UFZ HELMHOLTZ Centre for Environmental Research

TERENO-Langzeitmonitoring: Auswirkung von Extremereignissen auf Wildbienen und Vögel

Oliver Schweiger,
Mark Frenzel

Biodiversity declines

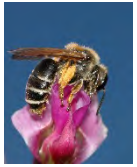
Review

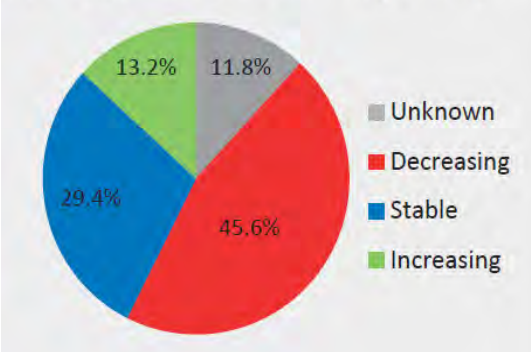
Cell

Global pollinator declines: trends, impacts and drivers

Simon G. Potts[1], Jacobus C. Biesmeijer[2], Claire Kremen[3], Peter Neumann[4], Oliver Schweiger[5] and William E. Kunin[2]

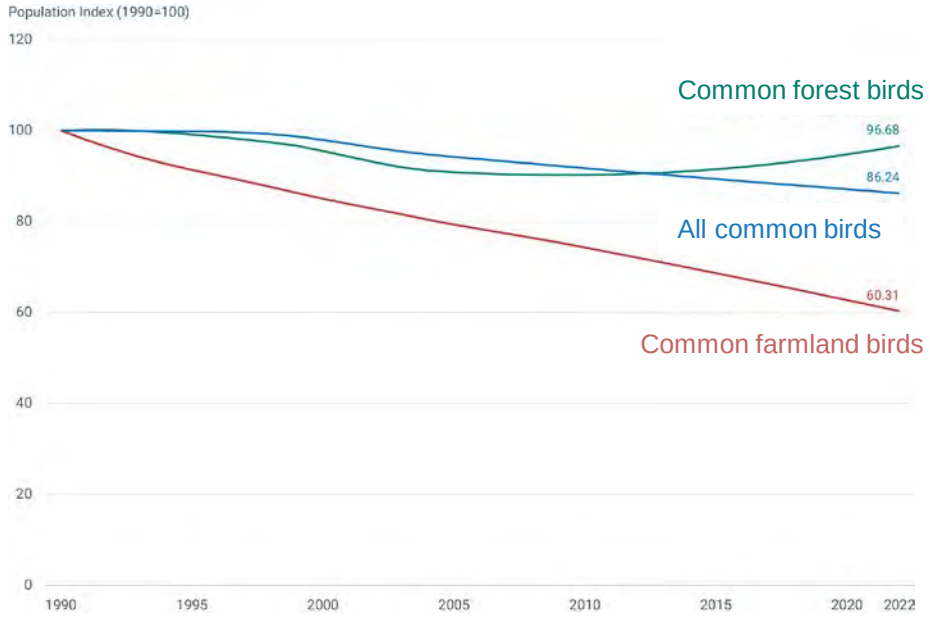
Population trends of bee species in Europe: 46% declining





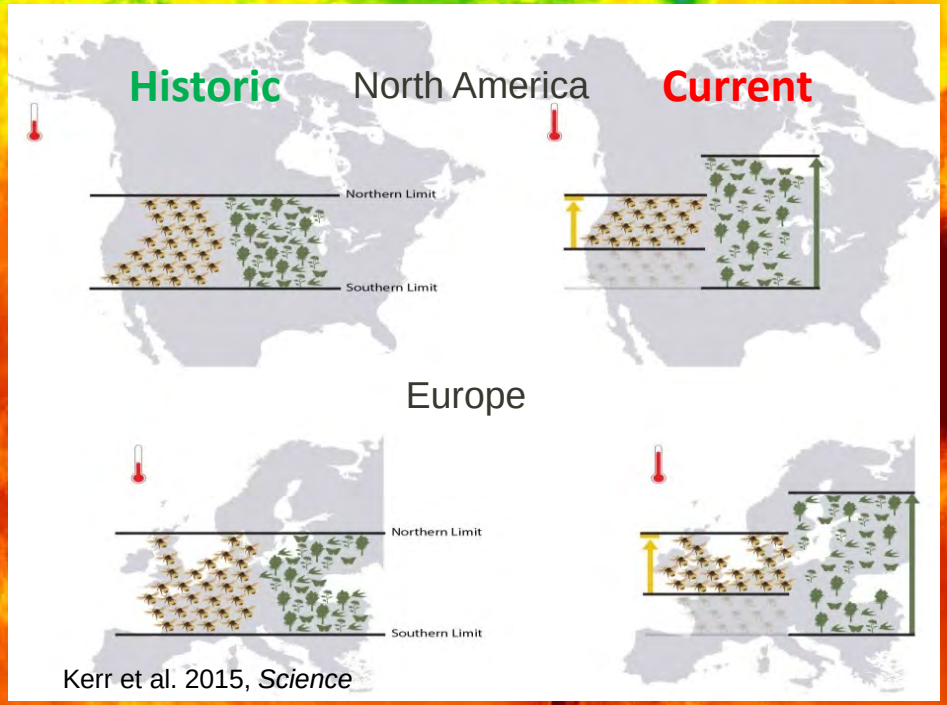
Nieto et al. 2014, EU

Common bird index

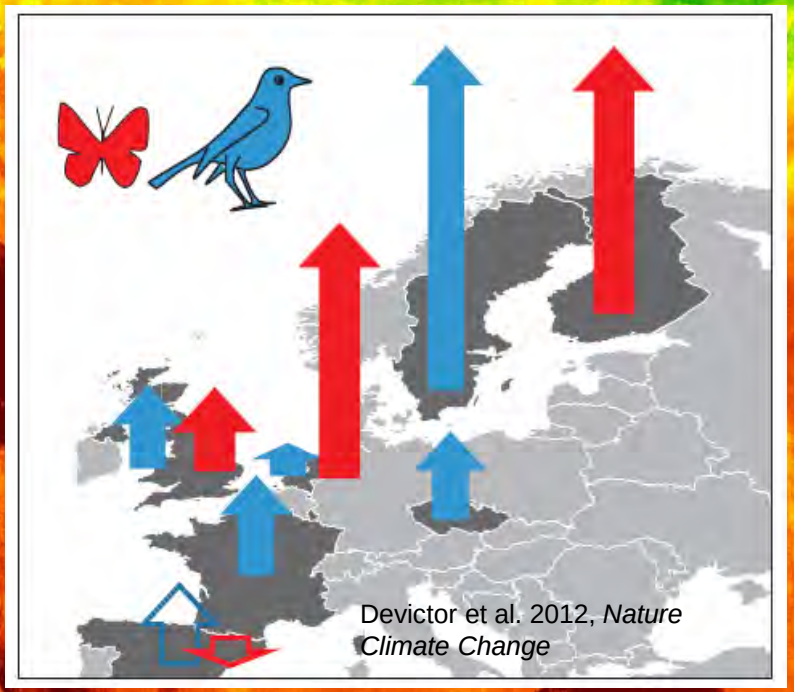


EBCC et al. 2021

Climate Change – recent effects



Kerr et al. 2015, *Science*



Devictor et al. 2012, *Nature Climate Change*

***Bumble bees* fail to track warming** at the cool end but suffer from range losses at the warm end

***Bird* and *butterfly* communities track warming but with a severe debt** (figure: Community Temperature index (CTI))

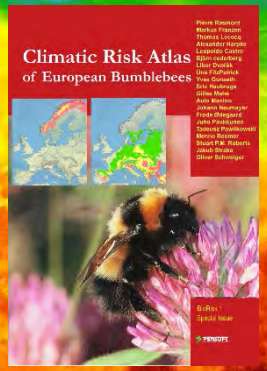
Climate Change – future effects

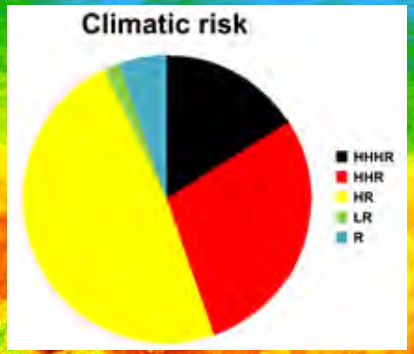
Climatic risk increases depending on the scenario

- Worst scenario: 45% of bumble bee species loose more than 85% of their range

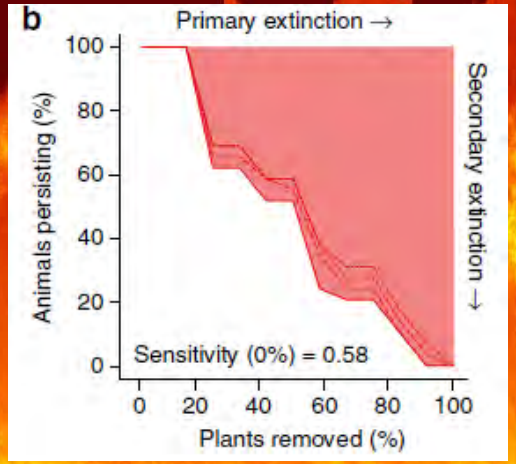
Impacts on trophic interactions and networks

- E.g. plant-pollinator or plant-bird
- Pollination services, seed dispersal





Rasmont et al. 2015, *BioRisk*



Schleuning et al. 2016, *Nature Communications*

Climate Change – extreme events

Not only gradual climatic changes, but also ⇨ extreme events

- E.g. heat waves, drought
- Predicted to increase in severity and frequency

What are the impacts of heat waves (could be even several months) **on bees and birds?**

What **are** the impacts of heat waves on birds and bees?

HYPOTHESES

Overall negative effects on population performance

- Direct physiological or behavioural effects
- Indirect effects via resources, e.g. flowers or prey

Birds more affected than bees

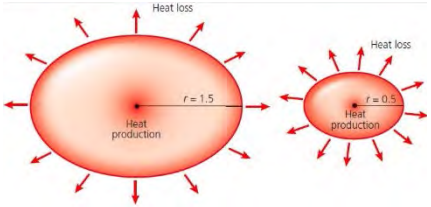
- Cascading and amplified effect from lower to higher trophic levels (most birds depend on insects to feed their offspring)

What **modifies** the impacts of heat waves on birds and bees (I)?

HYPOTHESES

Initial population stability

- Less stable populations suffer more than more stable populations



Species traits

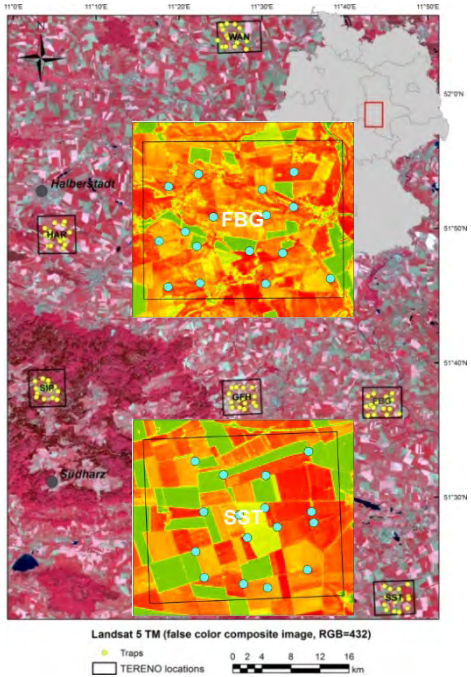
- *Temperature niche:* cold-adapted species suffer more
- *Body size:* bigger species suffer more; thermoregulation ⇨ smaller surface area / volume ratio improves heat conservation
- *Migration:* long-distance migrants suffer more ⇨ timing mismatch
- *Diet:* insectivorous species suffer more than omnivorous species
- *Habitat use:* open land species > forest species > urban species

What **modifies** the impacts of heat waves on birds and bees (II)?

Environment ⇨ potential for mitigation

- *Woody elements:* buffering effect via cooler microclimates
- *Flower resources:* buffering effect by good nutrition

Methods

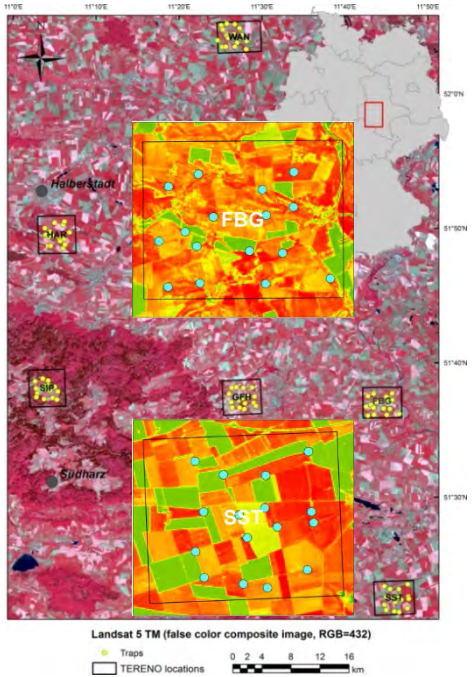


Hofmann et al. 2017, *PLoS ONE*

Bee and bird monitoring

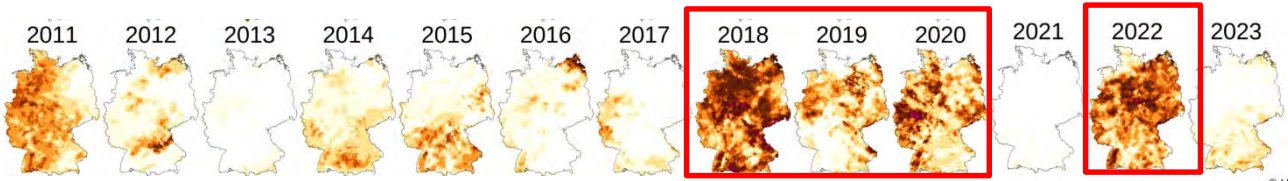
- **6 TERENO sites** (4 km x 4 km)
- **96 local bee communities** (16 per site); annually 2010 to 2021
- **120 local bird communities** (20 per site); focus on territories; 2009, 2012, 2013, 2014, 2017, 2020, 2023
- **Cover of woody elements** at local and landscape level
- **Proportion of mass-flowering crops** at local level

Methods

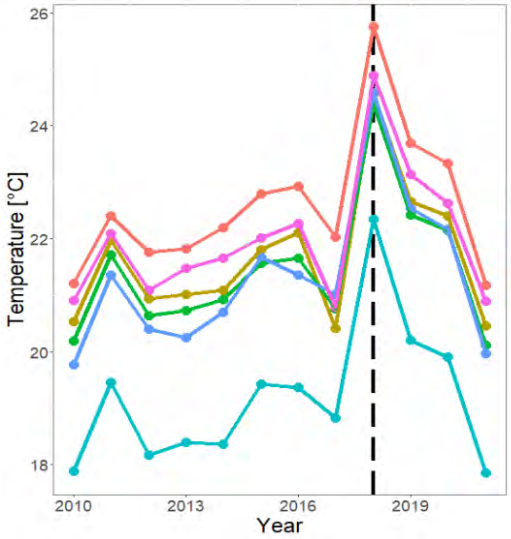


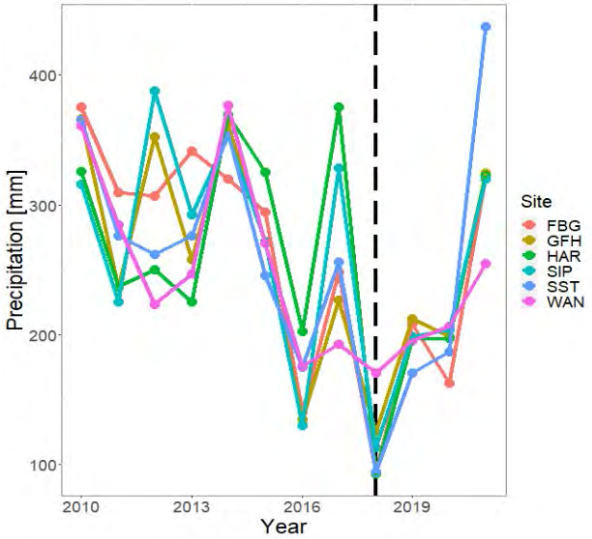
Hofmann et al. 2017, *PLoS ONE*

Severe drought in 2018-2020, 2022



UFZ-Dürremonitor, Friedrich Boeing ©μ





Methods

Species-level analyses

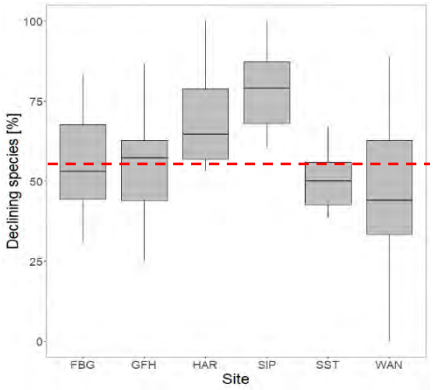
- Selection criteria **bee species**: at least 4 years of occurrence before 2018 in at least 10 locations
- Selection criteria **bird species**: at least 5 years of occurrence

- Mean **abundance before** and **after 2018** (heat wave!)
- **Population stability**: Coefficient of variation (CV) of abundance **before 2018**
- Dependent variable: Species response to heat wave = **proportional change after heat wave (⇨ population loss)**

Model: *change ~ population stability + species traits + environment + interactions + random effects*; AIC-based multimodel inference

Results – species declines

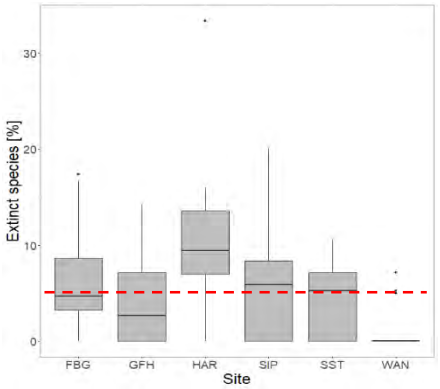
Bees



Declining species

Bees: average 55%

Birds: average 70%



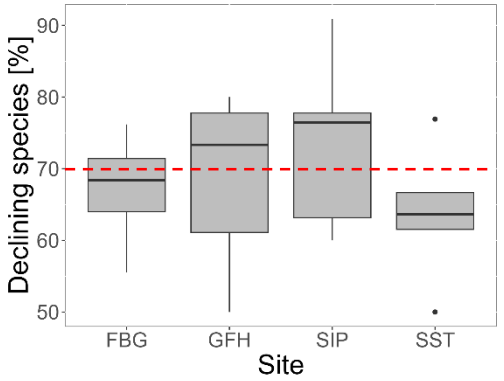
Locally extinct species

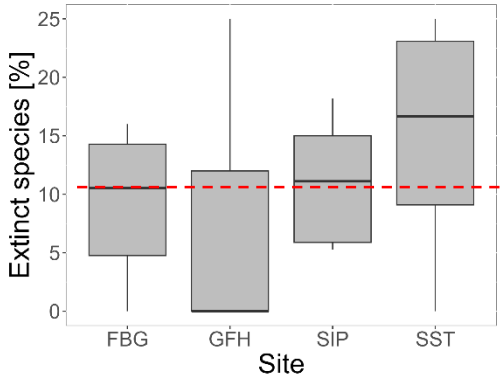
Bees: average 5%

Birds: average 10%

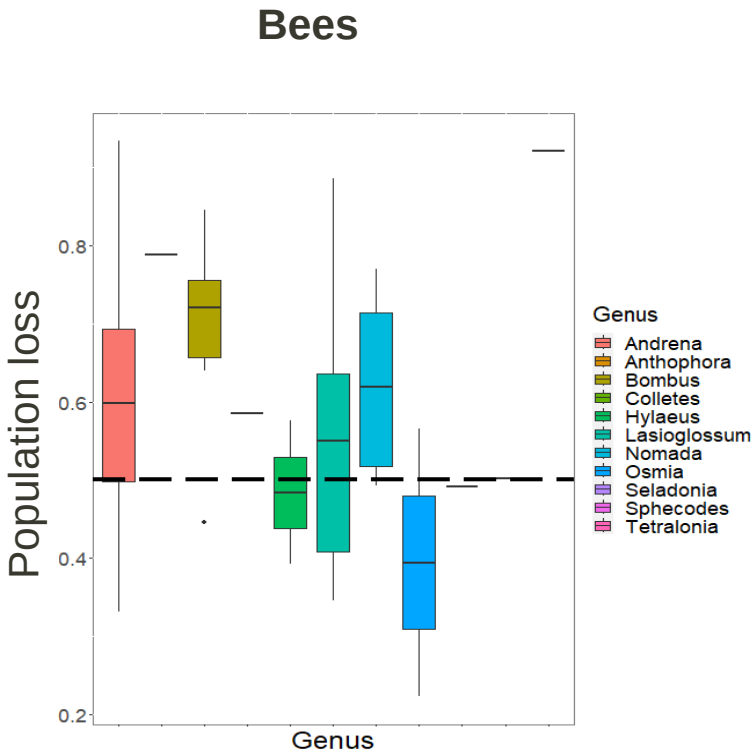
⇨ **Birds suffer more**

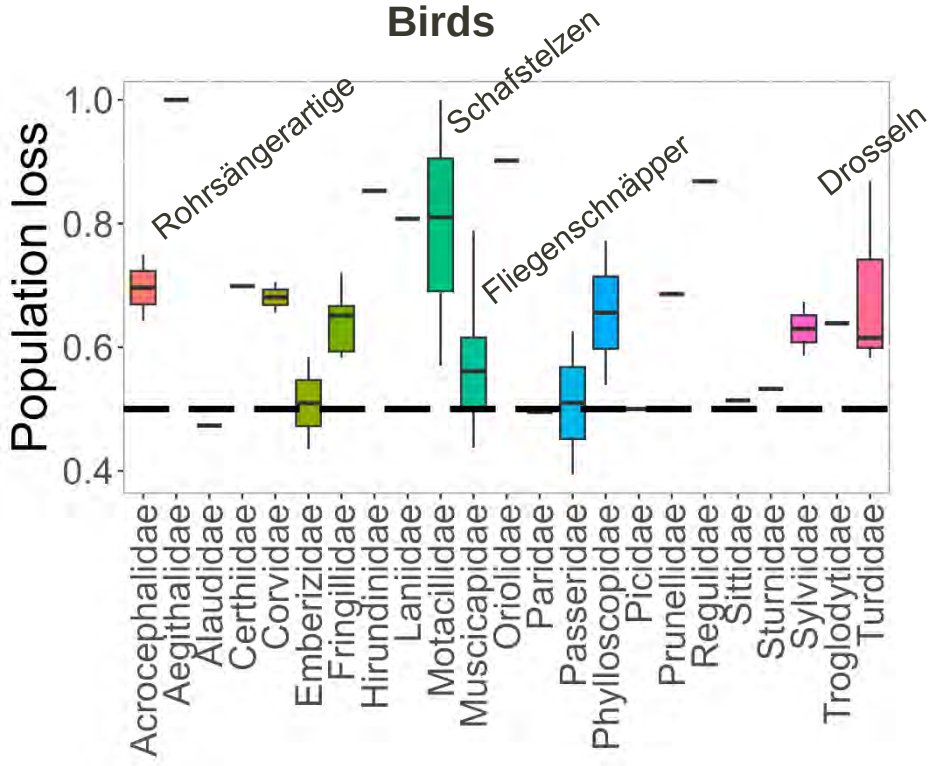
Birds



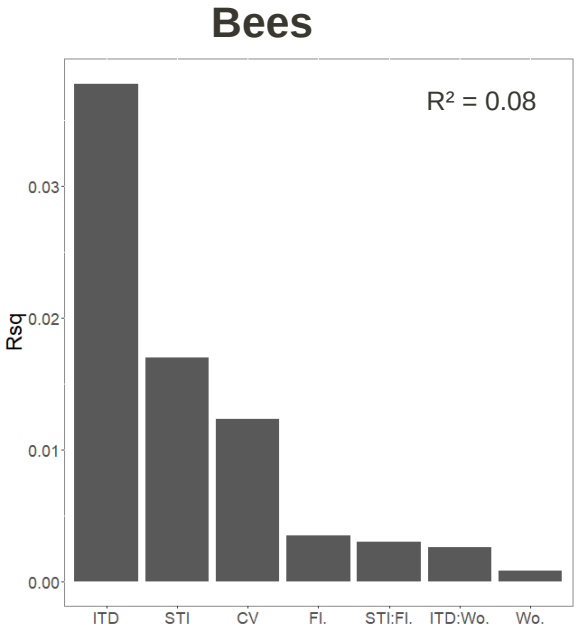


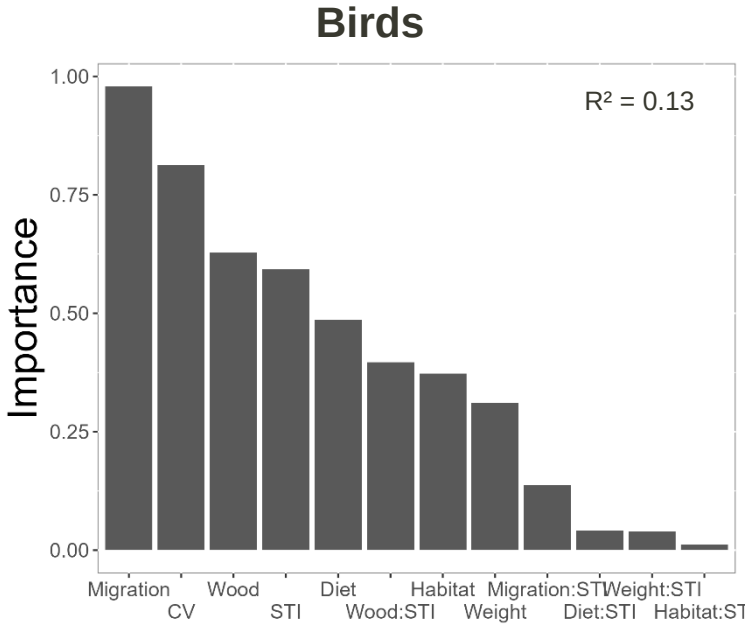
Results – Taxon specific population declines





Results – Relative importance of parameters





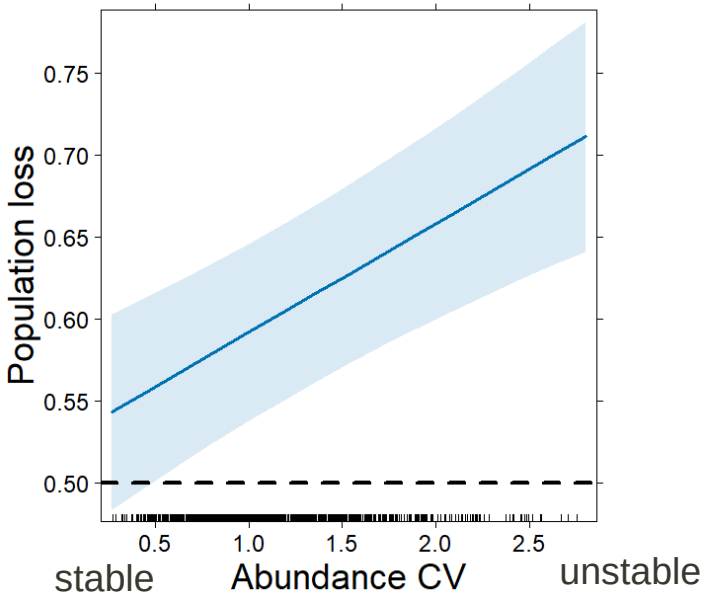
Traits > stability > environment

Traits > stability > environment > traits

⇨ **Species traits and population stability are most important**

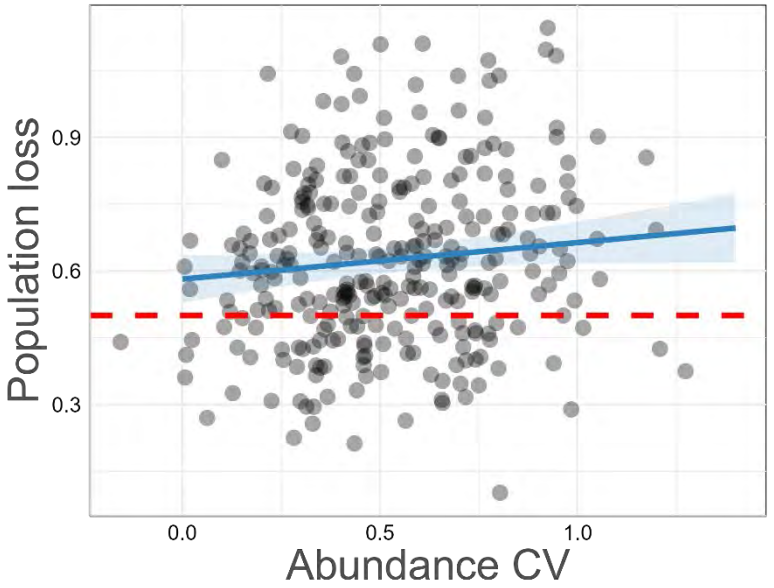
Results – Stability of populations (species)

Bees



CV = Coefficient of Variation

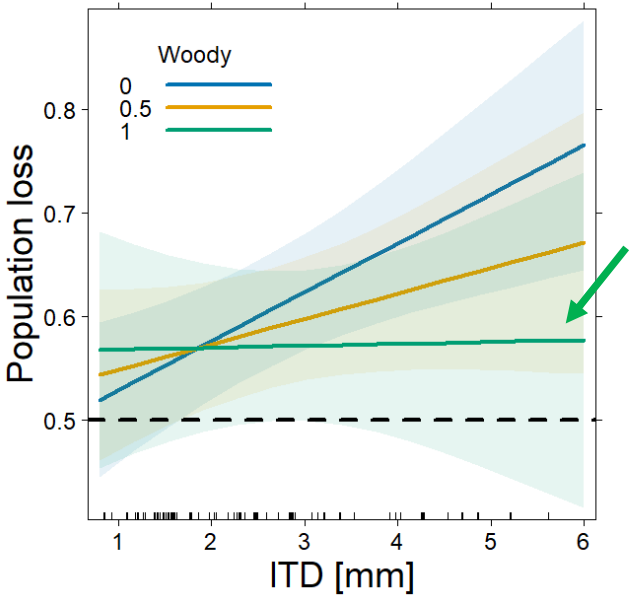
Birds



⇨ Stable populations are less affected by heat waves

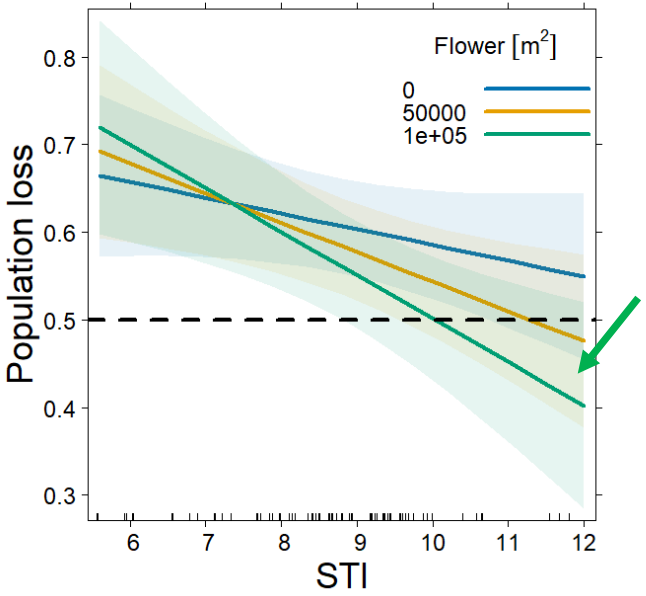
Results – BEES: traits and environment

Body size



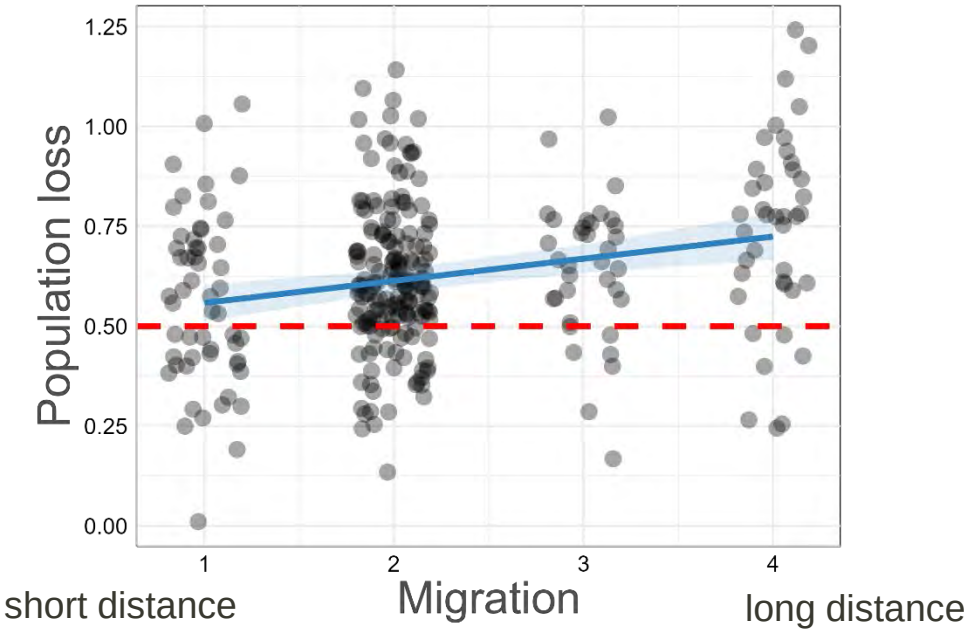
⇨ **Woody elements buffer impacts of heat waves for large bees**

Temperature niche



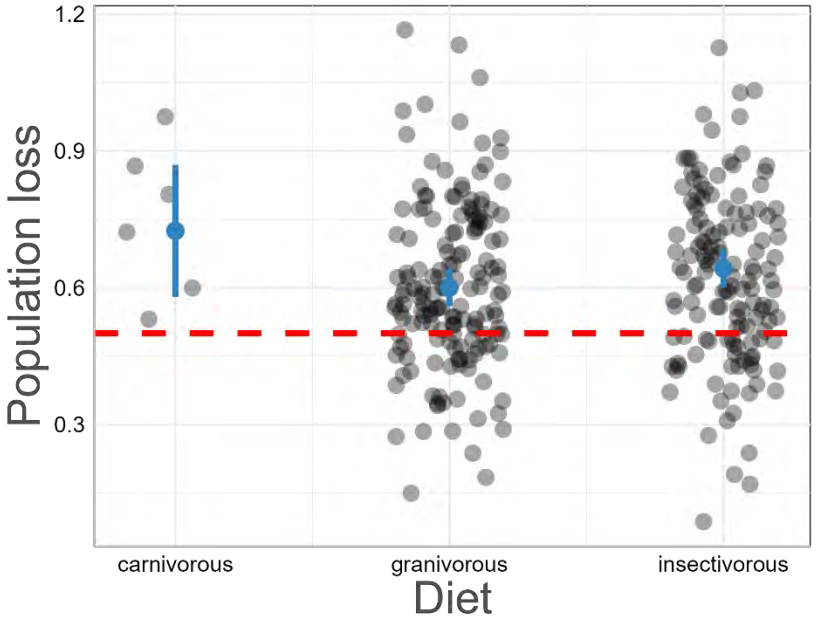
⇨ **Availability of flower resources buffer the impact of heat waves for warm-adapted bees**

Results – BIRDS: migration



⇨ **Population loss increases with migratory distance**

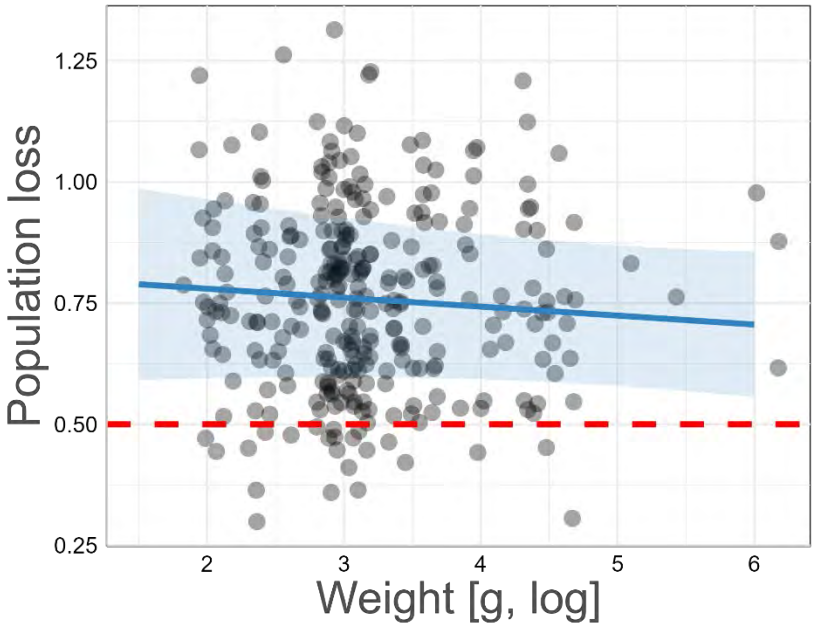
Results – BIRDS: diet



⇨ **Insectivorous species are slightly more affected than omnivorous species**

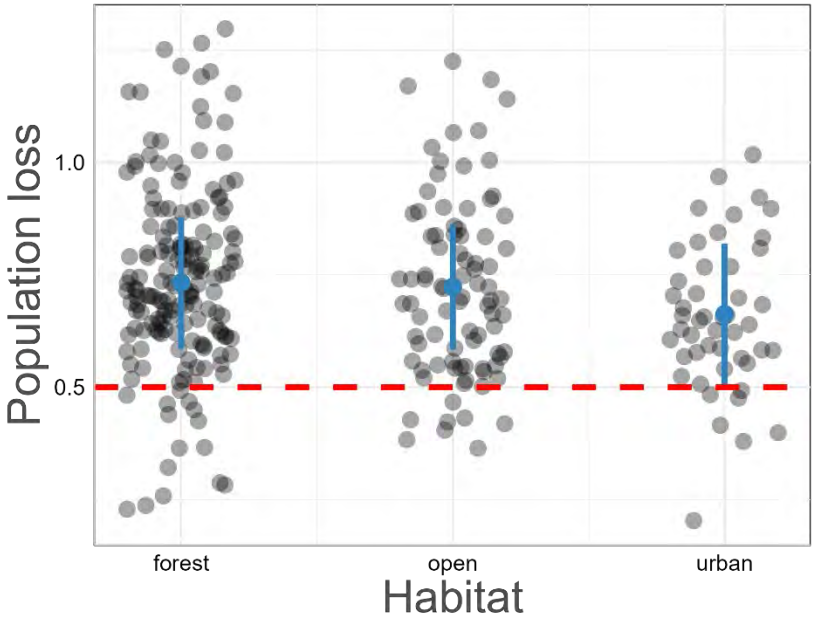
Indication of cascading effects?

Results – BIRDS: body size



⇨ **Contrast to bees: Larger species suffer less**

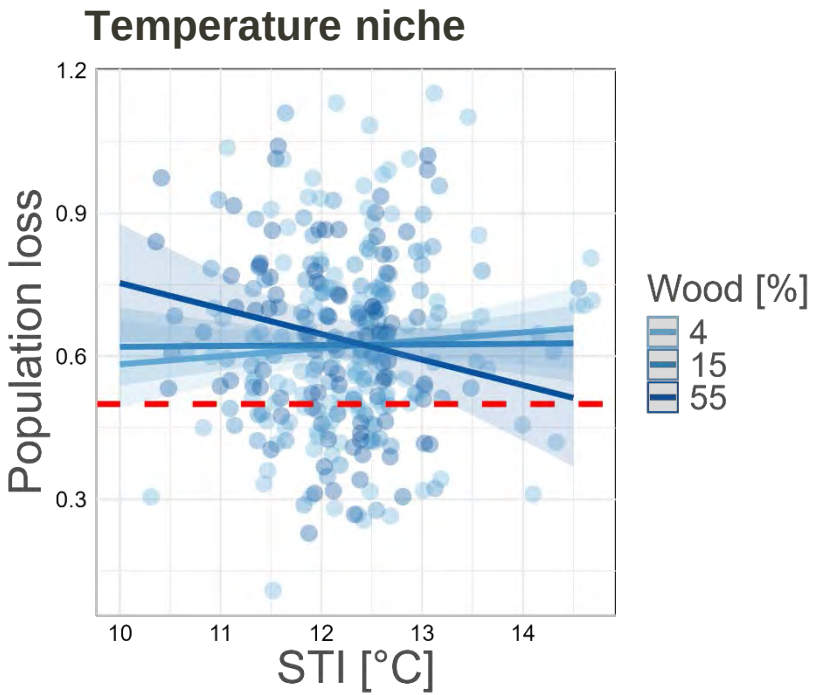
Results – BIRDS: habitat requirements



⇨ **No difference between forest and open habitat requirements**

No buffer effect of woody elements for birds?

Results – BIRDS: woody elements



⇨ Cold-adapted species suffer most in highly forested landscapes

Effect is smaller in open landscapes

Conclusions – Heat wave impact

Initial HYPOTHESES	Bees	Birds	
Overall negative effects on population performance	✓	✓	
Birds react stronger than bees	✓	✓	
Less stable populations suffer more than more stable populations	✓	✓	
Cold-adapted species suffer more	✓	✓	(see woody elements)
Bigger species suffer more	✓	✗	
Long-distance migrants suffer more		✓	
Insectivorous species suffer more than omnivorous species		✓	Small effect
Open land + forest species suffer more > urban		✓	Small effect

Conclusions - Heat wave impact

Initial HYPOTHESES

	Bees	Birds
▪ Woody elements buffer heat wave effects via cooler microclimates	✓	✗
▪ Flower resources buffer heat wave effects by good nutrition	✓	

Recommendations for mitigation

- Increase population stability
- Increase microclimatic heterogeneity
- Increase dietary resources (flowers for bees; bees for birds)
- Particularly focus on migratory birds

Thank you!

René Höhne

Mark Frenzel