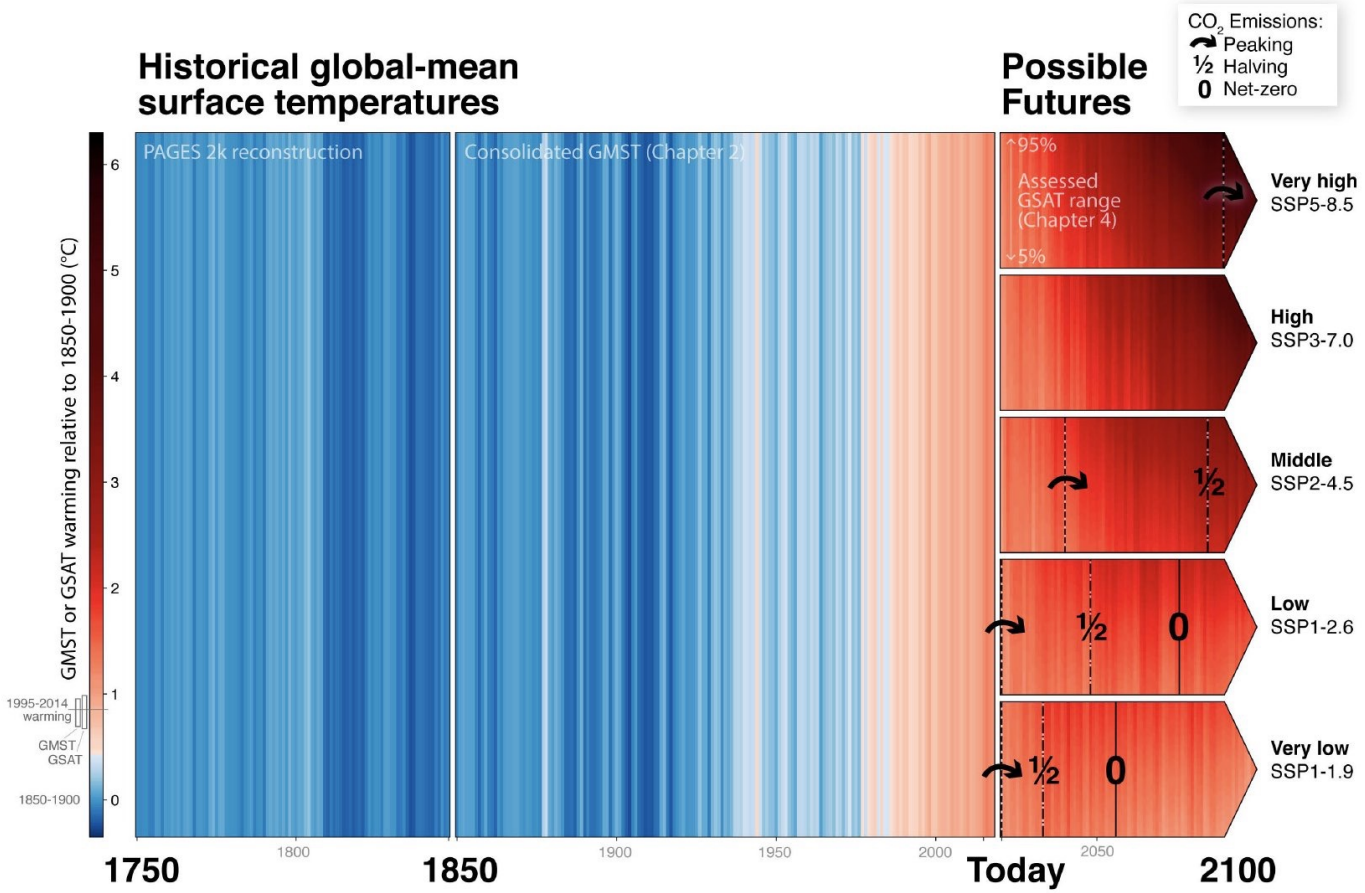
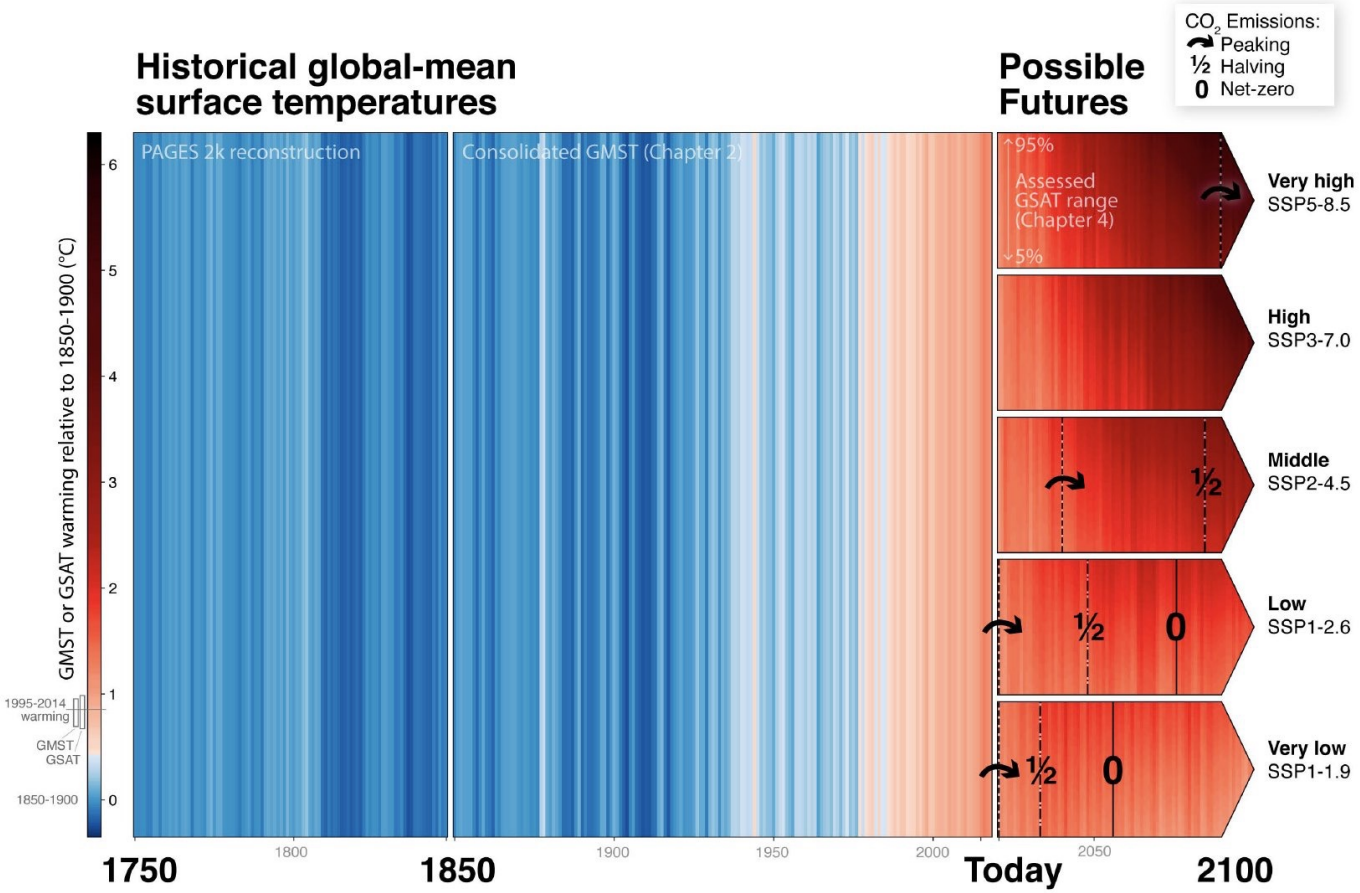
Tree diversity increases air temperature buffering in forests

Rémy Beugnon[†], Florian Schnabel[†], Yang Bo[†], Simone Cesarz, Nico Eisenhauer, Maria D. Perles Garcia, Georg Haehn, Werner Härdtle, Yuanyuan Huang, Matthias Kunz, Xiaojuan Liu, Nadia C. Castro Izaguirre, PA Niklaus, Goddert von Oheimb, Katrine A. Pietsch, Ronny Richter, Bernhard Schmid, Stefan Trogisch, Christian Wirth, Keping Ma[*], Helge Bruelheide[*]

INTRODUCTION: GLOBAL WARMING



INTRODUCTION: INCREASE OF CLIMATIC EXTREMES



INTRODUCTION: INCREASE OF CLIMATIC EXTREMES KILLS NATURE

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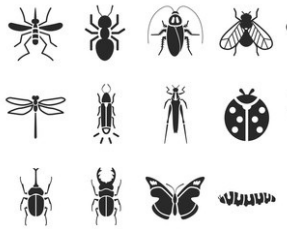
Ecosystem structure



IPBES reports

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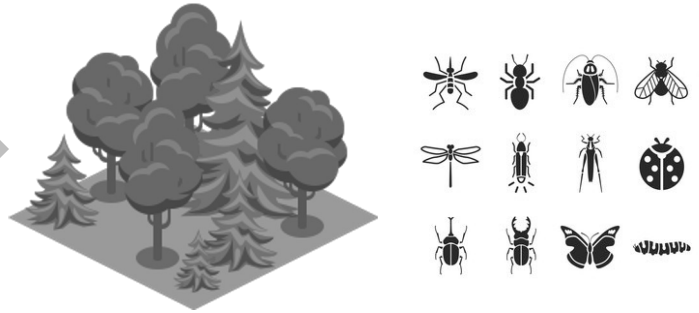
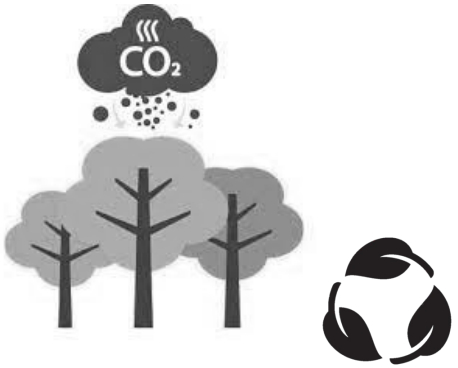
INTRODUCTION: INCREASE OF CLIMATIC EXTREMES KILLS NATURE

Ecosystem structure

Ecosystem functions





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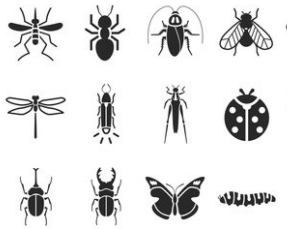
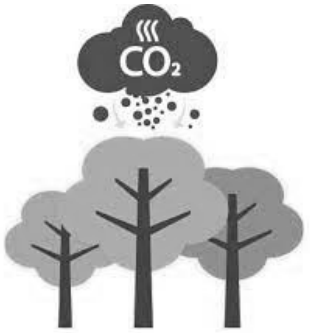
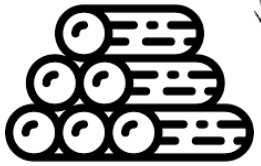


Ecosystem functions



Ecosystem services



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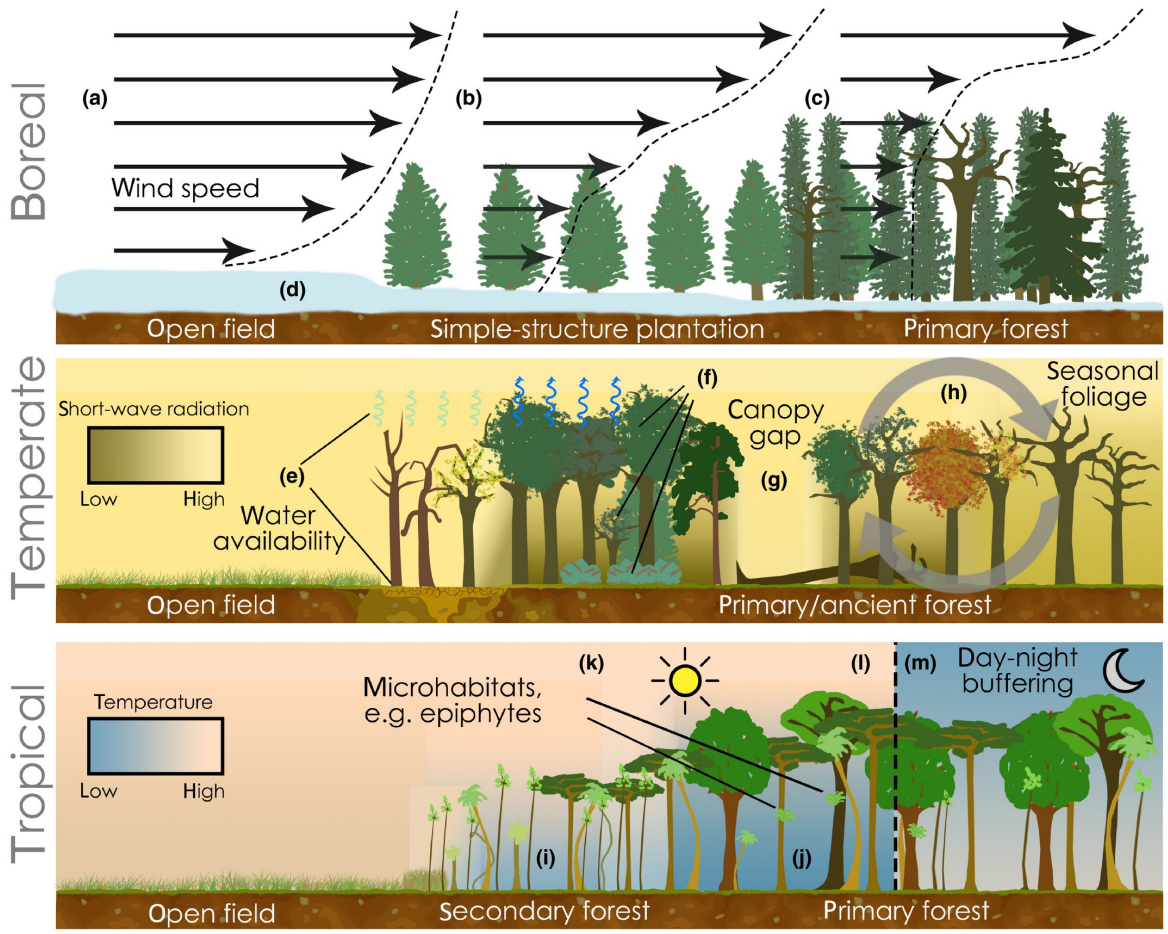
INTRODUCTION: FOREST POTENTIAL TO PROTECT FROM MACROCLIMATIC FLUCTUATIONS



de Frenne et al. 2013, 2019, 2021
Zellweger et al. 2020

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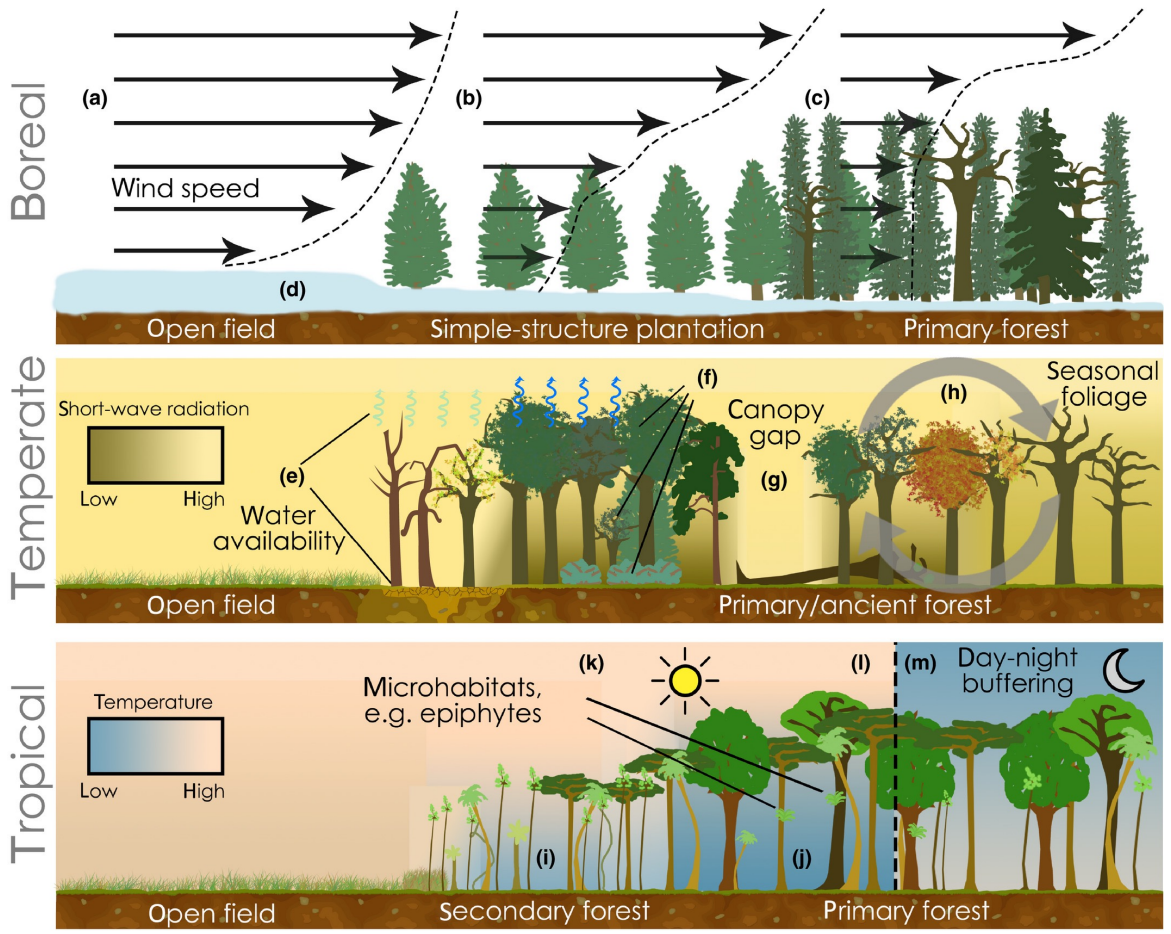
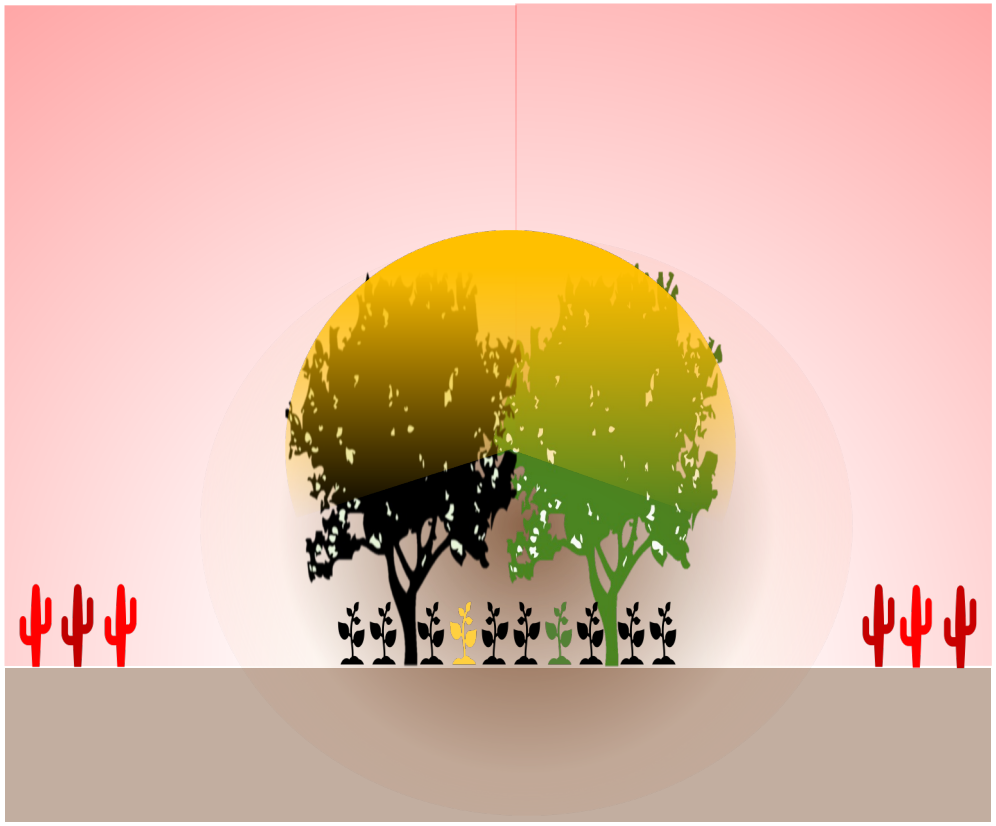
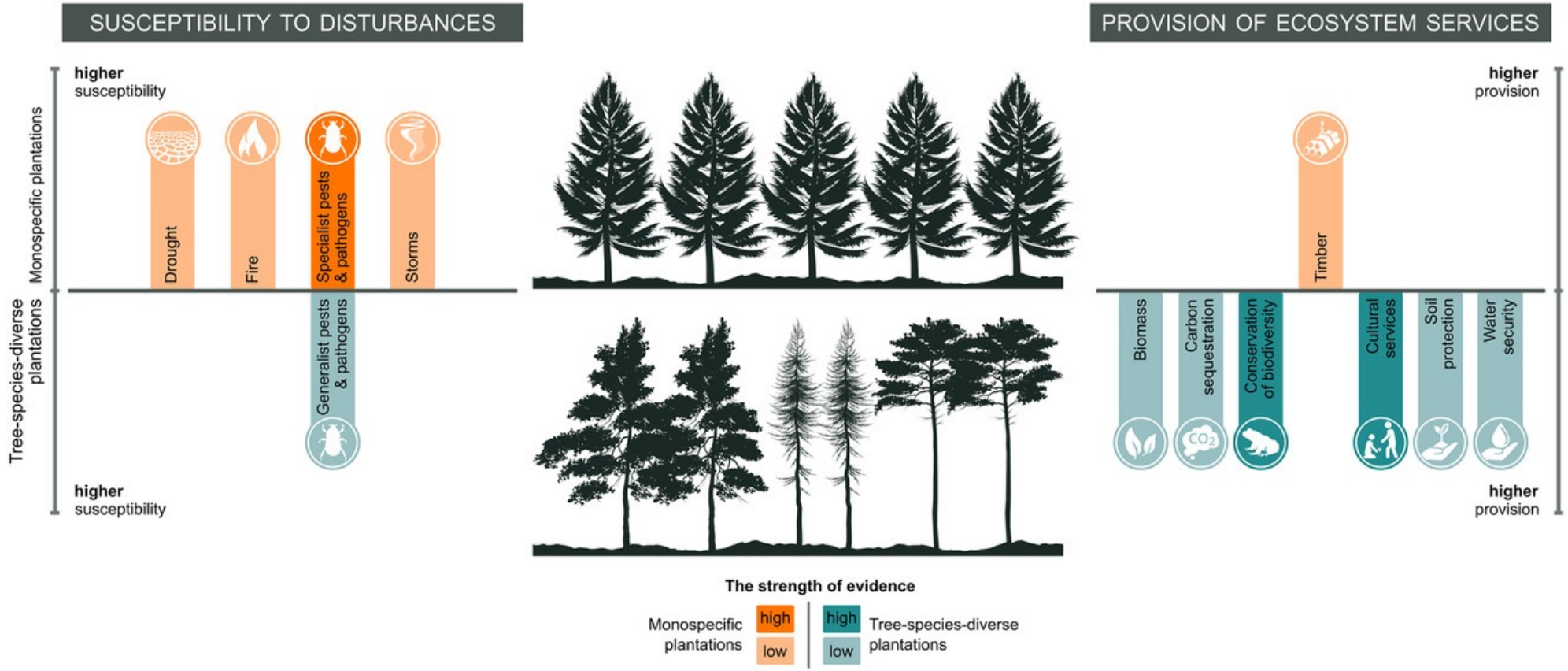


Thermal shield against climatic fluctuations



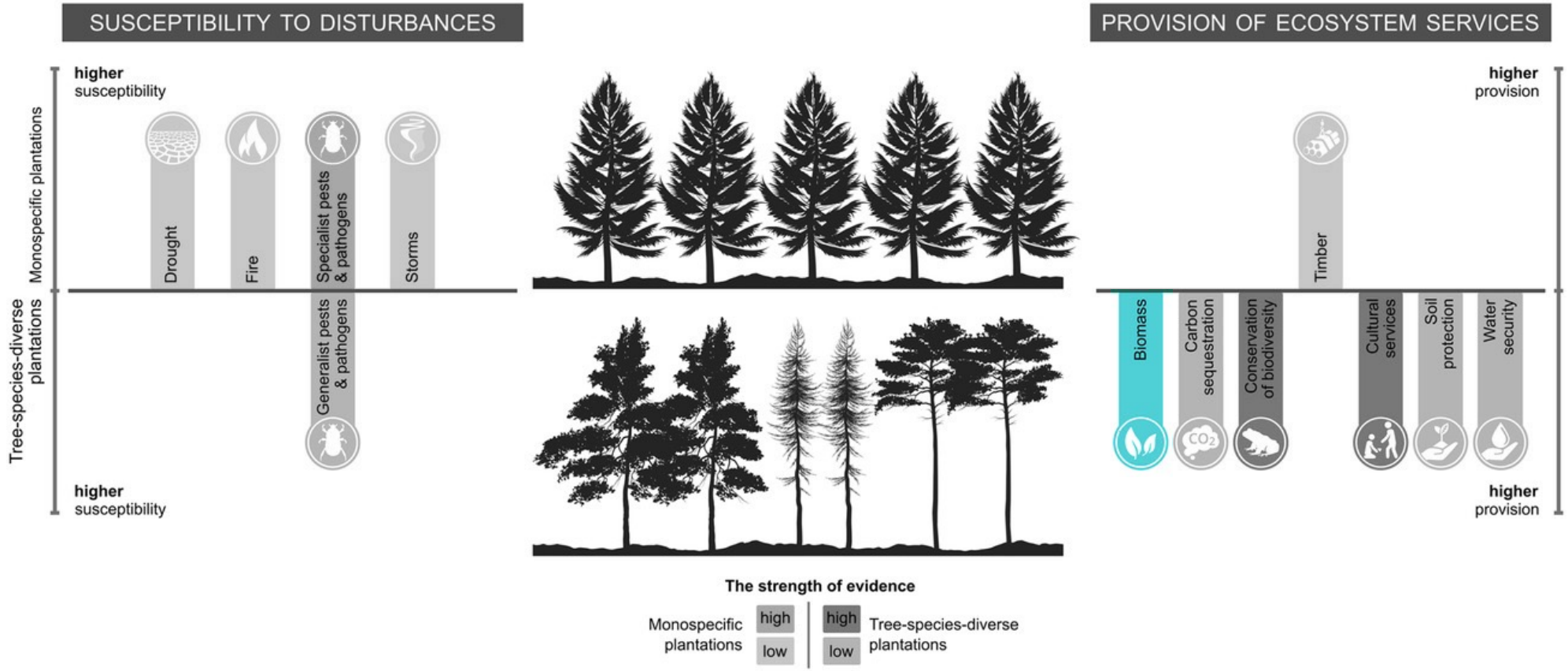
de Frenne et al. 2013, 2019, 2021
Zellweger et al. 2020

INTRODUCTION: BENEFITS OF TREE DIVERSITY – BEF RELATIONSHIPS



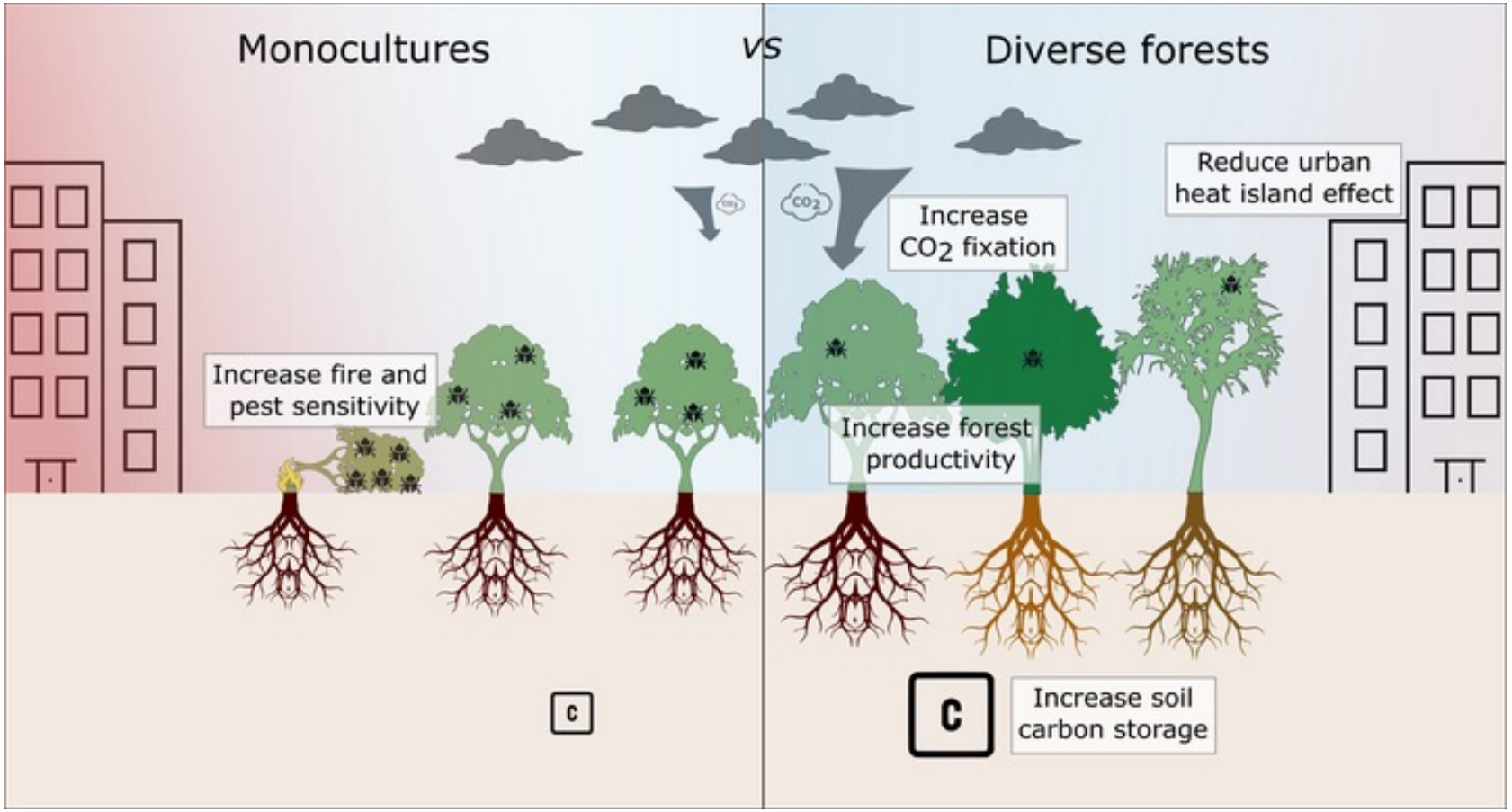
Messier et al. 2019

INTRODUCTION: BUFFERING OF CLIMATIC THREATS



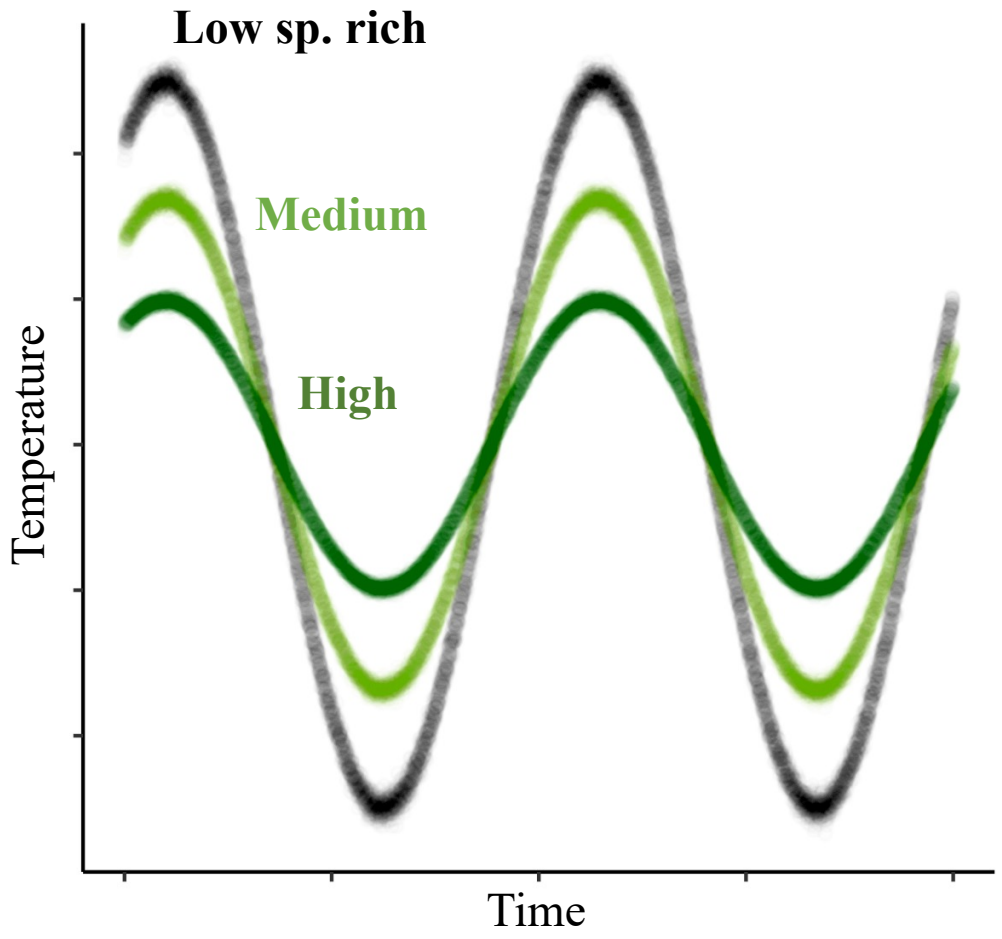
Messier et al. 2019
Huang et al. 2018

INTRODUCTION: DIVERSITY BUFFERING OF MACROCLIMATIC FLUCTUATIONS



Beugnon et al 2021
Zhang et al 2022

HYPOTHESIS: TREE SPECIES RICHNESS REDUCES TEMPERATURE FLUCTUATIONS



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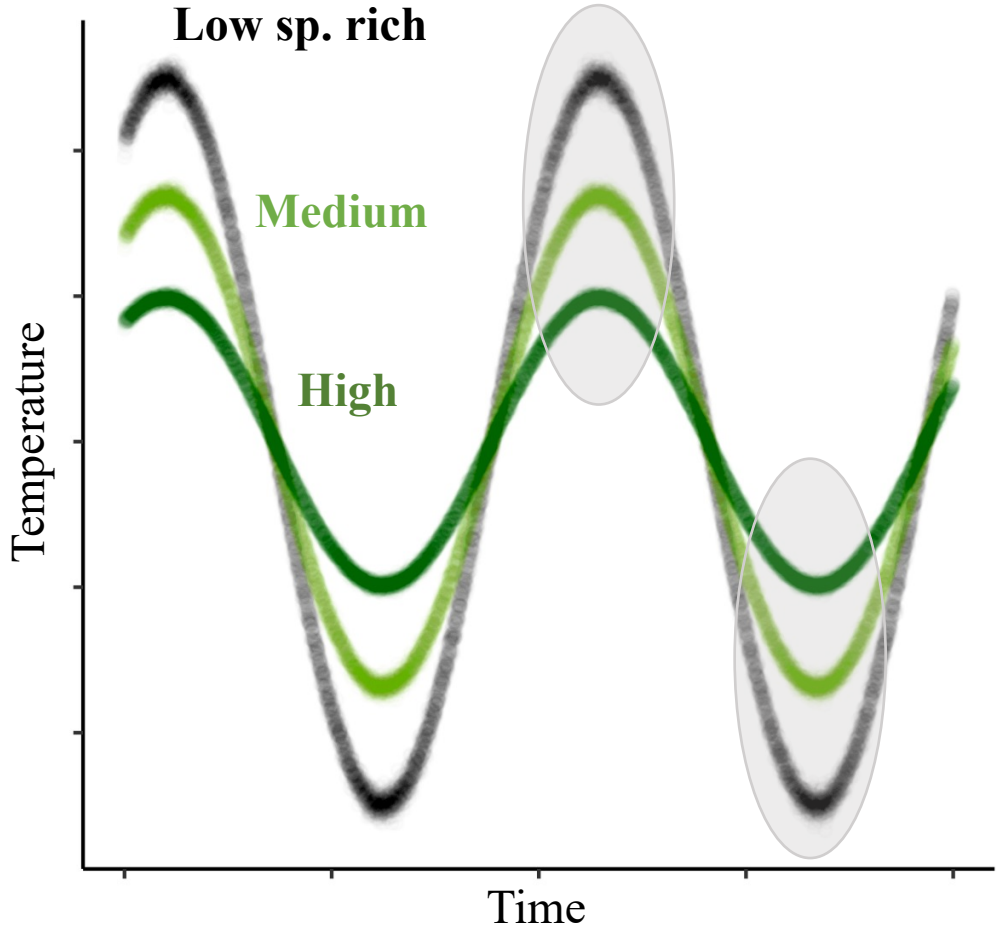

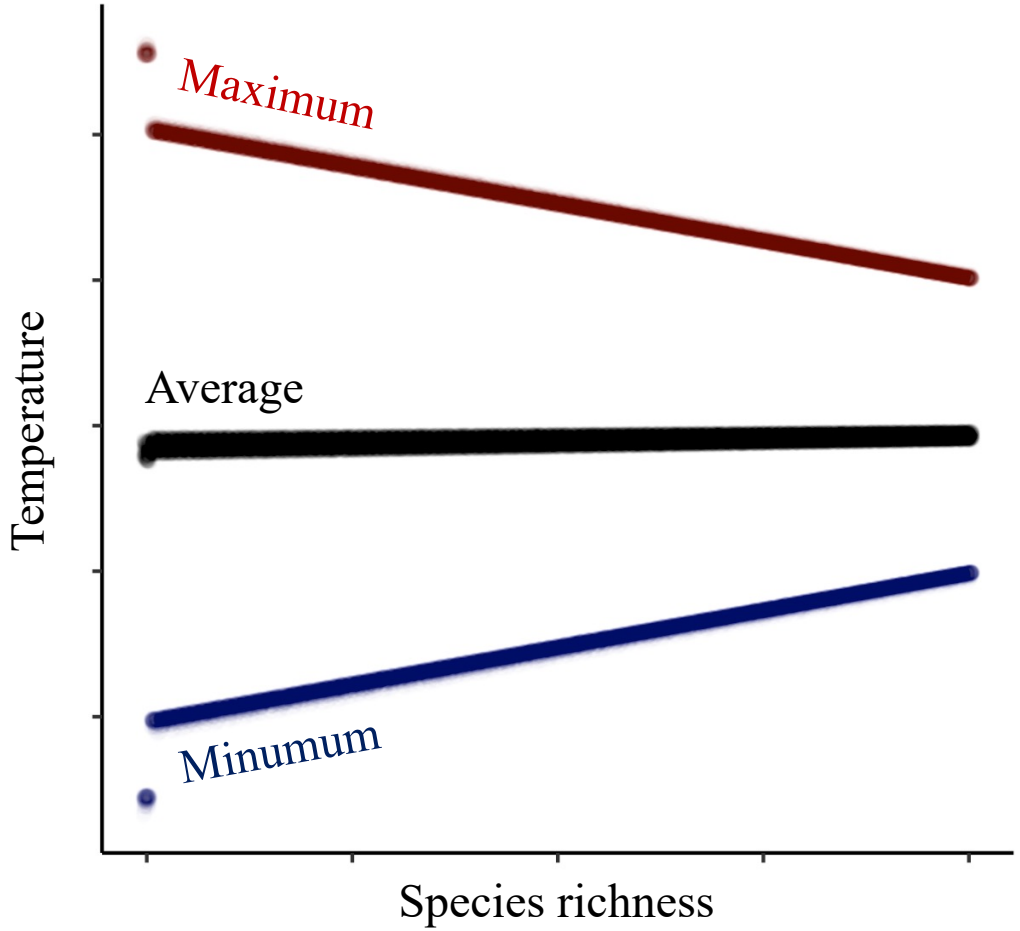

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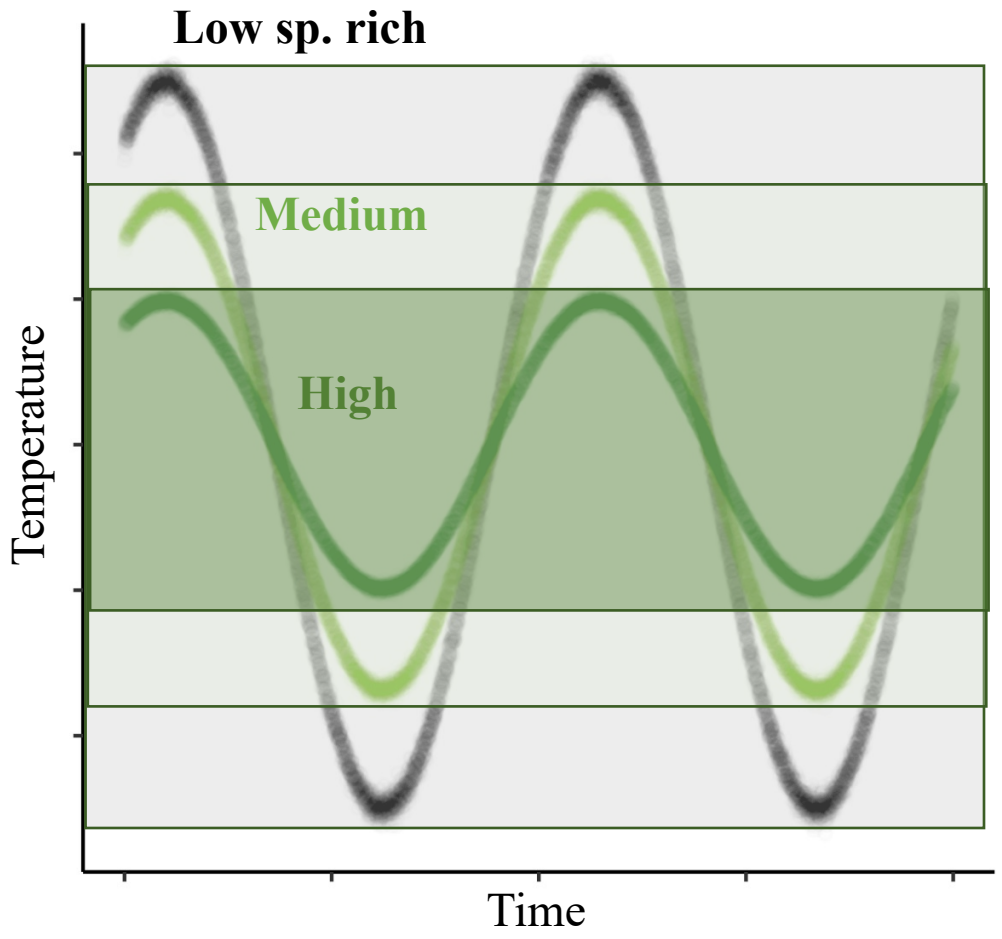
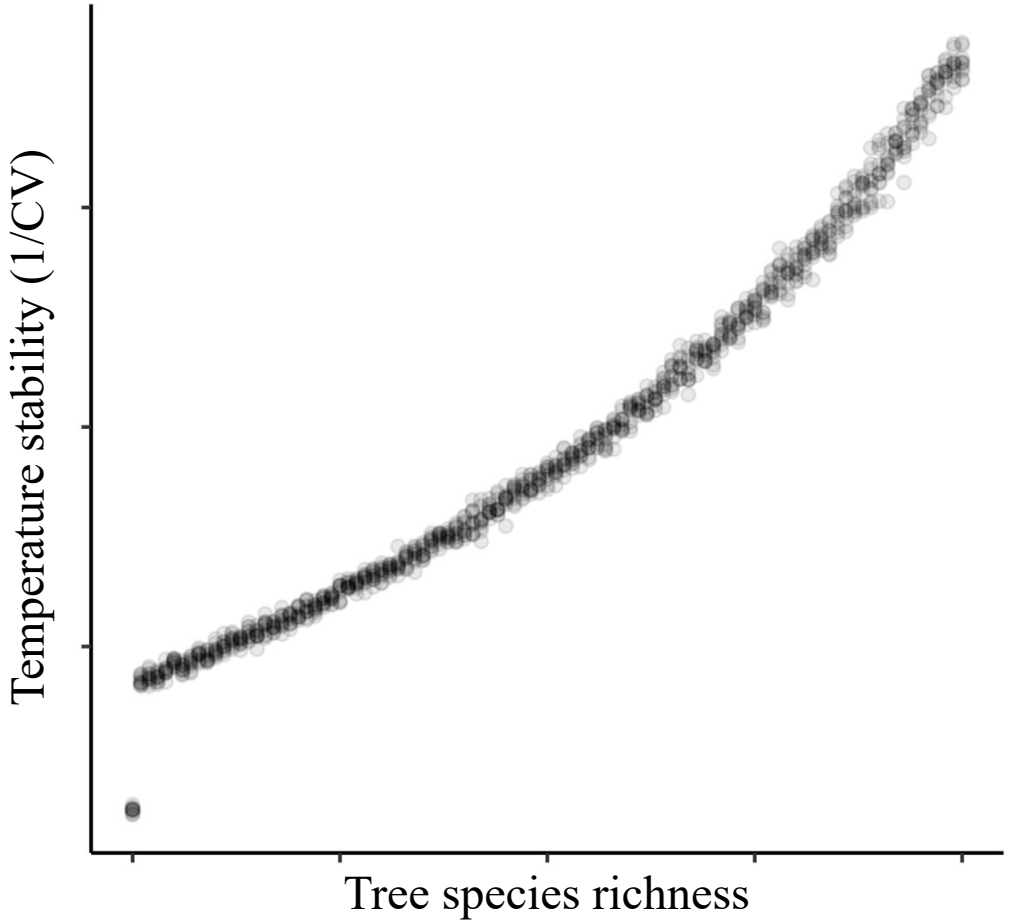
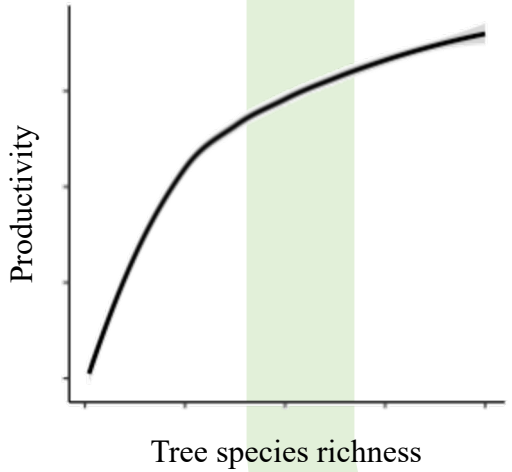




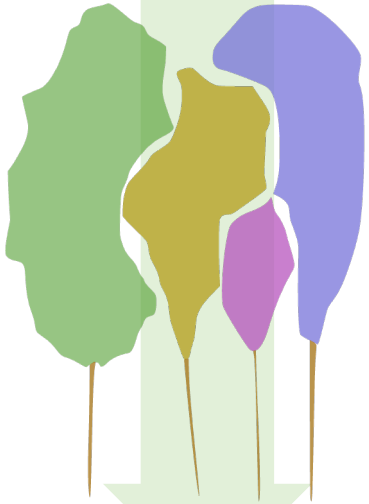
HYPOTHESIS: BUFFERING MECHANISMS

Tree diversity

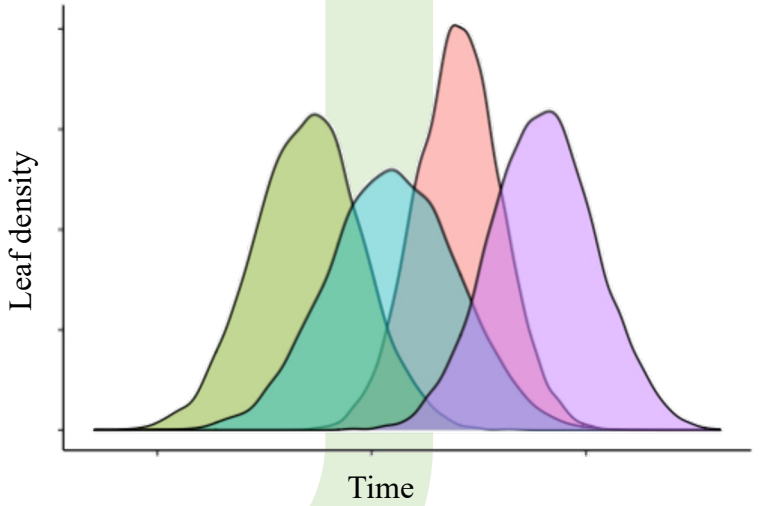
Biomass



Spatial complementarity



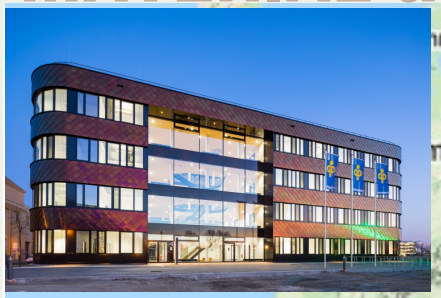
Temporal complementarity



Buffering of macroclimate fluctuations

Beugnon et al. 2021, Huang et al. 2018
Zhang et al. 2022, Sapijanskas et al. 2014

MATERIAL & METHODS: STUDY SITE



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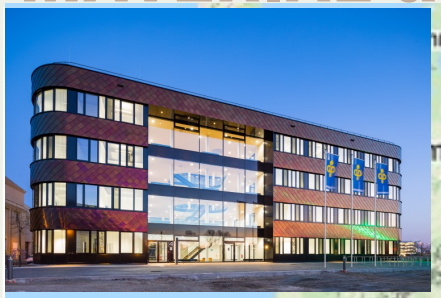
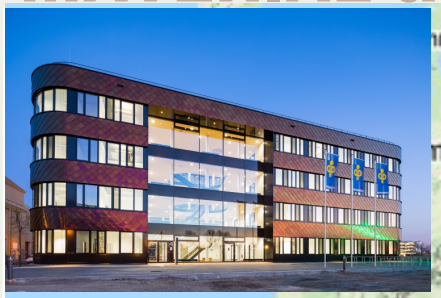


Subtropical Chinese forests: warm, rainy summers and cool, dry winters

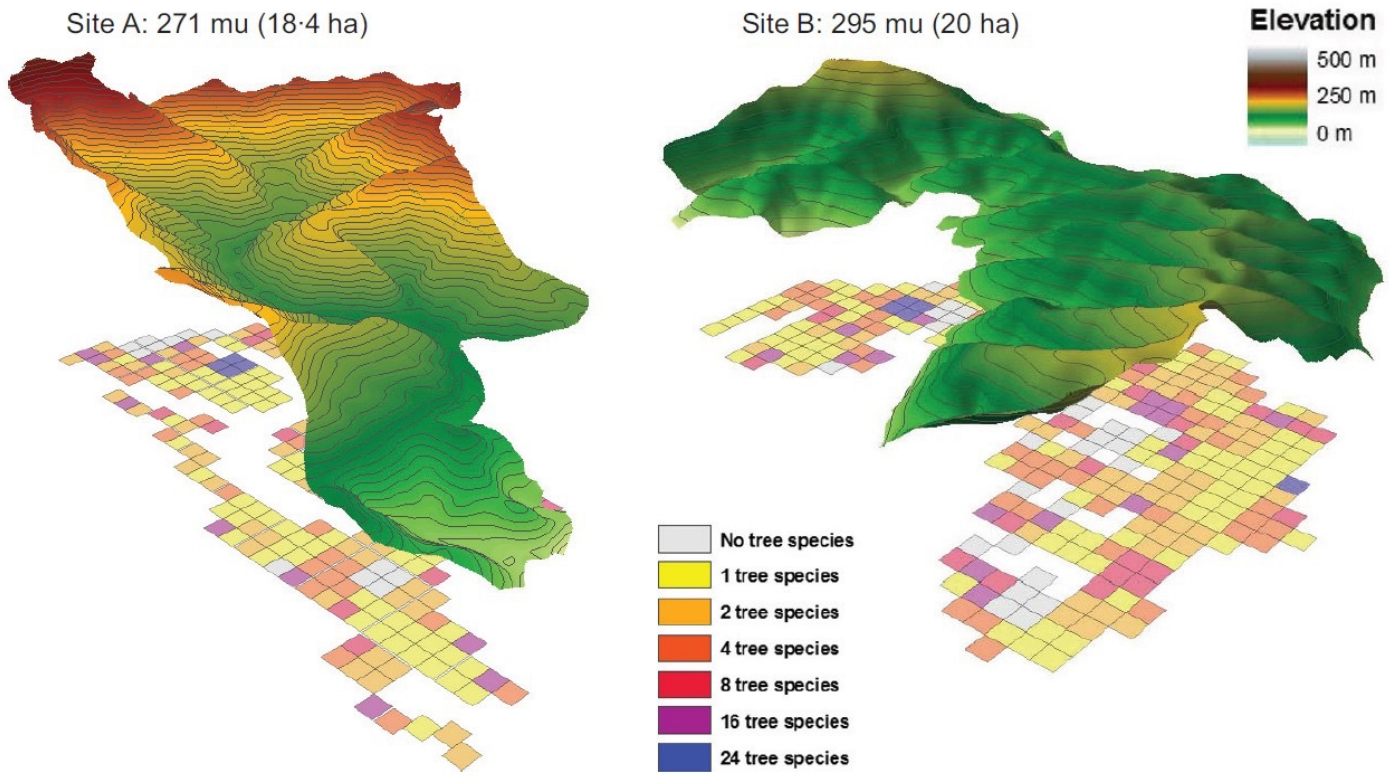
MATERIAL & METHODS: STUDY SITE



Biome with the highest average net ecosystem productivity among Asian forests.

MATERIAL & METHODS: BEF CHINA DESIGN

Bruelheide *et al.* 2014, Scholten *et al.* 2017



29.08-29.11° N, 117.90–117.93° E

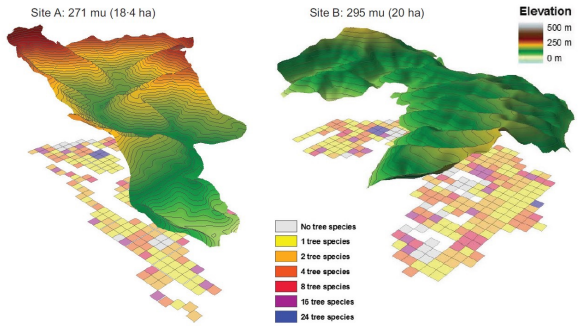
Mean annual temperature of 16.7 °C (*vs.* 10.2 °C in Leipzig)

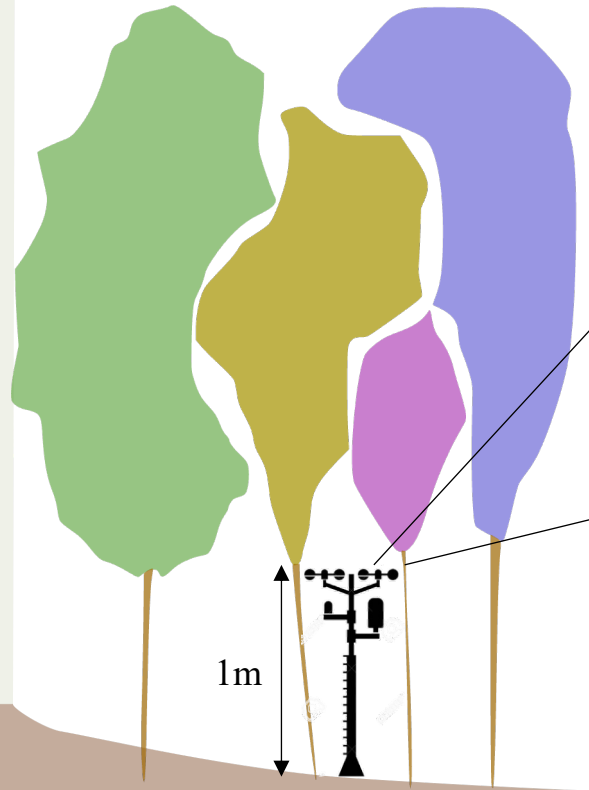
Mean annual rainfall of 1 821 mm (*vs.* 723 mm in Leipzig)

Natural vegetation: *Cyclobalanopsis glauca, Castanopsis eyrei, Daphniphyllum oldhamii, and Lithocarpus glaber*

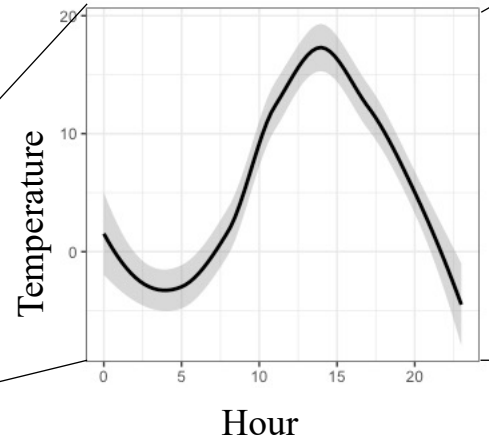
Planted in 2009 after a clear-cut of the previous commercial forests

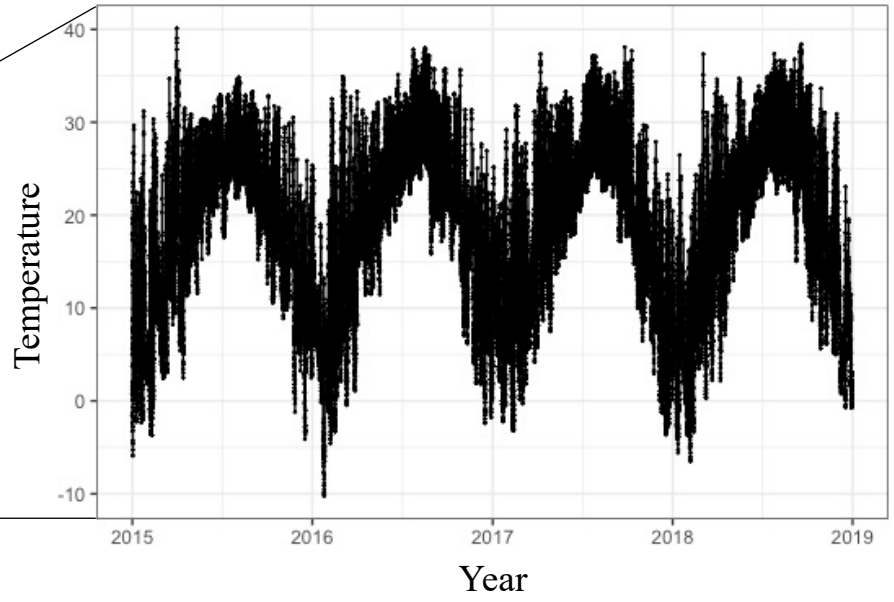
MATERIAL & METHODS: TEMPERATURE MEASUREMENTS



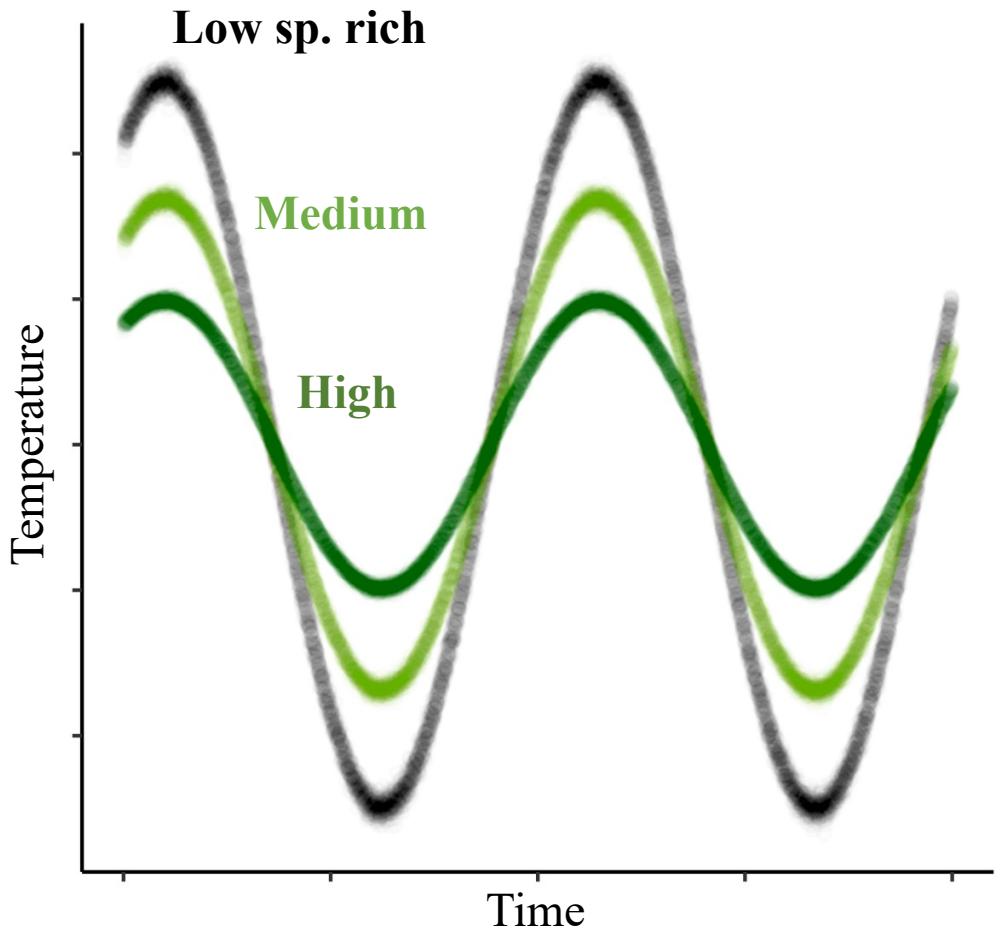


Temperature records

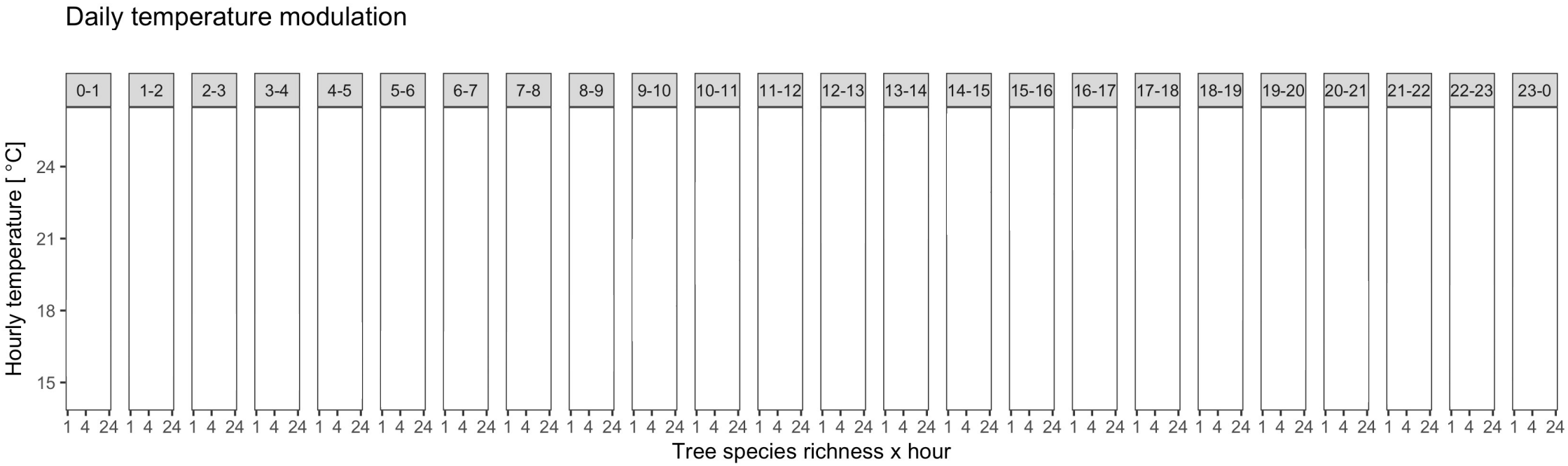




RESULTS: TEMPERATURE DAILY FLUCTUATIONS



RESULTS: TREE DIVERSITY BUFFERS TEMPERATURE FLUCTUATIONS



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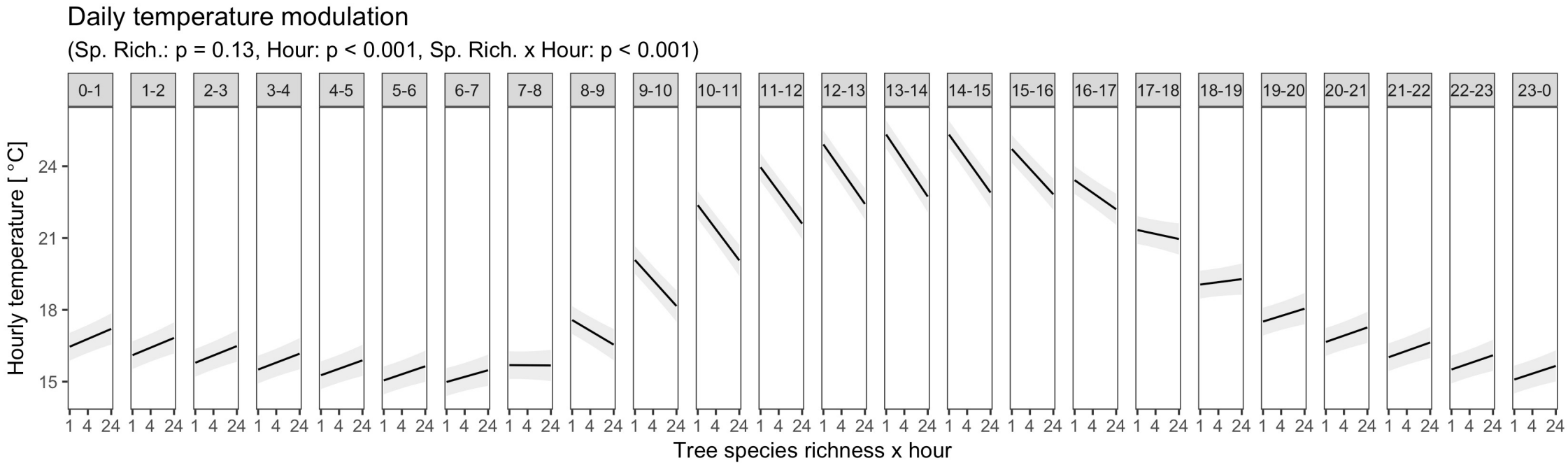
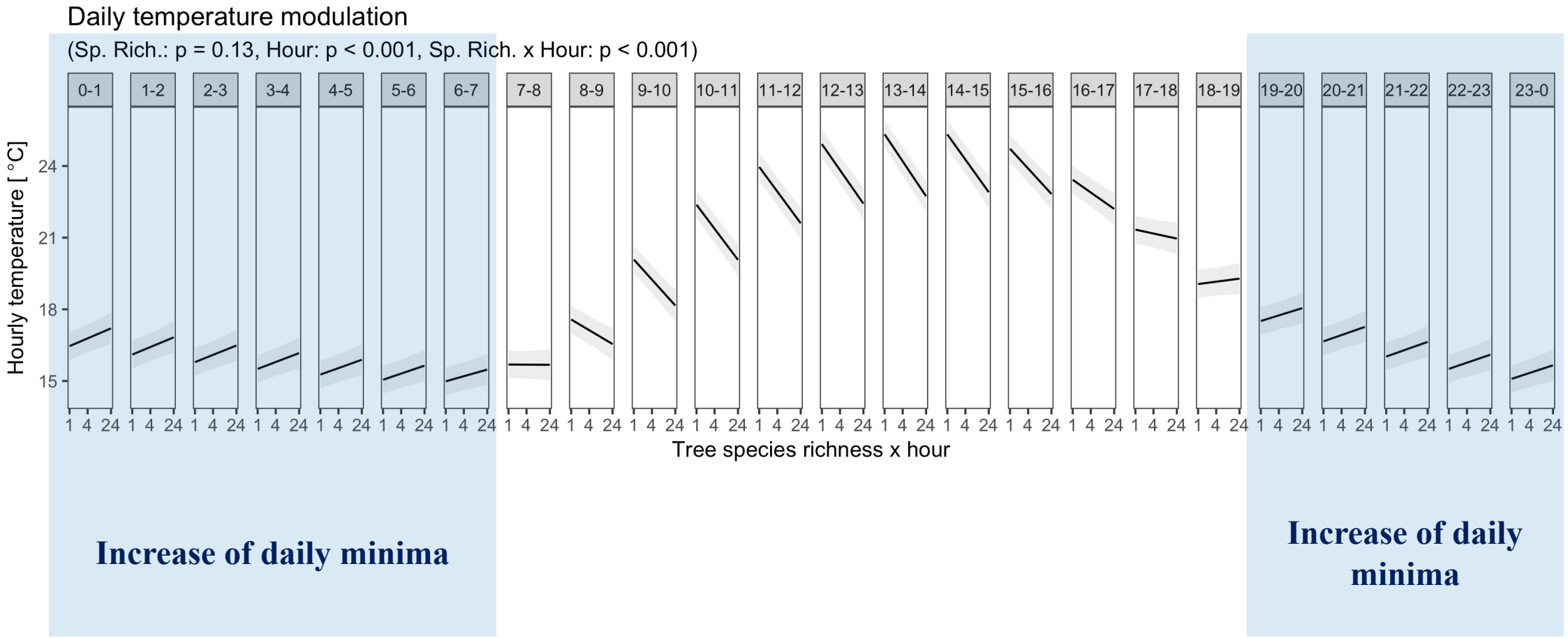
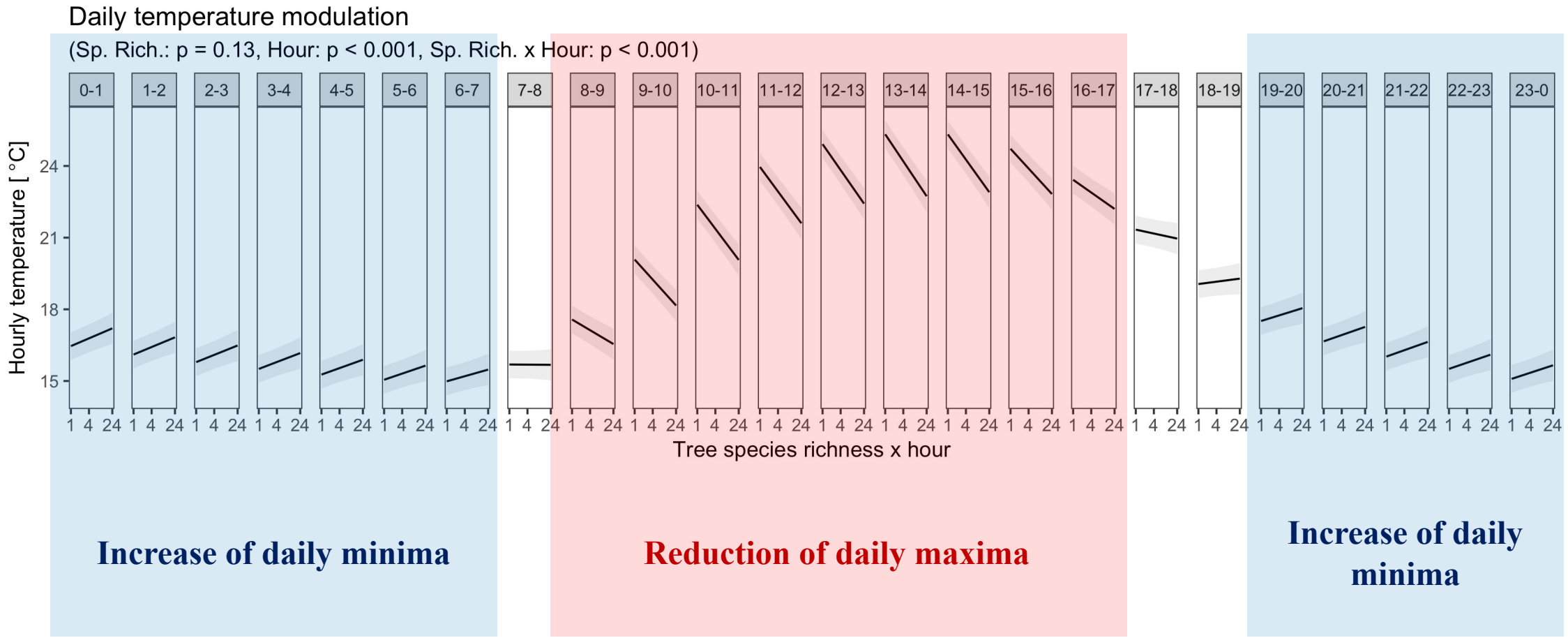


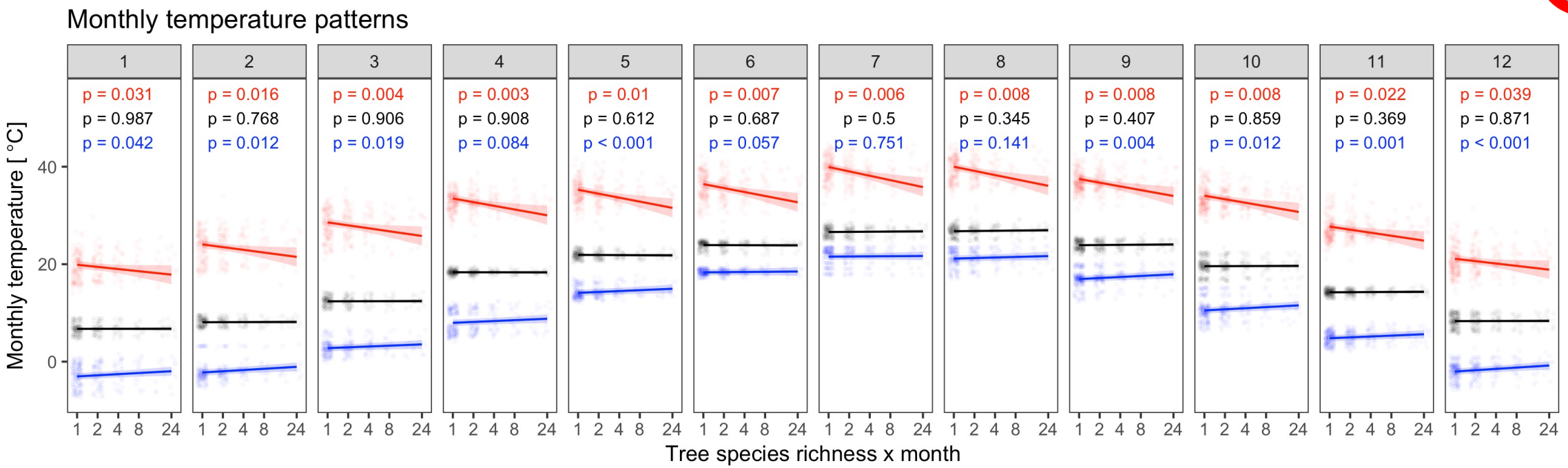
RESULTS: TREE DIVERSITY INCREASES TEMPERATURE MINIMA



RESULTS: TREE DIVERSITY DECREASES TEMPERATURE MAXIMA

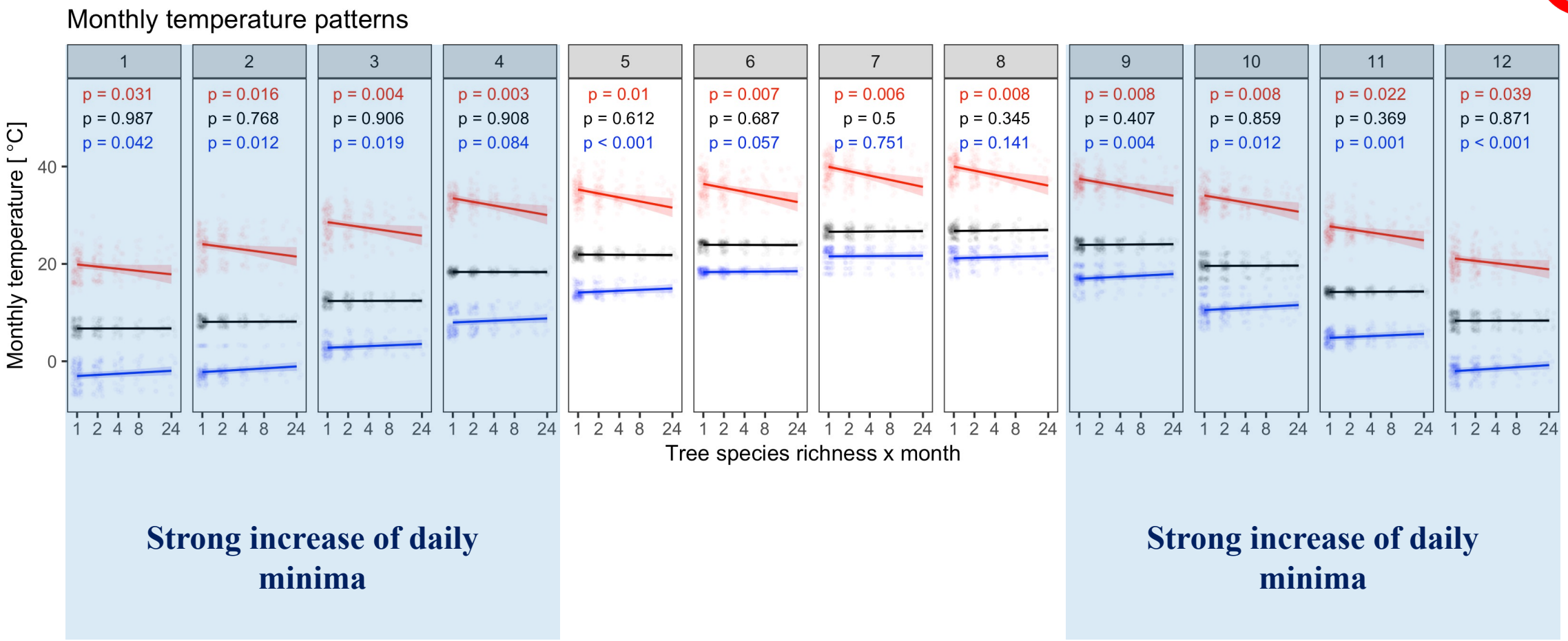


RESULTS: TREE DIVERSITY BUFFERS MONTHLY EXTREMES



Reduction of temperature extrema

RESULTS: TREE DIVERSITY BUFFERS TEMPERATURE EXTREMES



Strong increase of daily minima

Strong increase of daily minima

Reduction of temperature extrema

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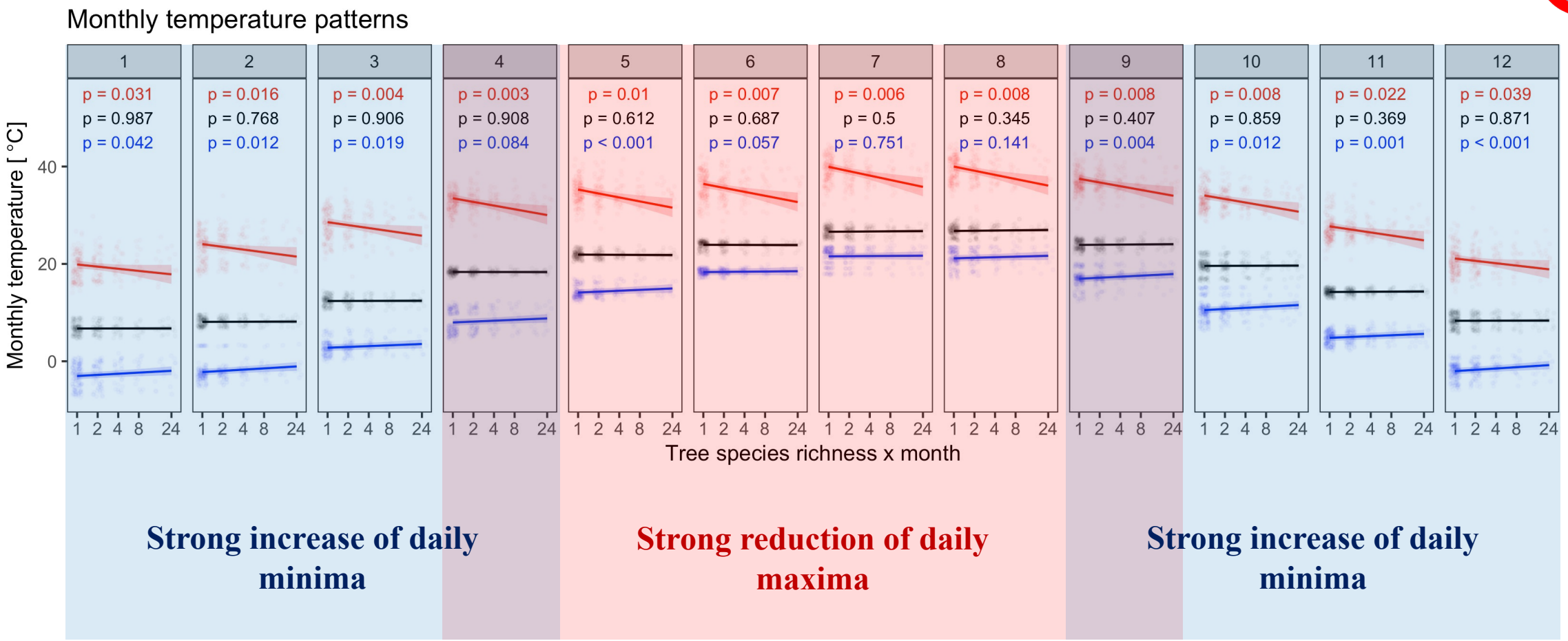
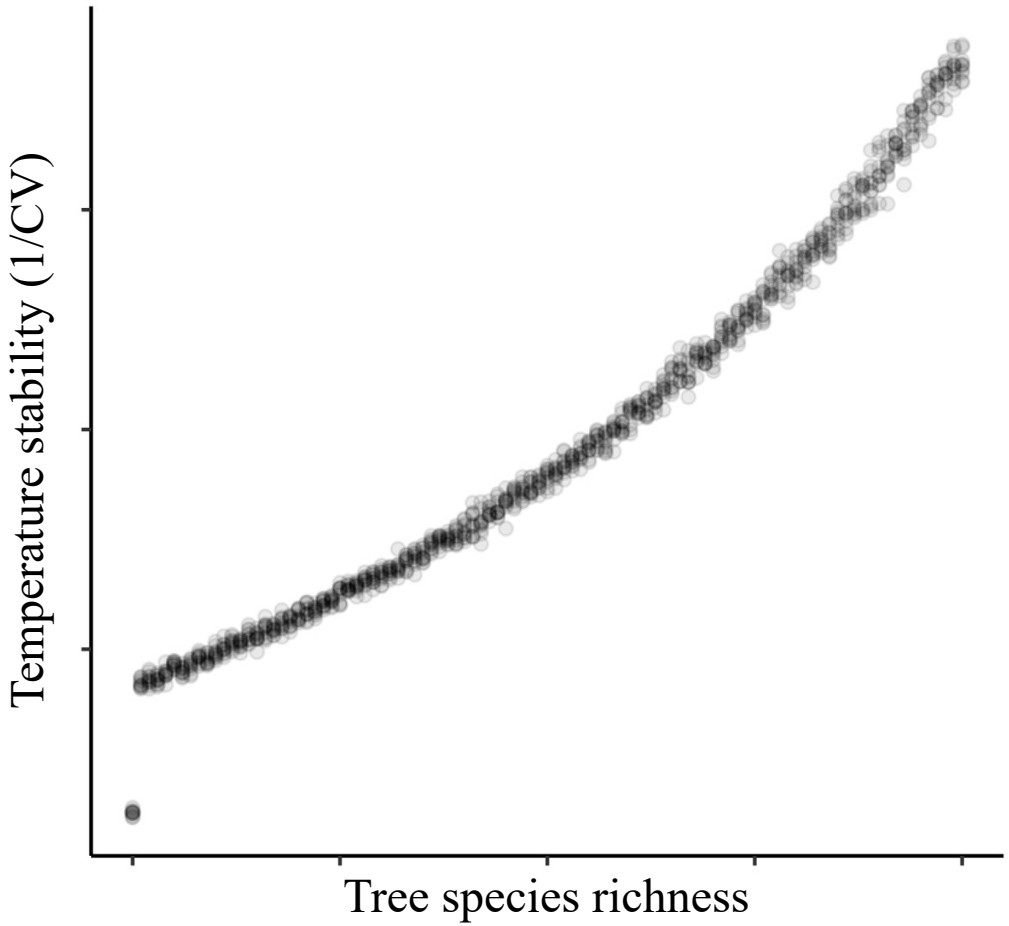
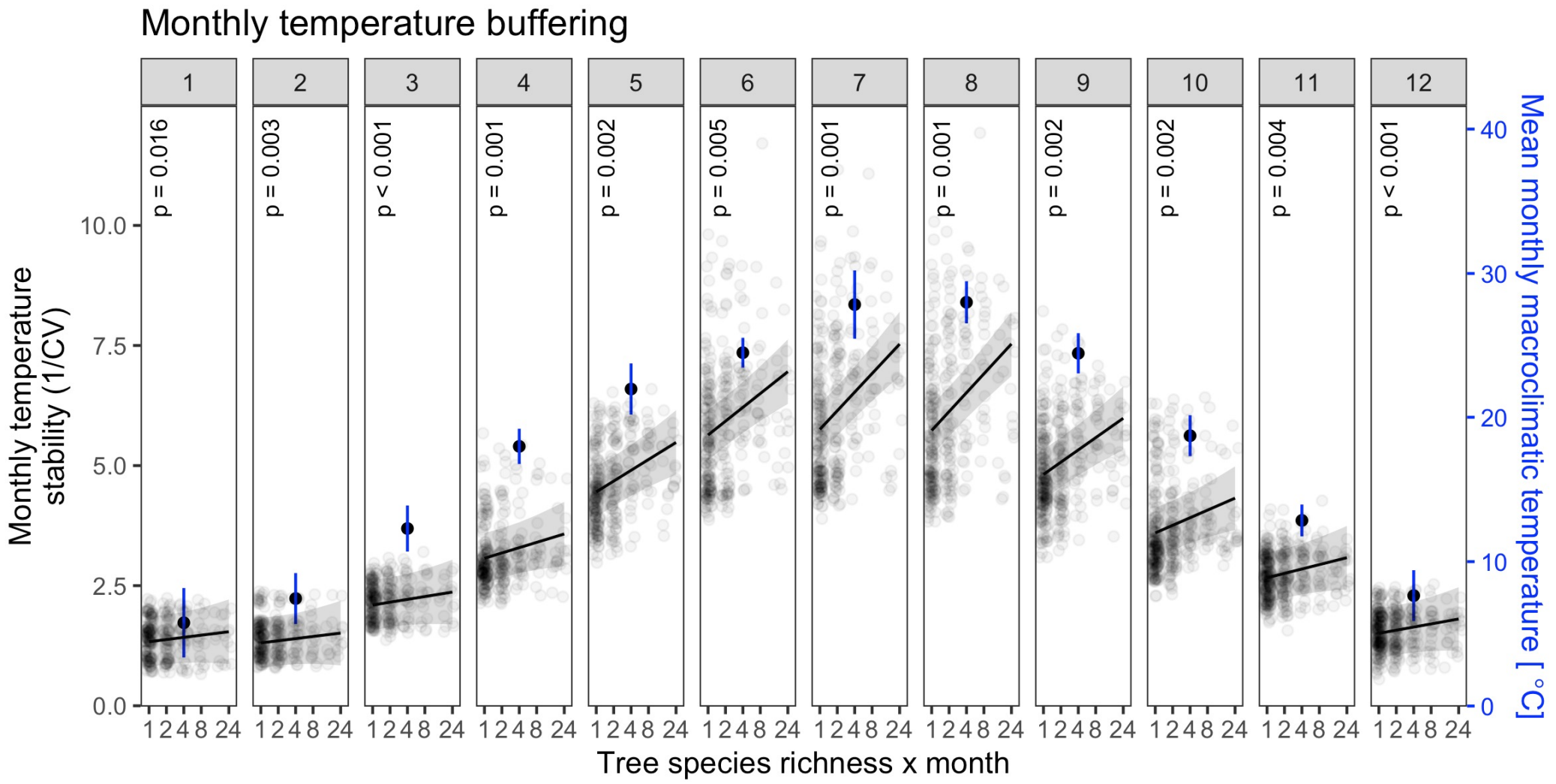


Reduction of temperature extrema

RESULTS: TREE DIVERSITY EFFECT ON TEMPERATURE STABILITY



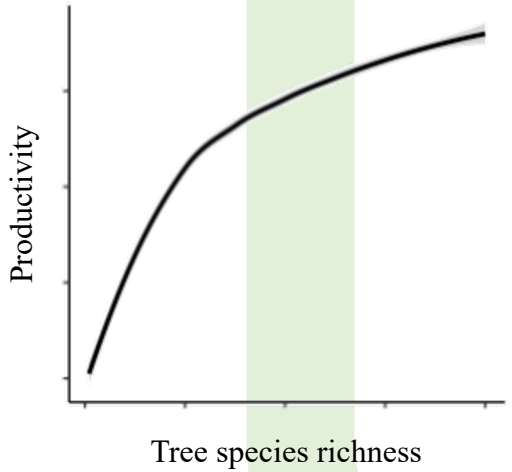
RESULTS: TREE DIVERSITY INCREASES TEMPERATURE STABILITY



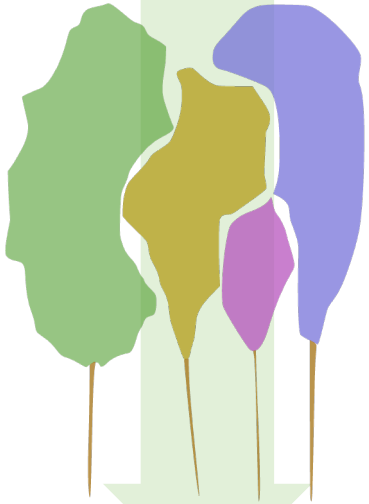
HYPOTHESIS: BUFFERING MECHANISMS

Tree diversity

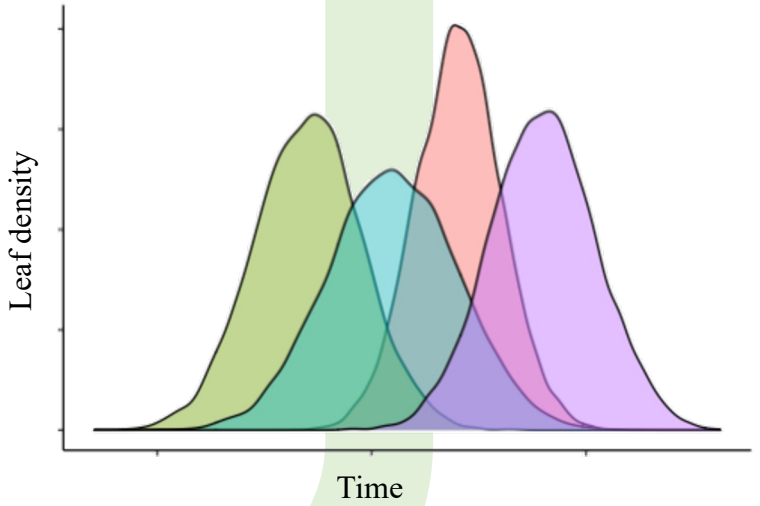
Biomass



Spatial complementarity



Temporal complementarity



Buffering of macroclimate fluctuations

Beugnon et al 2021, Huang et al 2018, Sapijanskas et al 2014

HYPOTHESIS: BUFFERING MECHANISMS

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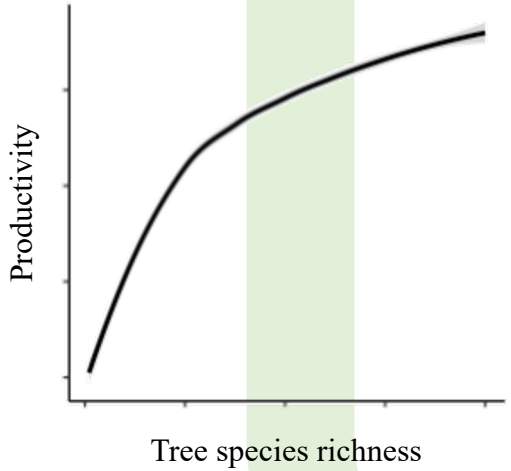

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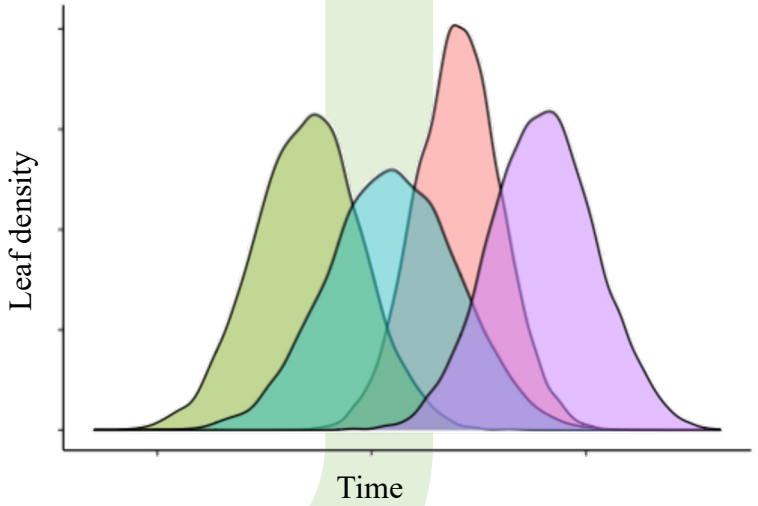

Buffering of macroclimate fluctuations

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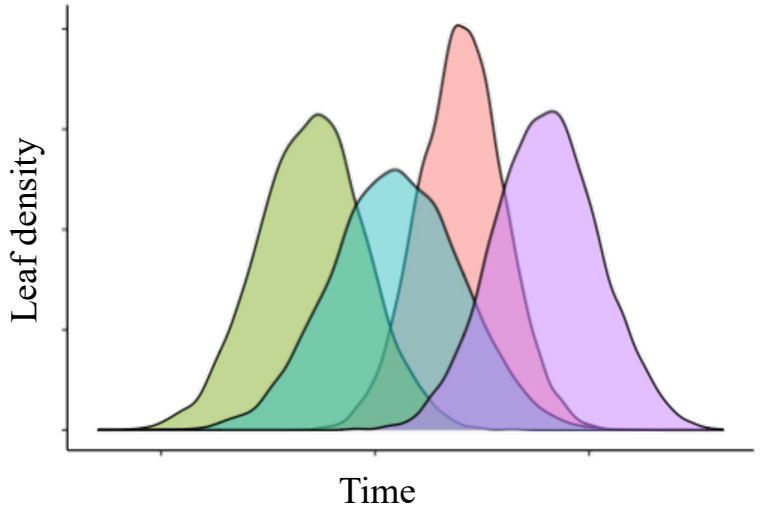
HYPOTHESIS: BUFFERING MECHANISMS AT MONTHLY SCALE

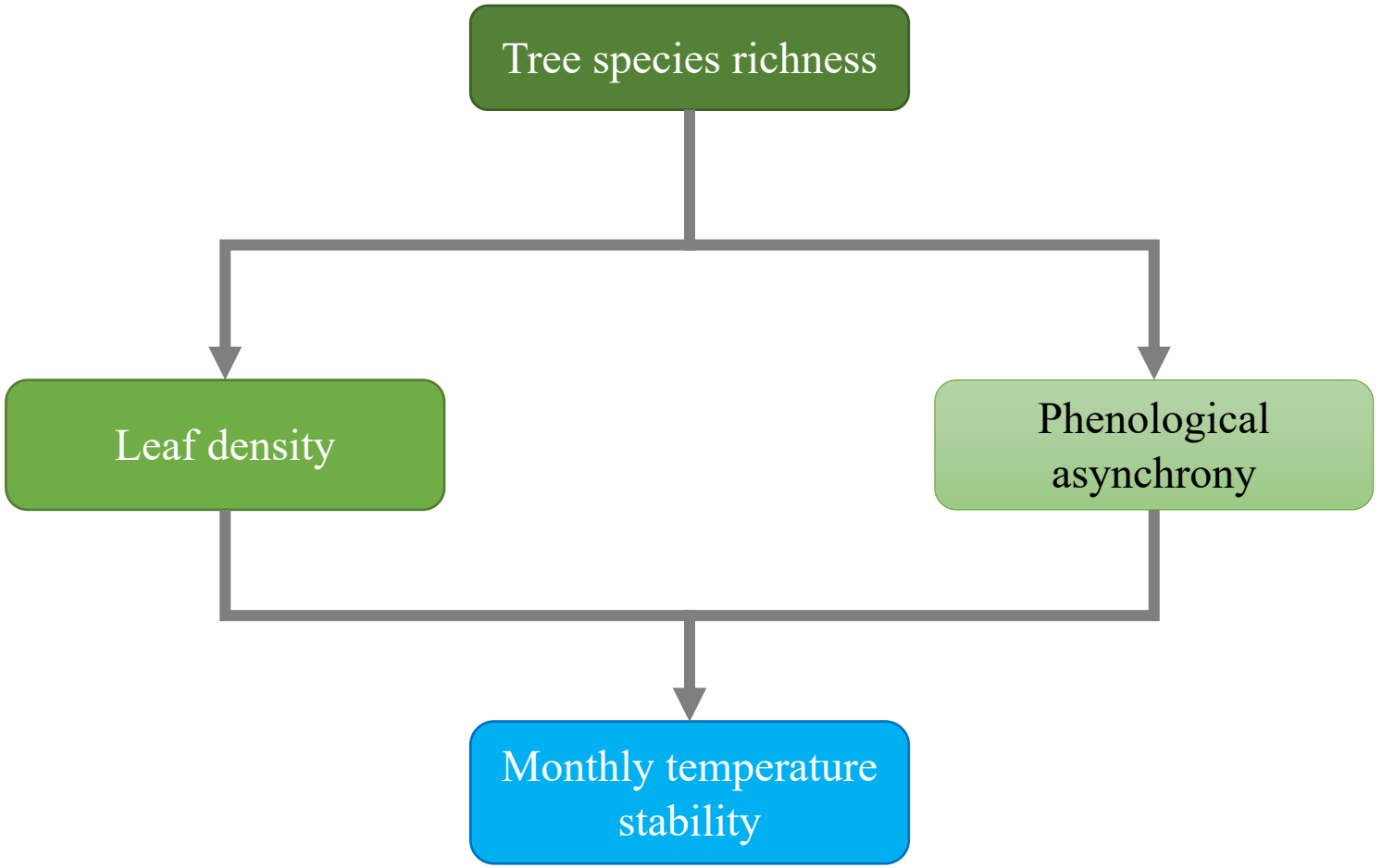
Tree leaf phenology measurements



CWM of leaf density

FDis of leaf density

RESULTS: MECHANISMS BEHIND TREE DIVERSITY BUFFERING OF CLIMATIC FLUCTUATIONS



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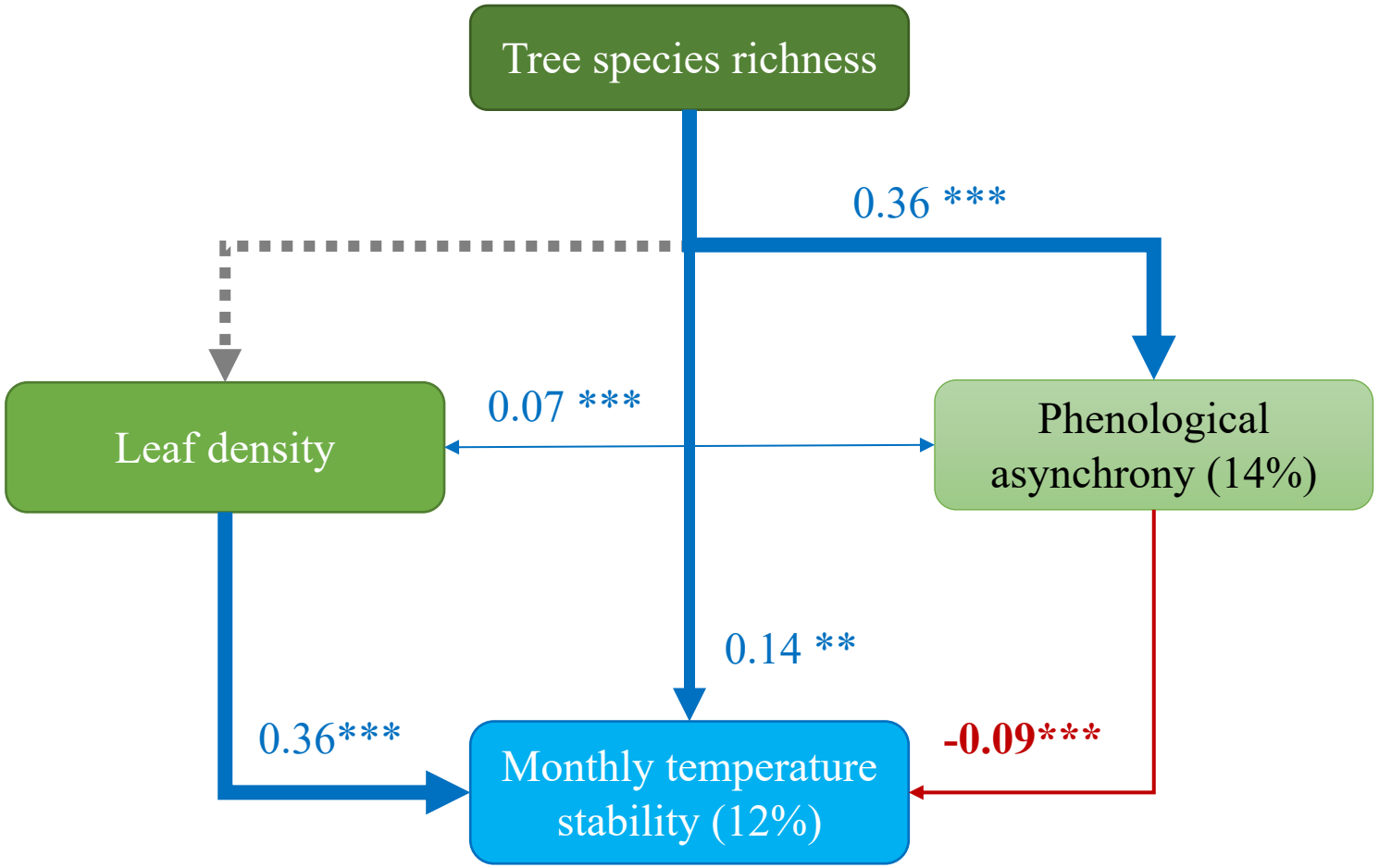
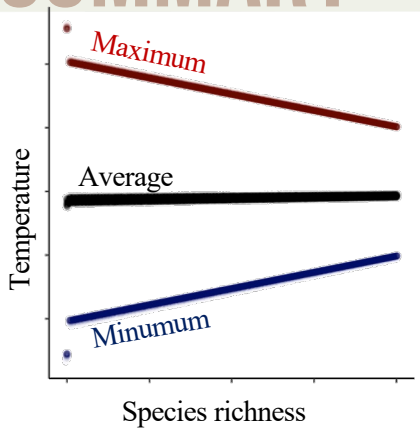
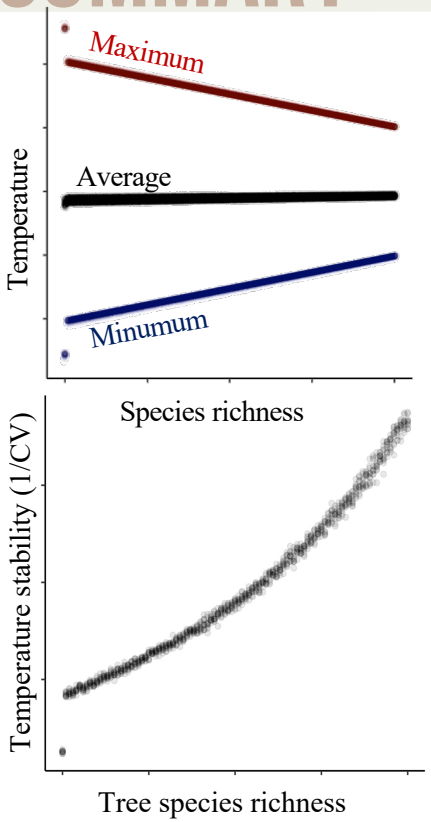


SUMMARY



Tree species richness reduces temperature extremes

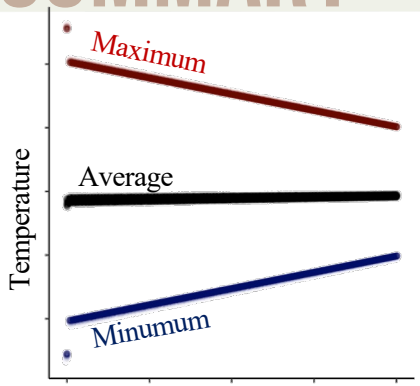
SUMMARY



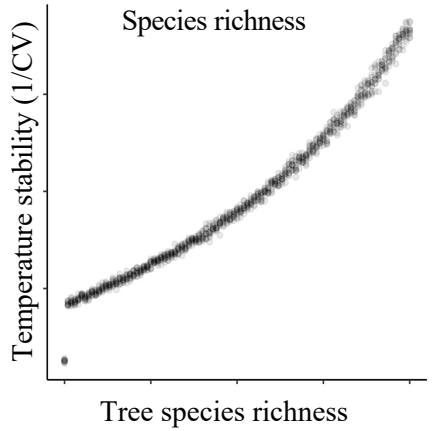
Tree species richness reduces temperature extremes

Tree species richness increases temperature stability

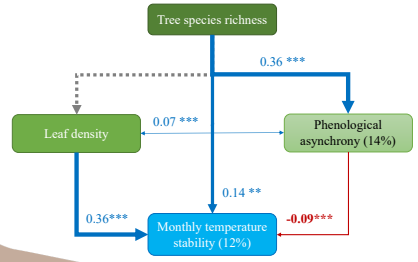
SUMMARY



Tree species richness reduces temperature extremes



Tree species richness increases temperature stability



Two mechanisms explaining tree species richness on monthly temperature buffering:

- **biomass production**
- **temporal asynchrony**

PERSPECTIVES: DIVERSE FORESTS TO PROTECT MICROCLIMATE

Messier et al 2019

Beugnon et al 2021, Schnabel et al. 2021

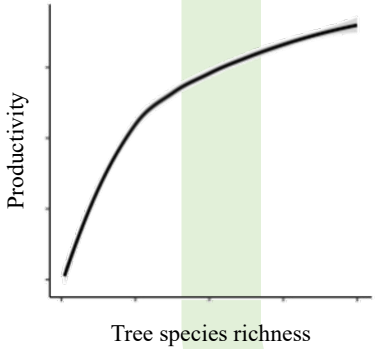
PERSPECTIVES: DIVERSE FORESTS TO PROTECT ECOSYSTEM FUCNTIONS

Messier et al 2019
Beugnon et al 2021, Schnabel et al. 2021

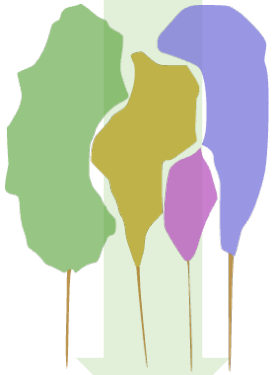
PERSPECTIVES: A NEW MECHANISM TO UNDERSTAND BEF RELATIONSHIPS

Tree diversity

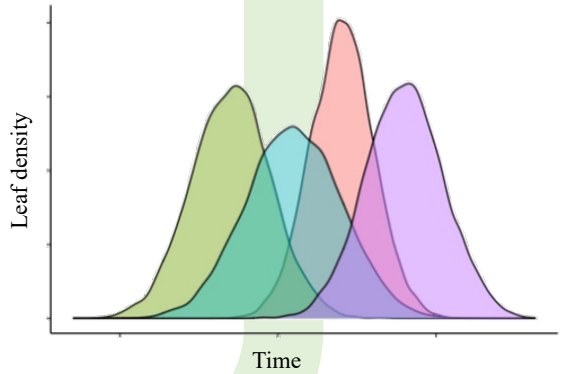
Biomass



Spatial complementarity

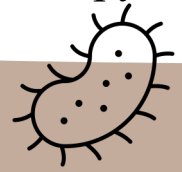


Temporal complementarity



Buffering of macroclimate fluctuations

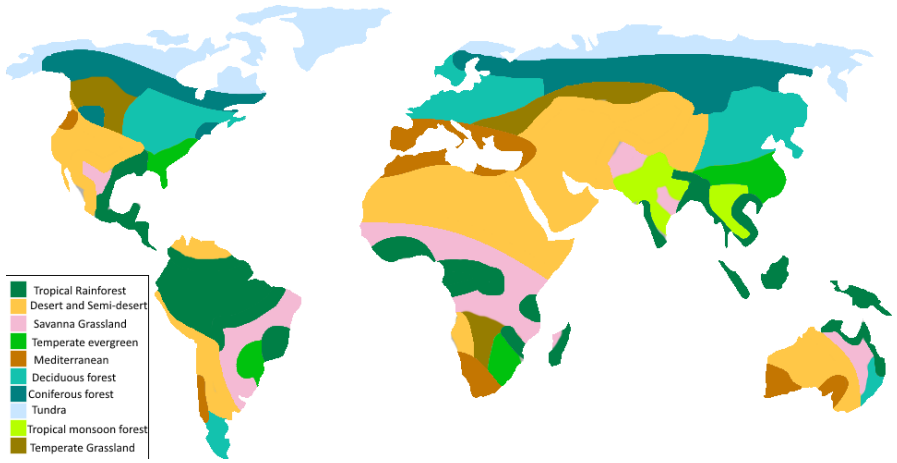
Below canopy composition and functions



FOLLOW UP

A global analysis …

…
across ecosystems,
…



… across land uses

Vegetation diversity buffers soil microclimatic extremes: phenomenon and mechanisms

Rémy Beugnon[1,2,3], Jonas Lembrechts[4], Nico Eisenhauer[1,2], Stephan Hättenschwiler[3] & Manfred Wendisch[2]

with SoilTemp & BREATHING NATURE

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Introduction

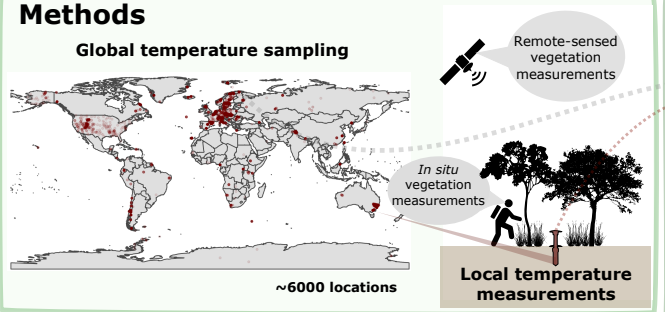
- The frequency and intensity of extreme climatic events is increasing.
- Belowground communities and functions are highly sensitive to changes in microclimatic condictions (Cesarz *et al.*, 2021, Gottschall *et al.*, 2019).
- Vegetation has shown its potential to mitigate external macroclimatic conditions by buffering macroclimatic fluctuations (de Frenne *et al.*, 2019, 2021).
- Higher vegetation diversity increases primary productivity and vegetation periode (Huang *et al.*, 2018; Sapijanskas *et al.*, 2014).
- Vegetation diversity should increase the buffering of macroclimatic fluctuations.

Objectives

Here, we propose to:

- Quantify the effect of vegetation diversity on climatic buffering …
- … across ecosystems using the SoilTemp database and remote-sensing measurements of the vegetation.
- Understand the mechanisms behind vegetation diversity effects on climatic buffering using *in situ* measurements of the vegetation.

Methods



Hypotheses

Perspectives

Vegetation diversity could protect undercanopy communities against climate change

Call for contributors

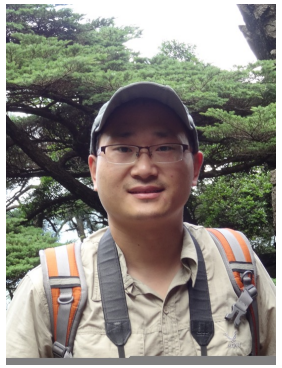
You measured soil temperature and would like to contribute to these analyses drop us a line!

remy.beugnon@idiv.de
@BeugnonRemy

experimental interaction ecology · iDiv · Centre d'Ecologie Fonctionnelle & Evolutive

SCAN ME

THANK YOU

Rémy Beugnon†, Florian Schnabel†, Yang Bo†, Simone Cesarz, Nico Eisenhauer, Maria D. Perles Garcia, Georg Haehn, Werner Härdtle, Yuanyuan Huang, Matthias Kunz, Xiaojuan Liu, Nadia C. Castro Izaguirre, PA Niklaus, Goddert von Oheimb, Katrine A. Pietsch, Ronny Richter, Bernhard Schmid, Stefan Trogisch, Christian Wirth, Keping Ma*, Helge Bruelheide*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