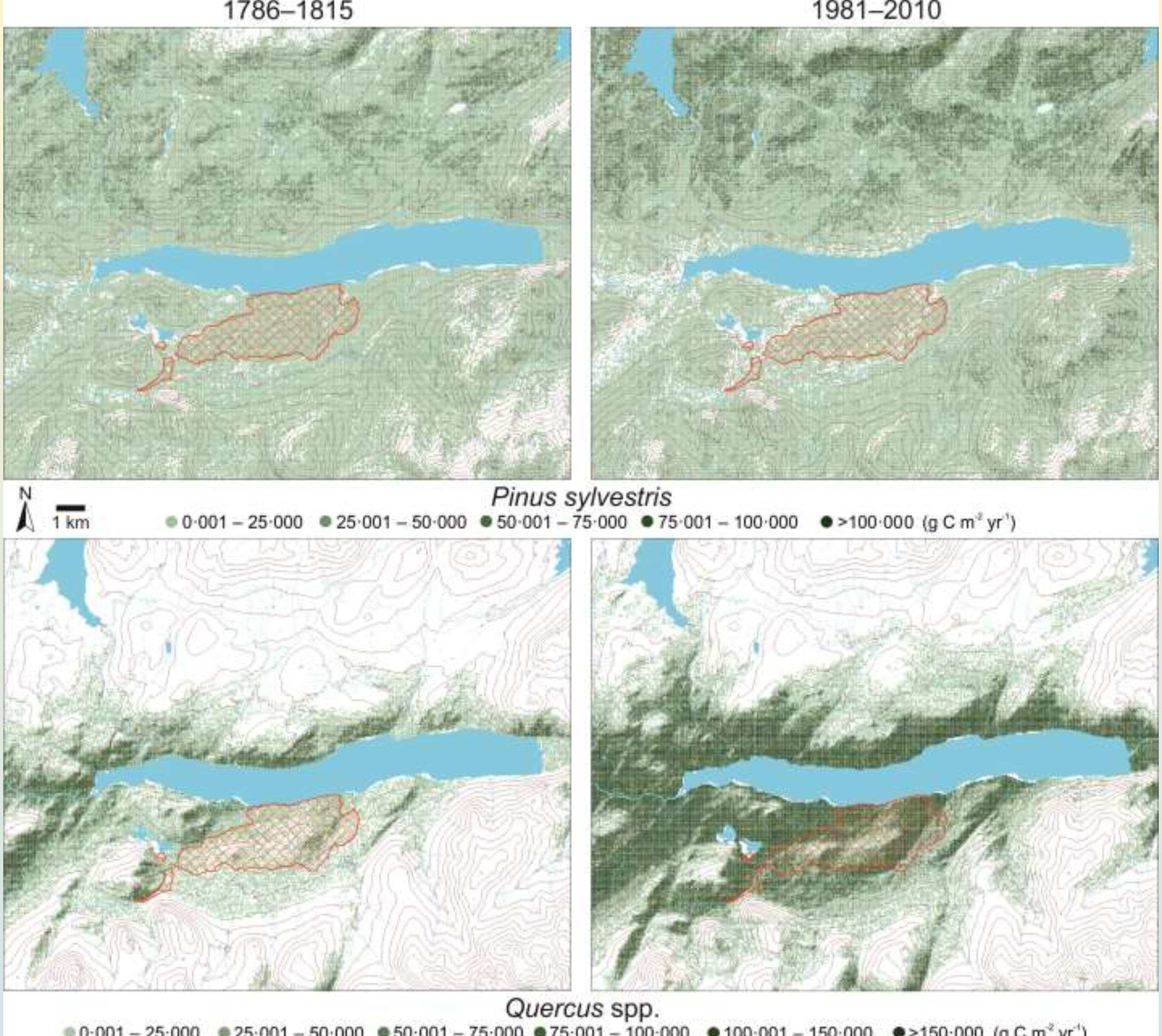
1786–1815
1981–2010
N
1 km
Pinus sylvestris
0·001 – 25·000
25·001 – 50·000
50·001 – 75·000
75·001 – 100·000
>100·000 (g C m⁻² yr⁻¹)
Quercus spp.
0·001 – 25·000
25·001 – 50·000
50·001 – 75·000
75·001 – 100·000
100·001 – 150·000
>150·000 (g C m⁻² yr⁻¹)

	Black Wood of Rannoch		Glen Affric & neighboring areas		Rhidorroch	
	Preindustrial	Present	Preindustrial	Present	Preindustrial	Present
aNPP of *P. sylvestris* (g C m^{-2} yr^{-1})						
Mean	6.516	4.581	3.469	3.265	0.207	0.108
Variance	2.521×10^{-2}	2.441×10^{-2}	2.983×10^{-2}	3.361×10^{-2}	4.536×10^{-4}	2.461×10^{-4}
t-statistic[a]	19.358		3.477		2.933	
Degrees of freedom	4,025		7,210		415	
p	6.766×10^{-80}		5.095×10^{-4}		3.545×10^{-3}	

[a] *t*-statistic calculated for a paired *t*-test.

Probabilities are for a two-tailed test.

Gunnar's Tree – Black Wood of Rannoch

Conclusions

- Present forest vegetation not in equilibrium with present climate
- Vegetation has accumulated a 'climatic debt' over two centuries of climatic change
- Caledonian pinewoods unsustainable in present areas and hence in SACs
- Urgently need to protect and encourage pinewood development in areas suitable now and in future

Loxia scotica
Scottish Crossbill
Only UK endemic bird species; restricted to Caledonian pinewoods.

Durham University
Department of Biosciences

Species on the move: northern range margin shift in British taxa

Suzanna Mason, Centre for Ecology and Hydrology

@SuzannaCMason

Species on the move: Northern range margin shift in British taxa





Geographical range margins of many taxonomic groups continue to shift polewards

SUZANNA C. MASON[1,2]*, GEORGINA PALMER[2], RICHARD FOX[3], SIMON GILLINGS[4], JANE K. HILL[2], CHRIS D. THOMAS[2] and TOM H. OLIVER[1]

[1]*NERC Centre for Ecology and Hydrology, Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB, UK*
[2]*Department of Biology, University of York, Wentworth Way, York, YO10 5DD, UK*
[3]*Butterfly Conservation, Manor Yard, East Lulworth, Wareham, Dorset, BH20 5QP, UK*
[4]*British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU, UK*

Suzanna Mason

Georgina Palmer, Richard Fox,
Simon Gillings, Jane Hill, Chris Thomas, Tom Oliver

LINNEAN SOCIETY BIOLOGICAL Journal

Biological Journal of the Linnean Society, 2015, **115**, 586–597. With 4 figures.

THE UNIVERSITY *of York*

Butterfly Conservation

BTO Looking out for birds

Species on the move: Range shift and climate change

- As the climate warms, many species shift their ranges in response
  - Most studies focus on data-rich groups such as butterflies and birds

- It is important that we monitor species' distributions so that we can effectively deal with problems that may arise
  - Relevant for predictive modelling and conservation efforts

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Butterfly Conservation

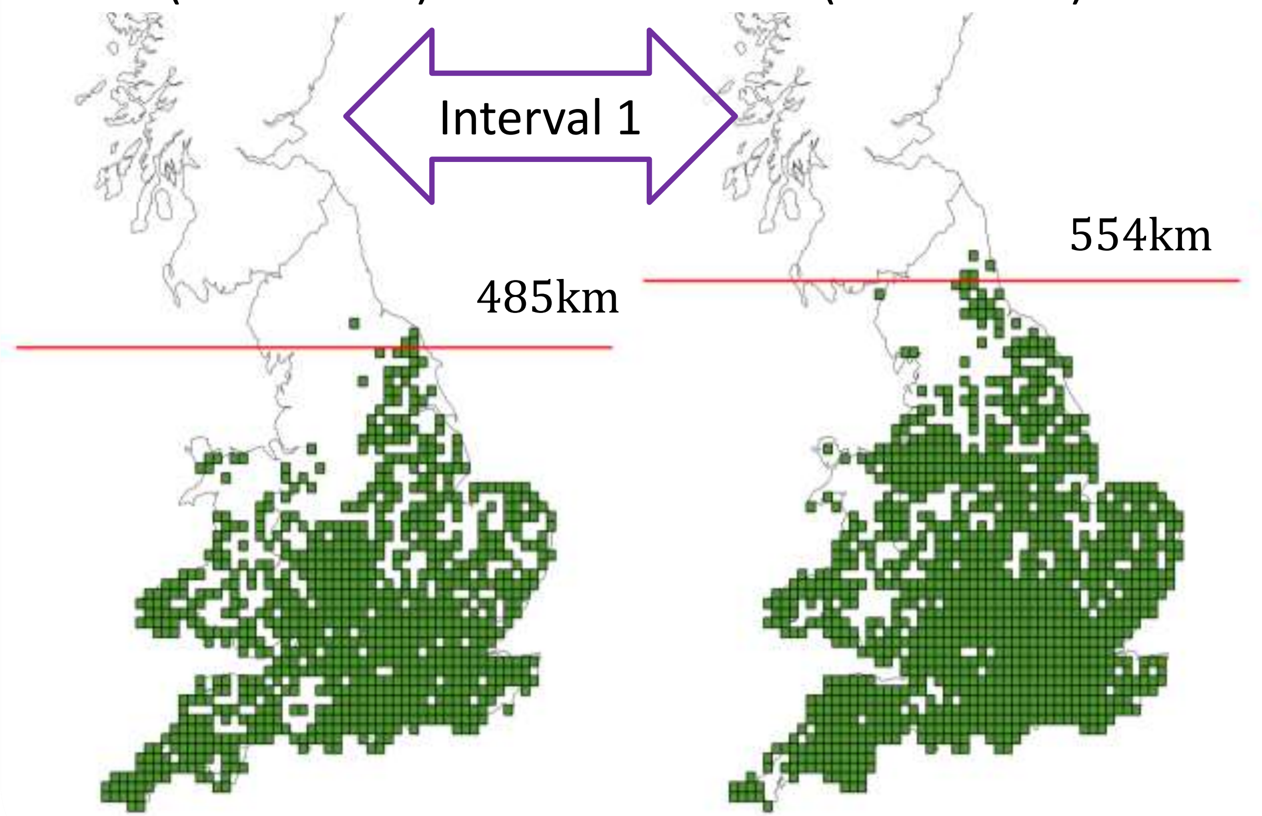
BTO Looking out for birds

Species on the move: Measuring northern range margin shift

@SuzannaCMason

Time period 1 (1966-1975)

Time period 2 (1986-1995)



Small skipper butterfly
Thymelicus sylvestris

Presence of
Thymelicus sylvestris

Occupied 10km square

Northern range margin

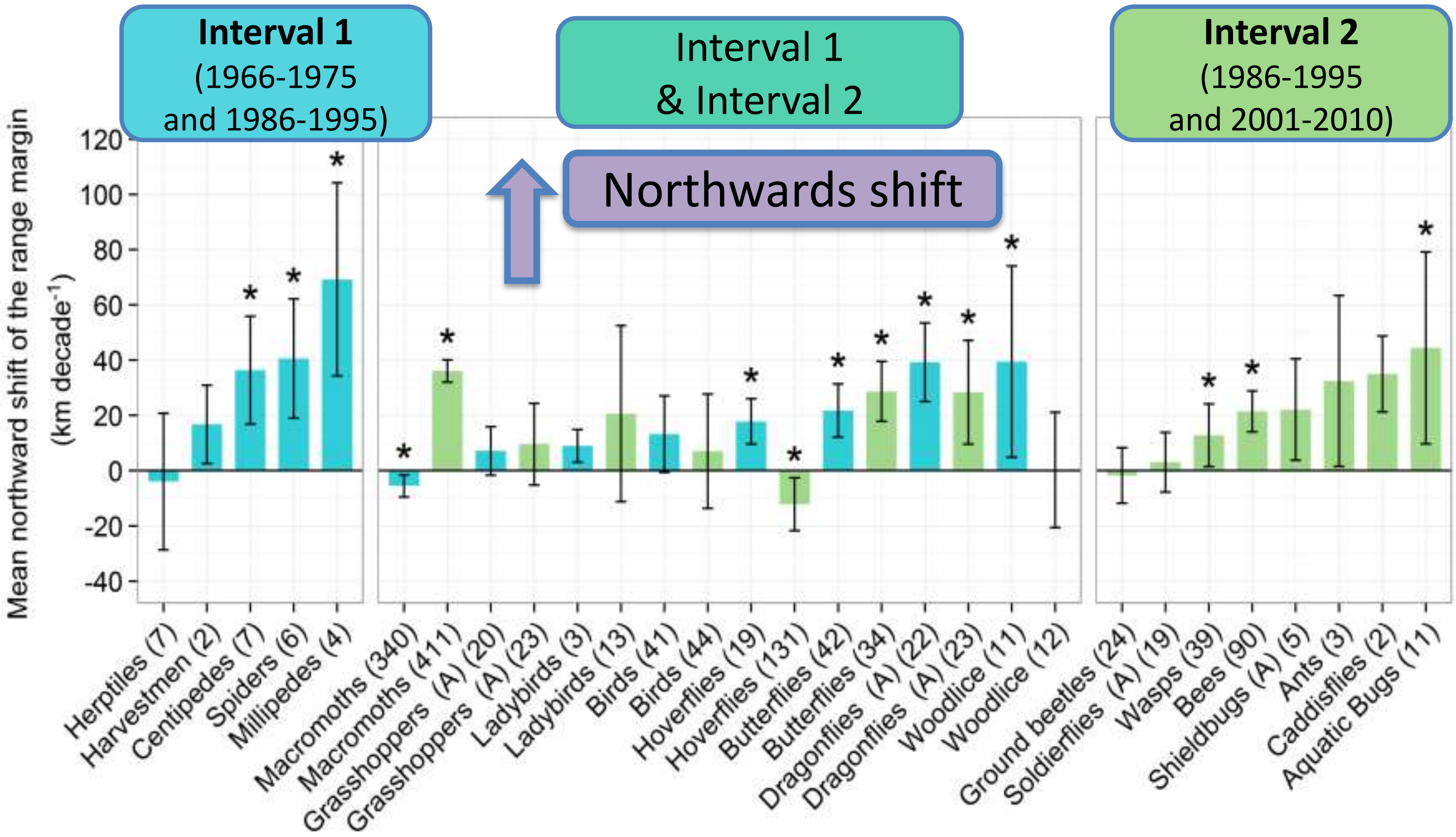
THE UNIVERSITY *of York*

Butterfly Conservation
Saving butterflies, moths and their habitats

BTO
Looking out for birds

Species on the move: Northern range margin shift in British taxa

@SuzannaCMason



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Butterfly Conservation

Saving butterflies, moths and their habitats

BTO

Looking out for birds

Species on the move: Range shift and its consequences

@SuzannaCMason

Changes in species ranges are relevant to the National Adaptation Programme:

- Risks to species and habitats due to inability to respond to changing climatic conditions.
- Risks to agriculture, forestry, landscapes and wildlife from pests, pathogens and invasive species
- Opportunities from new species colonisations

THE UNIVERSITY of York

Butterfly Conservation
Saving butterflies, moths and their habitats

BTO
Looking out for birds

Ecological responses to climate change: the importance microclimate

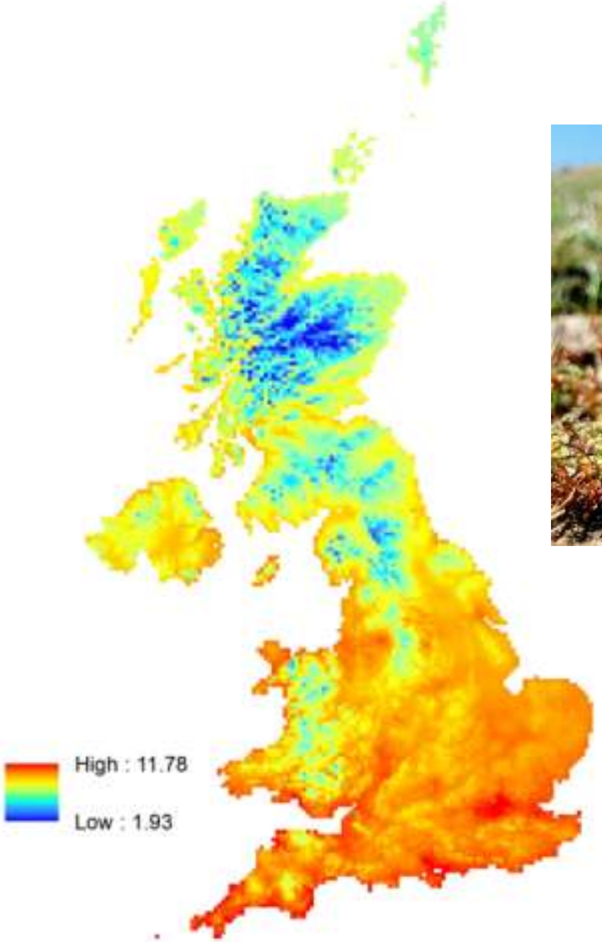
Ilya Maclean, University of Exeter

Ecological responses to climate change: the importance of microclimate

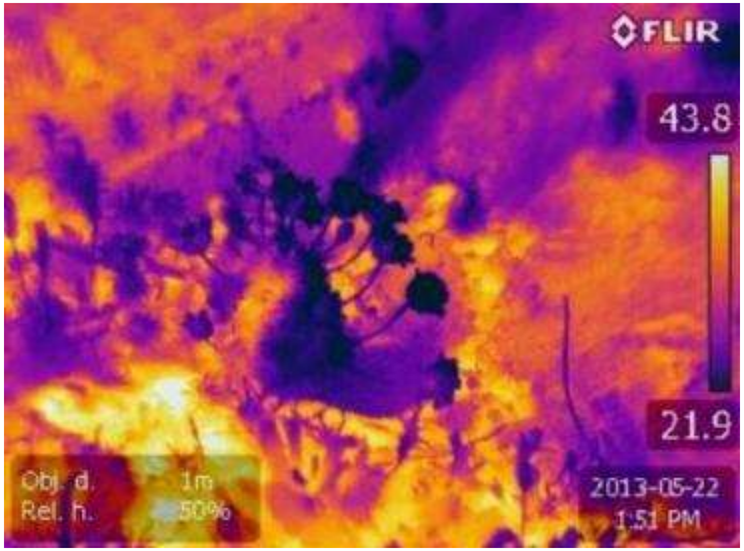
Ilya Maclean
Environment & Sustainability Institute, University of Exeter
i.m.d.maclean@exeter.ac.uk

Discrepancies in scale

UK temperature, April 2015 Range: 9.85 ºC



c. 20 x 30 cm of a SW-facing slope in Cornwall
Range: 21.9 ºC



Modelling microclimate:

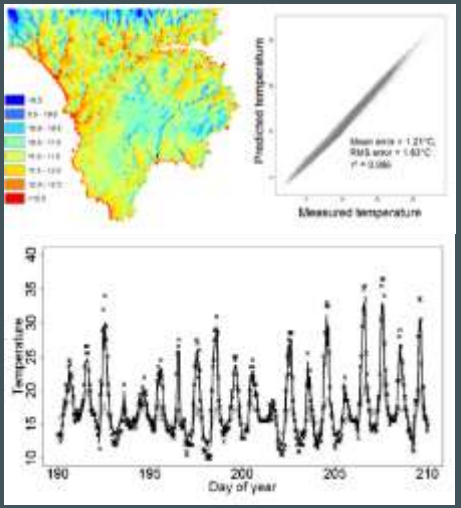
High temporal resolution climatic measurements

+

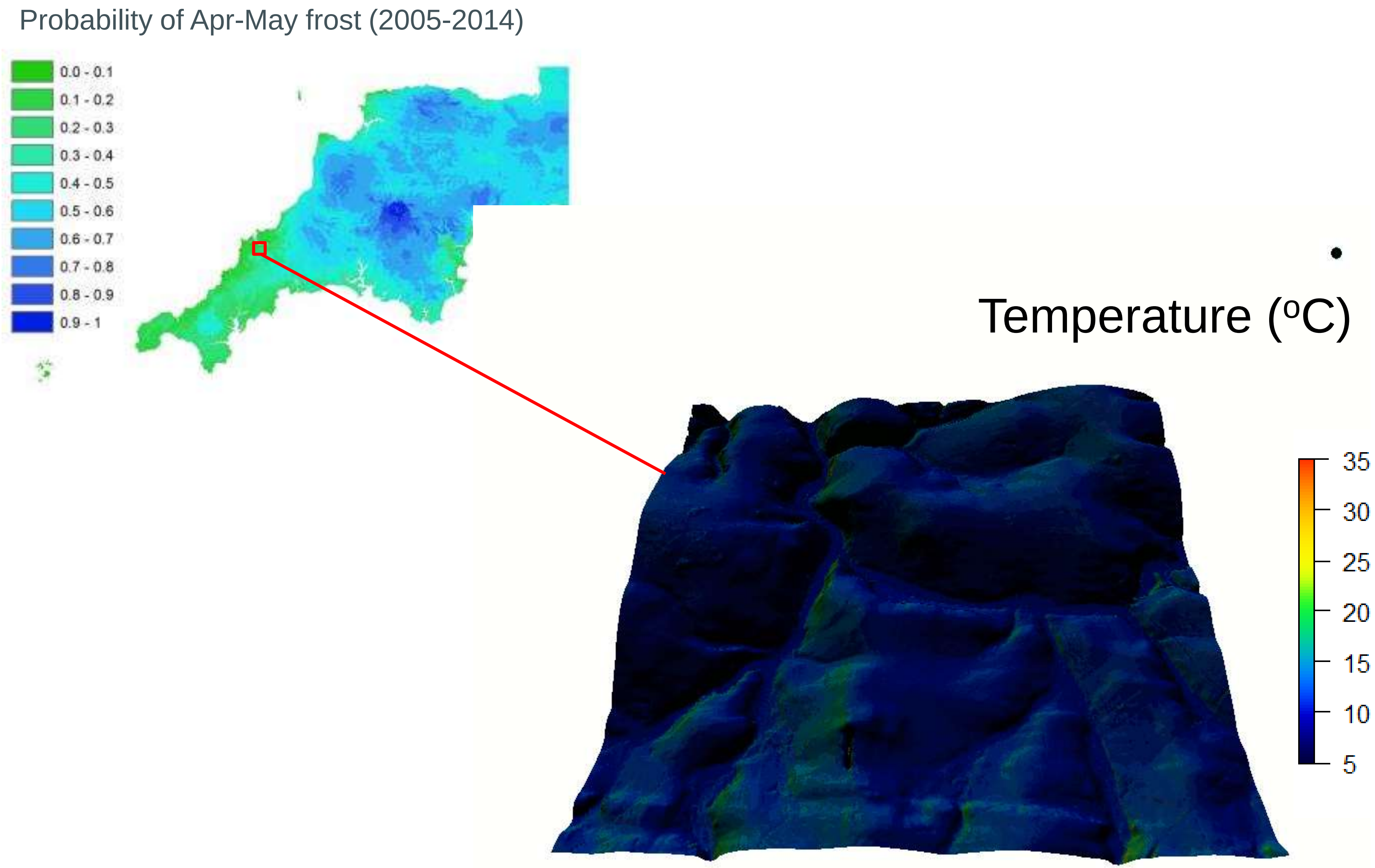
High spatial resolution environmental measurements

→

High spatial and temporal resolution climate

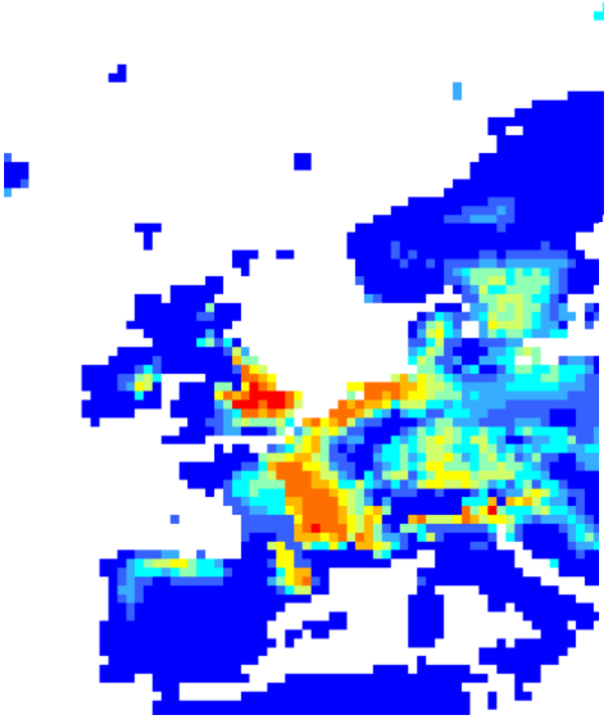


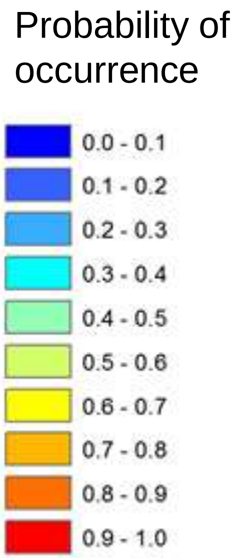
Bennie *et al.* (2008) *Ecol. Model.*; Bennie *et al.* (2010) *Agr. Forest. Meteorol*.; Suggitt *et al.* (2011) *Oikos;* Maclean *et al*. (2012) *Ecol. Model.*; Maclean *et al.* (in press) *Glob. Change Biol*.

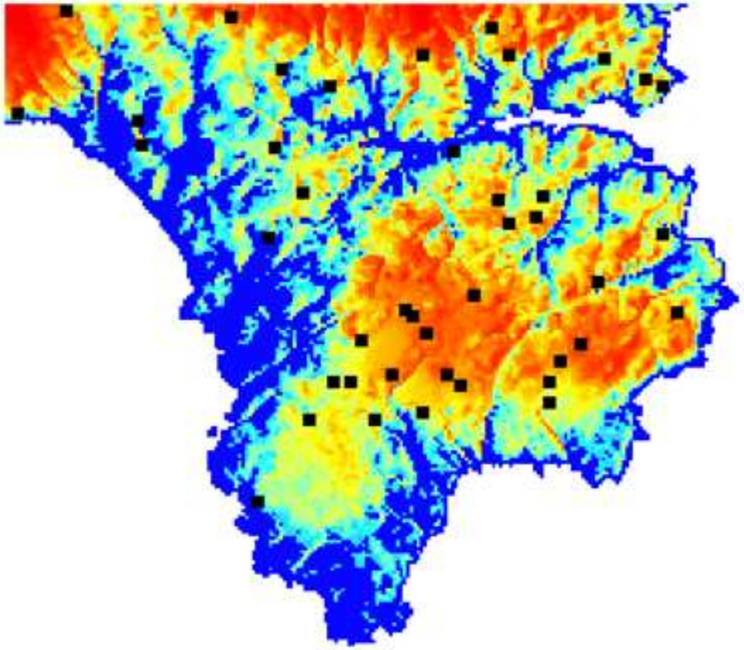

Probability of Apr-May frost (2005-2014)
0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
Temperature (ºC)
35
30
25
20
15
10
5

Implications of resolution for bioclimate model predictions:

Predicted present day distribution of bog stitchwort (*Stellaria uliginosa*)

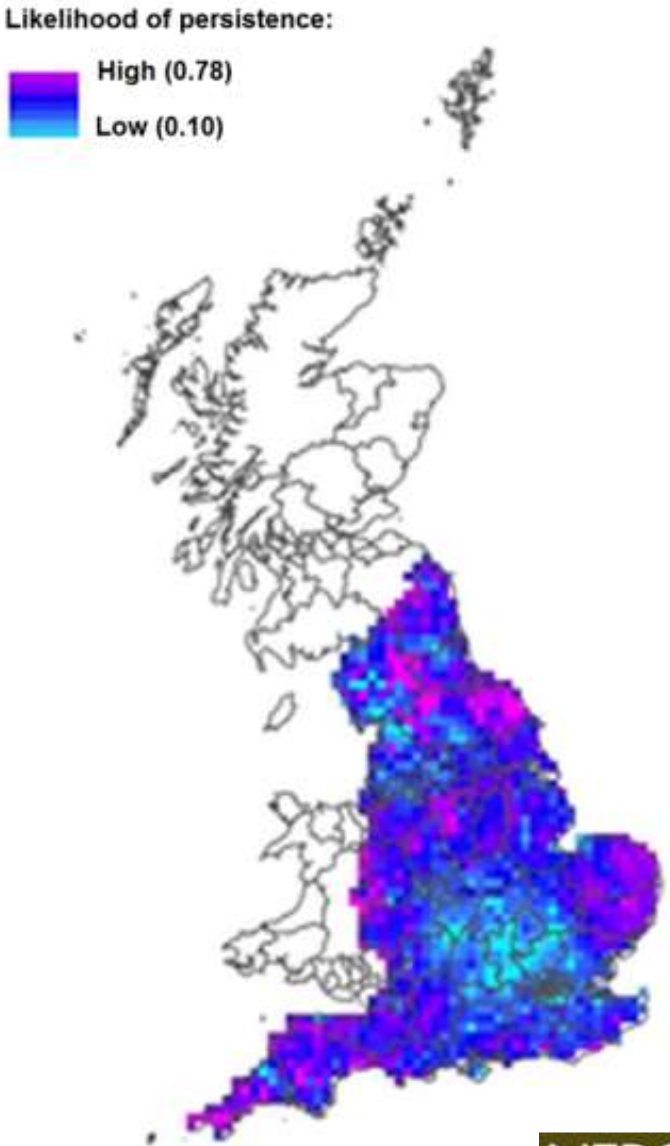






Maclean & Early (in prep)

Locations of climate refugia:



Suggitt *et al.* (2014; 2015; submitted)

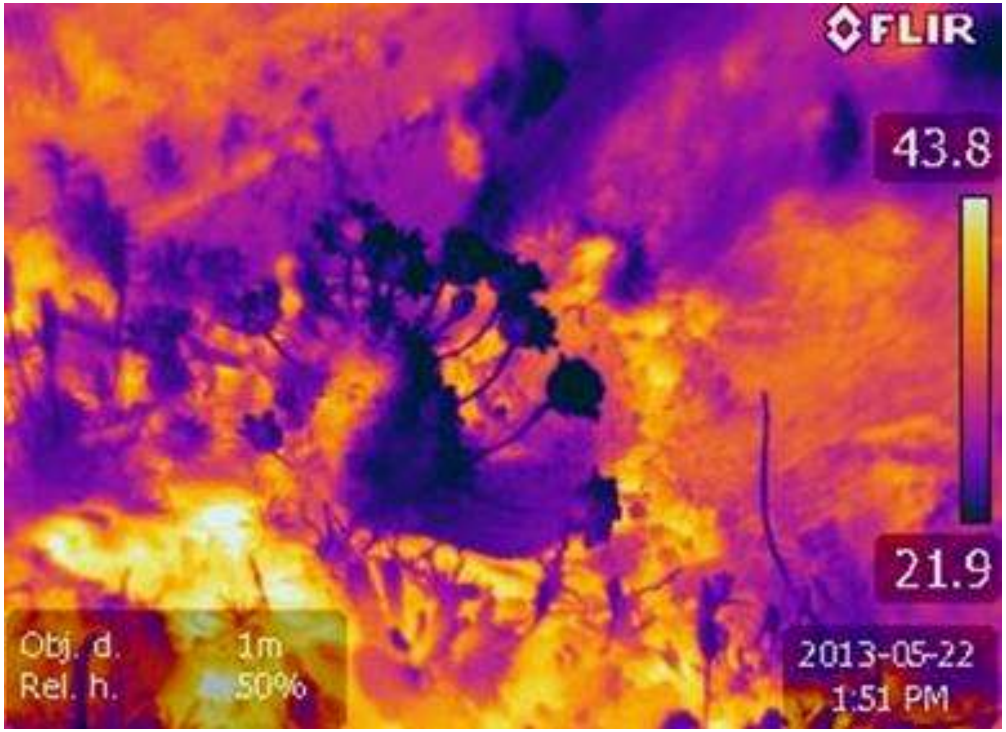
Refugia from climate change: an adaptation tool?

Andrew Suggitt, University of York

What is a refugium?

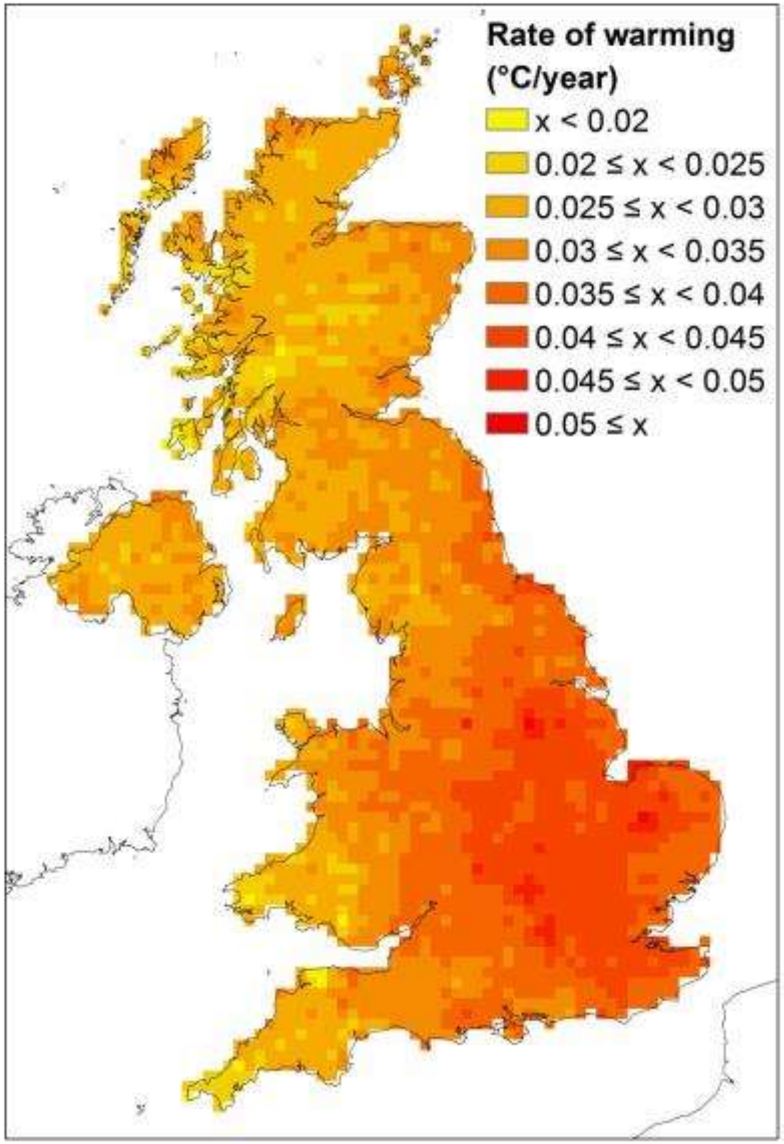
Andrew J Suggitt

andrew.Suggitt@york.ac.uk



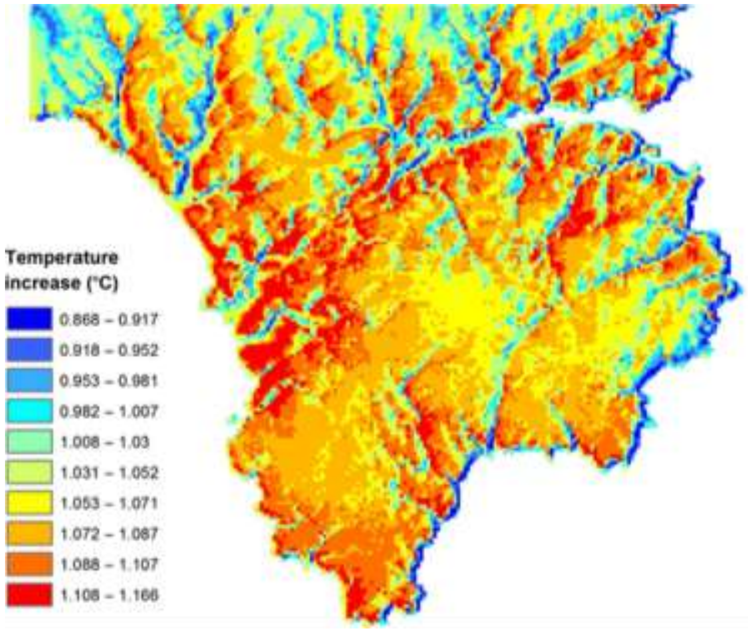
Ref: Suggitt et al. 2014 British Wildlife

UKCP09 summer warming 1961-2006



Solar index is good proxy for (microclimate) temperature

Maclean *et al.* 2016- *Glob. Change Biol.*

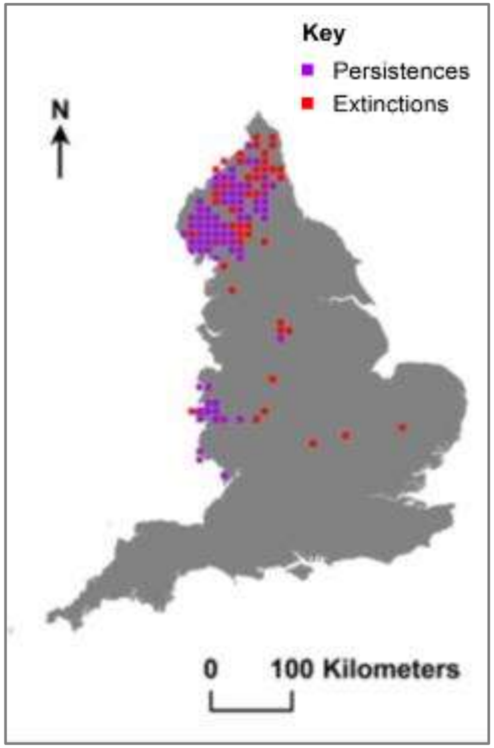


Biological data

CEH BRC models (2014)
Species with a declining
(10 year) distribution trend

Pearce-Higgins *et al.* (2015)
Species at risk from
future climate change

430 species
(Plants, Bryophytes, Lepidoptera, Coleoptera)



In summary:
Microclimatic buffering has reduced extinction risk from climate change

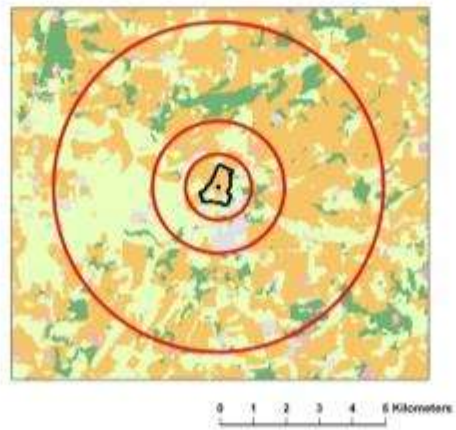
Headline results	
Evidence for prevalence:	Buffering has benefitted many warming-afflicted species.
	Similar prevalence of buffering effect in warming-afflicted plants and animals.
Evidence for effect size:	Overall effect on extinction risk is beneficial at high levels of warming, *regardless* of positive/negative warming response.
	Buffering has substantially reduced extinction risk for warming-afflicted species.

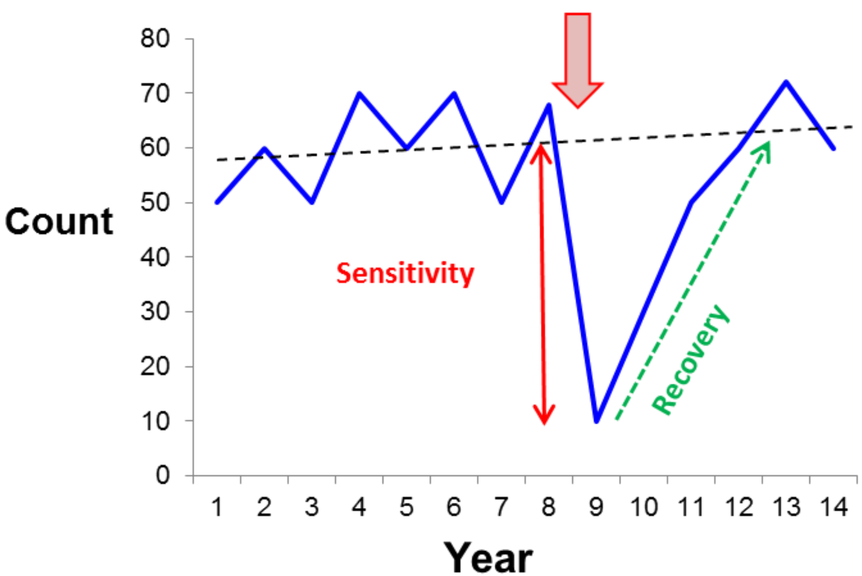
Is biodiversity conservation business as usual under climate change?

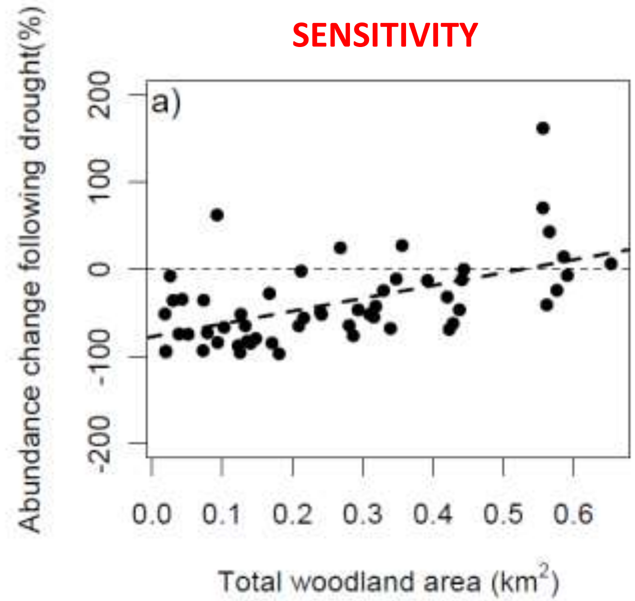
Tom Oliver, University of Reading

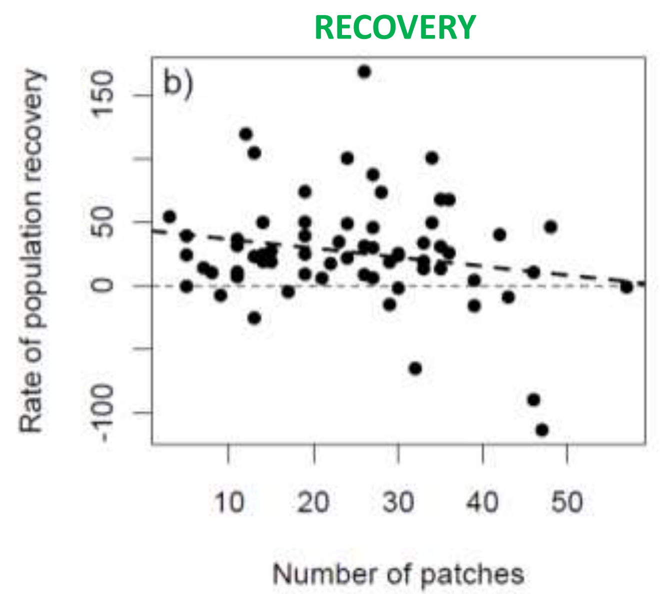
Land use- climate interactions on butterfly species

Aphantopus hyperantus



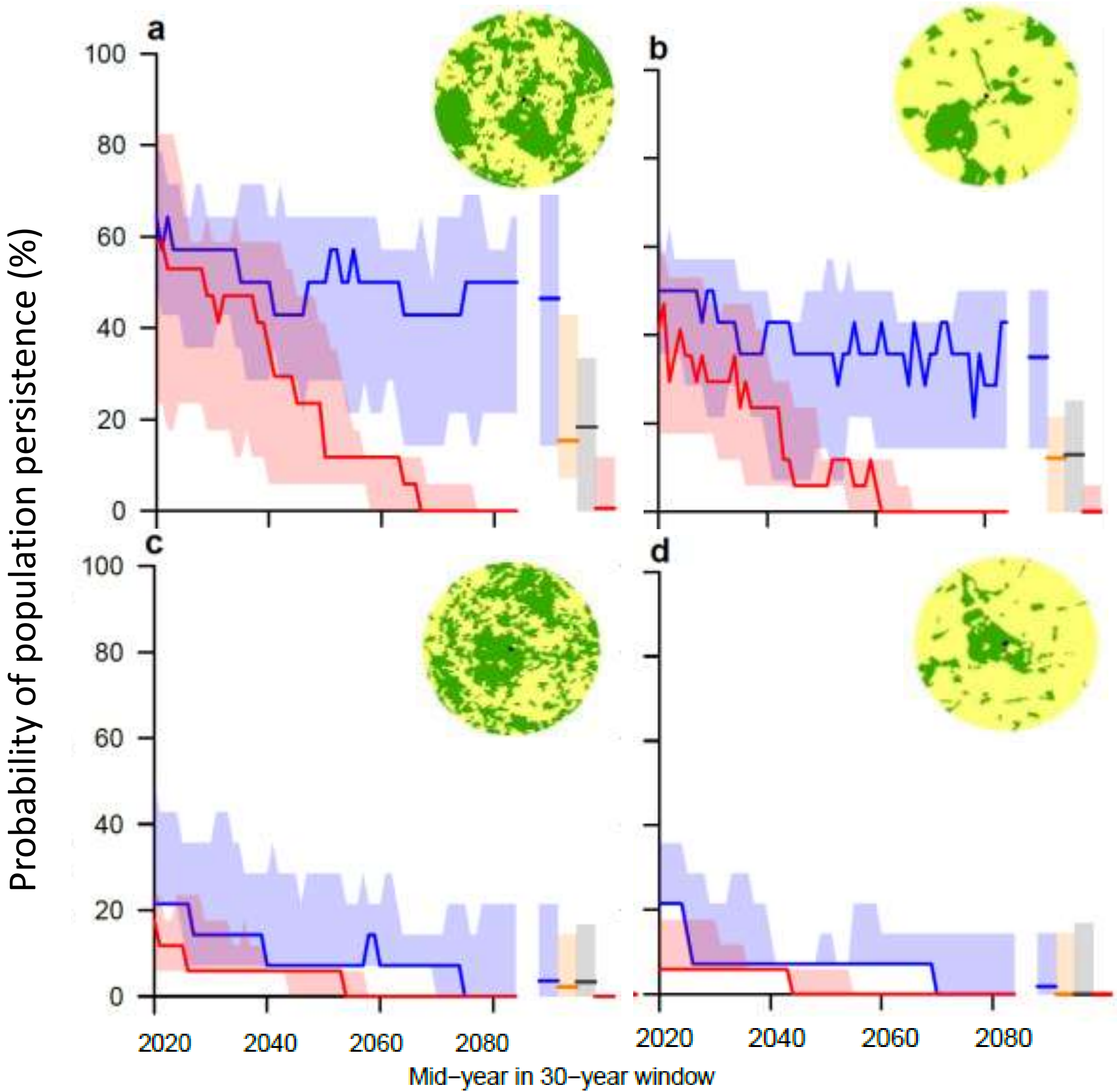






(Oliver, Brereton & Roy. 2013, *Ecography*)

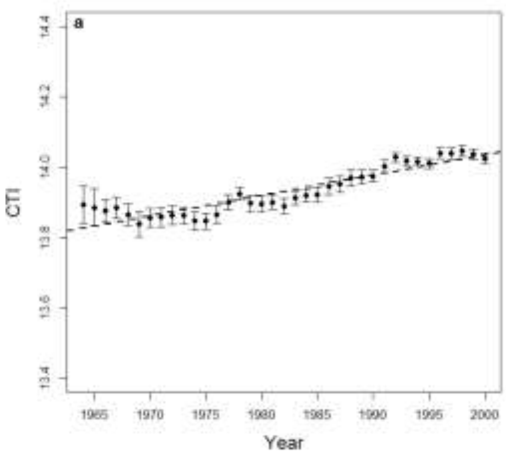
Land use- climate interactions on butterfly species



Oliver et al. (2015) *Nature Climate Change* 5, 941–945.

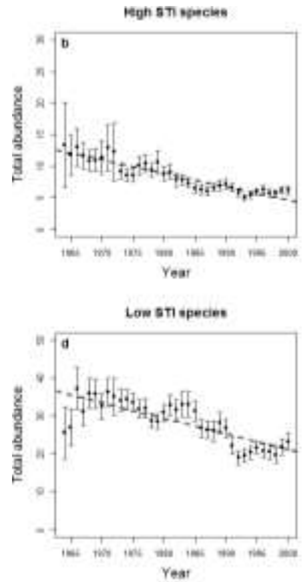
Bird and butterfly community impacts

Birds

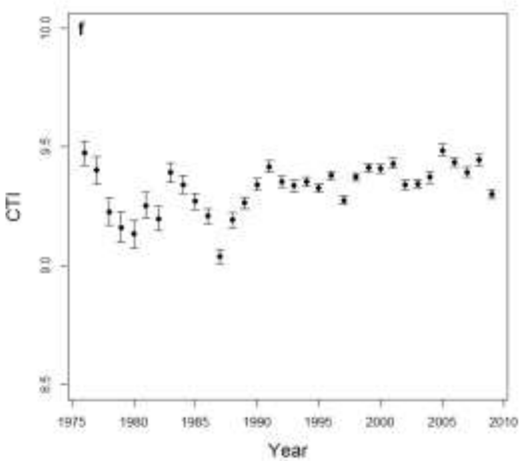


Warm-associated species

Cold-associated species

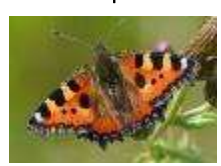


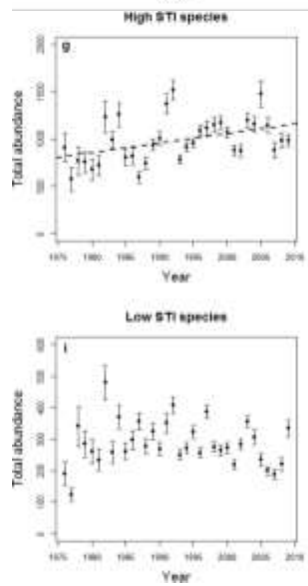
Butterflies



Warm-associated species

Cold-associated species





Community temperature index (CTI) increases in both groups, but in **birds** driven by *loss* of both warm species and (faster) loss of cold species,
for **butterflies**: driven by *increase* in warm species

Bird and butterfly community impacts

Interactions between climate change and land use

Intensive land use accelerates the loss of cold associated birds and butterflies

Intensive land use limits ability of warm associated birds to increase

(Oliver et al *Global Change Biology* 2017)

Climate Change Adaptation

University of Reading

Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2012, **49**, 1247–1255 doi: 10.1111/1365-2664.12003

FORUM

A decision framework for considering climate change adaptation in biodiversity conservation planning

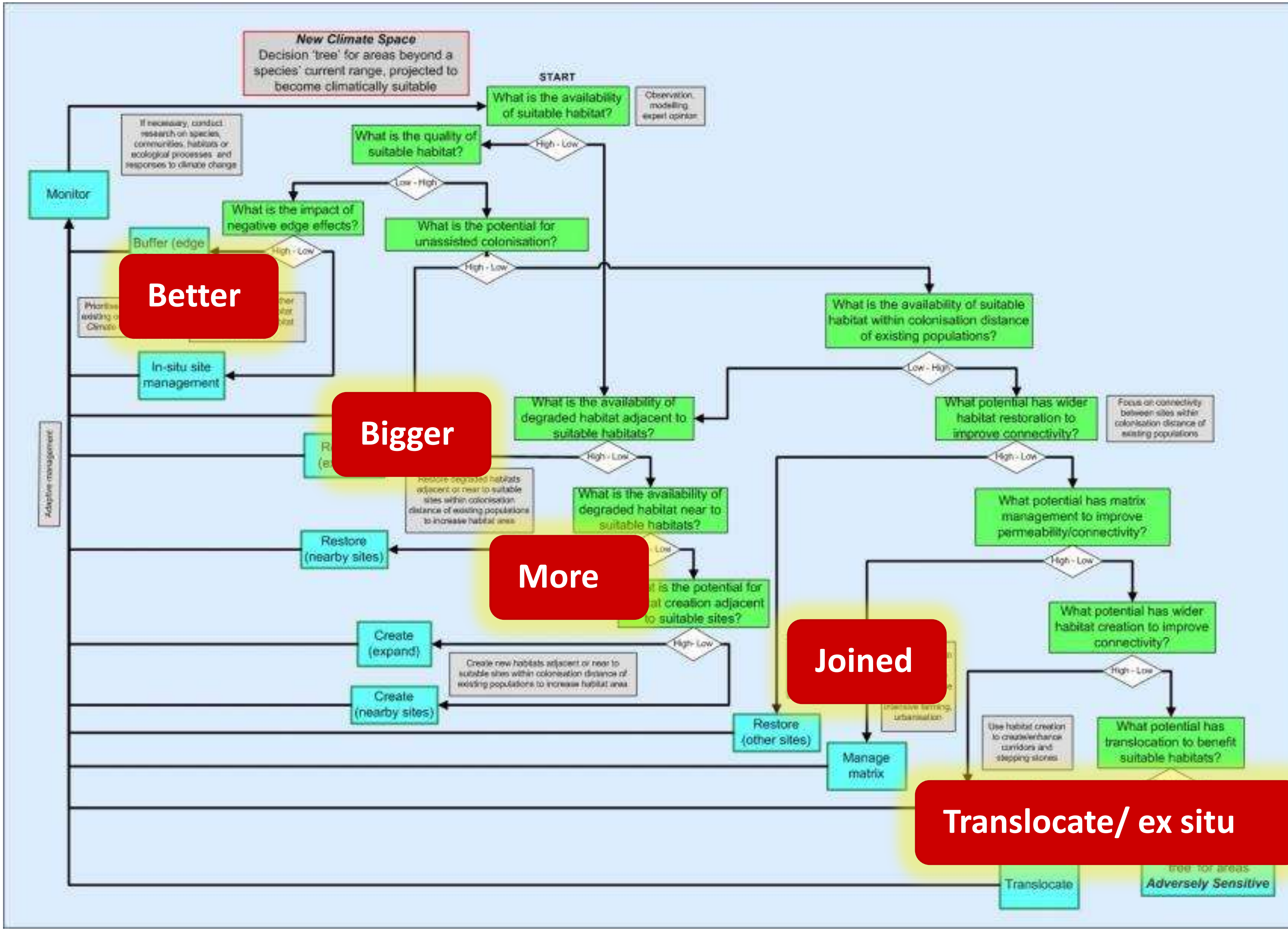
Tom H. Oliver[1]*, Richard J. Smithers[2], Sallie Bailey[3], Clive A.Walmsley[4] and Kevin Watts[5]

[1]Centre for Ecology & Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford Wallingford, Oxfordshire, OX10 8BB, UK; [2]AEA Technology plc, The Gemini Building, Fermi Avenue, Harwell, Didcot, OX11 0QR, UK; [3]Forestry Commission, Silvan House, 231 Corstorphine Road, Edinburgh, EH12 7AT, UK; [4]Countryside Council for Wales, Maes-Y-Ffynnon, Penrhos Garnedd, Bangor, LL57 2LQ, UK; and [5]Forest Research, Alice Holt, Farnham, Surrey, GU10 4LH, UK

Classified from ‘High Risk’ to ‘High Benefit’ (Thomas et al. 2011 MEE)

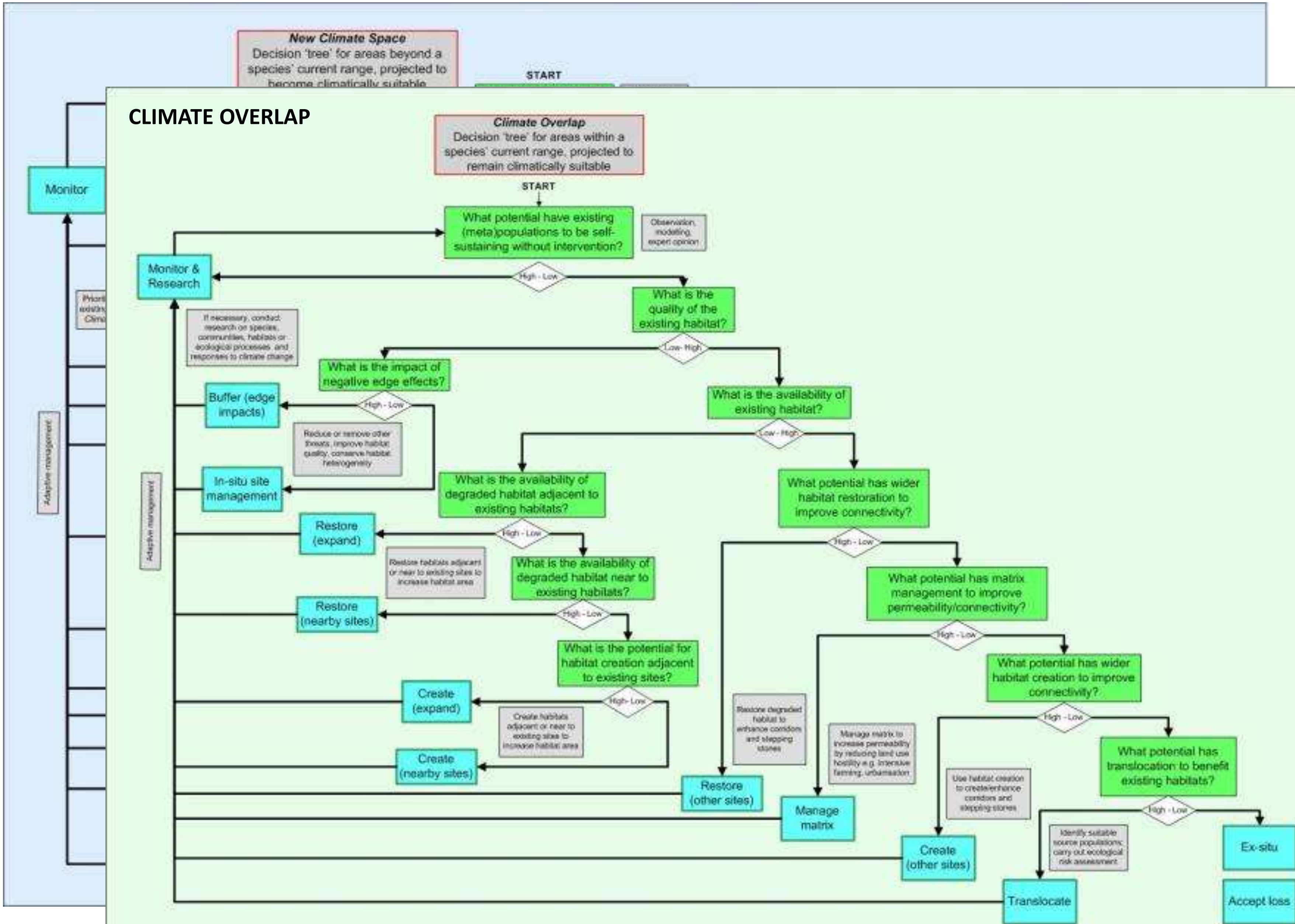
The Decision Framework

NEW CLIMATE SPACE

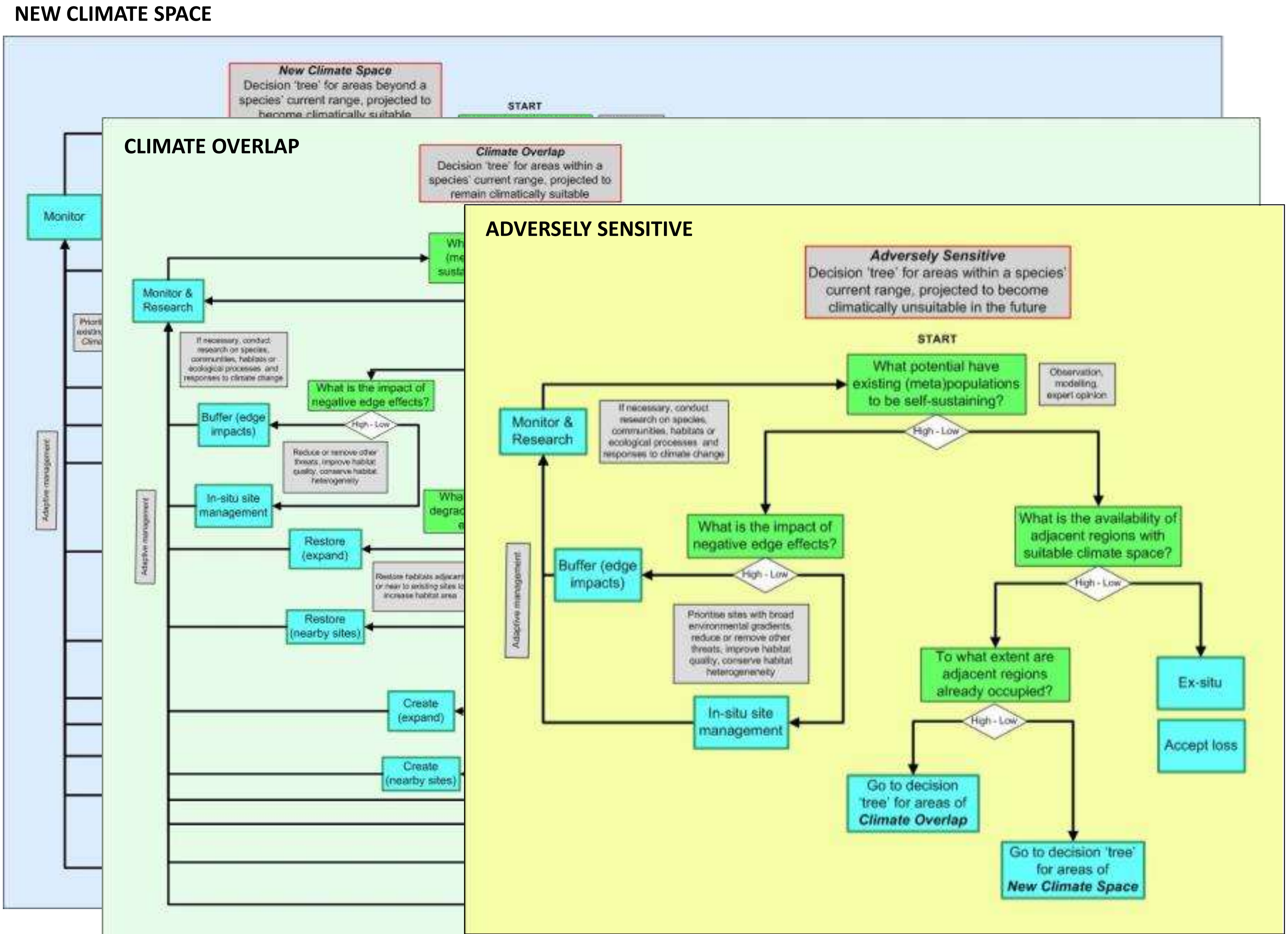


The Decision Framework

NEW CLIMATE SPACE



The Decision Framework



Extending the work

University of Reading

Application of the decision framework for 30 threatened UK species

Comparison of recommended actions with existing conservation actions (JNCC) that do not explicitly account for changing climate

KEY SIMILARITIES

1. Need for monitoring and research
2. Importance of in-situ management

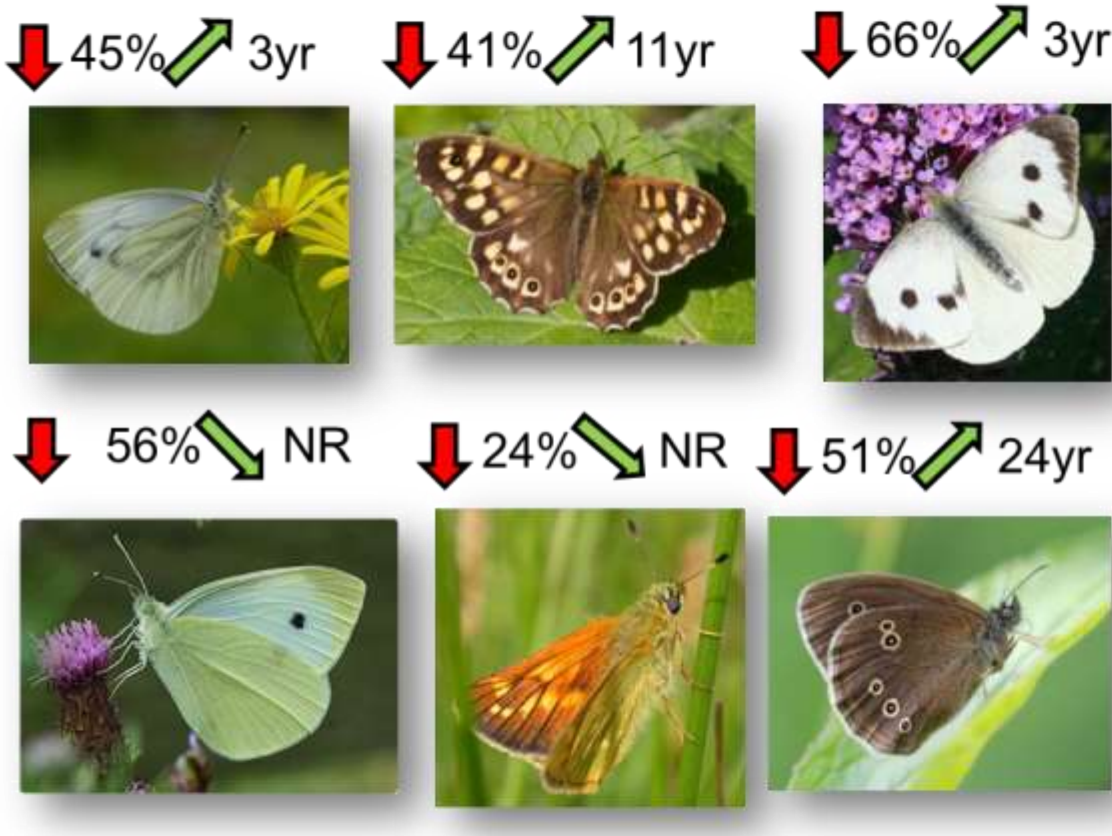
KEY DIFFERENCES

1. Increased focus on actions in New Climate Space and less in Adversely Sensitive Areas
2. Different balance of actions (e.g. Buffer edge impacts versus matrix management)

Oliver, T.H., et al. (2016). Are existing biodiversity conservation strategies appropriate in a changing climate? *Biological Conservation*, 193, 17-26

Land use- climate interactions on biodiversity

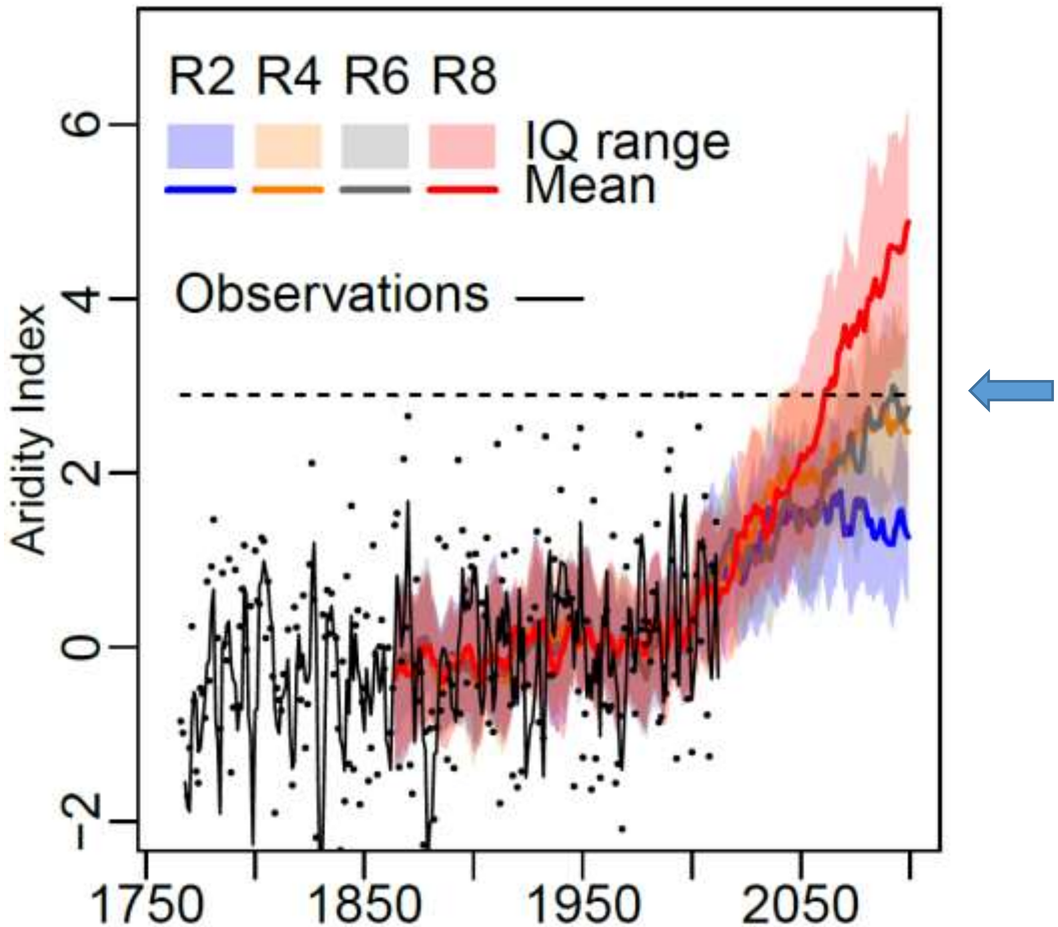
- Analysis of six butterfly species identified as particularly drought sensitive
- Projected population persistence under increased drought frequency and under four different land use scenarios



Oliver et al. (2015) *Nature Climate Change* 5, 941–945.

Predicted changes in summer aridity

Central England- Projected changes in summer aridity



Four RCP emissions scenarios

17 Global Circulation Models from IPCC CMIP5 database (2014)

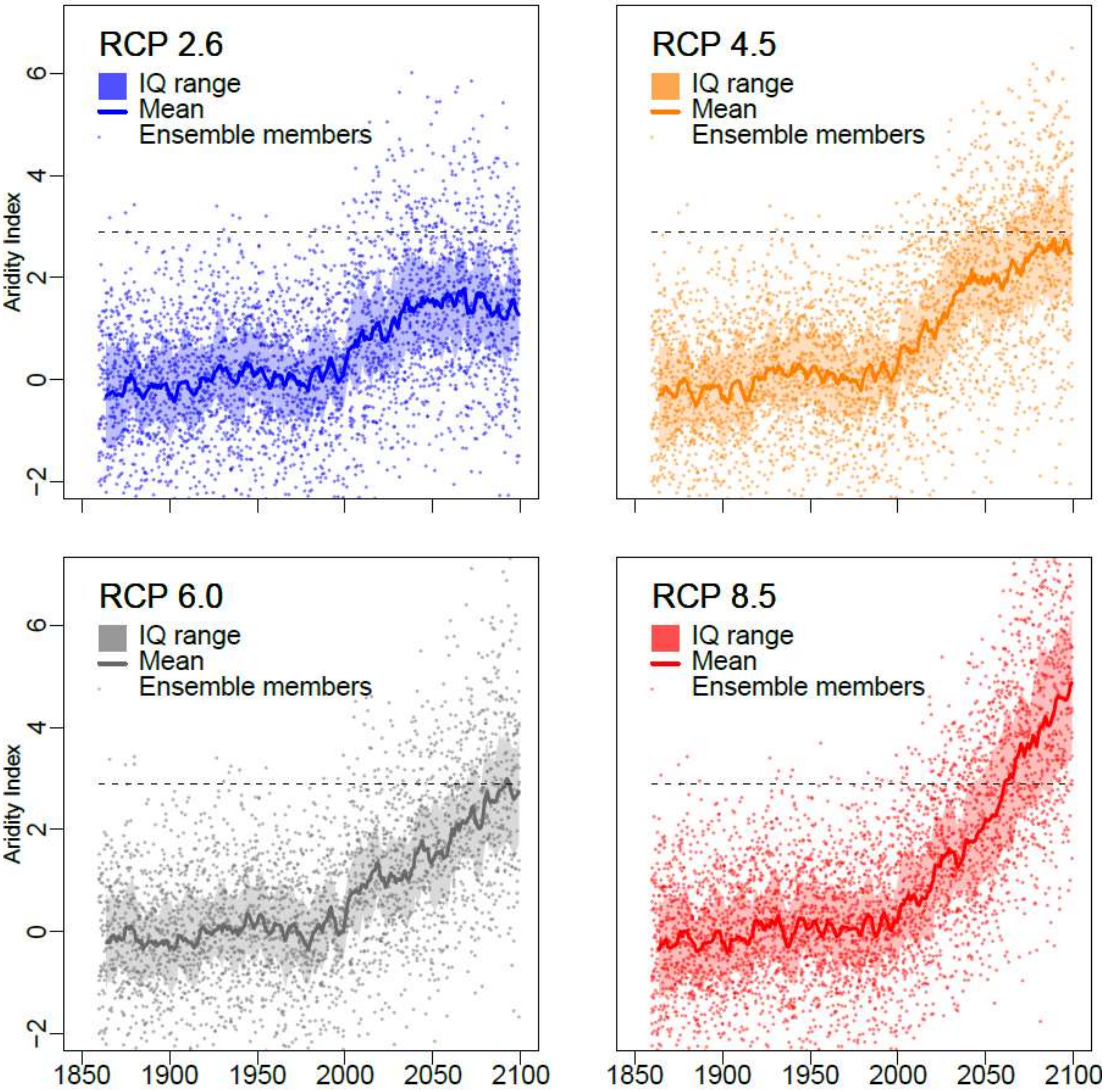
1995 observed aridity

Aridity index = $-(P_i-P)/\sigma+0.5(T_i-T)/\sigma$

(Marsh et al, 2004, *Weather)*

Oliver et al. (2015) *Nature Climate Change* 5, 941–945.

Projected changes in summer



1995 observed aridity

1995 observed aridity

Deploying the garden army: The role of green space in climate change adaptation and mitigation

Eleanor Webster, Royal Horticultural Society

Royal Horticultural Society

Sharing the best in Gardening

Deploying the ‘Garden Army’: The role of green space in climate change adaptation and mitigation

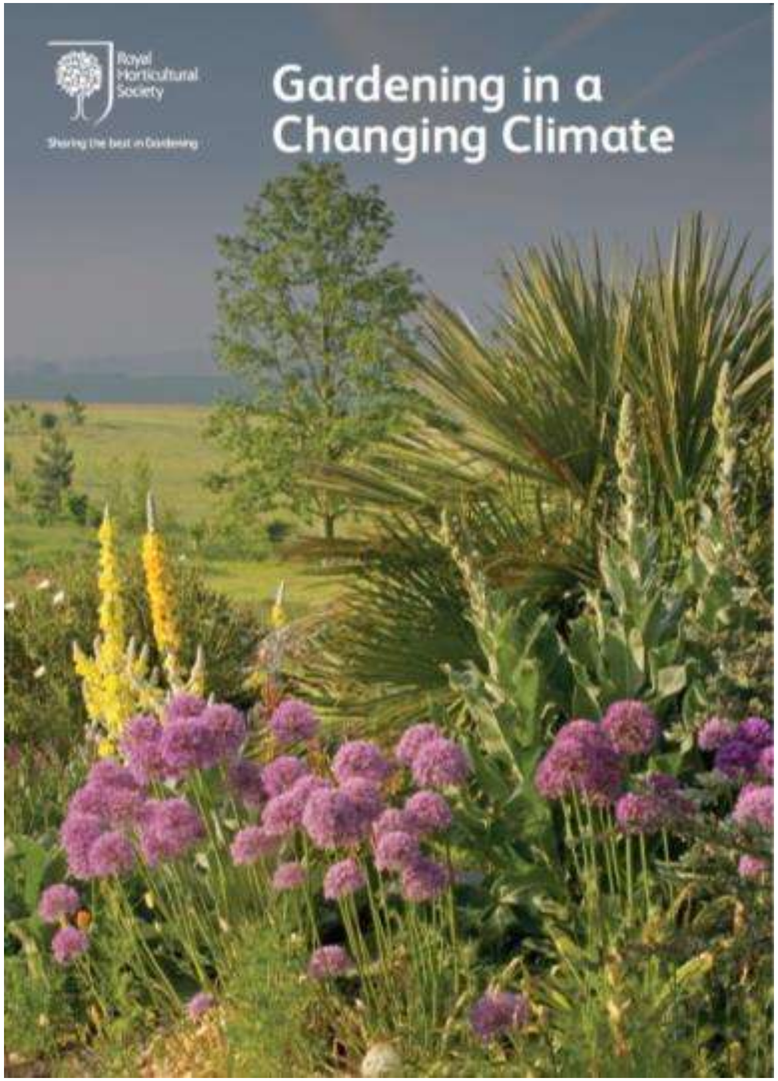
Dr Eleanor Webster, RHS Climate Scientist

eleanorwebster@rhs.org.uk

@_eleanorwebster

The RHS Report, 2017

- Projections for future climate change
- Results of a survey
- Flowering times
- Interactions with wider environment
- Design and management tips



Wider importance

- Housing pressures in addition to climate change
- ‘Garden grabbing’ on the rise
- Horticulture affected by risks identified in Defra CCRA 2017: soil health, resource use, invasive non-native species.

Eliciting change: The Garden Army

Royal Horticultural Society

Sharing the best in Gardening

50% of UK adults are engaged in gardening[1]

Domestic gardens account for nearly 25% of urban space[2]

Garden soils store almost 25% more carbon per unit area than arable soils[3]

Willing demographic

[1] https://www.gov.uk/government/statistics/taking-part-201314-focus-on-reports

[2] Gaston, K.J., Warren, P.H., Thompson, K. and Smith, R.M., 2005. Urban domestic gardens (IV): the extent of the resource and its associated features. *Biodiversity and Conservation*, *14*(14), pp.3327-3349.

[3] Edmondson, J.L., Davies, Z.G., McHugh, N., Gaston, K.J. and Leake, J.R., 2012. Organic carbon hidden in urban ecosystems. *Scientific reports*, *2*, p.963

Royal Horticultural Society

Sharing the best in Gardening

Thank you

eleanorwebster@rhs.org.uk

@_eleanorwebster

Climate information for informing plant pest risk in UK

Debbie Hemming, Met Office Hadley Centre

Hadley Centre Climate Programme

Climate Service: Food, Farming and Natural Environment

Plant Pest & Disease work package

Met Office Hadley Centre | Department for Environment Food & Rural Affairs

Vegetation-Climate Interactions Group, Met Office, Exeter
Expertise: Vegetation-Climate Interactions, Climate Monitoring & Modelling
Debbie Hemming, Catherine Bradshaw, Neil Kaye

Plant Health Risk and Horizon Scanning Team, Defra, York
Expertise: Pest Risk Analysts & Plant Health Entomologist
Richard Baker, Dominic Eyre, Matthew Everatt, Anastasia Korycinska

Plant Health Modelling Coordinator, Defra, London
Expertise: Plant Health Research Strategy & Modelling
Willem Roelofs

2016-17:

- **Compare climate indices of relevance for pests in UK and France**
- **Estimated UK emergence dates for priority pests and web tool**

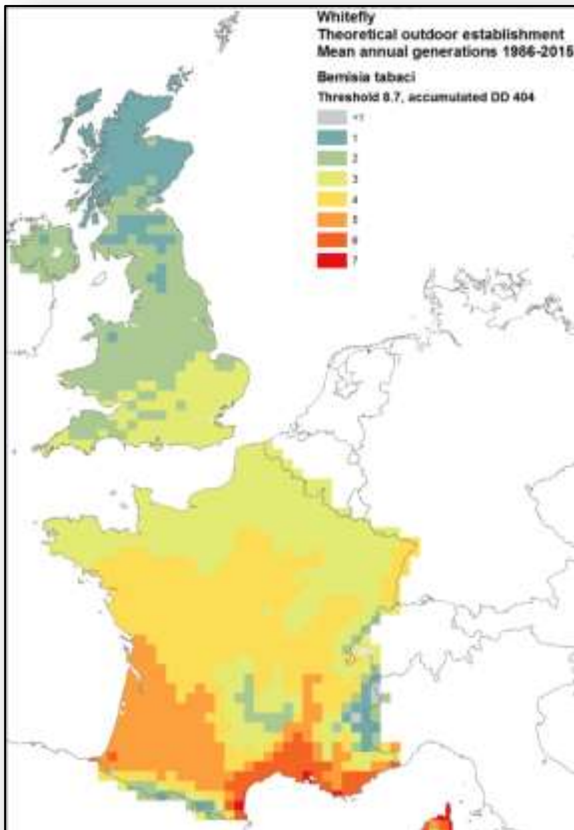
Building on previous work…

Compare climate indices of relevance for pests in UK and France

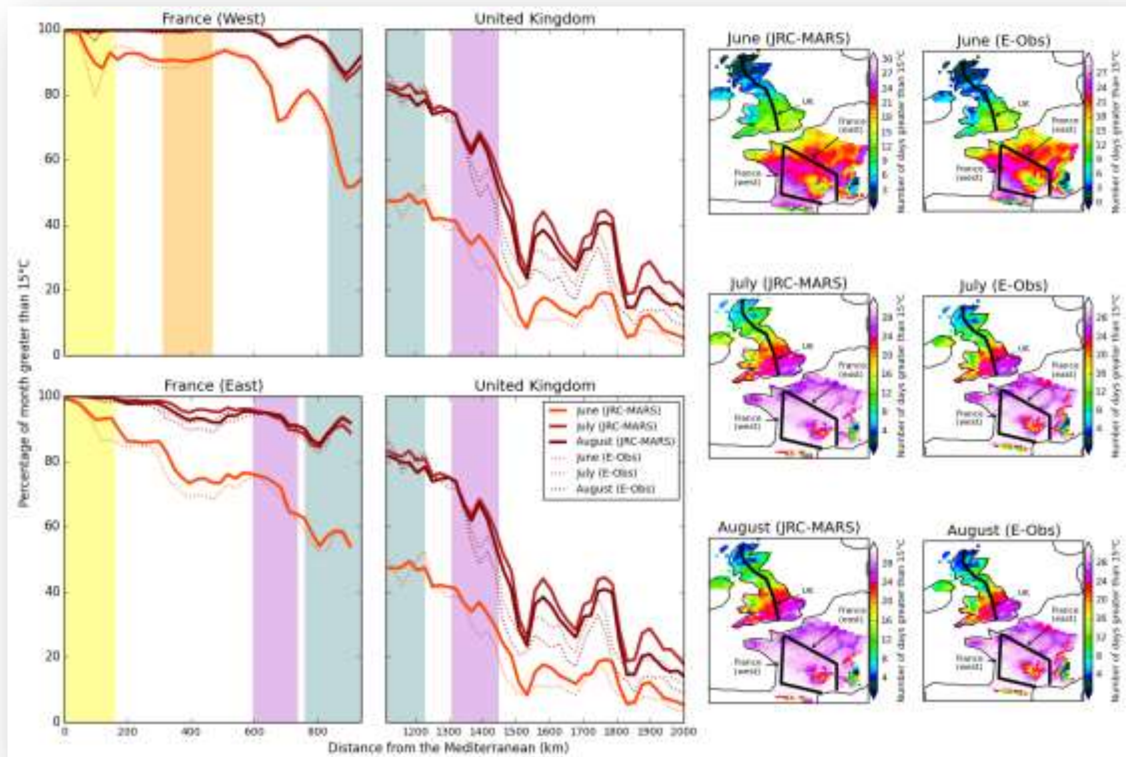
Conundrum:
Phenology models applied to Tobacco whitefly, a high priority non-native UK quarantine pest suggest that there should be adequate thermal degree days for multiple summer generations in UK, yet they have only been found outdoors in south of France.

Approach:
Identified and mapped 49 climate indices for climate extremes and conditions considered important for whitefly life cycle.

Conclusions:
- The Tobacco whitefly is experiencing greater levels of chilling injury in UK than France.
- It is unlikely to establish outdoors in UK under current climate conditions.
- With continued climate change the risk of establishment will increase and the situation needs to be kept under review with regular monitoring.



Percentage of time with optimal temperature (>15C) for egg to adult development

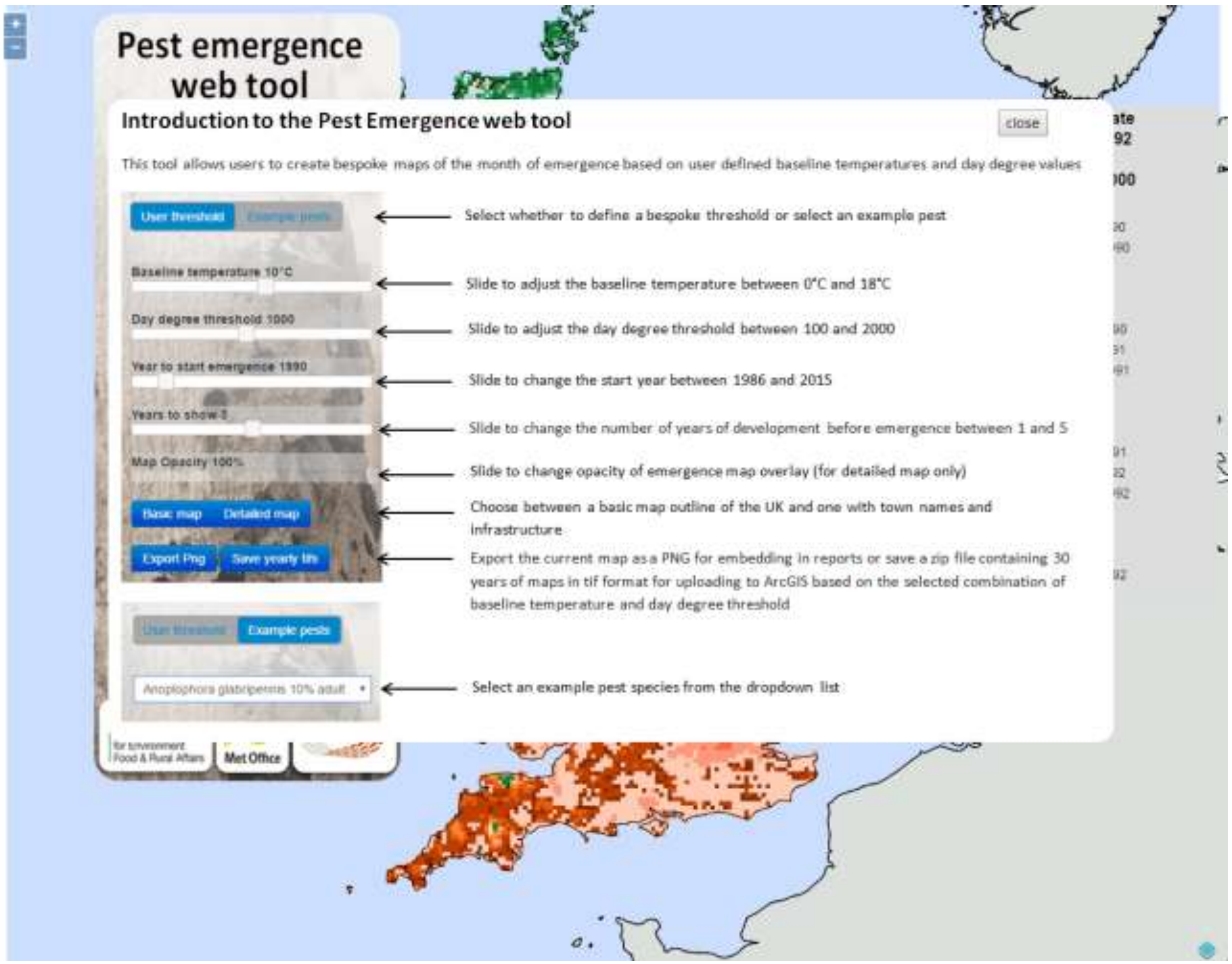


Met Office Hadley Centre

Estimated UK emergence dates for priority pests – web tool

Department for Environment Food & Rural Affairs

https://defra.stage.fera.co.uk/



The Wallace Initiative Phase III – accessing data on the potential climate change impacts on more than 100,000 species of insects, plants and animals

Jeff Price, University of East Anglia

Wallace Initiative I & II

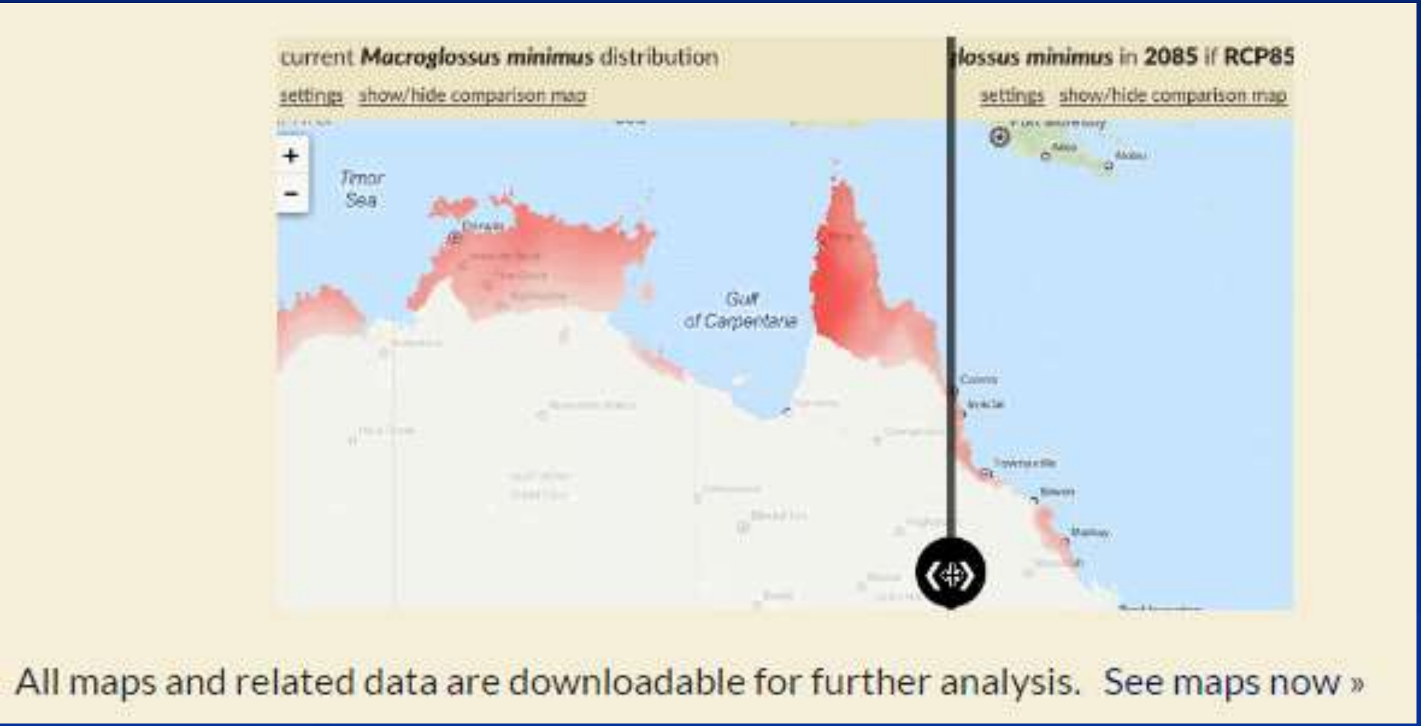
- Wallace Initiative designed to assess potential global terrestrial biodiversity changes under climate change to identify the most likely refugia.
- Phase 1 looked at ~50,000 plants and animals, 7 climate models, 50km resolution
  - one NCC paper, AVOID, PhD, several MSc
- Phase 2 looked at ~90,000 plants and animals, 21 climate models, 20 km resolution, temperatures spanning 1.5°C – 6.5°C, four dispersal scenarios (none, realistic, optimistic, full)
  - Helix, AVOID2, Impala, PhD, MSc, WWF, 7 papers in prep

Wallace Initiative III

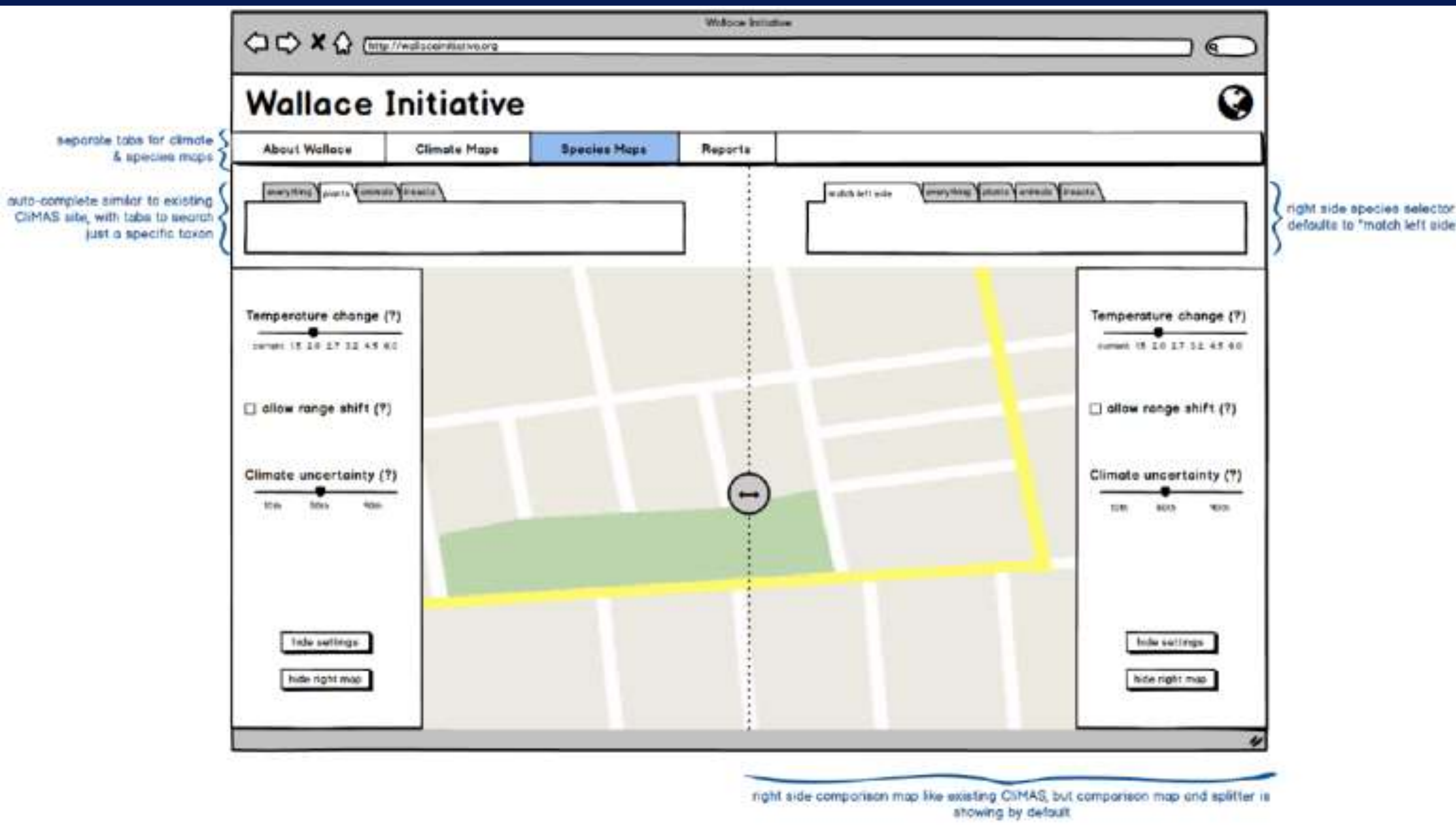
- Wallace Initiative Phase 3 adds in invertebrates and a new web portal (mid-2017)
- Models for ~75,000 plants, 8000 birds, 2000 mammals, 2000 reptiles, 1000 amphibians, 1600 butterflies, 6400 moths, 600 dragonflies, 840 bees (Apidae), 1600 other pollinators, 7600 beetles, 940 ants, 200 mosquitos, etc.
- Phase IV (HD) – planned running of some taxa at 5km resolution, late 2017?

Wallace Initiative III

Web portal built along the lines of Climas - http://climas.hpc.jcu.edu.au/ and will contain both maps (initially) and summary reports for each of 800 ecoregions (to follow)



Wallace Initiative III



With a mobile friendly version planned.

Ongoing Projects

- IMPALA – Looking at the impacts on protected areas at 1.5 versus 2C (BEIS/NERC)
- Helix – Looking at impacts of high-end climate change
- Examining the potential impacts of land use and land use change tied with climate impacts on biodiversity
- Examining optimal areas for restoration in the Brazilian Atlantic Rainforest
- Examining the role of refugia in helping define increases in the PA boundaries in Colombia
- Wallace's pARCs – Identifying the Super Parks as well as regions where protected areas are badly needed
- Looking at climate change and pollinators
- Always looking to work with others on projects

Wallace Initiative

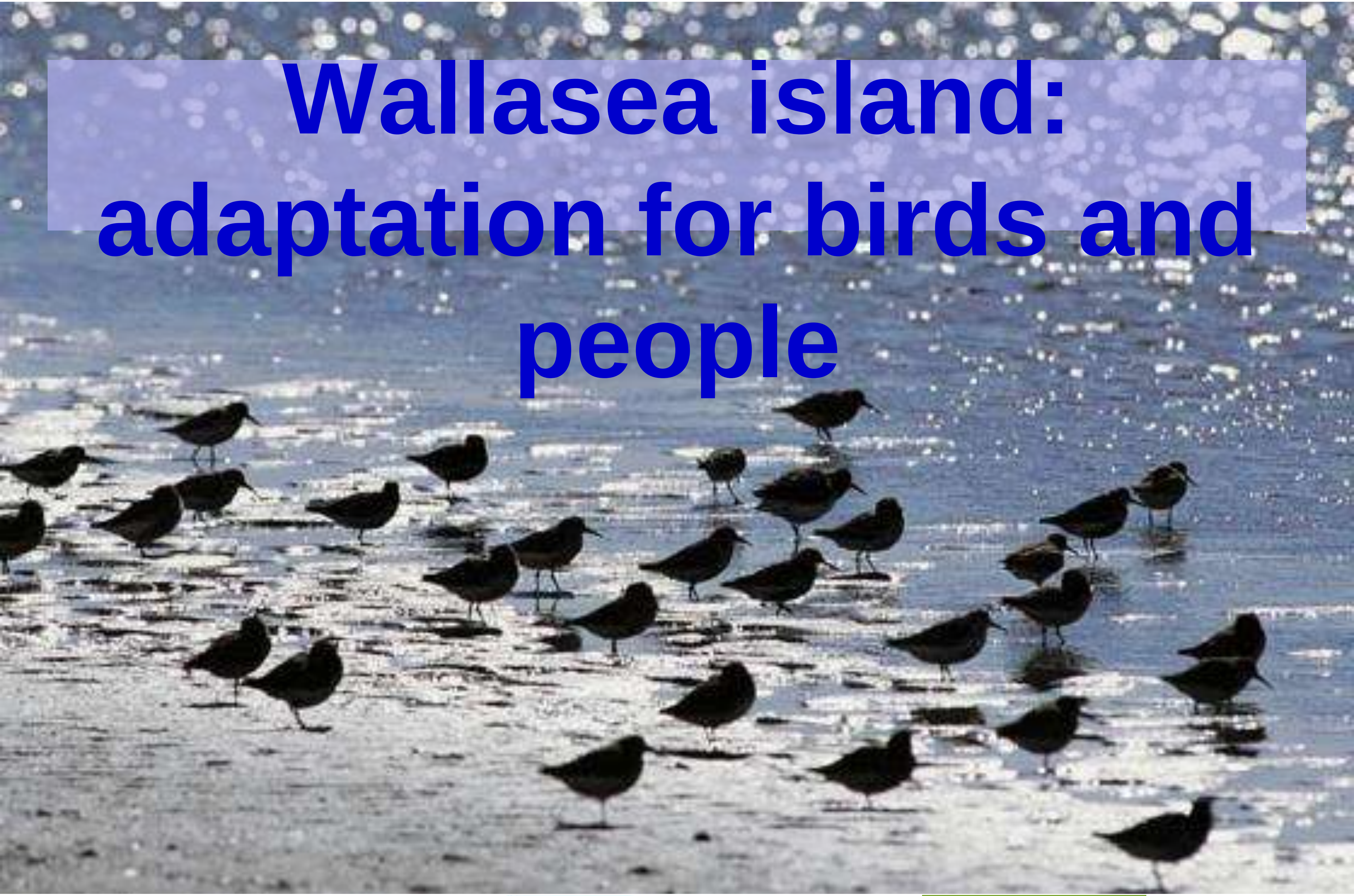
- UK - Dr. Jeff Price, Senior Researcher, Tyndall Climate Change Centre, University of East Anglia (jeff.price@uea.ac.uk); Professor Rachel Warren, Tyndall Climate Change Centre, University of East Anglia (r.warren@uea.ac.uk)

- Australia - Professor Jeremy VanDerWal, Director of the Centre for Tropical Biology and Climate Change, James Cook University, Australia; Dr. Erin Graham; Professor Ian Atkinson; Dr. Linda Beaumont; Daniel Baird

Wallasea Island: Adaptation for birds and people

Olly Watts, RSPB

Wallasea island: adaptation for birds and people



The big problem

Google earth

Overall project aims

Biodiversity

Flood risk management

Sea level r

Carbon storage

Public enjoyment & well-being

Beneficial use of waste material

Overall ecological aims

To provide:

1. Valuable habitat under a wide range of future sea levels

2. Habitat for <u>current</u> priority species

3. Habitat for species which might colonise (or re-colonise) the UK, but for which there is probably <u>very little suitable habitat</u>

4. Close views of birds for visitors

5. And be relatively cheap to maintain (largely through management by water level control)

Current priority breeding birds

Currently fairly stable population in the UK, but need alternative nesting areas to move to, when existing sites become unsuitable

53% decline on salt marsh 1985-2011 (Malpas *et al*. 2013) & vulnerable to future loss of salt marsh nesting habitat

37% decline 1984-2007 (Conway & Burton, 2009) & vulnerable to increased recreational pressure

Future breeding birds?

?

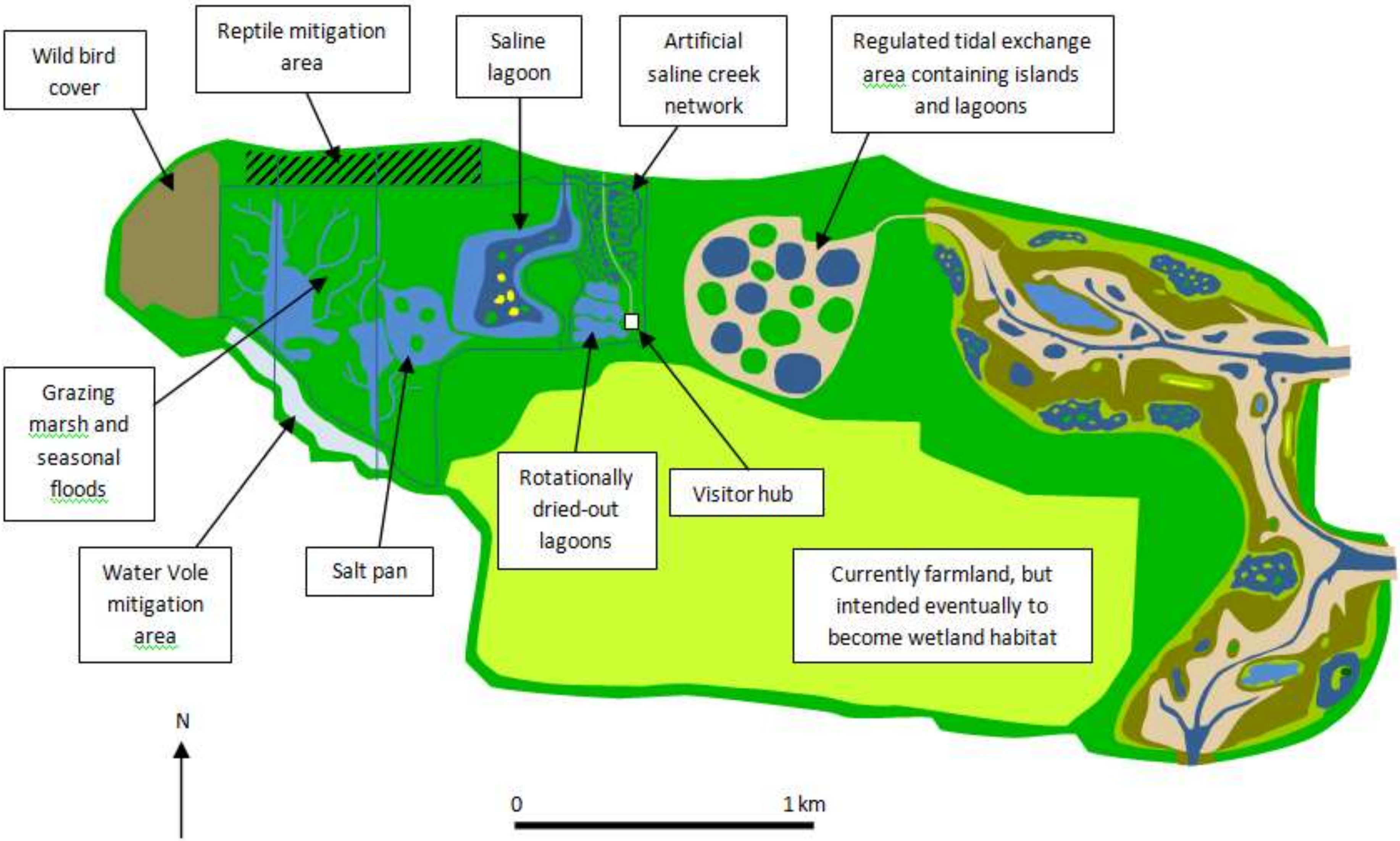
Wildlife present in the existing habitat

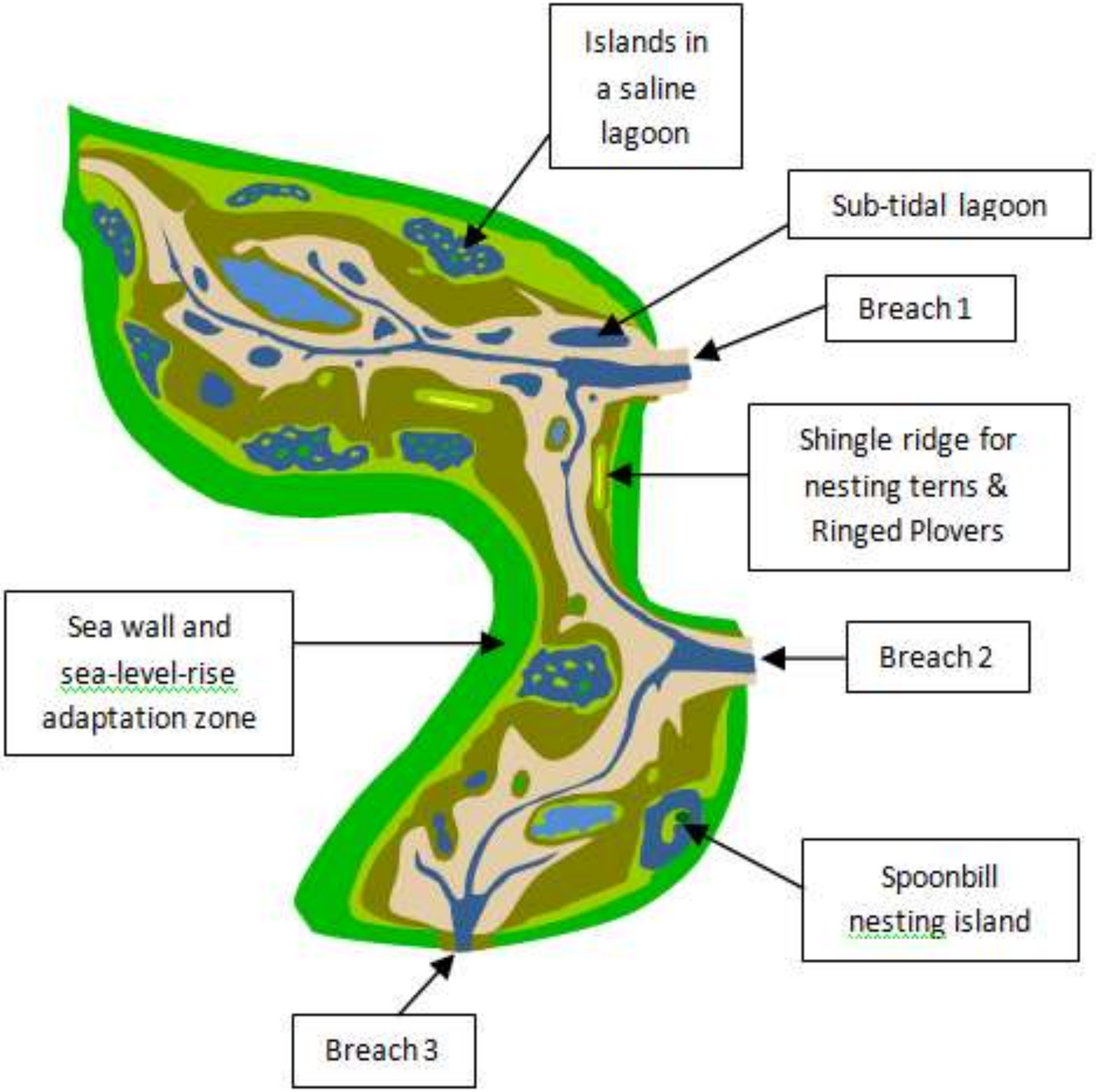
Other valuable wetland features for wildlife both now & in the future

Transitions between high salt marsh & non-tidal grassland

Temporary saline water bodies & their margins

Dark Emerald Damselfly
Lestes macrostigma


Wild bird cover
Reptile mitigation area
Saline lagoon
Artificial saline creek network
Regulated tidal exchange area containing islands and lagoons
Grazing marsh and seasonal floods
Water Vole mitigation area
Salt pan
Rotationally dried-out lagoons
Visitor hub
Currently farmland, but intended eventually to become wetland habitat
N
0
1 km


Islands in a saline lagoon
Sub-tidal lagoon
Breach 1
Shingle ridge for nesting terns & Ringed Plovers
Sea wall and sea-level-rise adaptation zone
Breach 2
Spoonbill nesting island
Breach 3

One year on…….

The regulated tidal exchange area

The regulated tidal exchange area

‘Underwater’ anti-predator fencing

Fish & free-swimming invertebrates in the RTE area in August 2016 (mean no. per $m^2 \pm$ 1 SE)

Species	SW corner	NE corner
Three-spined Stickleback	4.5 ± 2.5	2.5 ± 1.6
Common/Sand Goby	2.5 ± 1.4	1.0 ± 0.7
Brown Shrimp	0.5 ± 0.5	7.1 ± 2.0
Common Ditch Shrimp	1.0 ± 1.0	-
Gammarus sp(p)	-	1.0 ± 1.0
Idotea chelipes	-	7.1 ± 2.8

Benthic invertebrates in NE corner of the RTE area in 2016 (mean no. per m^2 ± 1 SE)

Species	May	August
Chironomid larvae	640 ± 153	4,770 ± 748
Hydrobia ulvae	-	574 ± 153
Cerastoderma edule	-	44 ± 30
Hediste diversicolor	-	22 + 22

Breeding birds in Year 1 (pairs)

Avocet	101
Black-headed Gull	197
Common Tern	8

And now Phase Two is underway

Warming oceans and human health – it's the little things that matter

Camille Parmesan, University of Plymouth

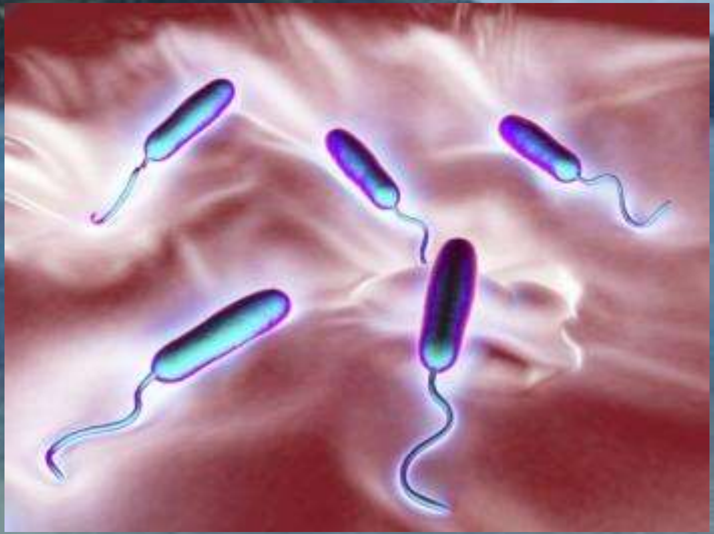
IUCN

Explaining Ocean Warming:

Causes, scale, effects and consequences

Edited by D. Laffoley and J. M. Baxter

Parmesan & Attrill (2016) ***Impacts and effects of ocean warming on human health (disease).***



Katie Pitz, Woods Hole

Current Climate Change is Moving Species

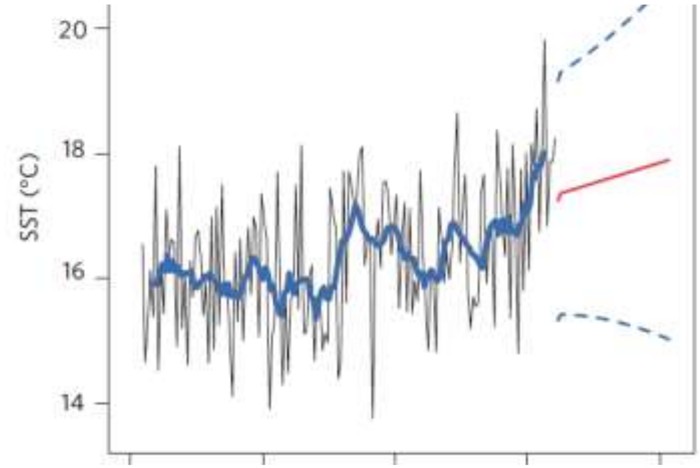
- ~4,000 species with long term data
  - 40% - 60% of terrestrial species have shifted poleward and upward
  - ~2/3 of marine species have shifted to cooler waters
- Most data from charismatic species, but parasite and pathogen diversity mirrors general biodiversity patterns
- Marine species moving at 1.5x to 5x the rate of terrestrial species
- So impacts of shifting disease organisms and vectors may first be seen in oceans

nature climate change
LETTERS
PUBLISHED ONLINE: 22 JULY 2012 | DOI: 10.1038/NCLIMATE1628

Emerging *Vibrio* risk at high latitudes in response to ocean warming

Craig Baker-Austin[1*†], Joaquin A. Trinanes[2,3†], Nick G. H. Taylor[1], Rachel Hartnell[1], Anja Siitonen[4] and Jaime Martinez-Urtaza[5†]

Baltic Sea: Temperature

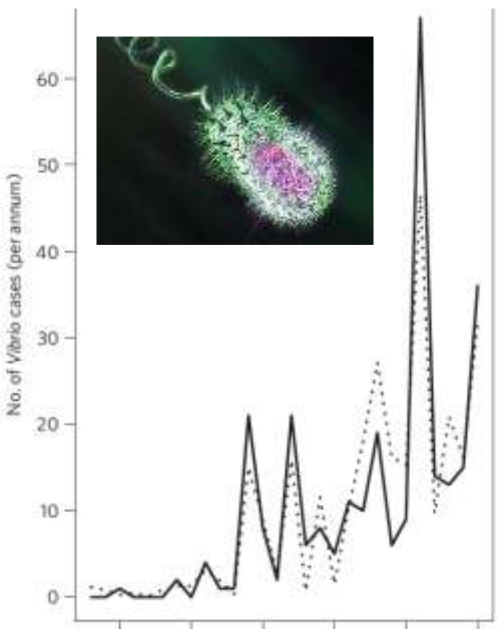


1850 1900 1950 2000 2050
year

Vibrio = group of bacteria

- many harmful species

Baltic Sea: Vibrio Cases



85 90 2000 2010
year

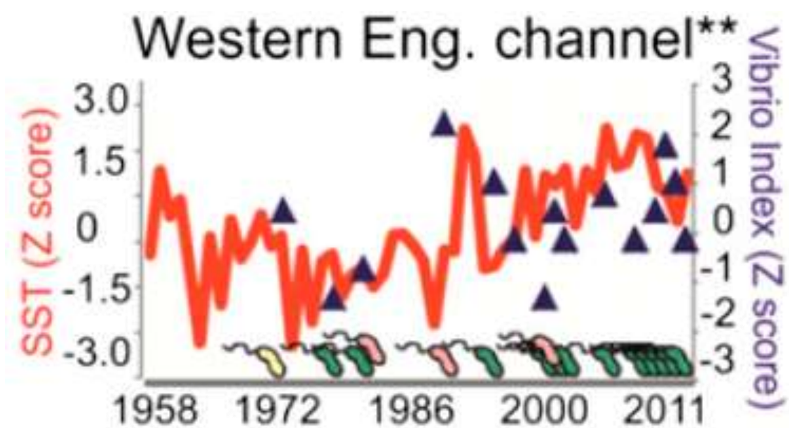
Vibrio vulnificus

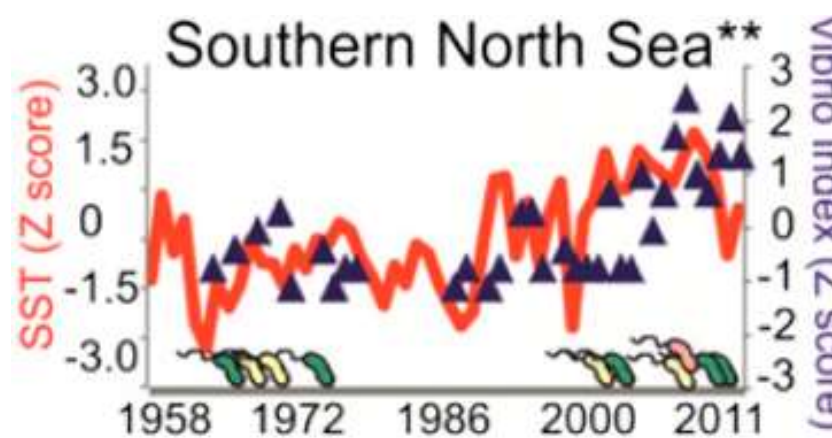
- > 15% fatalities with wounds
- > 50% fatalities from food poisoning

Vibrio spp Increasing in Coastal Waters of N Atlantic & N Sea

- Northward range shift of pandemic (pathogenic) *Vibrio parahaemolyticus)* into British oysters first documented in 2012
- Expansion occurred along southern coast into both commercial shellfish sites and a marine protected area

Powell *et al.* 2013 *Microb Ecology*





Analyses of zooplankton collected by SAHFOS Continuous Plankton Recorders for *Vibrio spp*

Vezzulli *et al. PNAS* 2016

Findings

- **UK government reports on disease and climate change focus on terrestrial species (mosquitos), no mention of marine sources**
- **Many marine pathogens *(Vibrio spp)* impact wild species and humans**
- **UK Vibrio Scheme provides technical guidance on how to identify *Vibrio spp*, but no systematic monitoring mentioned (Public Health England)**
- **NHS does not include *Vibrio spp* as "reportable", so not tested for in suspected food poisoning cases**

Recommendations

- **Biodiversity assessments should include the little species: key disease organisms and their vectors and reservoirs**
- **Encourage the design and implementation of systematic surveys of coastal waters for "warm water" sp: *e.g. Vibrio* spp, algae spp known to carry harmful toxins**
- **Implement regular testing of UK seafood for above**
- **Make *Vibrio* spp reportable under NHS, both for suspected food poisoning and for bathing-related illness.**

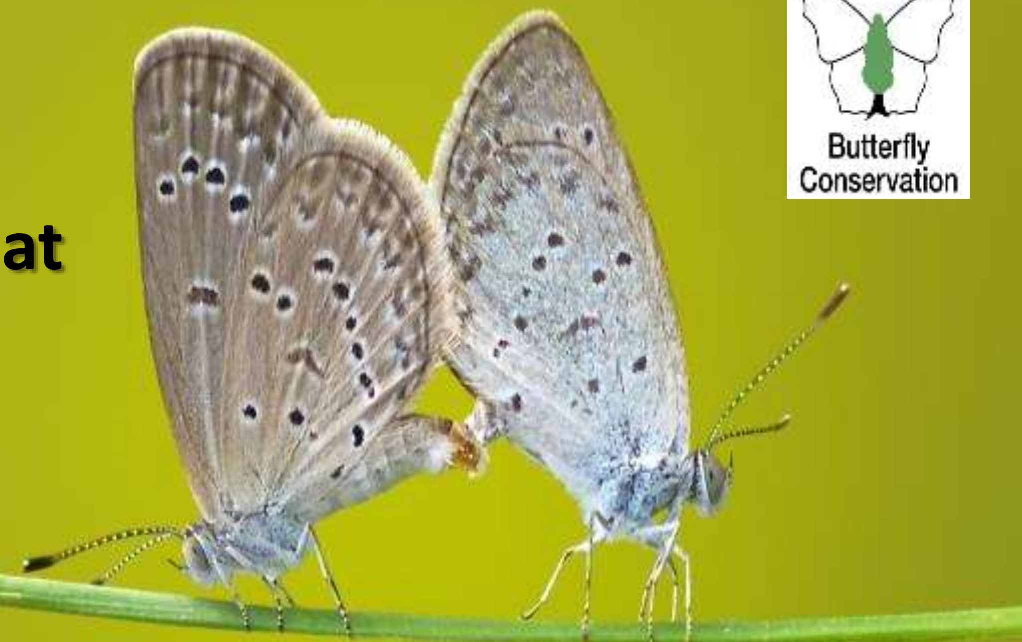
Sensitivity of UK Butterflies to local climatic extremes

Osgur McDermott Long, University of Plymouth

Sensitivity of UK Butterflies to local climatic extremes

Which life stages are most at risk?

Journal of Animal Ecology, 2016



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Dr. Aldina Franco (CEEC)
Dr. Jeff Price (Tyndall Centre)

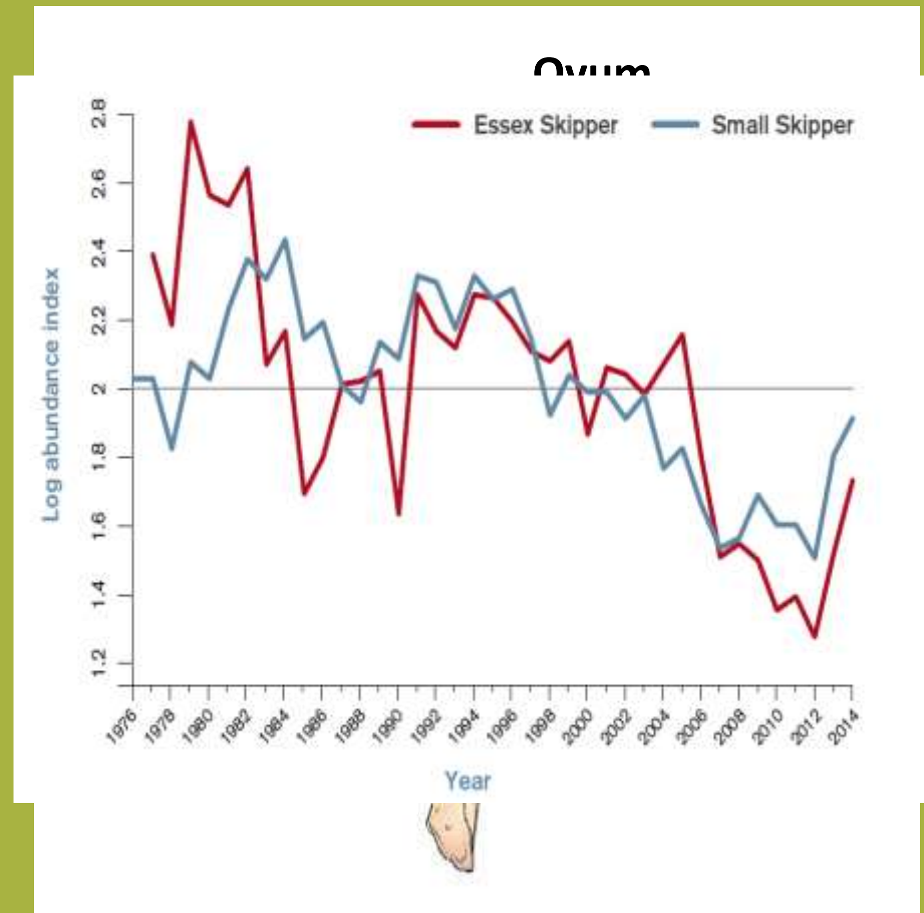
Why Butterflies, why Extremes?

<u>Why Butterflies</u>

- Butterflies declining
- Complex lifecycle
- Bioindicators

<u>Why Extremes</u>

- Extremes increased in frequency
- Understudied



Take home message from all models

Warm winters are **significantly** associated with **butterfly declines**

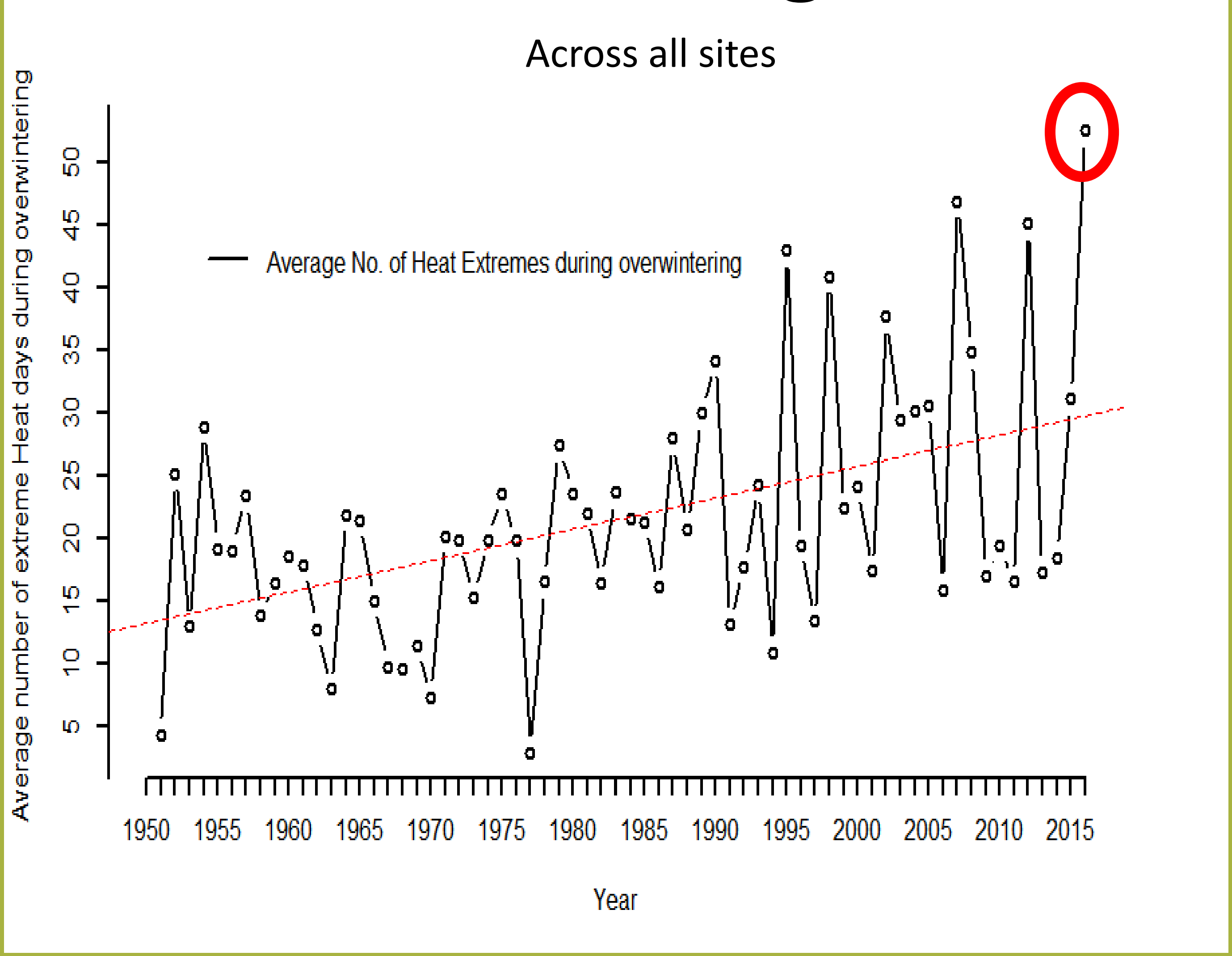
Mechanisms

- Early emergence
- Increased pathogens
- Life timings cue mismatches

Further and more detailed results see:

McDermott Long, O., Warren, R., Price, J., Brereton, T. M., Botham, M. S., & Franco, A. M. A. (2016, October 31). Sensitivity of UK butterflies to local climatic extremes: Which life stages are most at risk? *Journal of Animal Ecology*. doi:10.1111/1365-2656.12594

Extremely warm winters are increasing



Butterfly abundances in 2016

70% of butterfly species declined in 2016 (UKBMS)

Warm winters have the potential to drive declines in abundance of UK butterflies.

Big Butterfly count species	% change 2016 BigBC	Warm Winter Impact Model prediction
Common Blue	-55	---
Holly Blue*	-48	+++
Small Tortoiseshell	-47	---
Comma	-46	---
Peacock	-42	---
Gatekeeper	-40	---
Small Copper	-30	---
Brimstone	-20	---
Large Skipper	-2	---