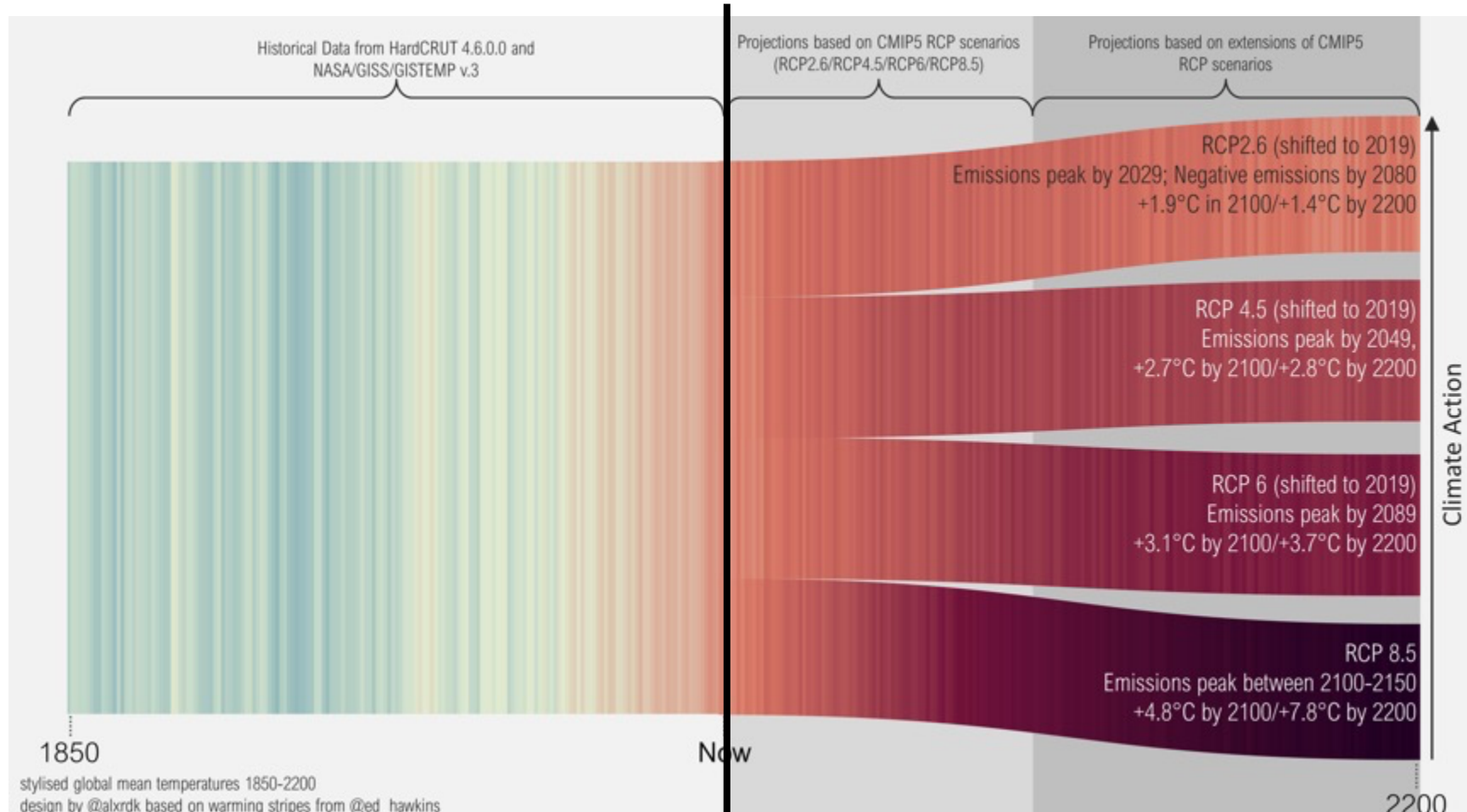
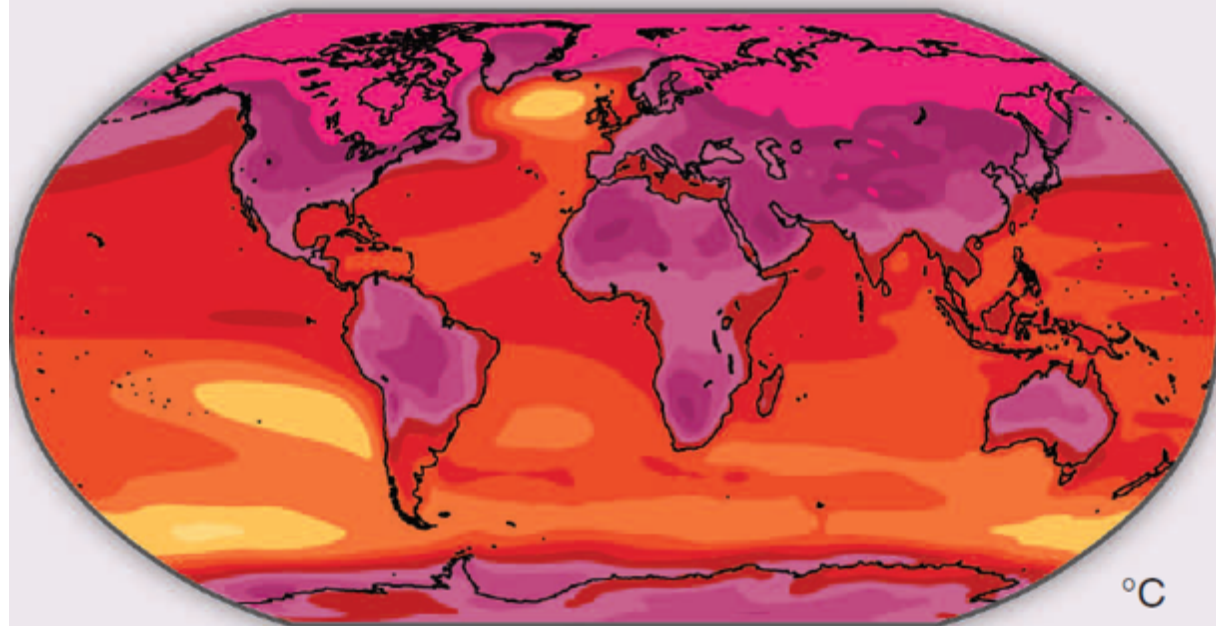


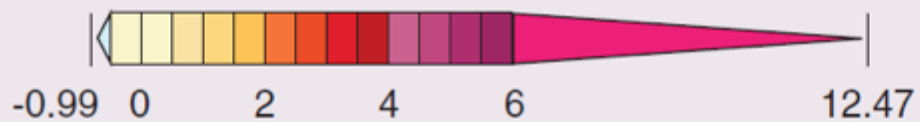
Research round up: climate change



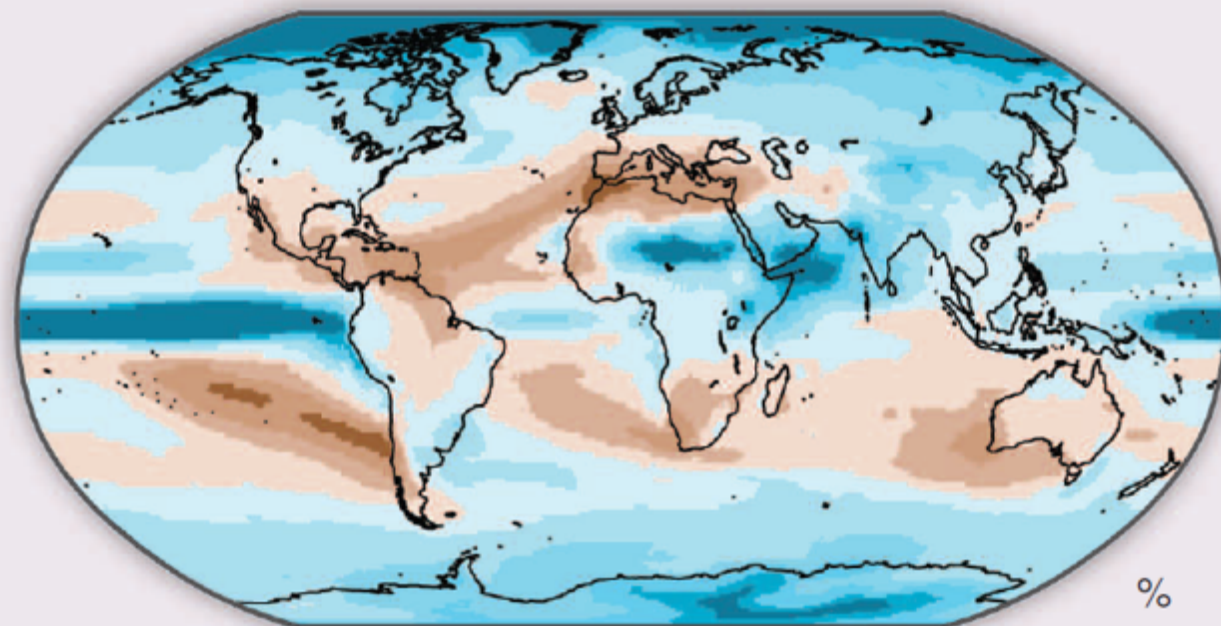
CMIP5 late-21st-century RCP8.5



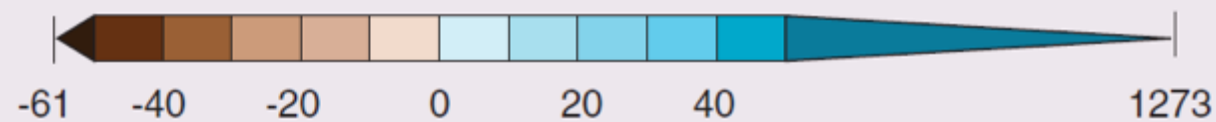
°C



CMIP5 late-21st-century RCP8.5



%



(Diffenbaugh & Field 2013)



AP Rick Rycroft

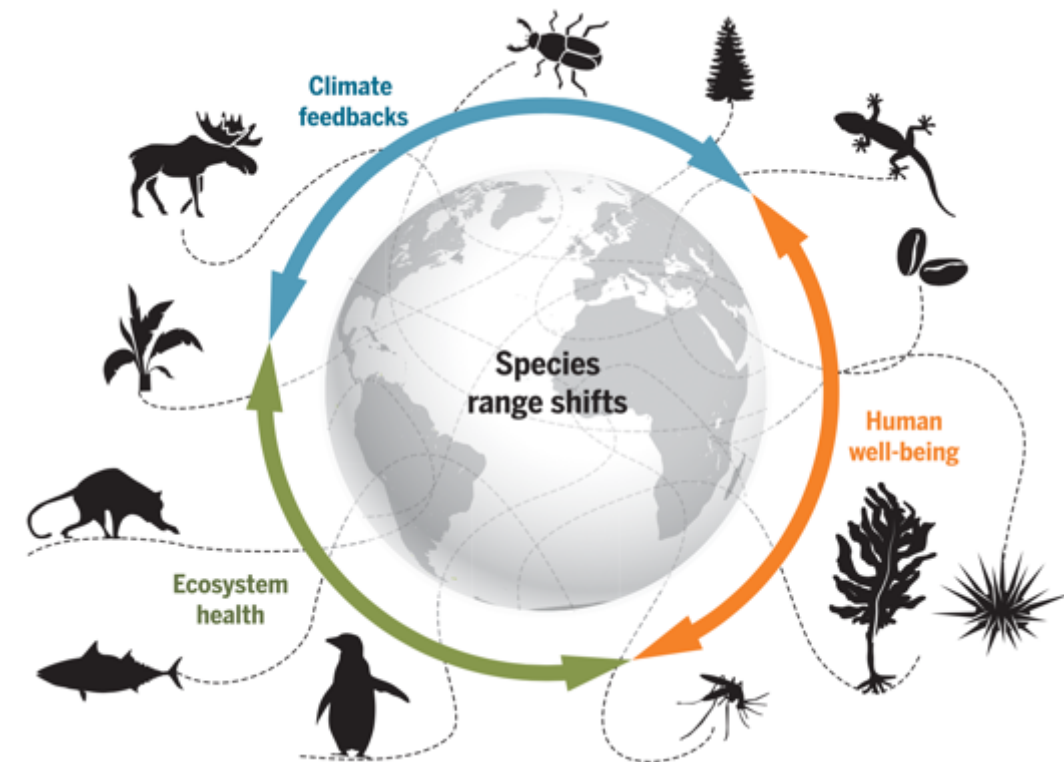
Impacts of climate change

- **Predicted distribution modelling:** 18-35% of species committed to extinction
- Dispersal ability: no dispersal 38-52% vs. complete dispersal 21-32%

(Thomas et al. 2004, Nature, 427: 145-148)

- **Species range shifts** impact production of natural resources, food security, disease transmission and carbon sequestration.
- Novel biotic communities and changes in ecosystem functioning

(Pecl et al. 2017, Science, 355: eaai9214)



Impacts of climate + land-use change

- Mammal habitat predicted to decline globally by 5-16%
- Climate change main driver of loss.
- Greatest losses in Africa (25%) due to land-use change, South America (22%) due to climate change.
- Least affected Europe (4%).
- Greatest declines Afrotheria (>50%), primates
- Lower declines in bats

(Baisero et al. 2020, One Earth, 2: 578-585)



Bats & Climate Change



(Muñoz-Garcia et al. 2016, Comp. Biochem. Phys. A, 191: 156-165)

Impacts of climate change on bats

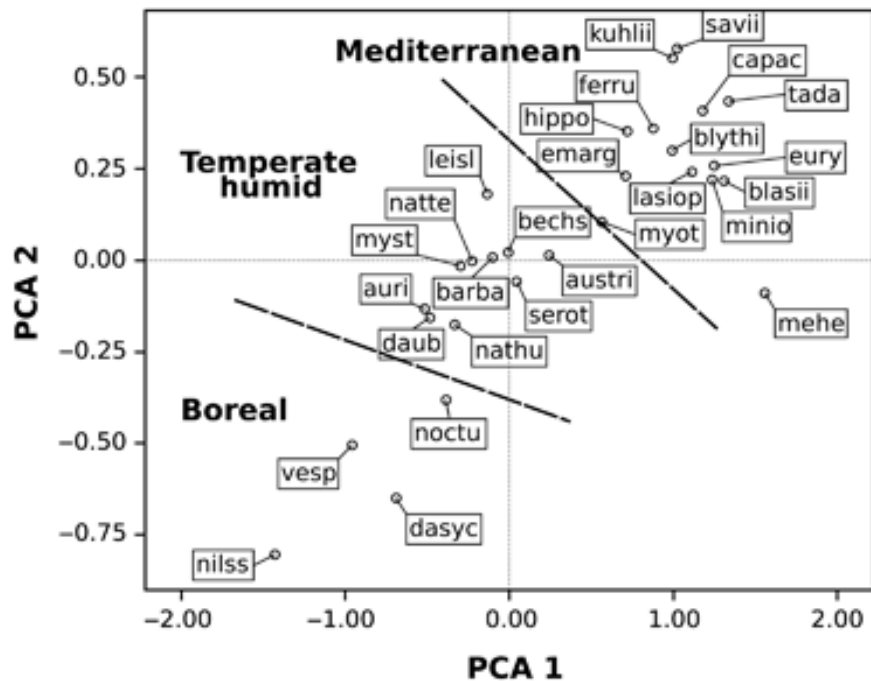
- Main risk factors:

- Biogeography – small range size, high lats, high altitudes, water stressed areas
- Foraging niche - frugivores, aerial hawkers
- Dispersal – restricted dispersal behaviour

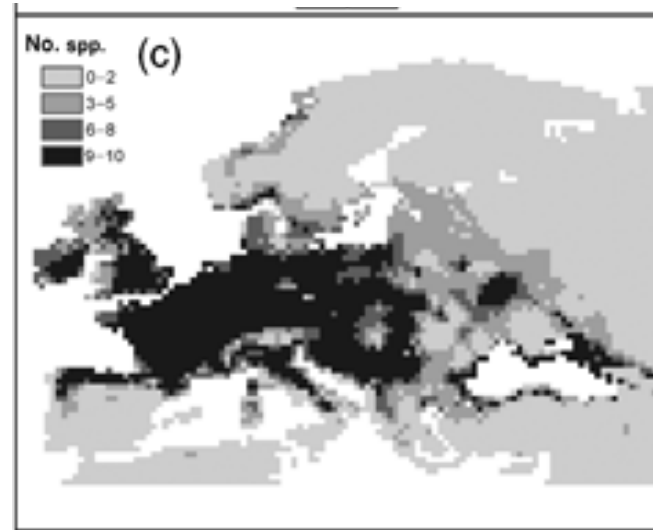
- Highest risk species in Europe:

Pipistrellus maderensis (EN), *Plecotus teneriffae* (EN), *Barbastella barbastellus* (NT), *Nyctalus lasiopterus* (NT), *Miniopterus schreibersii* (NT).

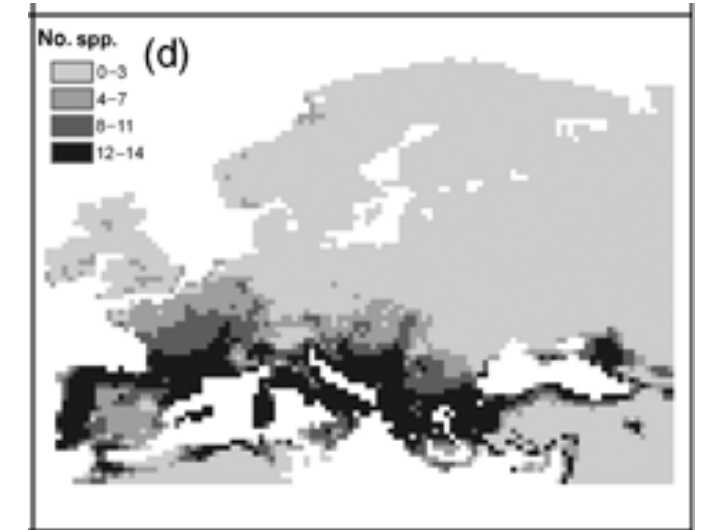
Predicted changes in geographic range Europe



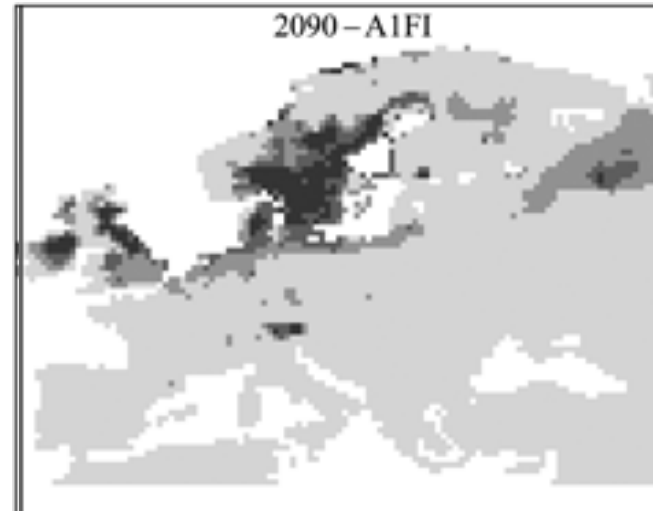
Temperate sp.



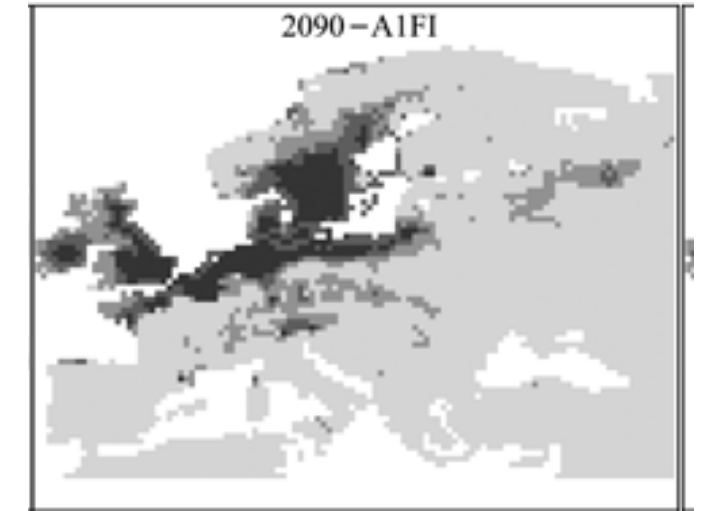
Mediterranean sp.



2090 - A1FI



2090 - A1FI

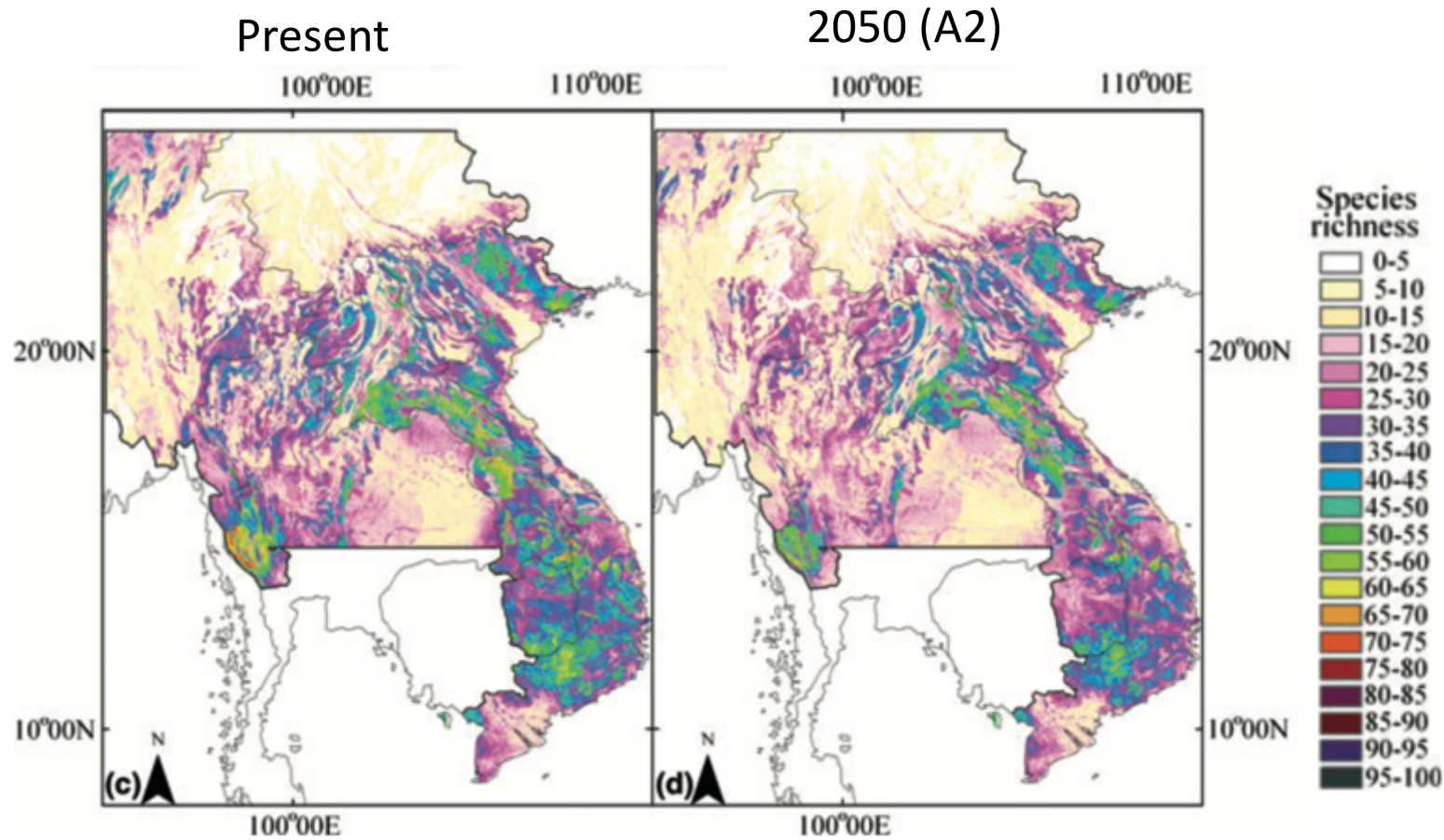


(Rebelo et al. 2010, Glob. Change Biol.,
16: 561-576)

Predicted changes in geographic range

SE Asia

- 171 bat sp.
- Climate + land-use change
- 1% no range loss
- 9% complete loss of current range

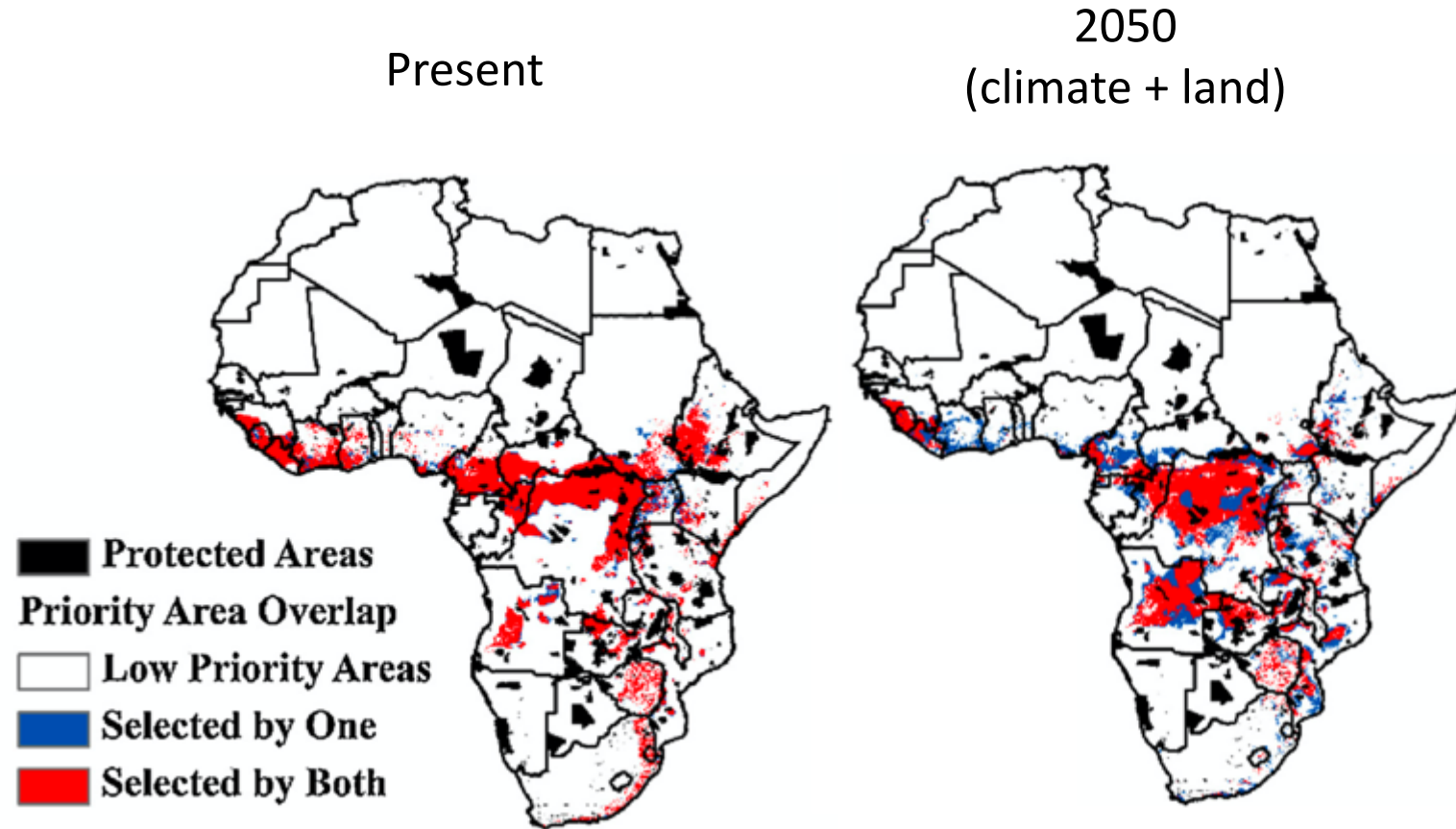


(Hughes et al. 2012, Glob. Change Biol., 18: 1854-1865)

Predicted changes in geographic range

Africa

- Shift in priority areas for conservation of 169 bat sp.
- Climate + land-use change
- Low current representation in PAs (5%)
- 2050: 9% decrease

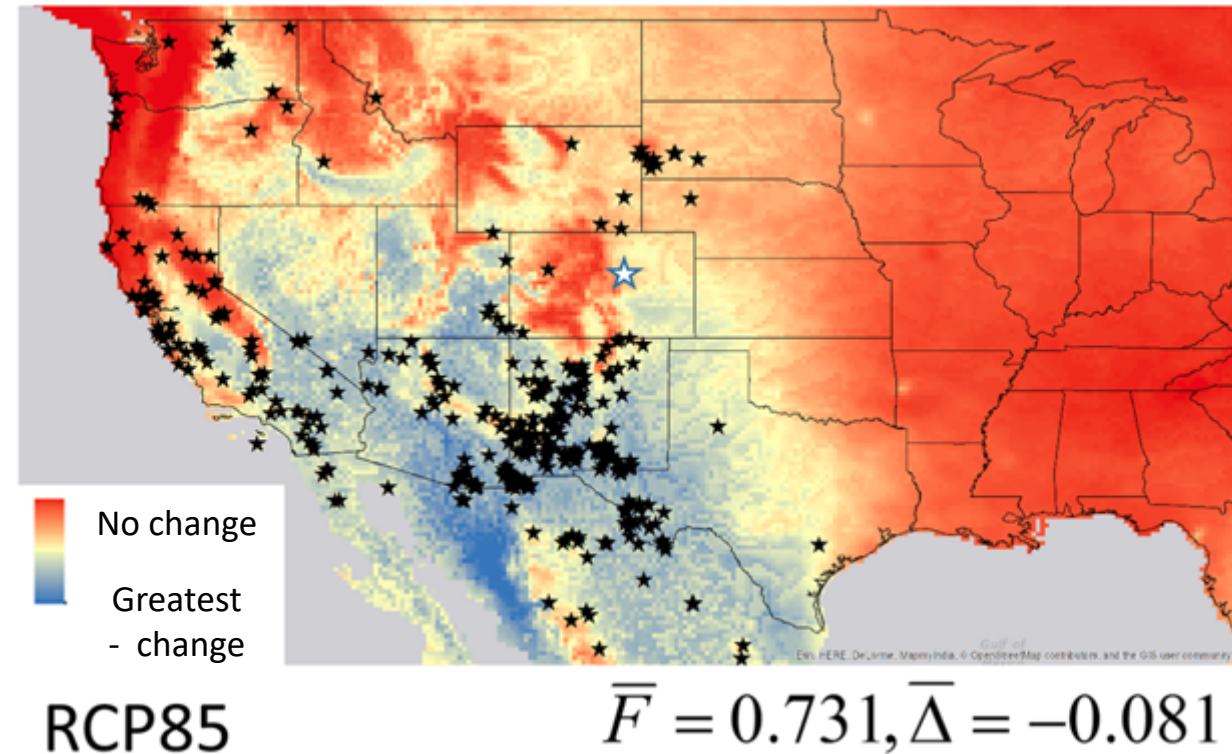


(Smith et al. 2016, Ecological Indicators, 69: 276-283)

Simulated bat population declines

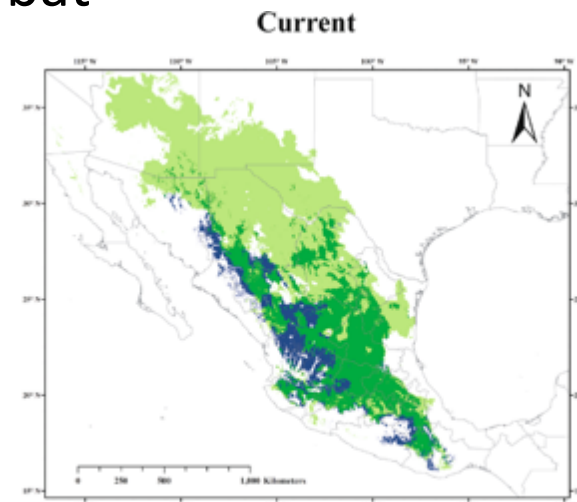
North America

- Population dynamics models
- Changes in female fertility rates
- *Myotis thysanodes*
- Hotter and drier conditions = reduced lactation and reproductive output
- >90% population reductions

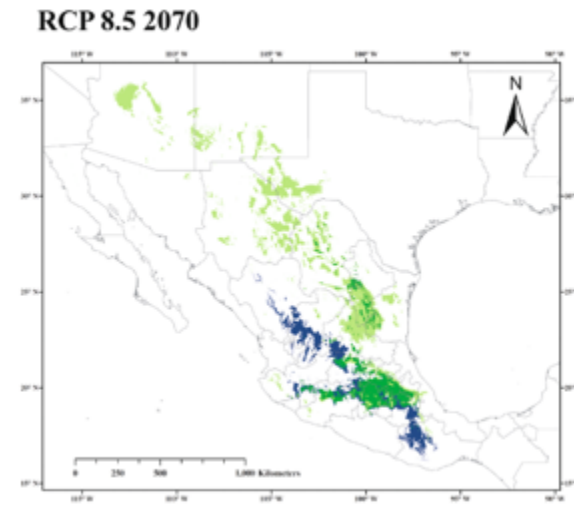


Disruption of ecological relationships

- Trophic mis-matches
- Modelled potential future distribution of *Leptonycteris nivalis* and the *Agave* plants they pollinate during migration from Mexico to the US.
- Overlap between the *Agave* and the pollinating bat reduced by > 75%.
- Food decline will threaten populations of this bat and the maintenance of pollination.



Overlap percentage (dark green): 26.20%



Overlap percentage (dark green): 4.49%

(Gomez-Luis & Lacher 2019, Scientific Reports, 9: 14048)

Observed range expansion

- Opportunistic bat species may expand their geographic range northwards
- Potential disruption of bat assemblage structure and dynamics
- *Pipistrellus kuhlii* ~400% range expansion in last 40 yrs
- Explained by climate change, not urbanisation



(Ancillotto et al. 2016, Sci. Nat., 103: 15)

Fig. 1 Eurasian range of *Pipistrellus kuhlii* (shades of grey). Dark grey historical range (after Stebbings and Griffiths 1986), light grey current range comprising 1980–2013 occurrence data

Heat waves and bat die-offs

- Increased numbers of bat mass mortality events due to heat waves
- Well-known for flying foxes in Australia (Wellbergen et al. 2008, Proc. Roy. Soc. B)
- Cave-dwelling insectivorous bats Cambodia: heat stress (Pruvot et al. 2019, J. Wildlife Res)
- Overlooked yet not rare in Mediterranean basin (anthropogenic roosts).
- Dark south-facing bat boxes: ecological traps in Mediterranean summer

(Bideguren et al. 2019 Biodivers. Conserv.)



422 J. A. Wellbergen et al. Temperature extremes and flying-foxes

Table 2. List of colonies affected in the Northern Rivers region (NSW, Australia) during the temperature extreme of 12 January 2002.

colony ^a	15.00 hours air-temperature at nearest weather station (°C)	estimated number of <i>P. poliocephalus</i> and <i>P. alecto</i> present	% <i>P. alecto</i> among <i>Pteropus</i> spp. present	estimated minimum number of <i>Pteropus</i> spp. that died	% <i>P. alecto</i> among <i>Pteropus</i> spp. that died
Lumley Park	41.7	4000	35.0	51	98.0
Booyong	41.8	15 000	33.3	200	97.8
Dallis Park	42.9	28 000	42.9	1453	91.9
Coffs Creek	43.3	3600	—	75	6.7
Moore Park ^a	42.9	—	—	500	85.0
Kyogle 2002 ^a	43.2	—	—	300	100.0
Casino	43.3	—	—	affected	—
Currie Park ^a	42.4	24 000	50.0	1000	87.9
Mollies Grass	42.4	2000	50.0	100	80.0

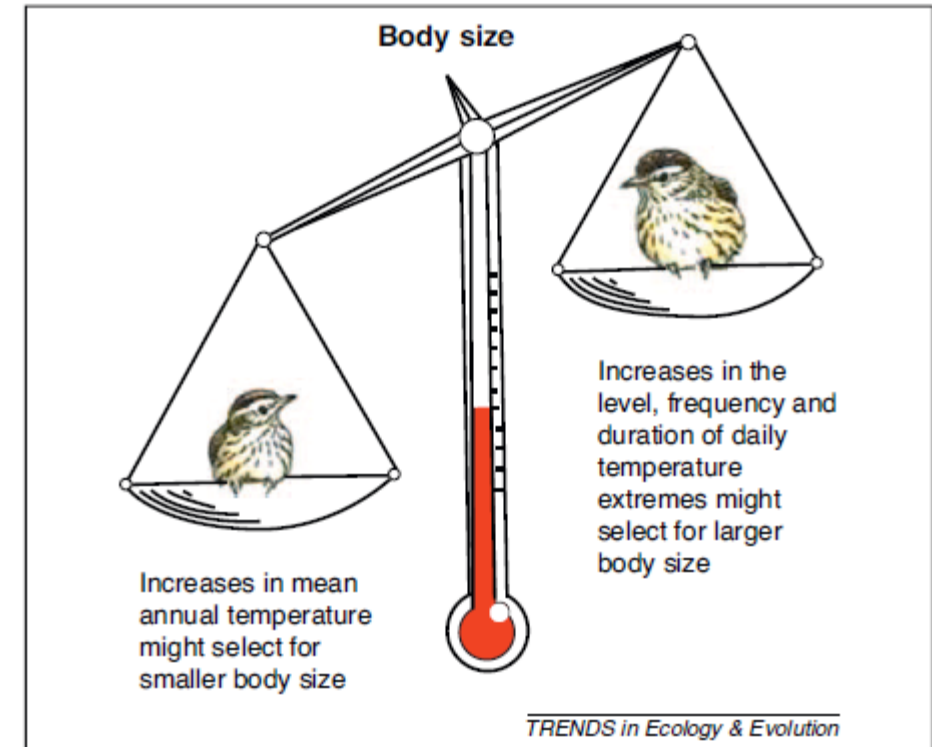
^a These colonies were also occupied by the unaffected *Pteropus scapulatus*, a smaller congener with a more inland distribution (Hall & Richards 2000).

Changes in body size?

- Classical interpretation: body size decrease
- To counter dehydration due to heatwaves, larger body size would be more convenient.
- No real evidence for climate-change driven selection for body size.
- Morphological changes in bats:
 - land use change
 - artificial illumination

Declining body size: a third universal response to warming?

Janet L. Gardner¹, Anne Peters^{2,3}, Michael R. Keamey⁴,
Leo Joseph⁵ and Robert Heinsohn¹



(Yue et al. 2020, *J. Mammalogy*, 101: 61-79; Tomassini et al. 2014, *J. Biogeography*, 41: 944-953)