Functional traits and climate drive inter-specific differences in disturbance mortality

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SFE²-GFÖ Joint meeting - Metz

22/11/2022

Introduction

Forest disturbances in a changing world

- Disturbance: partial or total destruction of plant biomass by a biotic or abiotic agent [1]

Wind

Fire

Animals

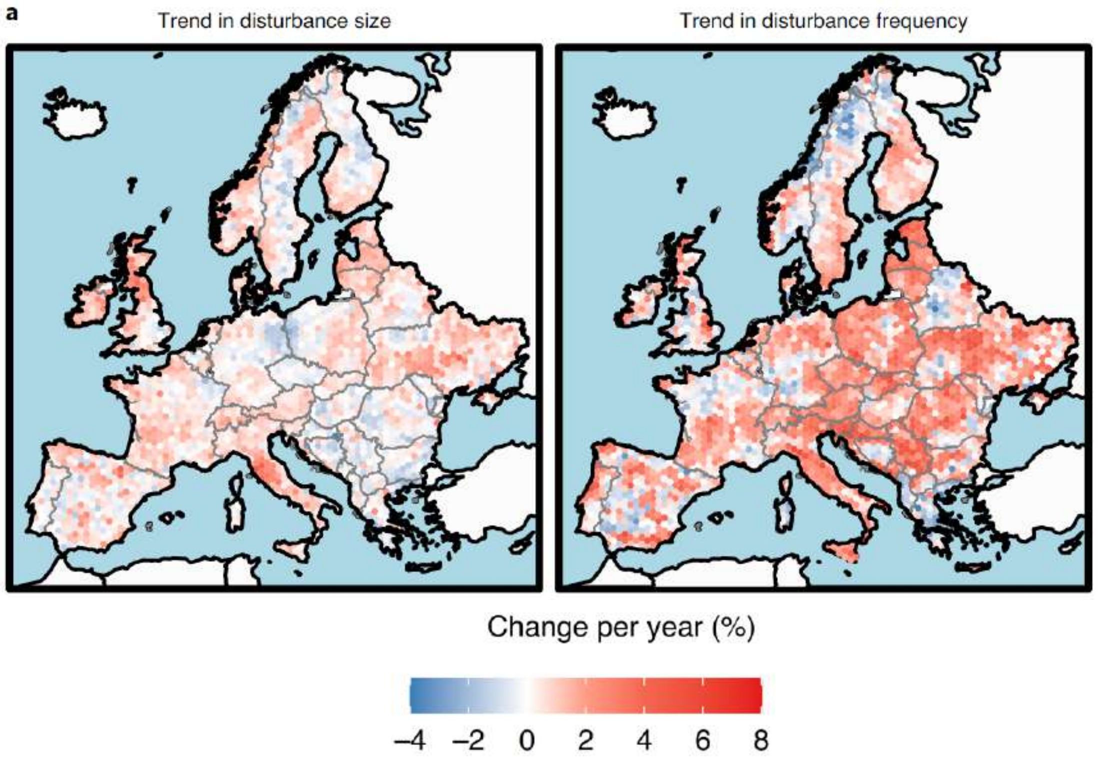
[1] Grime 1977 – American Naturalist

Introduction

Forest disturbances in a changing world

- Disturbances: partial or total destruction of plant biomass by a biotic or abiotic agent [1]

- Over the past decades, increasing rates of disturbances observed across Europe [2,3]



[1] Grime 1977 – American Naturalist

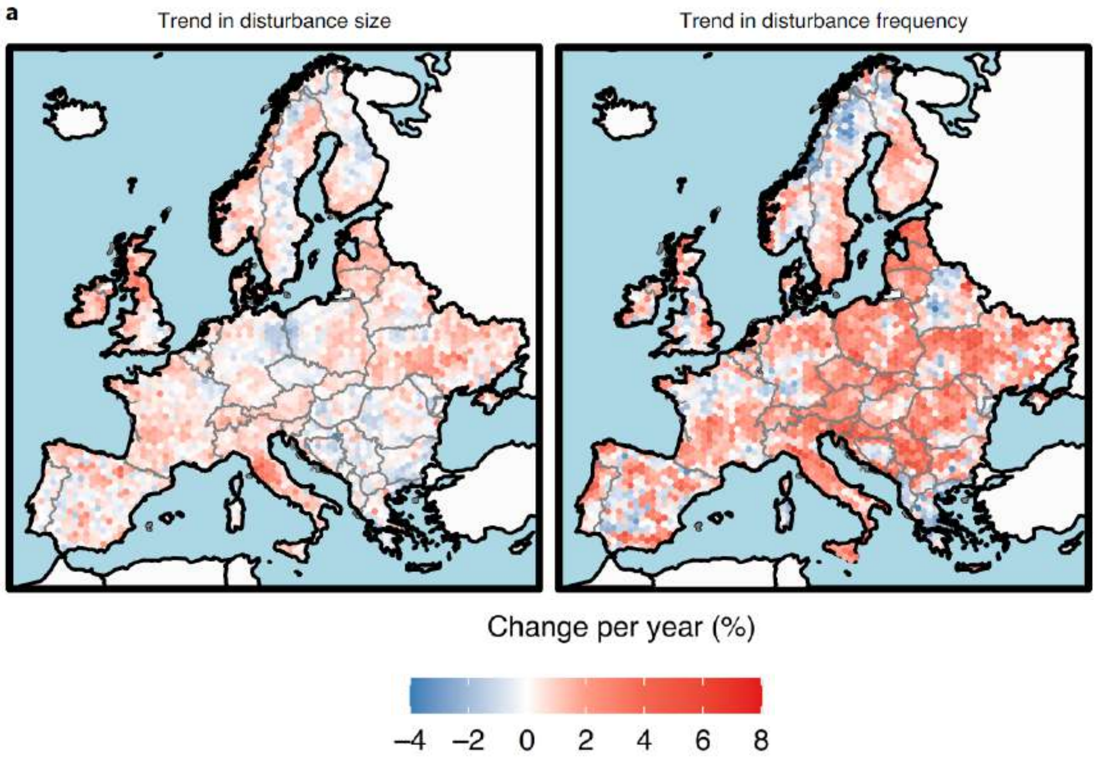
[2] Seidl et al. 2011 – Global Change Biology

[3] Senf et al. 2021 – Nature Sustainability

Introduction

Forest disturbances in a changing world

- Disturbances: partial or total destruction of plant biomass by a biotic or abiotic agent [1]
- Over the past decades, increasing rates of disturbances observed across Europe [2,3]
- It is thus crucial to understand disturbance mortality to forecast forest dynamics under climate change



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Drivers of disturbance mortality

- Primary factor: disturbance intensity – e.g., wind speed, fire energy

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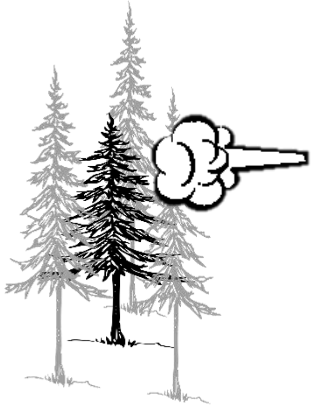
VS



Higher trees are more easily overthrown by wind (more exposed and higher lever arm) [1]

VS

Small trees are easier to burn (thinner bark) [2]

[1] Gardiner 2021 – J of Forest Research

[2] Michaletz & Johnson 2007

Introduction

Drivers of disturbance mortality

- Primary factor: disturbance intensity – e.g., wind speed, fire energy

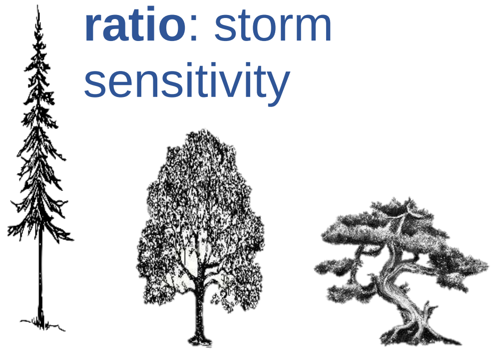
- Other crucial factor: tree size, with a different effect depending on the disturbance agent

- Differences in species sensitivity: potentially strong, but largely understudied and generally ignored in forest dynamics models [3]

  - Can be explained by functional traits
  - Or climate in native distribution

Bark thickness: fire resistance

Height – diameter ratio: storm sensitivity



Leaf traits: biotic sensitivity

Abies alba

Quercus suber

[1] Gardiner 2021 – J of Forest Research

[2] Michaletz & Johnson 2007

[3] Schmitt et al. 2019 – Functional Ecology

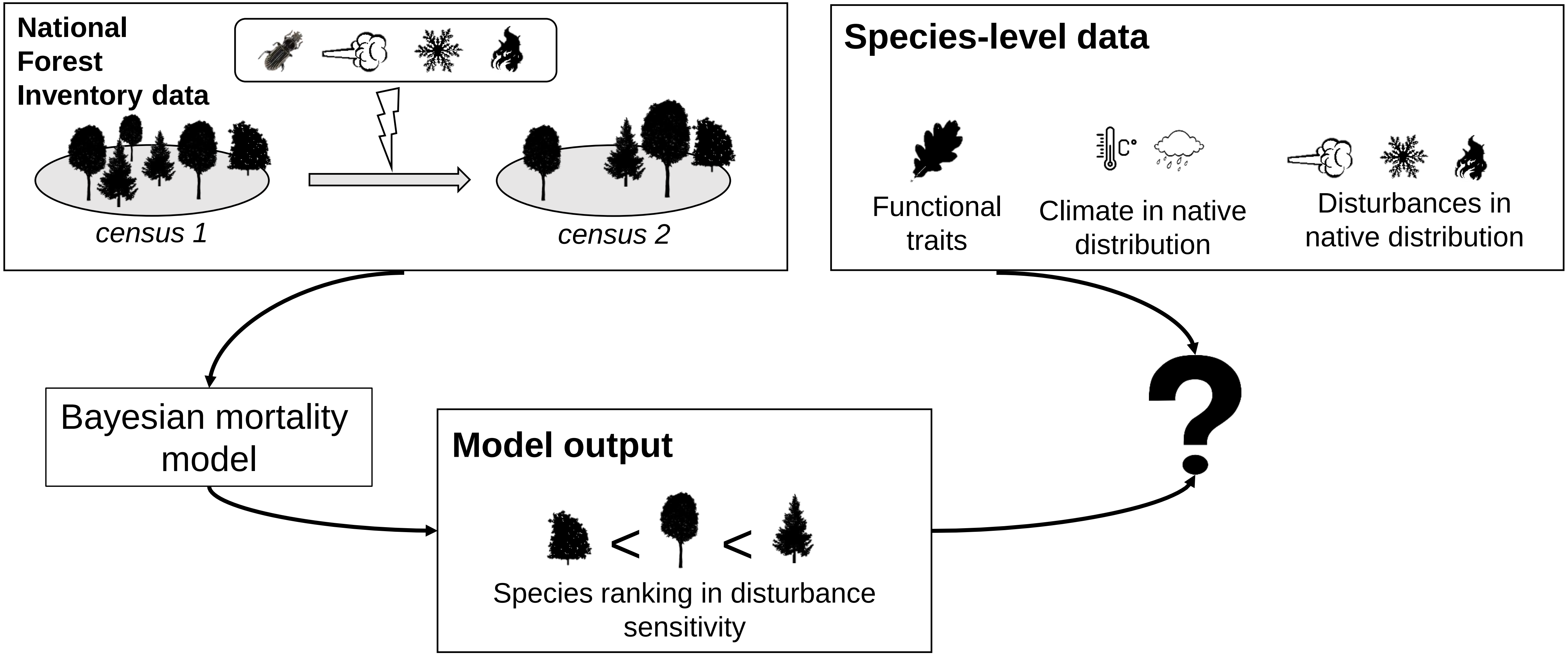
Introduction

Objectives of the study

1. Estimate mortality probabilities per species and disturbance type
2. Test the effect of different functional traits on species sensitivity
3. Test the effect of species mean climate on sensitivity

Methodology

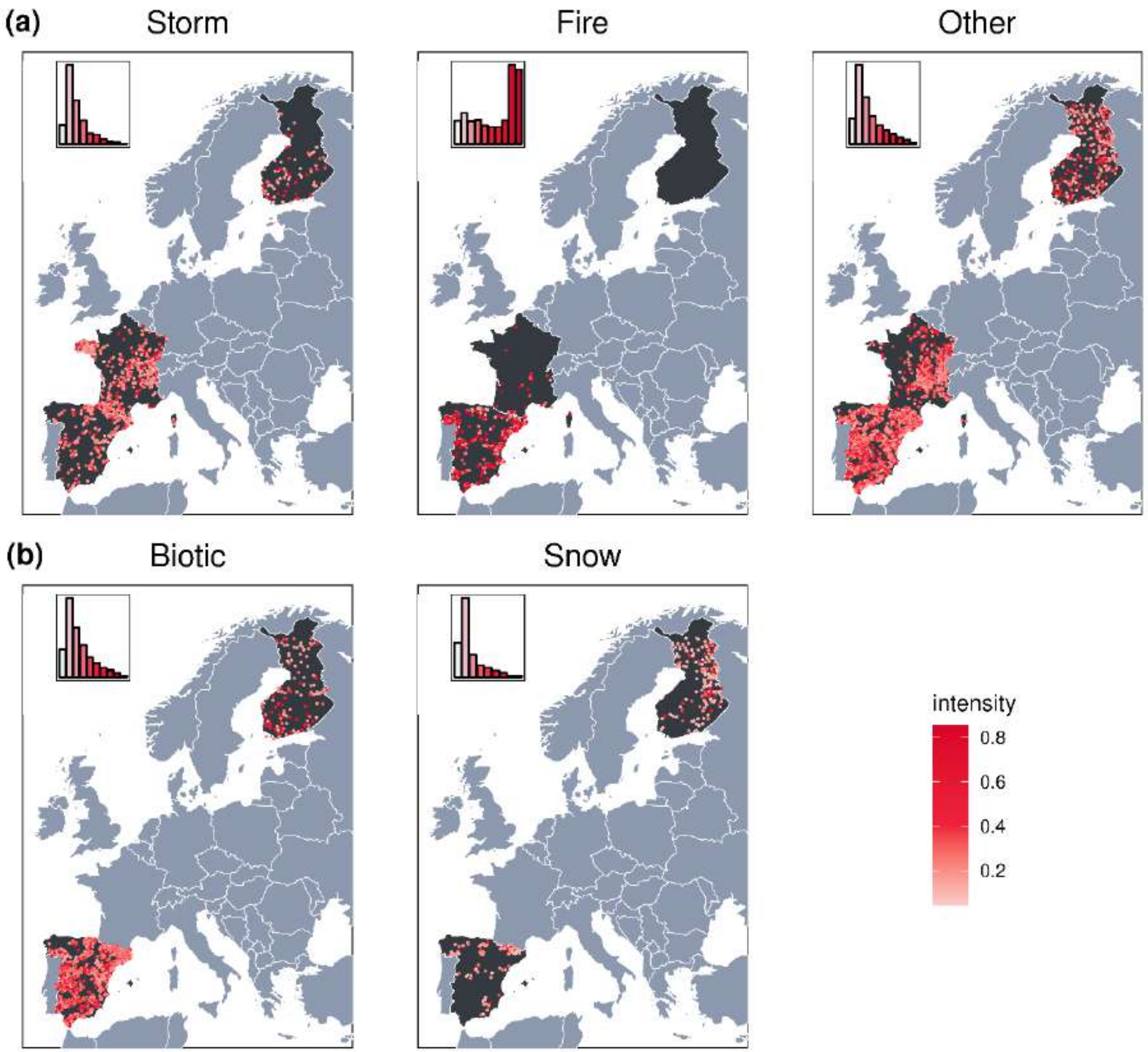
Overview



Methodology

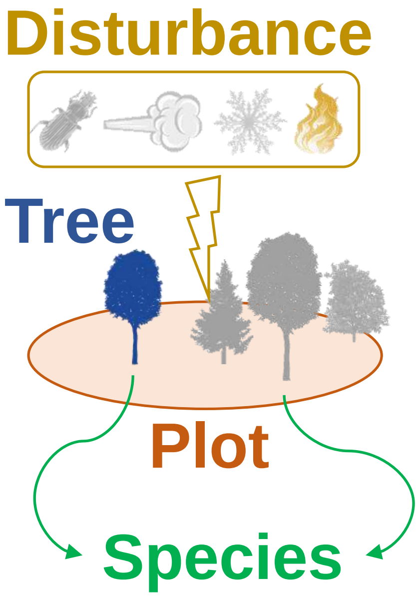
NFI data

- NFI data of three countries: Spain, Finland and France



Methodology

Modeling mortality probability



Probability to die modeled as a function of:

- Tree diameter
- Tree status within the plot
- Latent variable for disturbance intensity at plot level
- Parameters estimated for each species and disturbance

Species sensitivity to a disturbance :

Posterior estimation of mortality probability, with fixed values of the explanatory variables

Canham et al. 2001 – Can. J. of For. Research

Trouvé et al. 2021 – Ecological Applications

Methodology

Traits included in the analysis

Received: 15 August 2019 | Accepted: 12 September 2019
DOI: 10.1111/gcb.14904

INVITED PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

TRY plant trait database – enhanced coverage and open access

Received: 15 January 2020 | Revised: 8 June 2020 | Accepted: 28 July 2020
DOI: 10.1111/geb.13179

DATA PAPER

Global Ecology and Biogeography WILEY

Global root traits (GRooT) database

Ecology Letters, (2009) 12: 351–366 doi: 10.1111/j.1461-0248.2009.01285.x

REVIEW AND SYNTHESIS

Towards a worldwide wood economics spectrum

Ecological Monographs, 76(4), 2006, pp. 521–547

TOLERANCE TO SHADE, DROUGHT, AND WATERLOGGING OF TEMPERATE NORTHERN HEMISPHERE TREES AND SHRUBS

Ülo Niinemets[1,2] and Fernando Valladares[3,4]

Root mass frac.
H/dbh ratio
Bark thick.
Architectural traits

Stomata cond.
Leaf thick.
Drought traits

Wood dens.
Max. growth
Lifespan
Growth vs. survival

Leaf Nmass
Leaf C/N
Growth vs. defense

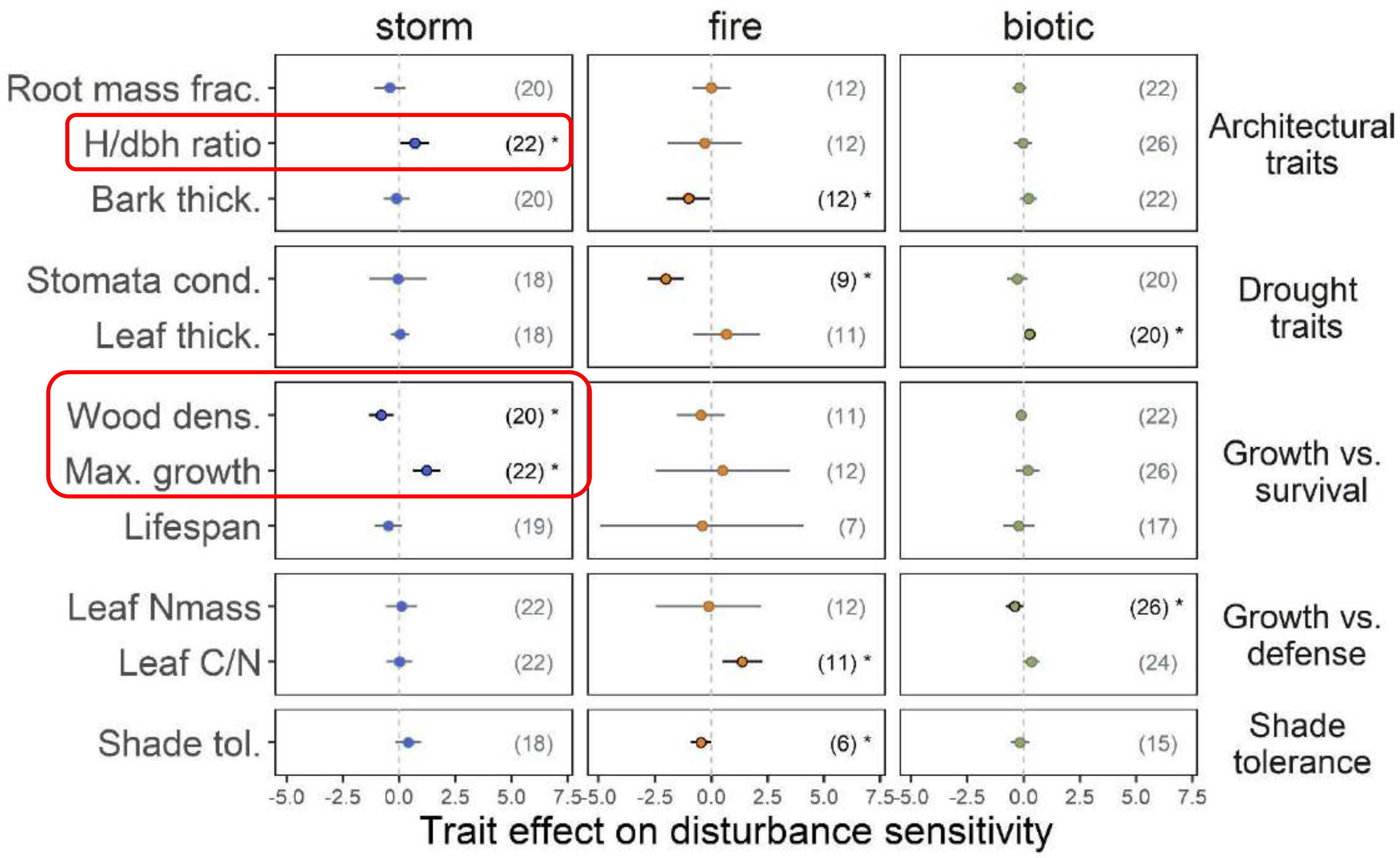
Shade tol.
Shade tolerance

Calculated from NFI data

Results

Effect of traits on sensitivity to different disturbance types

- Storm mortality driven by wood density, maximum growth and the height-dbh ratio
  → Importance of the trade-off between growth and mortality[1]



[1] Esquievel-Muelbert et al. 2020 – *Nature com*

Results

Effect of traits on sensitivity to different disturbance types

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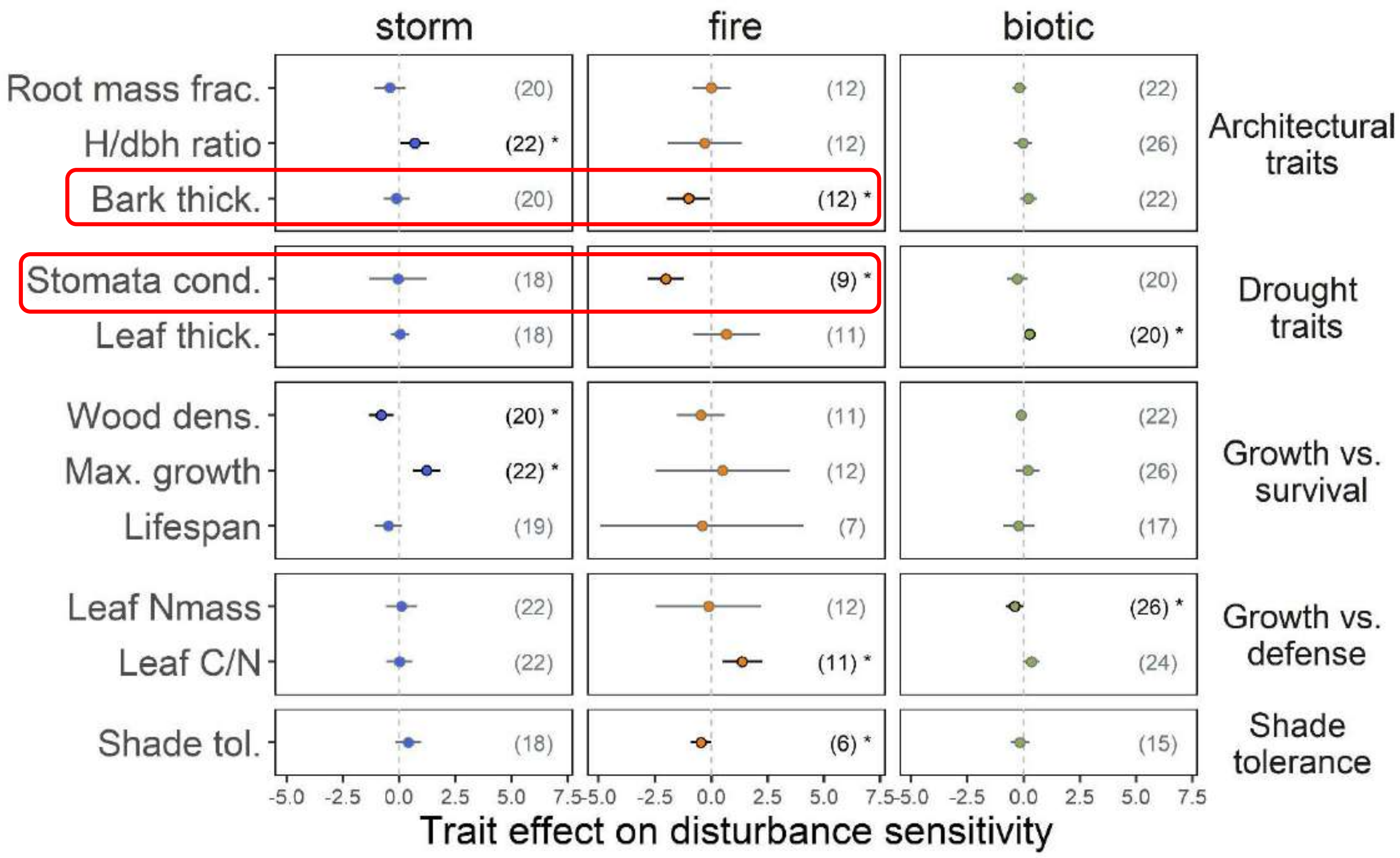
- Fire mortality driven by bark thickness as expected, but also by stomatal conductance
  → Convergence between traits selected by fire and drought[2]



[1] Esquievel-Muelbert et al. 2020 – *Nature com*

[2] Keeley et al. 2011 – *Trends in Plant Science*

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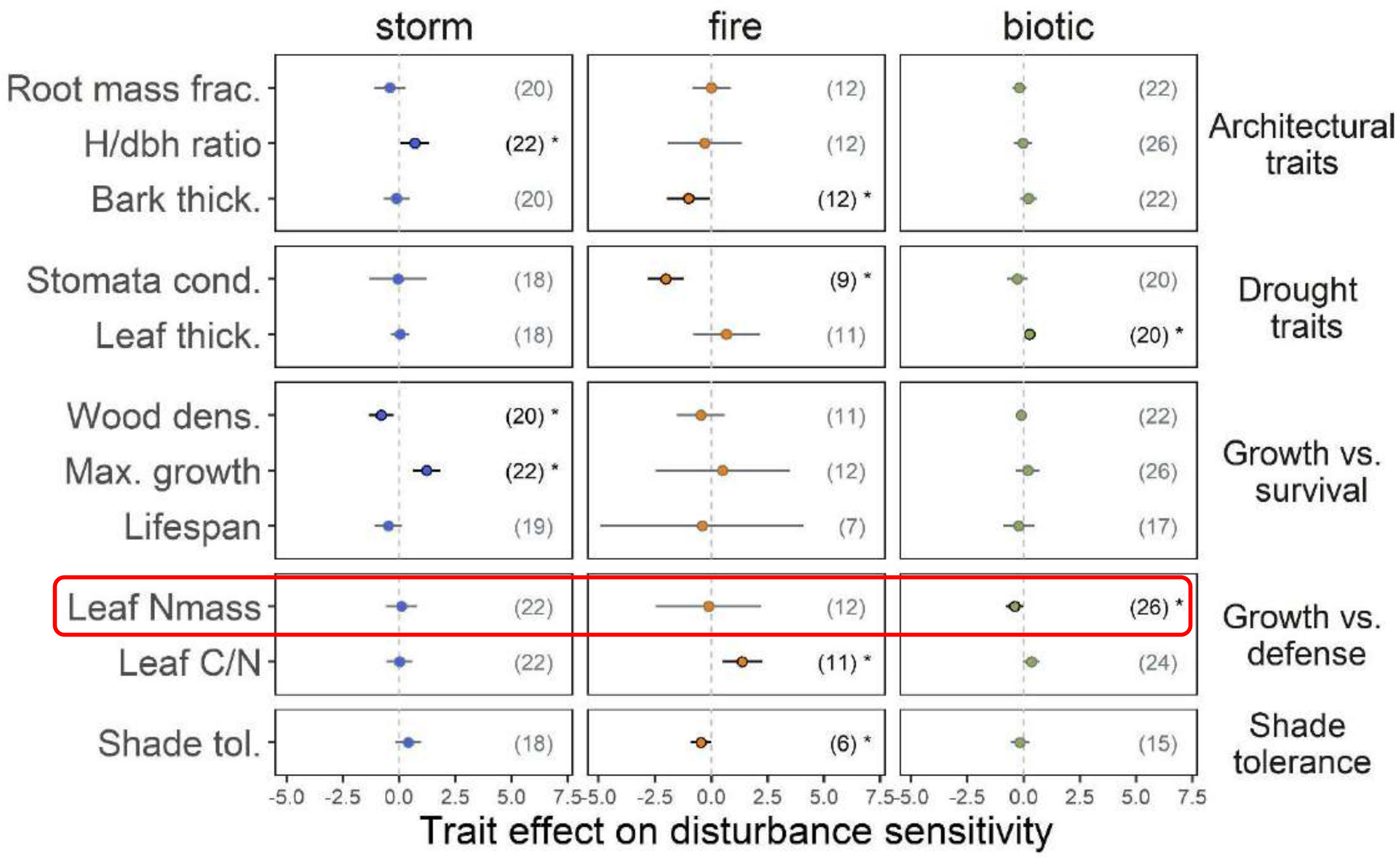
- Negative effect of leaf N content on biotic sensitivity
  → Defense vs tolerance trade-off: highly defended species are less able to tolerate herbivory[3]



[1] Esquievel-Muelbert et al. 2020 – *Nature com*

[2] Keeley et al. 2011 – *Trends in Plant Science*

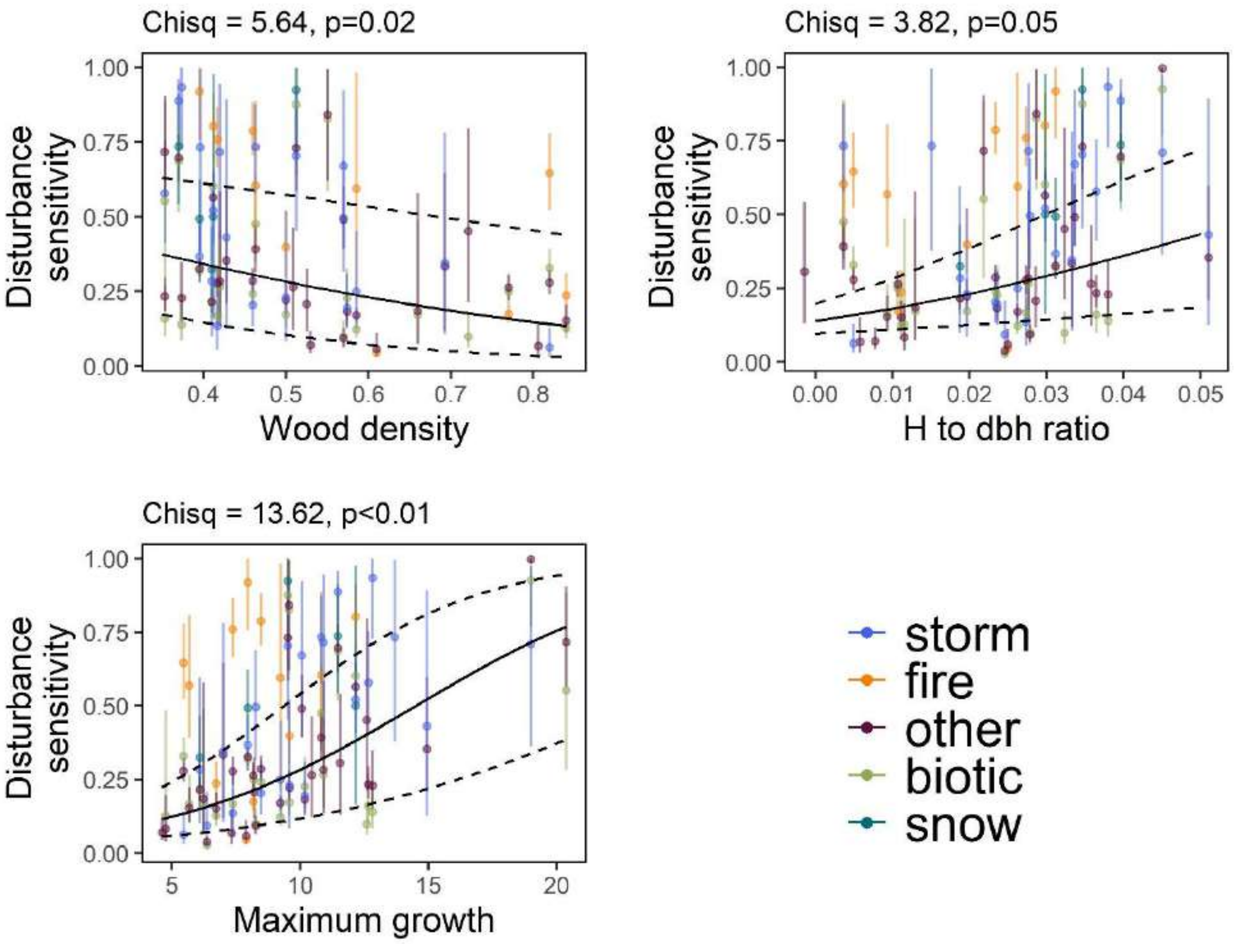
[3] Zust & Agrawal 2017 – *Ann Rev of Plant Biol*

Results

Synergy in tolerance traits

- Wood density, height to dbh ratio and maximum growth are correlated to the sensitivity to all disturbance types

- Indicates that there is a convergence and not a trade-off between sensitivity to different disturbance types



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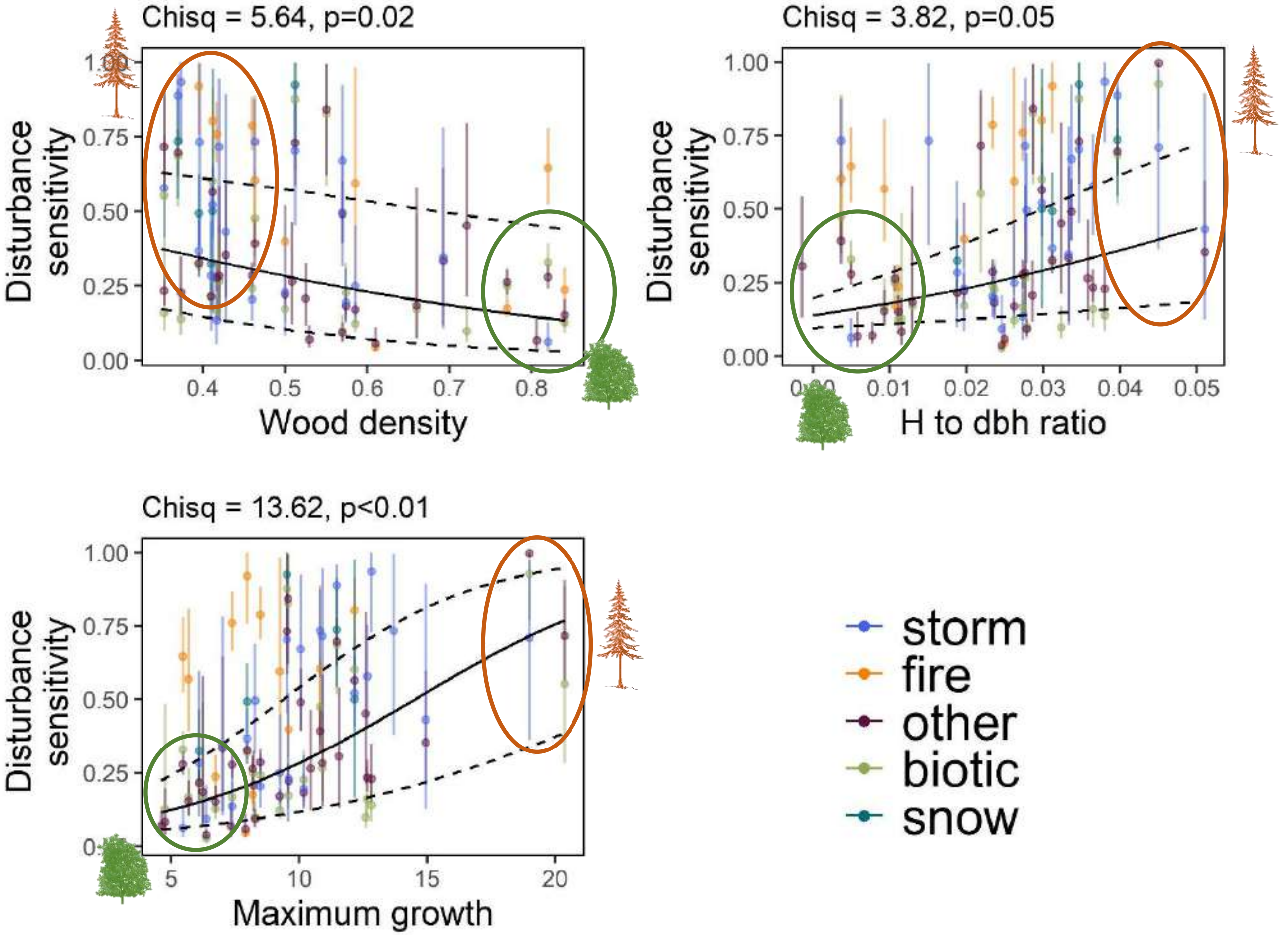
- Sensitive species = productive conifer species
- Resistant species = Mediterranean oaks

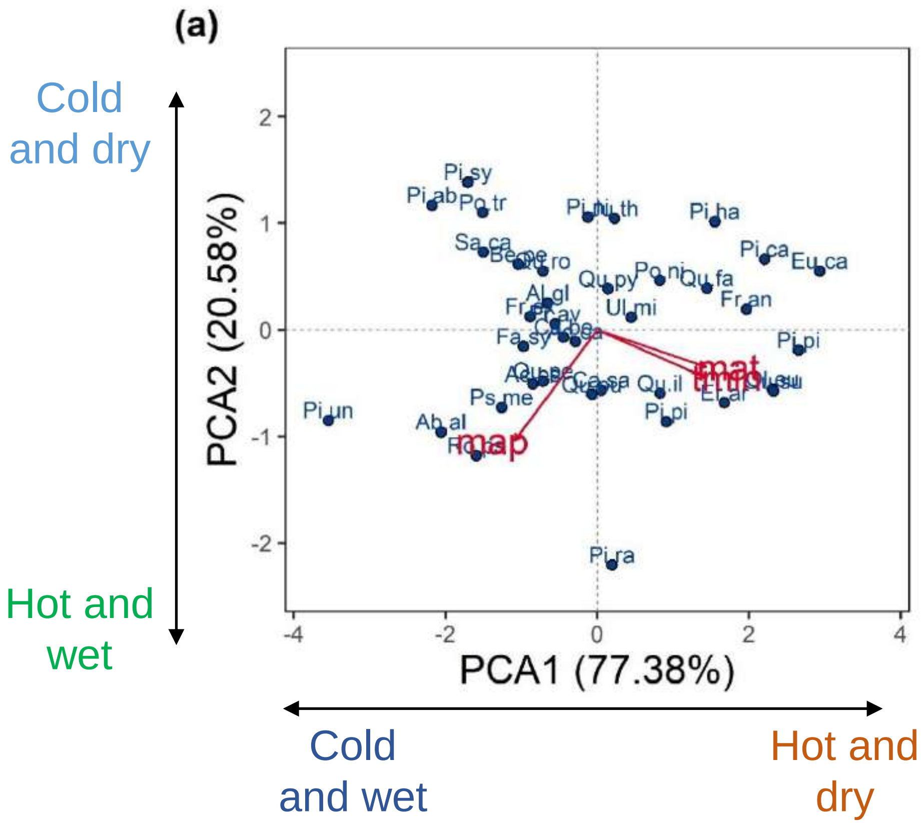


Results

Effect of species mean climate on sensitivity

- Species from warm and dry climates are more resistant to fire sensitivity

- **Fire = stronger selective force than the other disturbance types ?**



Conclusion

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- Species sensitivity to disturbances is well predicted by both functional traits and climate
- No trade-off between disturbance types, and characteristics of disturbance-adapted species are similar to those of drought adapted species → good news for climate change !
- Mortality probabilities that can be further re-used in forest dynamics models

THANKS FOR YOUR ATTENTION !