

Landscape effects on bird and butterfly population resilience

Tom Oliver¹

toliver@ceh.ac.uk,

Simon Gillings²,
Michael Morecroft³



Adapting England to changing climates

The 'Hopkins adaptation principles':

1. Conserve existing biodiversity
2. Reduce sources of harm not linked to climate
3. **Develop ecologically resilient and varied landscapes**
 - Conserve and enhance local variation within sites and habitats
 - Make space for natural development of rivers and coasts
4. **Establish ecological networks** through habitat protection, restoration and creation.
5. Make sound decisions based in analysis.
6. Integrate adaptation measures into conservation management, planning and practice.

Hopkins *et al.* 2007, Mitchell *et al.* 2007, Smithers *et al.* 2008,
Heller and Zavaleta 2009, *Biol. Cons.*

How can we measure 'resilience'?

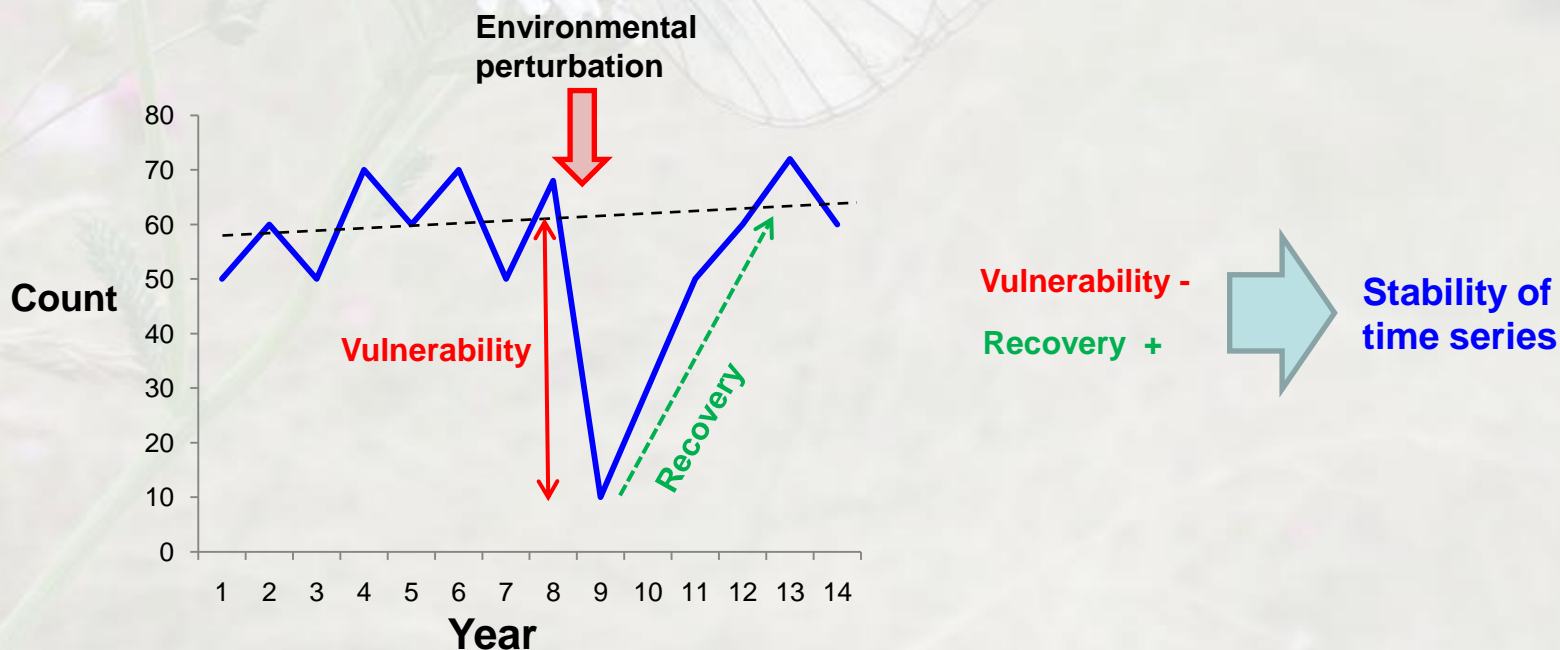
- **Resilience** is...

.....*the amount of disturbance a system can absorb and still remain in the same state or domain of attraction* (Holling, 1973)

.....*the ability of a system to return to a pre-disturbed state without incurring any lasting fundamental change* (IPCC, 2007)

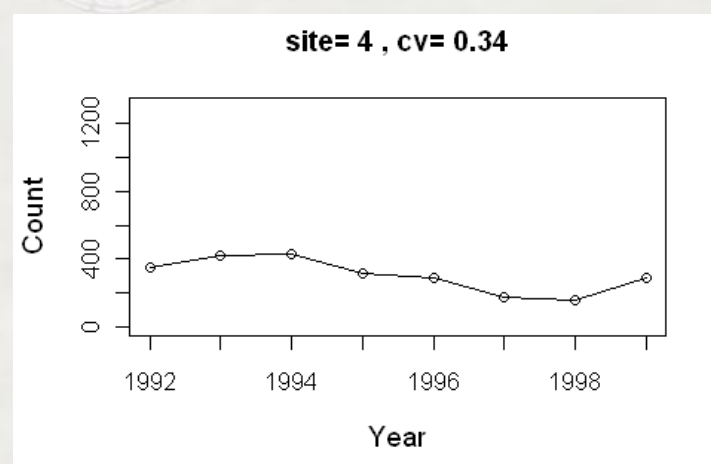
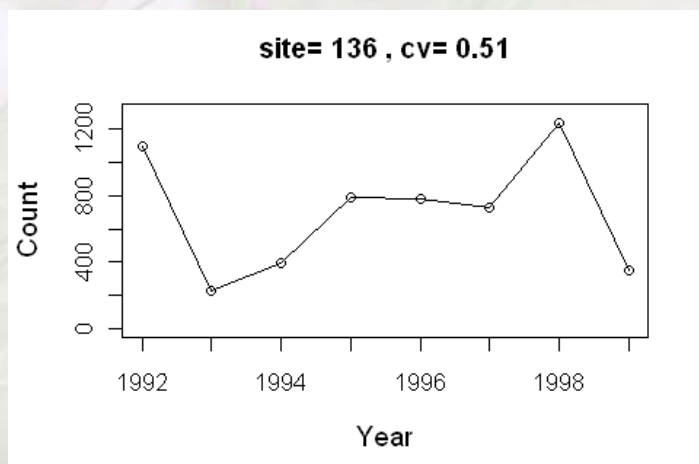
Population resilience

The ability of a population to withstand and recover from environmental perturbations



Population stability

- Can be measured using coefficient of variation (CV) or standard deviation of log time series (SD)
- Theory and experiment show that **stability** is **important for population persistence**, i.e. stable populations have lower extinction risk (Inchausti & Halley, 2003, *J. Anim. Ecol.*; Pimm *et al.* 1988, *Am. Nat.*)
- We may be able to **manipulate landscape structure** in order to **improve population resilience** to environmental perturbations
i.e. improve *adaptation capacity* (cf. Hopkins *et al.* 2007)



Study 1: Landscape heterogeneity and population stability

Specific case studies:

1. Fine-scale grassland heterogeneity reduces temporal variability and extinction risk of *Metriopectera bicolor* crickets (Kindvall, 1996, *Ecology*)
2. Diversity of habitat types at landscape scale increases persistence of *Rana temporaria* frogs in drought years (Piha, 2007, *Glob. Ch. Biol.*)

Is this a general phenomenon?

– Multiple species

- **Account for biases** in measures of variability (**Zero counts**; McArdle, Gaston and Lawton, 1990, *J. Anim. Ecol.*), **Time-series duration**; Pimm and Redfearn, 1988, *Nature*), **Mean abundance**; Taylor, 1961, *Nature*), **Long term population trends** (Lepš, 1993, *Oikos*); **Position in range** (Thomas, Moss & Pollard, 1994, *Ecography*)

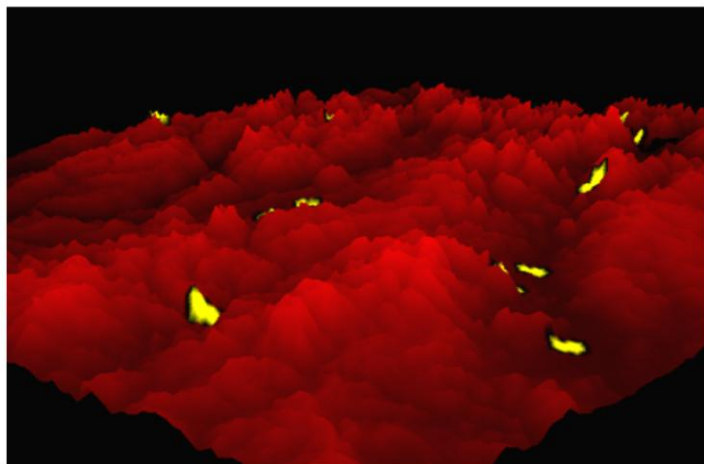
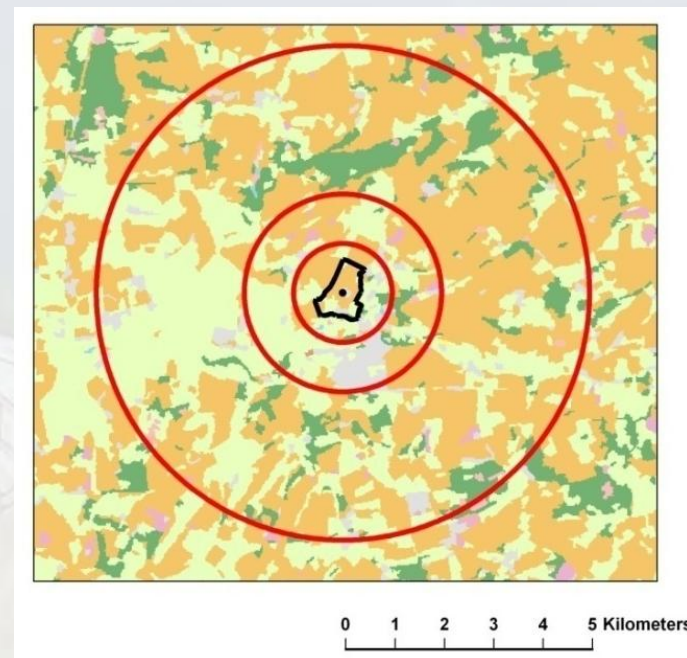
- Also, which at **which spatial scale** is it best to relate population variability to landscape structure?



Assessing landscape heterogeneity

BIOTOPE/ 'HABITAT' DIVERSITY

- 12 broad habitat types from CEH Land cover map
- Shannon- Wiener H' Index of habitat types 'used' by a particular species
- 1km, 2km, 5km radius around monitoring site

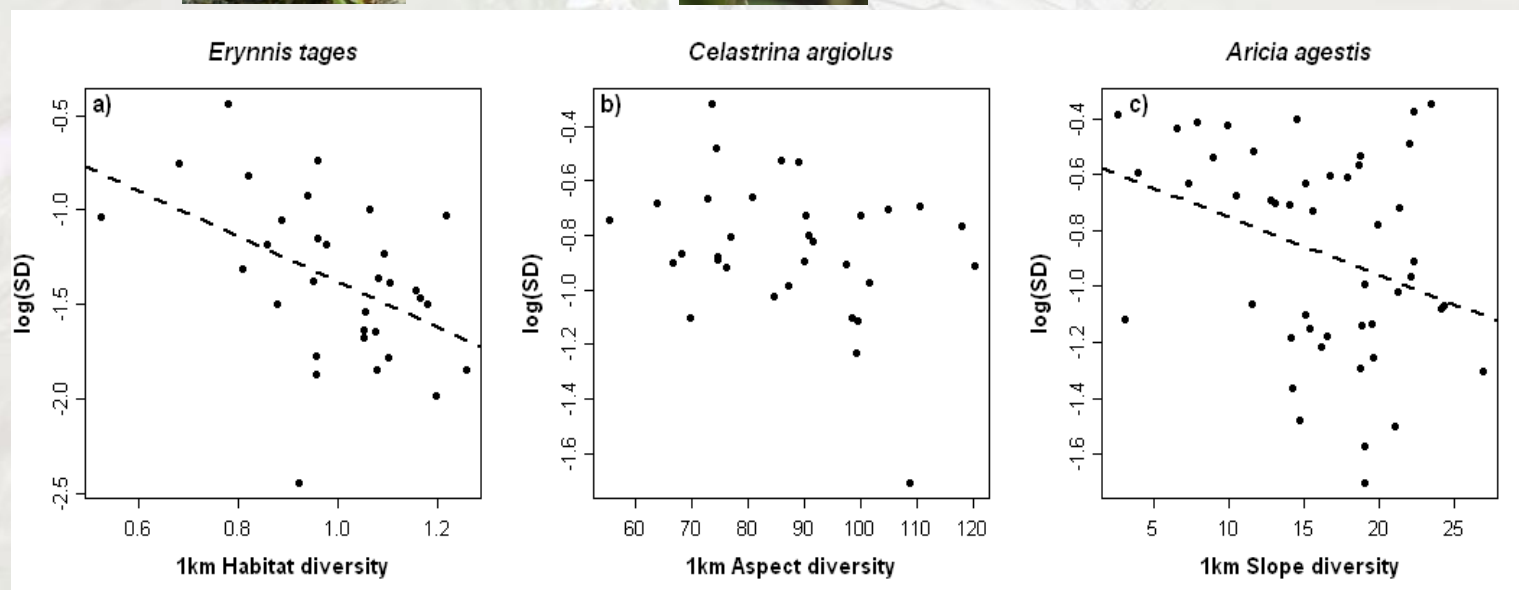
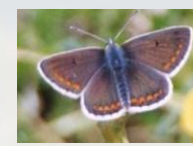


TOPOGRAPHIC DIVERSITY

- Slope and aspect from DEM
- Standard deviation of slope and aspect values used as a measure of topographic diversity

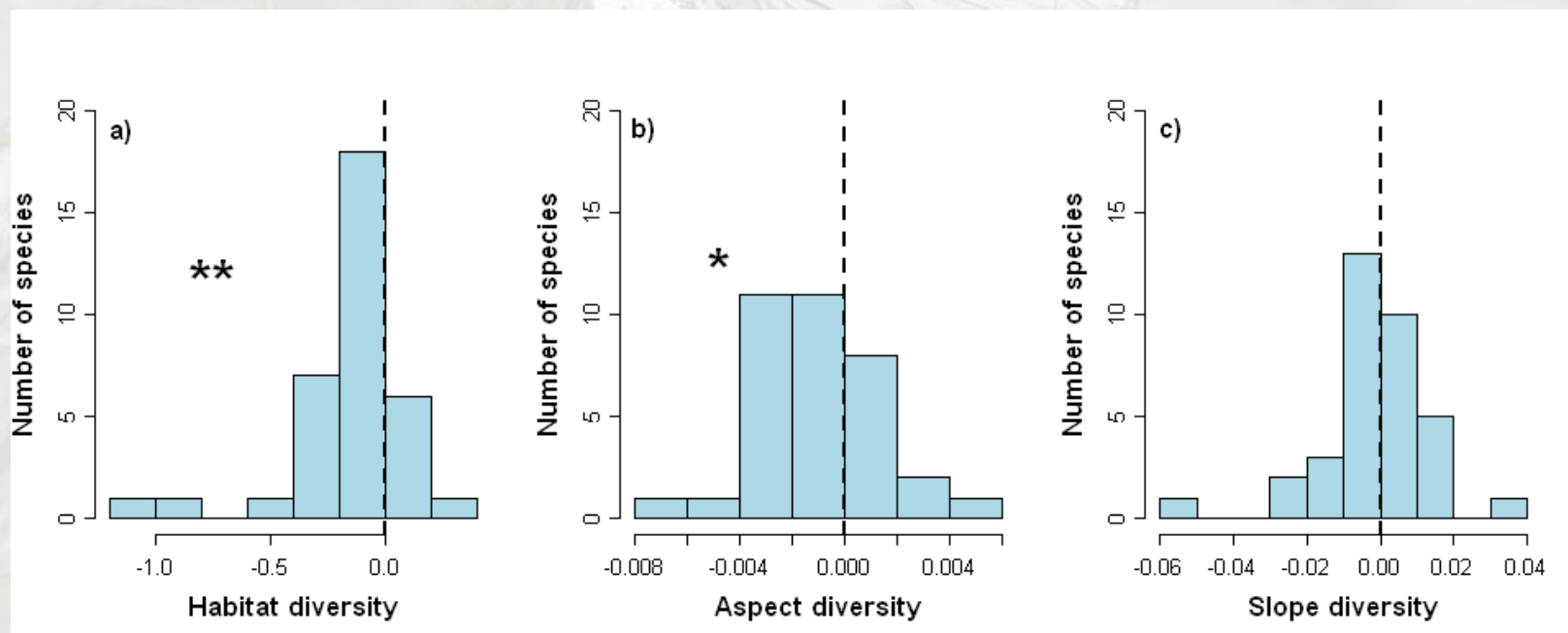
Results

- Many species show lower variability in landscapes with higher habitat or topographic diversity
- Three example species:

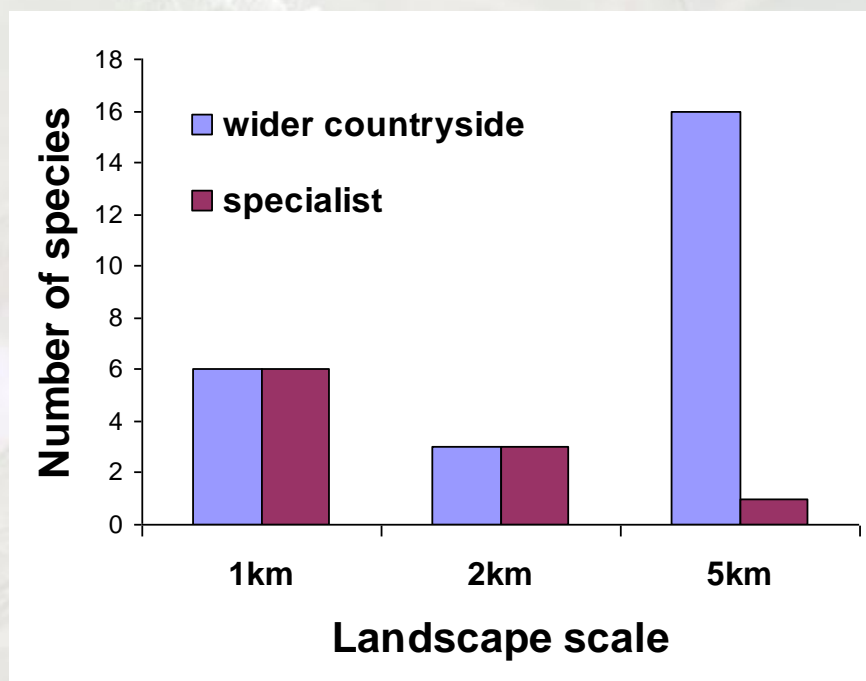


- Across all 35 species, there were significant relationships between habitat diversity and topographic aspect diversity on population variability
- The results were robust to the inclusion of mean abundance and population trend as covariates
- Habitat heterogeneity was significant at all spatial scales tested ($p < 0.05$). Aspect diversity was significant only at 1km around sites

Histograms of slope coefficients



- The **most appropriate spatial scale** to characterise landscape diversity differed between wider-countryside and specialist species.



Mechanisms?

1. **Different population dynamics** between habitat types/ topographic formations due to differences in microclimate, resource availability, land management, natural enemy intensity etc.
 - Leads to asynchronous dynamics, yet whole population across habitat types has a more stable average (den Boer, 1981, *Oecologia*; Thomas, 1991 *Oecologia*)
 2. **Dispersal** between habitat types dampens temporal variability
- e.g.
- short term behavioural thermoregulation or resource acquisition (Ashton *et al.* 2009, *Ecol. Ent.*; Dennis & Shreeve, 2003 *Oikos*)
 - different microclimates for different generations (Roy and Thomas, 2003, *Oecologia*)
 - different microsites between years depending on weather (Weiss *et al.*, 1988, *Ecology*; Davies *et al.*, 2006, *J. Anim. Ecol.*)

SHORT TERM



LONGER TERM

Implications for conservation

1. **Heterogeneity of the wider landscape is important** for maintaining **stable populations** of species.
2. Improving landscape heterogeneity should increase the resilience of populations to environmental change.
3. Species responses may depend on functional traits.



Implications for conservation

1. Heterogeneity of the wider landscape is important for maintaining stable populations of species.
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Implications for conservation

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NE-funded project: Testing CC adaptation policy

How do site- and landscape
scale attributes affect...

Population resilience?

- vulnerability to climatic extremes
- recovery
- stability

Community composition?

- species richness
- change in proportion of cold loving species
- change in proportion of warmth loving species

Data
sources:



Breeding Bird Survey (4171 sites 1994-present), Common Bird Census, (200 sites 1962-2000)

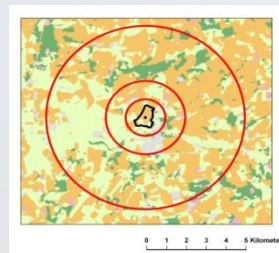


UK Butterfly Monitoring Scheme (1625 sites, 1976-present)

Project duration: October 2010 – 31st March 2011

NE-funded project: Testing CC adaptation policy

Characterising sites and landscapes (0.5, 2, 5, 10km radius around monitoring sites) using a range of metrics



ATTRIBUTE: **SOIL**

LANDCOVER

TOPOGRAPHY

METRICS:

Soil heterogeneity

- Shannon diversity of soil hydrology types

Soil Moisture

- Mean/ max/ min modelled soil moisture in summer drought
- Dominant soil type

Biotope Heterogeneity

- Shannon diversity

Biotope Configuration

- Patch density
- Euclidean distance between patches
- Mean shape index

Biotope Area

- Individual biotope area
- 'Suitability' estimate (bioclimate model)

Topography

- Mean/ max/ min slope, aspect (eastness, northness), altitude
- SD slope, aspect (eastness, northness), altitude

Acknowledgements

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