

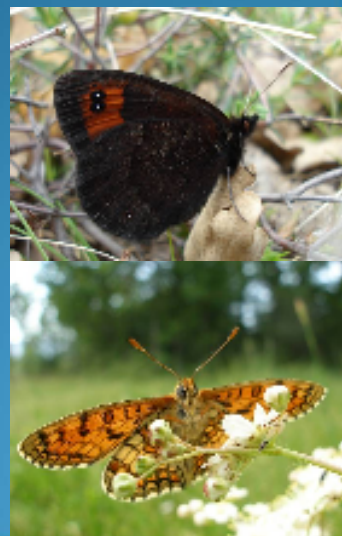
Spatial heterogeneity, climate change and conservation

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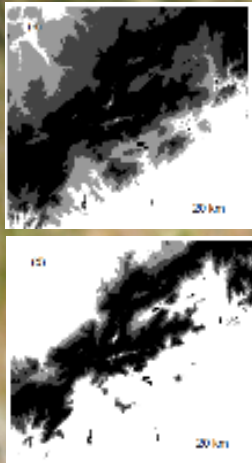


Background

- Climate warming causes poleward / uphill shifts in species distributions
- Three challenges for conservation:



1. To delay / prevent climate-driven declines (at low-latitudes / elevations)



2. To facilitate recovery / expansion (at high-latitudes / elevations)





3. To overcome pre-existing threats
in a changing climate



Achieving the three challenges:
Do the same things better?
Or change priorities / approaches?

The role of heterogeneity

- Ecological responses reflect fine-scale spatial and temporal variability in climate
- Habitat heterogeneity can:
 1. Allow for changing habitat associations
 2. Buffer against extreme events
 3. Reduce local extinction risk

The role of heterogeneity



Euphydryas editha

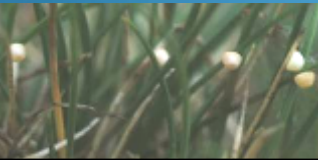


Hesperia comma

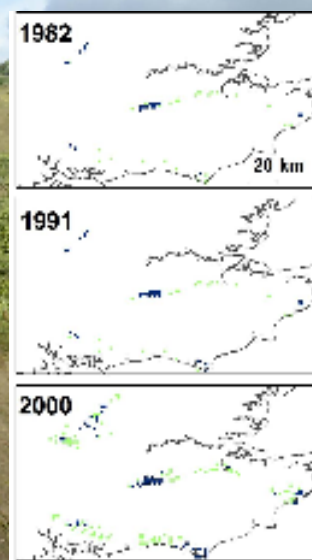
Does heterogeneity have a proven role for the three conservation / climate change challenges?

Habitat heterogeneity & range expansion through fragmented landscapes

- Effects of spatial & temporal variability in climate on population and metapopulation dynamics
 - Consequences for local and landscape management
 - Silver-spotted skipper *Hesperia comma* as exemplar
- NERC UK project (2009-12)



H. comma & chalk grassland in South East England: history of grazing, succession, and conservation management



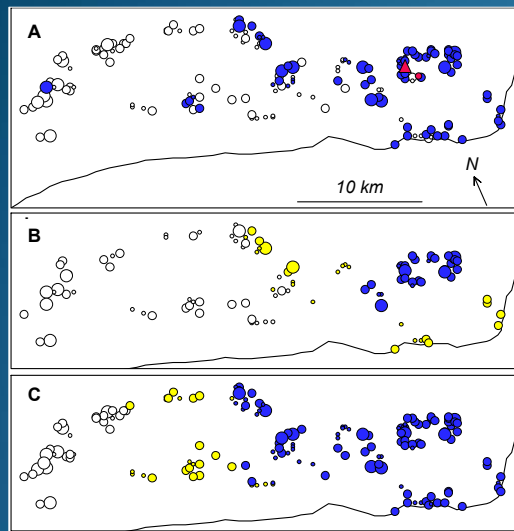
Climate change & *Hesperia comma*

- **High latitude range margin:**
- Habitat specialist, restricted to south-facing, short turfed chalk downs in SE England
- **Temperature increase:**
- Faster egg-laying rate, wider microhabitat range
Davies *et al.* (2006) *J. Anim. Ecol.* 75, 247-256.
- Wider range of aspects; greater habitat availability; faster metapopulation expansion



Thomas *et al.* (2001) *Nature* 411, 577-581.
Wilson *et al.* (2009) *Proc. R. Soc. B* 276, 1421-1427.
Wilson *et al.* (2010) *Ecography* 33, 73-82.

Expansion speeds up as niche broadens



A) Observed range, 1982-2000

Metapopulation simulations

B) 100°-300° aspect habitat

C) All aspects

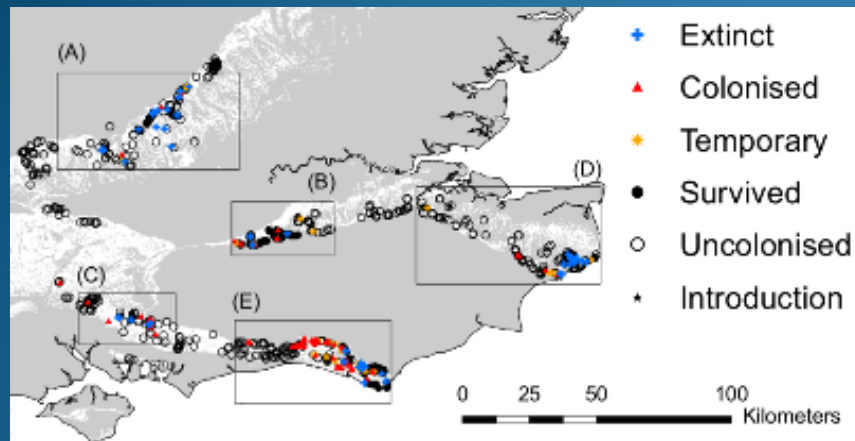
Blue - >50% occupancy

Yellow - 1-50% occupancy



Thomas *et al.* (2001) *Nature* 411, 577-581.

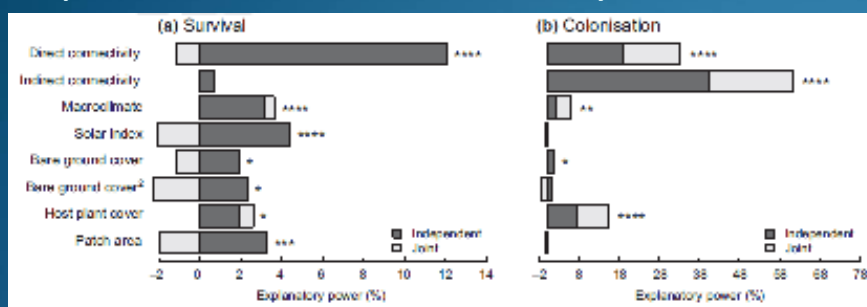
Expansion & climate variability, 2000-09



- 67 colonisations offset by 48 local extinctions

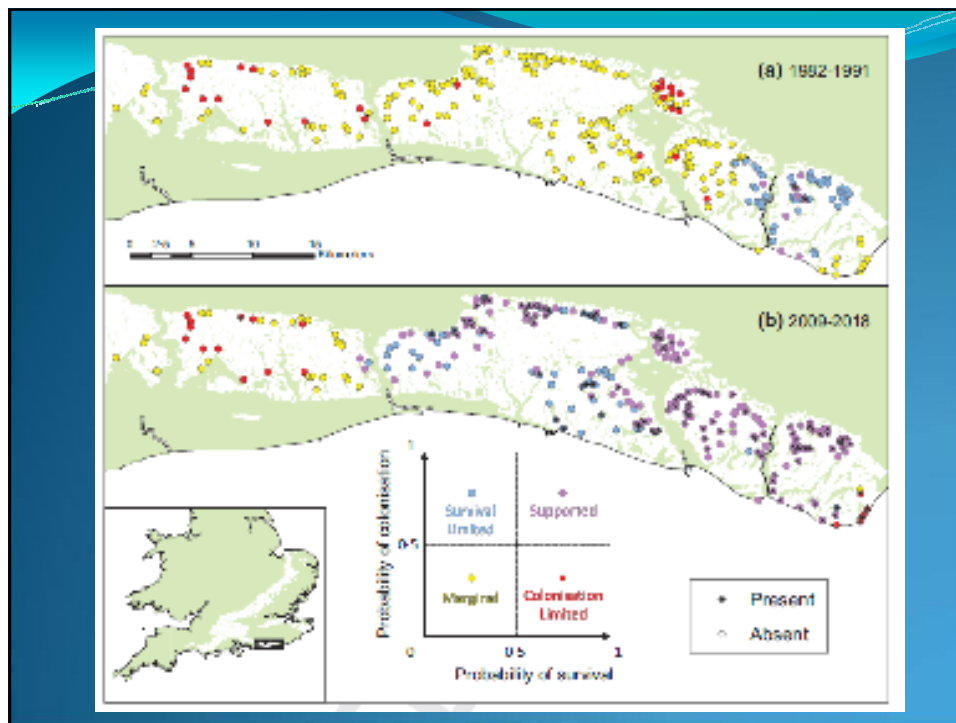
Lawson *et al.* (in press) *J. Appl. Ecol.*

Expansion & climate variability, 2000-09



- Survival - local factors; Colonisation - connectivity
- Populations near expanding front are vulnerable
- Management priorities shift during expansion

Lawson *et al.* (in press) *J. Appl. Ecol.*



Refuges against poor years:

Large

High quality (topoclimate + vegetation)

High connectivity

Local heterogeneity?



Range shifts & declines at lower latitudes

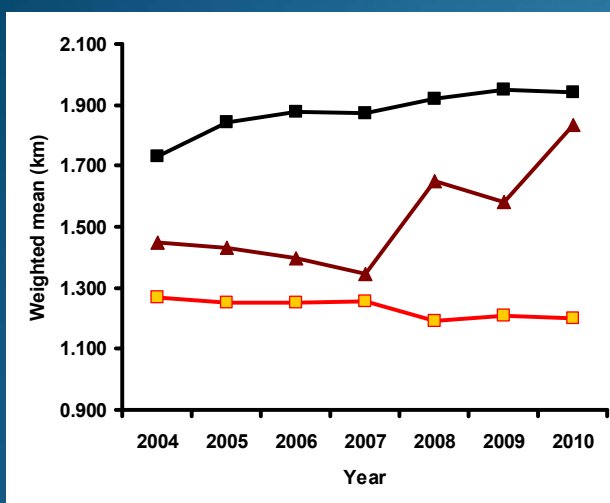
- Dynamics of range contraction also probably episodic
 - population dynamic responses to climate variability
- Challenges:
 - to identify micro-refugia & model persistence
 - to determine scope for adaptive management



Spatial heterogeneity at lower
latitudes: historic refugia in
mountain regions
(future refugia?)

Sierra de Guadarrama
central Spain

Population dynamics vary over elevation:



Erebia meolans

Argynnis niobe

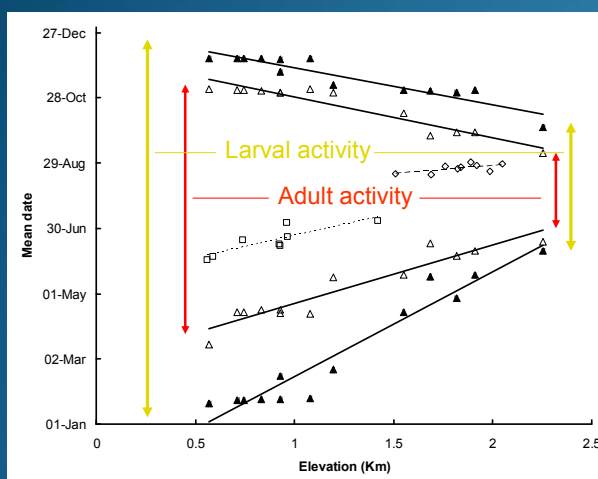
Zerynthia rumina



Regional topography can
buffer local population
variability

Protect a range of elevations or
topoclimates

Phenology varies over elevation:



Risk
spreading?



But late- &
high-flying
species –
synchrony

Gutierrez Illan et al. (in press) *Ecol. Entomol.*

Habitat associations vary over space:

- Egg sites in shadier locations at lower elevations (*Aporia crataegi*, *Euphydryas aurinia*)
Merrill et al. (2008) *J. Anim. Ecol.* 77, 145-155
- Larvae in shadier locations at lower elevations (*Parnassius apollo*)
Ashton et al. (2009) *Ecol. Entomol.* 34, 437-446

Protect / manage a range
of habitats & microhabitats



Habitat associations vary over time:

- Bare ground selection by egg-laying *Hesperia comma*
Davies et al. *J. Anim. Ecol.* 75, 247-256.
- But bare ground still selected across the *H. comma* range margin in England
- Habitat similar in C. Spain
- Local heterogeneity allows for temporal variation, yet keeps “best” habitat

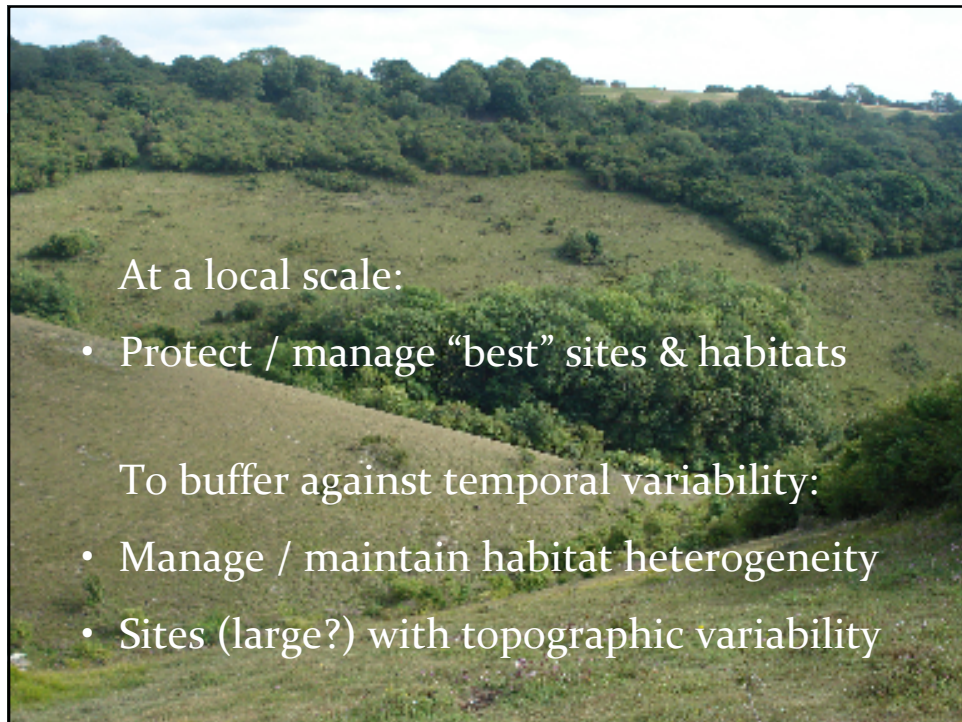


Conclusions

- Spatial and temporal variability is superimposed on long-term trends and large-scale gradients in climate
- Consequences for population & metapopulation dynamics
- Opportunities of heterogeneity for conservation:
 - Conservation in micro-refugia
 - Exploit favourable years for range expansion
 - Buffer against unfavourable years



Using spatial heterogeneity to adapt conservation to climate change



At European scale:

- Monitoring & conservation across latitudinal / elevation ranges of species
- Protecting current variability key for adapting to change



Acknowledgements

UK: C.D. Thomas, J.J. Bennie, C.R. Lawson, J. Hodgson, I.M.D. Maclean, C.T.R. Holloway, D.B. Roy, T. Brereton, R. Fox, Z.G. Davies, J. Hopkins, and many field assistants

Spain: D. Gutierrez, J. Gutiérrez, S.B. Diez, D. Martinez.

Funding: NERC (UK), British Ecological Society, Spanish Ministry of Education & Science, Univ. Rey Juan Carlos, The Royal Society

