What traits make species sensitive to climate change in northern ecosystems?

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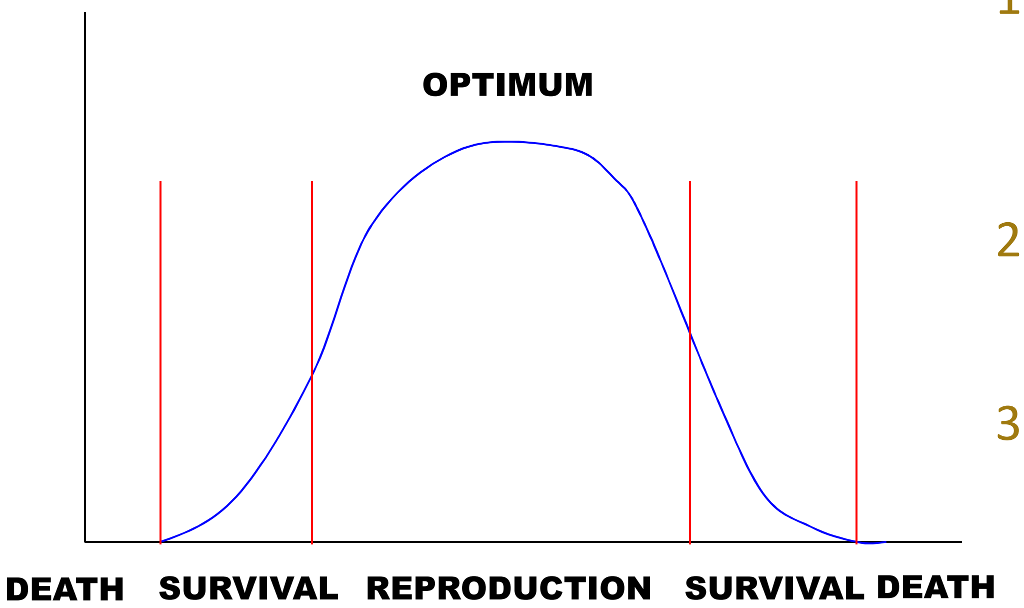
Background – species respond individualistically to climate change

- Individuals and populations have temperature limits and an optimum



- If environment (e.g. climate) changes, a species has three options:

1. Adaptation to new conditions
   - Phenotypic plasticity
   - Evolutionary (genetic) change
2. Movement to new areas
   - Density of suitable habitats
   - Species traits
3. Extinction
   - Regional
   - Global

Background – importance of species traits

- Often considered to modify species' responses to climate change
- Several studies have focused on relationship between species traits and observed distributional changes
  - In Great Britain half of butterflies that are mobile habitat generalists increased their distribution area, whereas other species declined
  - Warren et al. 2001 – Nature 414: 65-69.

- A meta-analysis in 2011
  - Angert et al. 2011 – Ecology Letters 14: 677-689.
- Species that have..
  - High dispersal ability
  - High reproductive rate
  - Generalized resource requirements

  ..are likely to show greater range shifts than species lacking these abilities
- Several taxa showed such traits, BUT explanatory power was low

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Goals and methods

- As part of an ongoing research project (SUMI) we aim at identifying species that are particularly vulnerable to climate change in Finland
  - SUMI – Protected area network in a changing climate (2017-2019)
- What species traits make species vulnerable (or vice versa – adaptive) to impacts of climate change?

- Screening potential peer reviewed studies on the following taxa:
  - Vascular plants
  - Mosses
  - **Lichens**
  - **Saproxylic fungi**
  - Birds
  - Herbivorous insects
  - **Saproxylic beetles**
- Special focus on EU Nature directive species
- Web of Science
  - E.g. climat* AND change AND name of taxon
- Google, Google scholar

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...methods

- Observed and predicted impacts of climate change were gathered
- Species responses were classified into
  - Positive
  - Neutral
  - Negative
- Positive and negative responses were transformed into binary (dummy) variables
- Species traits were extracted from multiple sources
  - Primary studies often report only few traits
- Statistical models built to connect species responses to traits
  - GLMs, GLMMs with binomial error structure

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Saproxylic fungi – projected changes

- Responses of 64 species of saproxylic fungi to projected climate change
  - Mazziotta et al. 2016 – Global Change Biology 21: 637-651.
  - Three emission scenarios: B1, **A1B**, and A2
- Positive responses related to
  - Preference of large trees
  - Early decaying stage
  - Dependence on aspen
- Negative responses related to
  - Dependence on other fungi
  - Non-preference of large trees
  - Dependence on other trees (than aspen)
  - Warm microclimate

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Trait variable	Positive response	Negative response
Red List class 2010	NS	NS
Latitudinal amplitude	NS	NS
Latitudinal centre	NS	NS
Spore size	NS	NS
Fungus age	NS	NS
Dependence on other sp.	NS	Yes + <0.01
Preference of large trees	Yes + <0.05	Yes - <0.01
Decay stage	Early + <0.05	NS
Tree species	Aspen + <0.05	Other sp. + <0.001
Microclimate	NS	Warm + <0.05

Saproxylic beetles – projected changes

- Responses of 64 species of saproxylic beetles to projected climate change
  - Mazziotta et al. 2016 – Global Change Biology 21: 637-651.
  - Three emission scenarios: B1, **A1B**, and A2
- Positive responses related to
  - Southern occurrence
  - Early decaying stage
  - Dependence on aspen
- Negative responses related to
  - Early adult activity period
  - Dependence on other trees (than aspen)

Trait variable	Positive response	Negative response
Red List class 2010	NS	NS
Latitudinal amplitude	NS	NS
Latitudinal centre	South + <0.05	NS
Body length	NS	NS
Larval develop. time	NS	NS
Adult occ. start	NS	Early + <0.05
Adult occ. length	NS	NS
Preference of large trees	NS	NS
Decay stage	Early + <0.01	NS
Tree species	Aspen + <0.001	Other sp. + <0.001
Microclimate	NS	NS

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Lichens – projected changes

- 33 responses of 30 species of lichens to projected climate change
  - Five papers (2007-2017)
  - Statistical test GLMM to account for multiple projections per species
- Positive responses related to
  - Increasing threat status
  - Lichen growth form
    - Crustose > foliose or fruticose

Trait variable	Positive response	Negative response
Red List class 2010	Incr. class + <0.10	NS
Growth surface (soil, rock, epiphytic)	NS	NS
Growth form (crustose, foliose, fruticose)	Crustose + <0.001	NS
Photobiont type (Chlorococcoid algae, cyanobacteria, Trentepohlia)	NS	NS

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Lichens – observed changes

- 72 observed responses of 49 species of lichens
  - Fourteen papers (1998-2017)
  - Statistical test GLMM to account for multiple projections per species
- Positive responses related to
  - Epiphytic growth surface (>soil surface)
  - Might be connected also to other factors than climatic warming (nitrogen deposition)

Trait variable	Positive response	Negative response
Study type (experimental, observational)	NS	NS
Red List class 2010	NS	NS
Growth surface (soil, epiphytic)	Epiphytic + <0.001	NS
Growth form (crustose, foliose, fruticose)	NS	NS
Photobiont type (Chlorococcoid algae, cyanobacteria, Trentepohlia)	NS	NS

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Next steps and some conclusions

- Work will be continued to cover the taxa mentioned above
- Statistical connection between species responses and some of the traits was observed in all tested taxa
- How general are these patterns?
- Do statistical models show predictive power to identify species that are sensitive to impacts of climate change in Finland?

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