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Cost-effective biodiversity conservation under climate change

Charlotte Gerling

IRN QARESS Symposium

3rd of December 2024

Climate change & the "6th mass extinction"

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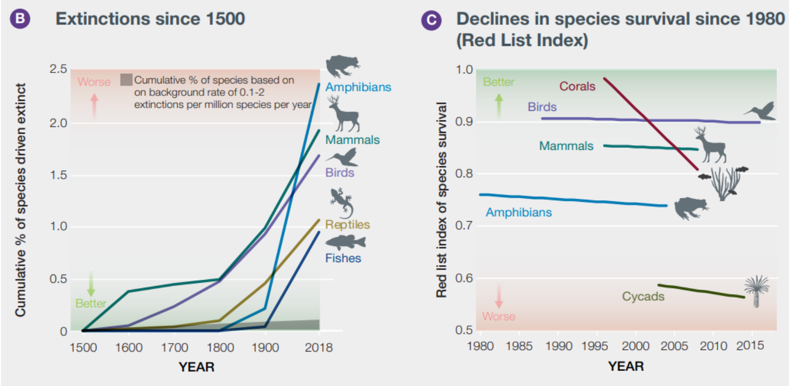
- Global biodiversity loss: increasing rates of extinction – "6th mass extinction"
- Causes of biodiversity loss (IPBES 2019, Dasgupta 2021)
  - **Land use change & agricultural intensification**
  - **Climate change** → becomes increasingly important
  - and others…

→ Particularly challenging in **agricultural landscapes**



- Contributions by economists: Species conservation – the static perspective
  - Choosing cost-effective conservation sites
  - Choosing cost-effective conservation measures

  → Cost-effectiveness: maximising conservation outcome for given costs

<u>Conservation measures</u>
- Extensive land use
- e.g. restrictions on the timing and number of harvests on a meadow

Image sources: IPBES (2019)

Climate change and biodiv conservation: the dynamic perspective

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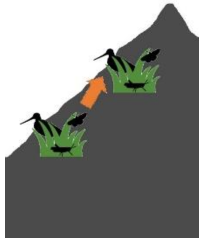
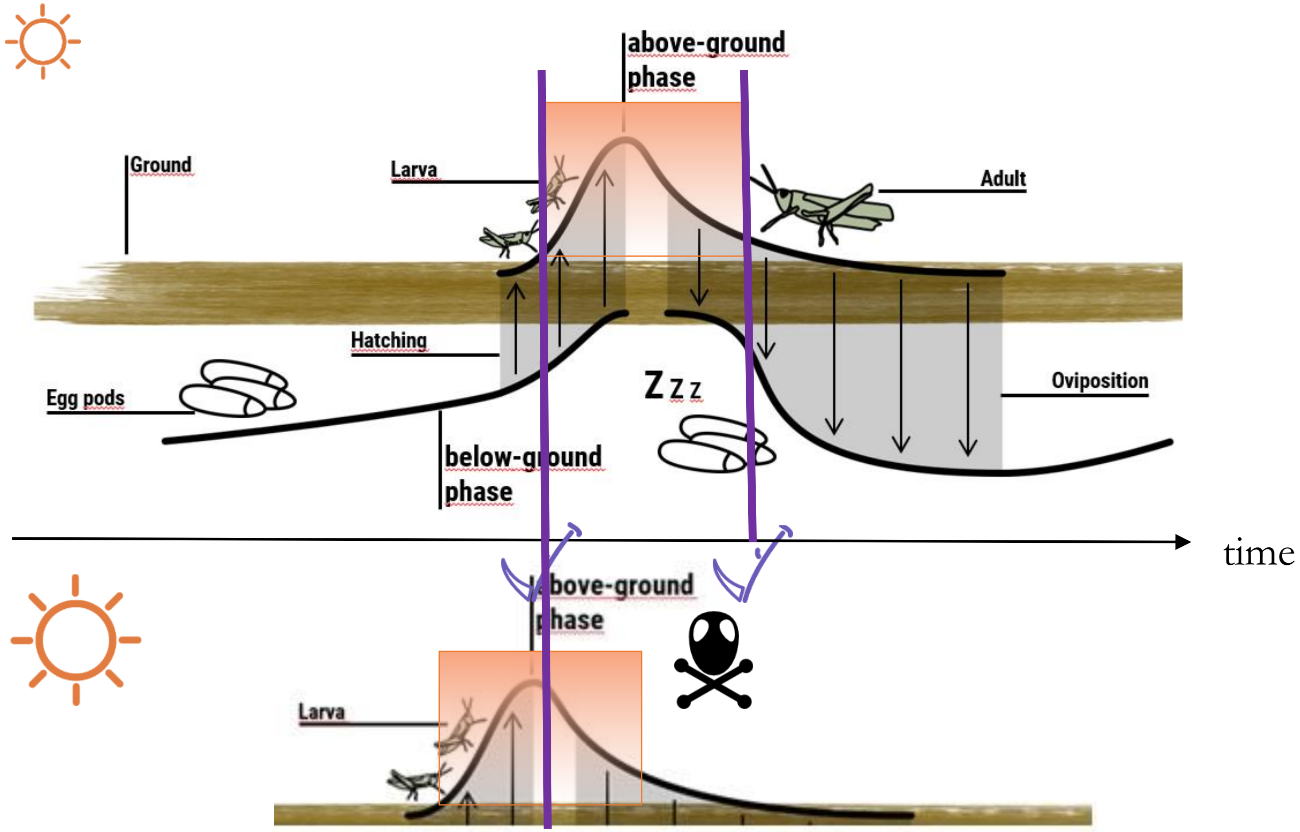
Temporal dimension

- **Ecological aspects**: phenological adaptations
  = adaptation of timing of life cycle stages

Spatial dimension

- **Ecological aspects:** range shifts
  - Species' ranges shift poleward/ uphill





Images: Johannes Leins

Climate change and biodiv conservation: the dynamic perspective

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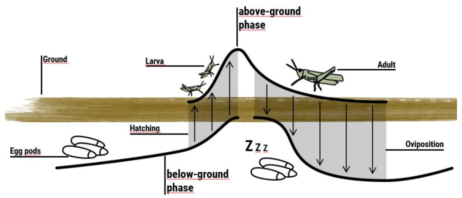


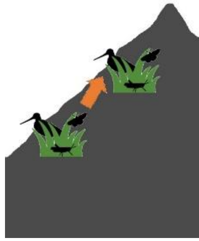
→ **Changes in effectiveness of measures**

- Impact of climate change on **conservation costs**?
  - Costs of measure depend on timing of harvest relative to profit-maximizing timing
  - Climate change advances profit-maximizing timing

→ **Relative changes in costs of different measures**

Spatial dimension

- **Ecological aspects:** range shifts
  - Species' ranges shift poleward/ uphill



→ **Spatially heterogeneous changes in benefits**

- Changes in **opportunity costs**
  - Some sites become more productive, others less

→ **Spatially heterogeneous changes in costs**

→ **Cost-effectiveness of conservation sites and measures may change**

Climate-ecological-economic modelling

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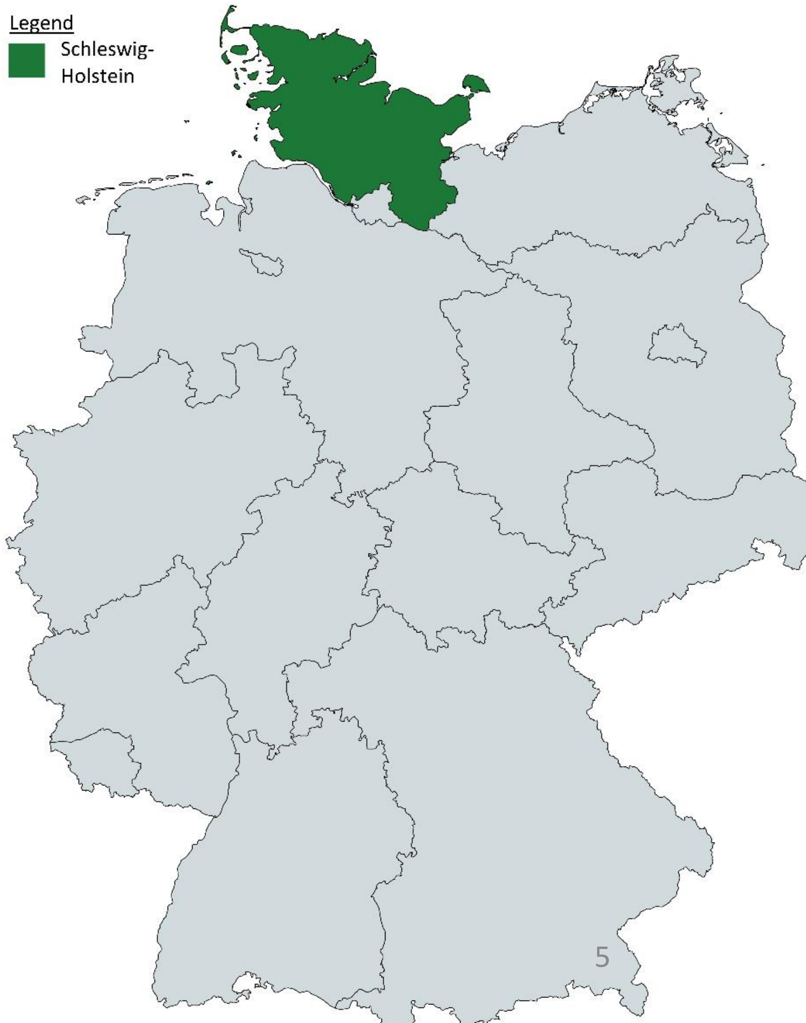
Set-up

- Case study: large marsh grasshopper (LMG) in Schleswig-Holstein

- Spatial scale
  - 12km * 12km climate cells
  - 250m * 250m grassland cells
- Conservation measures
  - Restrict timing and frequency of land use
  - Defined “phenologically”
- Determine cost-effective spatio-temporal allocation of conservation measures
- Compare two periods:
  - 2020-2039
  - 2060-2079



Images: Daniel Konn-Vetterlein, mapchart.net

A basic climate-ecological-economic model

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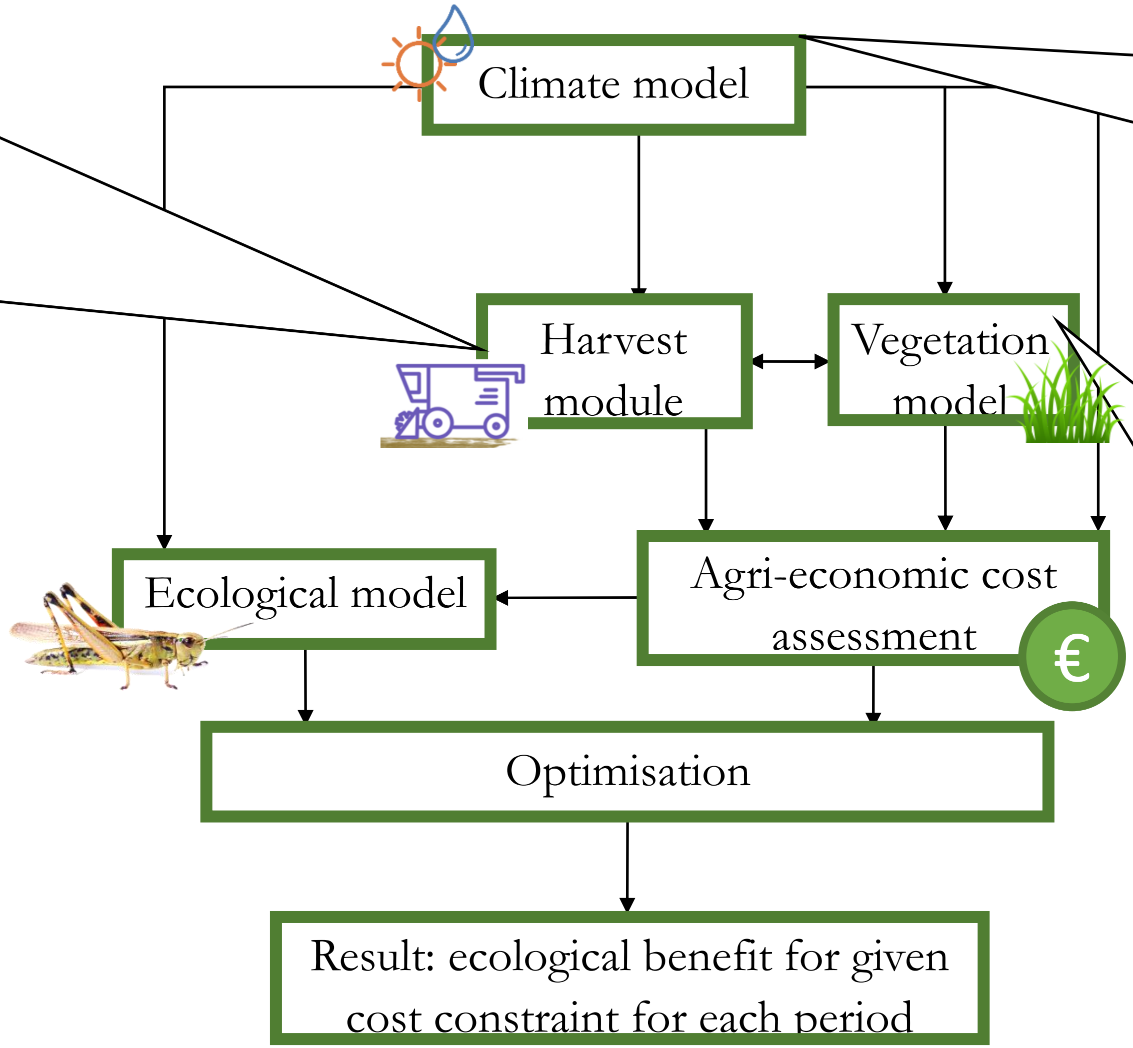
Yield-maximising timing of mowing

- For each grassland cell
- Depends on climatic conditions and productivity
- Considers extreme events: inundations



Temperature, soil moisture

- Daily values
- For each period
- RCP4.5

Vegetation (grass) growth

- Simplified version of model developed by Schippers and Kropff (2001)
- For each grassland cell
- Depends on climatic conditions and productivity

Images: Johannes Leins, Daniel Konn-Vetterlein, Charlotte Gerling, https://freepngimg.com/png/4787-grass-png-image-green-grass-png-picture

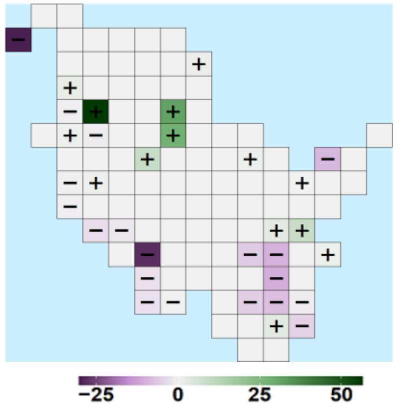
A basic climate-ecological-economic model

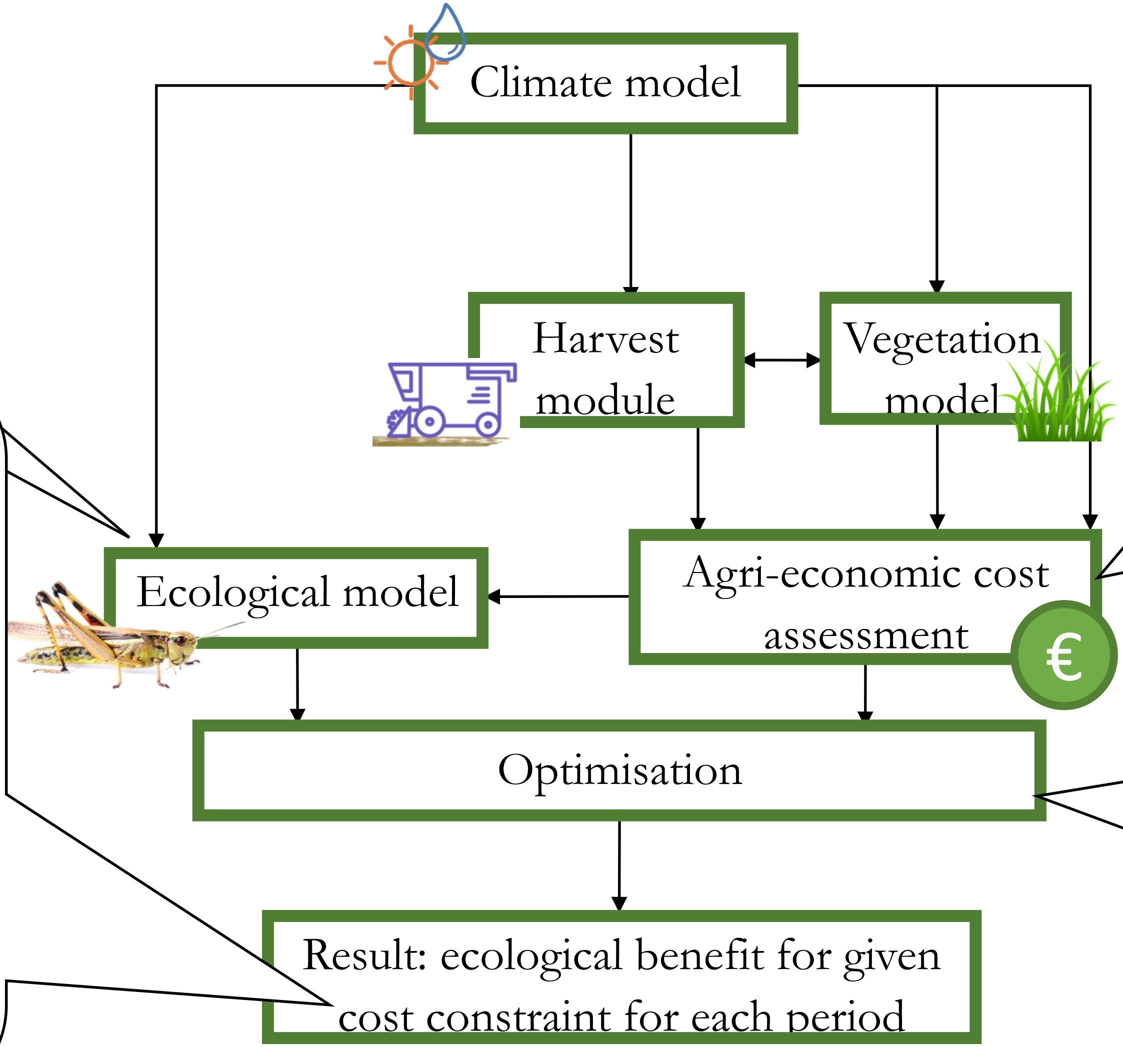
LMG population

- For each grassland cell
- Impact of grassland use and climatic conditions

1) Phenological measure remains cost-effective

2) Spatial shifts





1) Profit-maximising timing of mowing

2) Opportunity costs of conservation measures

- For each grassland cell
- Depends on climatic conditions and productivity

Spatio-temporal allocation of conservation measures

- For each period
- According to benefit-cost ratio

Images: Johannes Leins, Daniel Konn-Vetterlein, Charlotte Gerling, https://freepngimg.com/png/4787-grass-png-image-green-grass-png-picture

Analysis of policy instruments

- Analysis of **policy instruments**
- "Benevolent dictator" assumed in conservation planning rarely exists in reality
  → which policy instruments can be used to incentivise or implement conservation?

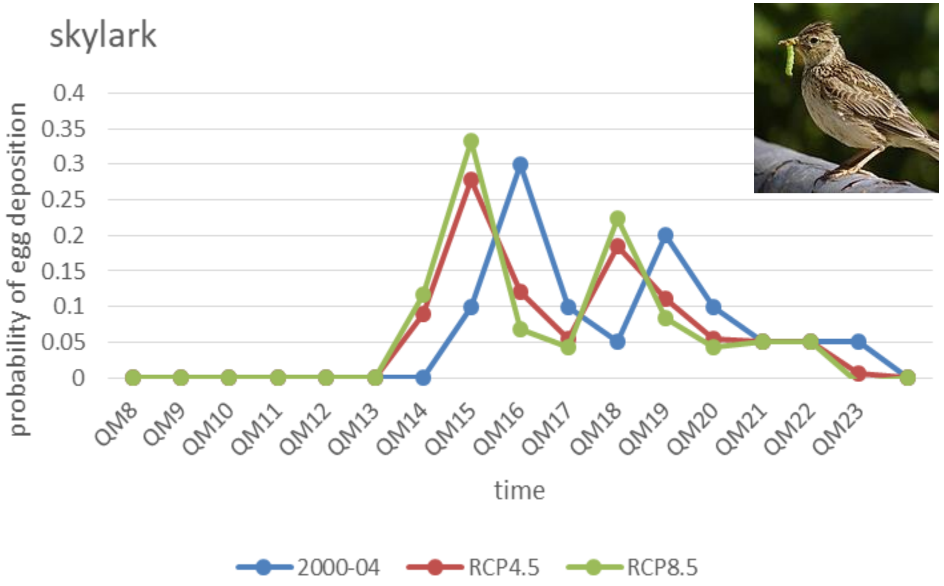
- Are they still suitable under climate change?
  - Agri-environment schemes
  - Land purchase
  - Instrument choice

Designing cost-effective agri-environment schemes under climate change

Cost-effective AES under recent (2000-2004) and future (2075-2079) climatic conditions

<u>Key methodological changes</u>

- Ecological model:
  - Impact of land use on 8 bird species (Wätzold et al. 2016)
  - Impact of climate change: phenological adaptations
    - Changes in timing of egg deposition
- Simulation and optimisation (based on Sturm et al. (2018))
  - Determine cost-effective conservation measures and payments



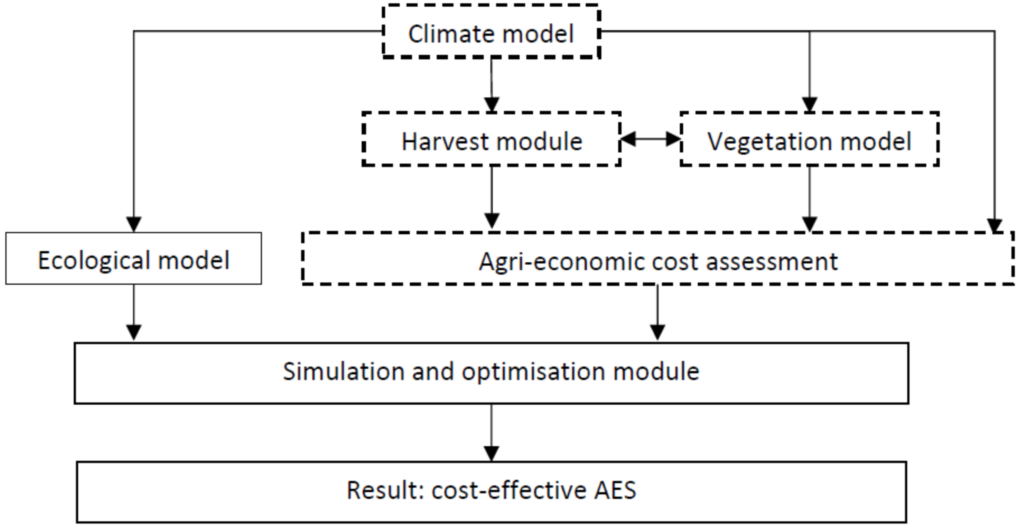


Image: Wikipedia

Designing cost-effective agri-environment schemes under climate change

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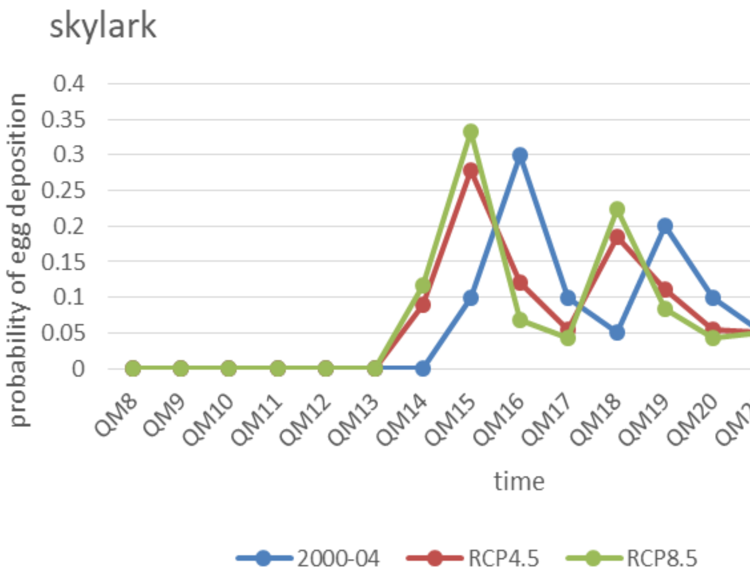

Results: Yes- the cost-effective AES changes!

- Different measure is chosen (RCP8.5)
- Reasons
  - Higher ecological benefit, less intensive land use
  - Extreme events (inundations) drive costs
  - → Relative costs of the measures differ between the two periods

Image: Wikipedia

Land purchase: sale vs. no sale

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General context

- Key trade-off: **habitat permanence** vs. **spatial flexibility**
- **Land purchase**:
  - High permanence
  - Increase flexibility by allowing for sale?

  → Compare two policy scenarios: **‘sale‘** vs. **‘no sale‘**

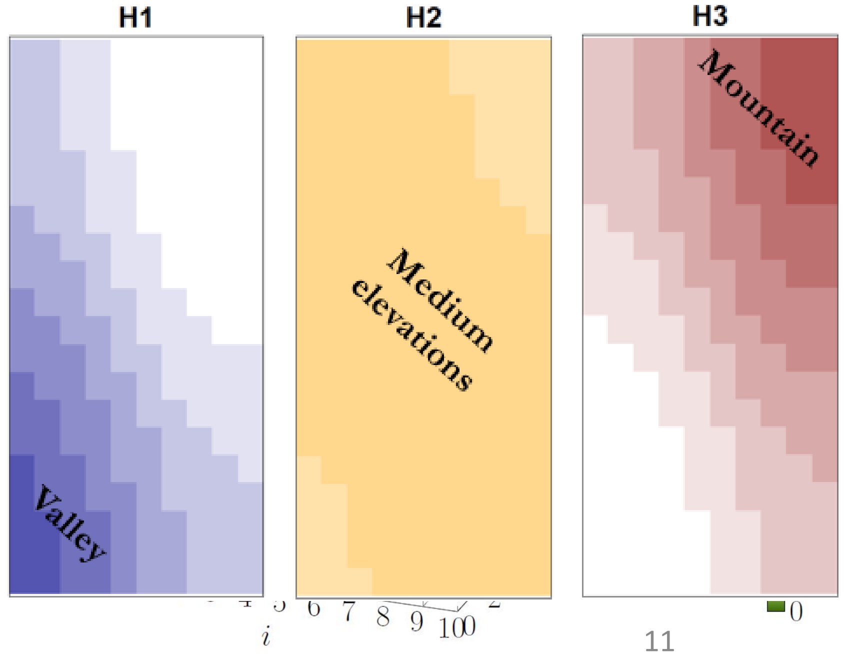
Key research questions

1) How does allowing for sale influence the conservation outcome under climate change?

2) How much habitat turnover do we have under the ‘sale’ and ‘no sale’ policies?

Model set-up

- Generic landscape with altitude gradient
- Habitat suitability for 3 habitat types based on elevation
- Climate change causes spatial shifts („uphill“)



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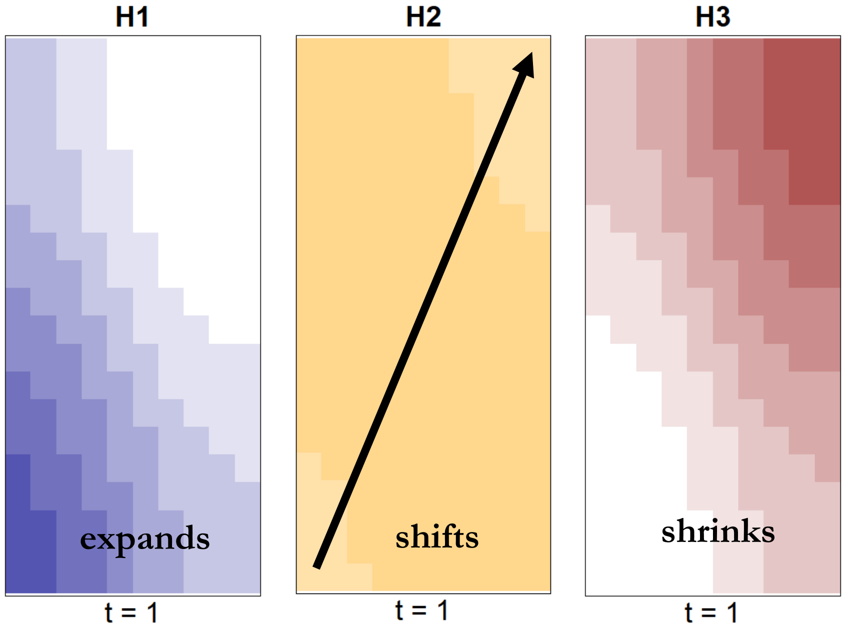

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Land purchase: sale vs. no sale

Key results

1) How does allowing for sale influence the conservation outcome under climate change?

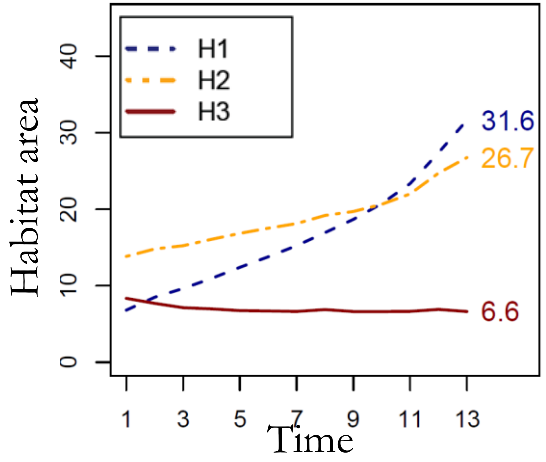
→ Role of **spatial flexibility** (improves outcome esp. for **most threatened** habitat type)

2) How much habitat turnover do we have under the 'sale' and 'no sale' policies?

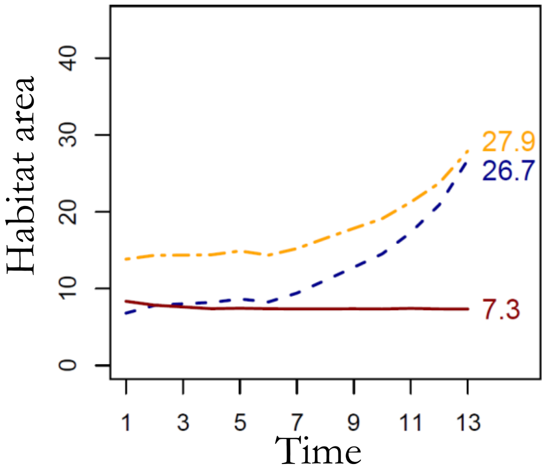
- Habitat turnover even in a static reserve network
- Only small differences ('sale' vs. 'no sale') for most threatened habitat type

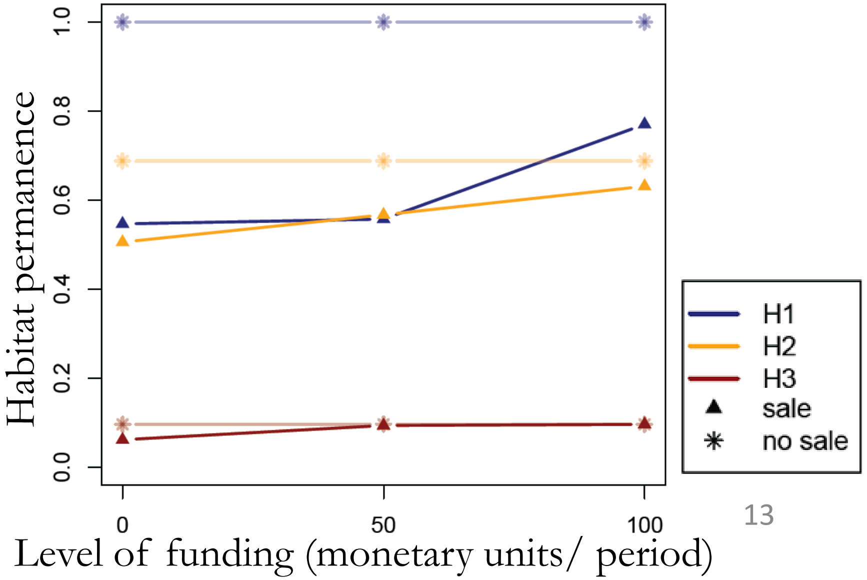
→ Role of **permanence** (important for **most threatened** habitat type; decreases for others)

a) 'No sale' – low funding



b) 'Sale' – low funding





Land purchase: sale vs. no sale

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Trade-off

- 'Sale' mainly benefits habitat types that become increasingly threatened
- 'No sale' mainly benefits permanence of habitat types that expand

Policy instrument choice

Compare the cost-effectiveness of…

- **Land purchase**:

  high management flexibility, low spatial flexibility

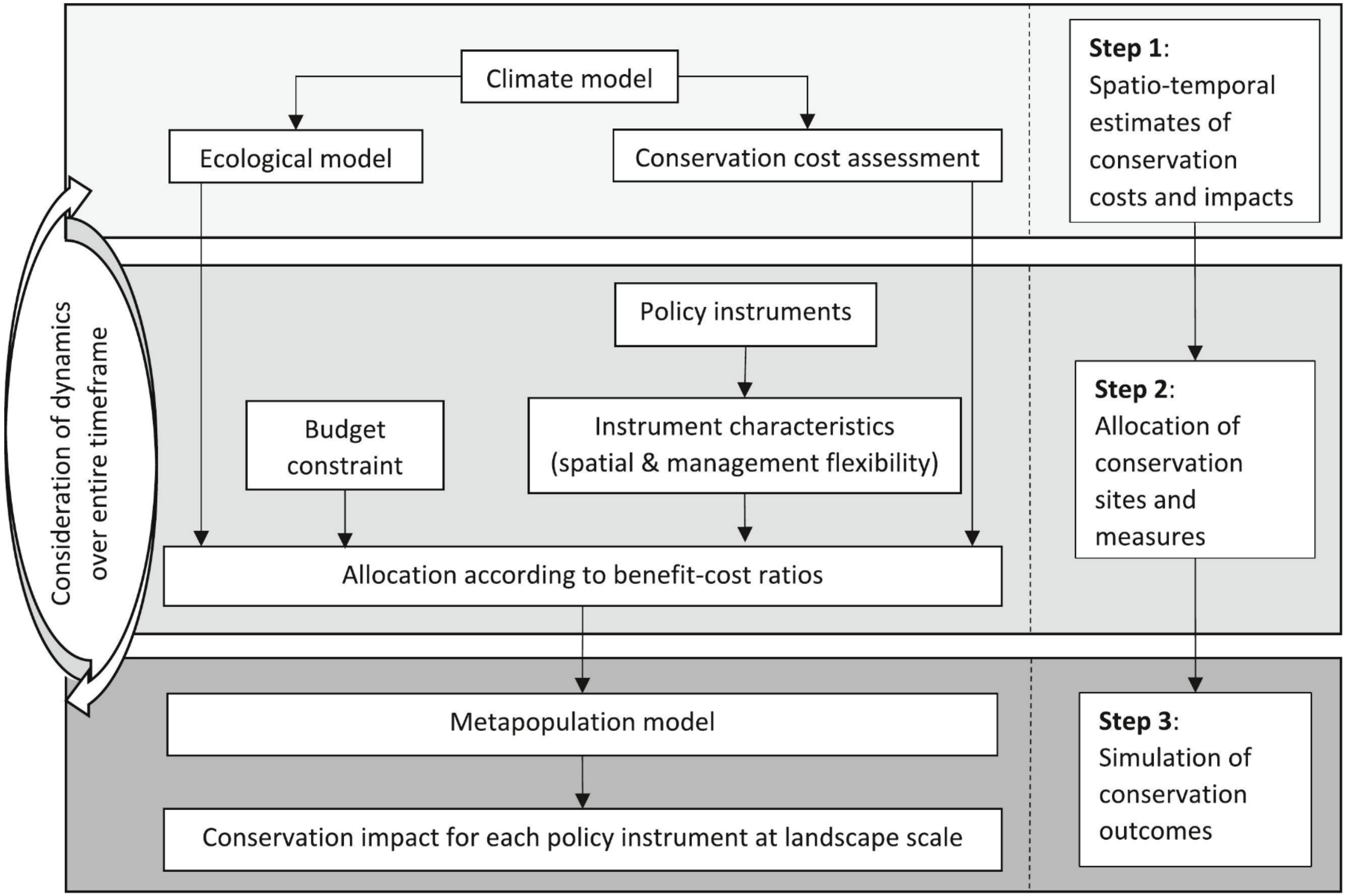
- **Conservation contracts**:

  medium management and spatial flexibility

<u>Key scenario analysis</u>

- Conservation agency has **limited agricultural knowledge** → producer surplus (farmers)
  - no profit/ **low profit**/ full profit

Policy instrument choice: model logic



Policy instrument choice: key results

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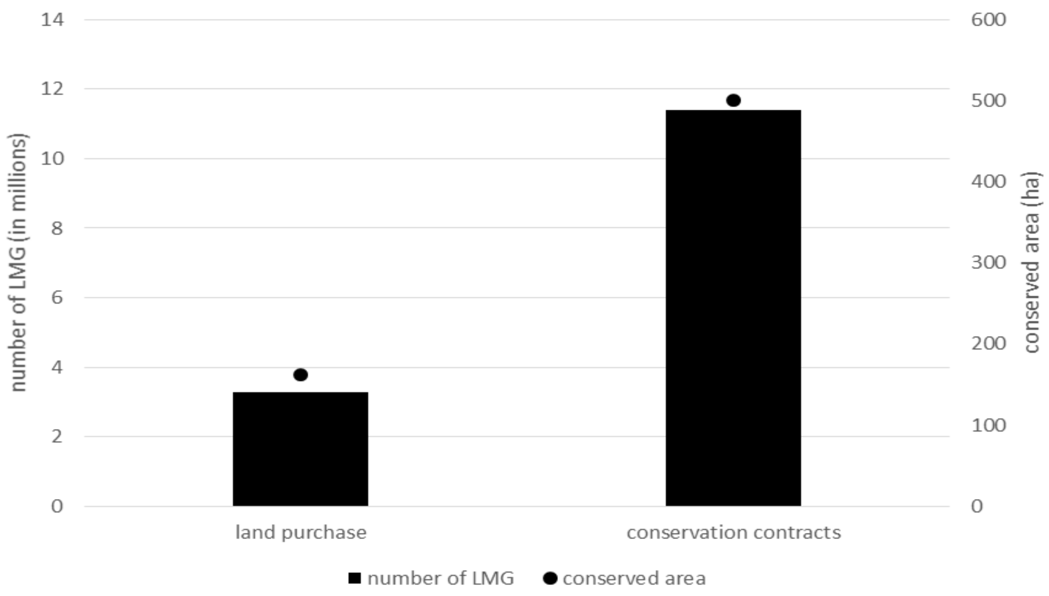
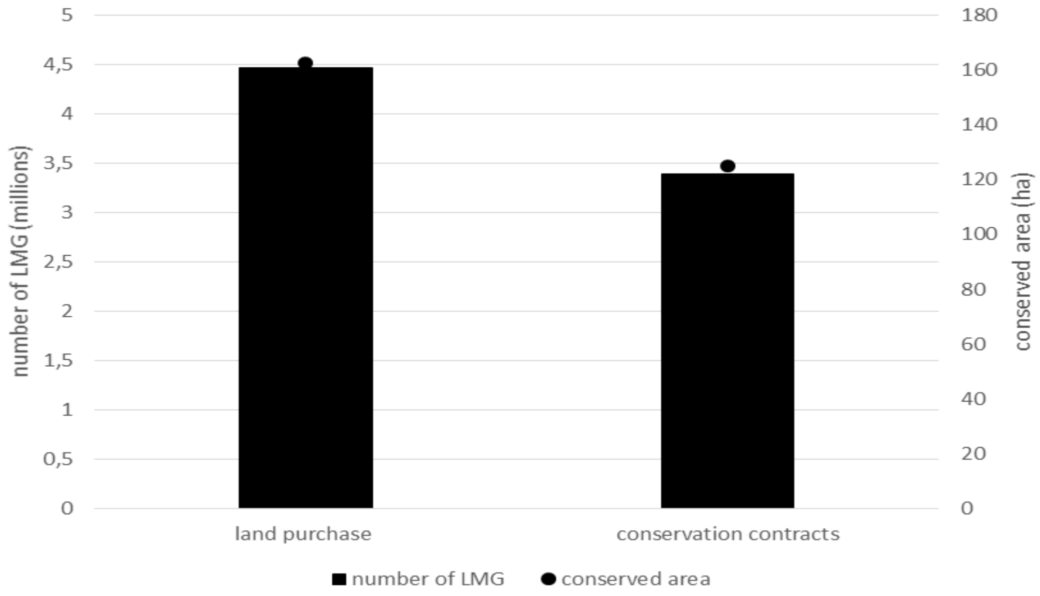
- Base case: higher ecological benefit for conservation contracts



- But: full profit assumption reverses ranking!



→ Degree to which the conservation agency is able to capture farmers' profit has a key influence on the evaluation of the policy instruments

Conclusion

- Consider the impact of climate change on species and conservation costs

- Policy instruments may have to be adapted
  - Spatial flexibility
  - Management flexibility

- **Interdisciplinary research** to leverage complementary expertise:
  - Ecologists: analyse impacts of climate change on ecosystems, species, communities…
  - Economists: analyse impacts of climate change on costs and appropriate policy context

Overview of publications

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Basic model

JOURNAL ARTICLE

Climate–ecological–economic modelling for the cost-effective spatiotemporal allocation of conservation measures in cultural landscapes facing climate change

Charlotte Gerling, Martin Drechsler, Klaus Keuler, Johannes A Leins, Kai Radtke, Björn Schulz, Astrid Sturm, Frank Wätzold

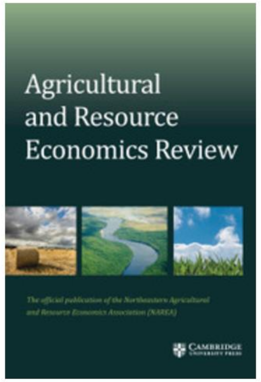
Q Open, Volume 2, Issue 1, 2022, qoac004,
https://doi.org/10.1093/qopen/qoac004

Land purchase

The 'Climate Adaptation Problem' in Biodiversity Conservation: The Value of Spatial Flexibility in Land Purchase

Charlotte Gerling[1] · Oliver Schöttker[1] · John Hearne[2]

Agri-environment schemes



Time to consider the timing of conservation measures: Designing cost-effective agri-environment schemes under climate change

Published online by Cambridge University Press: **28 April 2023**

Charlotte Gerling, Martin Drechsler, Klaus Keuler, Astrid Sturm and Frank Wätzold

Policy comparison

ELSEVIER
Ecological Economics
Volume 227, January 2025, 108414

Cost-effective policy instruments for biodiversity conservation under climate change – The need for flexibility

Charlotte Gerling [a], M. Drechsler [b], Johannes A. Leins [b], Astrid Sturm [a], Frank Wätzold [a]

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