Phylogenetic niche conservatism of *Picea* and *Quercus*: analysis and implications for palaeoclimate reconstructions

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Abstract

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Introduction

Why is climatic PNC in tree genera important?

➢ **Phylogenetic Niche Conservatism (PNC)** → Consequence of optimizing selection

- Tendency of species to **retain** ancestral niche-defining traits
- Plant taxa distributed across **different** continents show **consistent** climate responses

Different

Same

Different region but same niche (PNC)

Vegetation-climate relationship (Modern pollen)

Fossil pollen

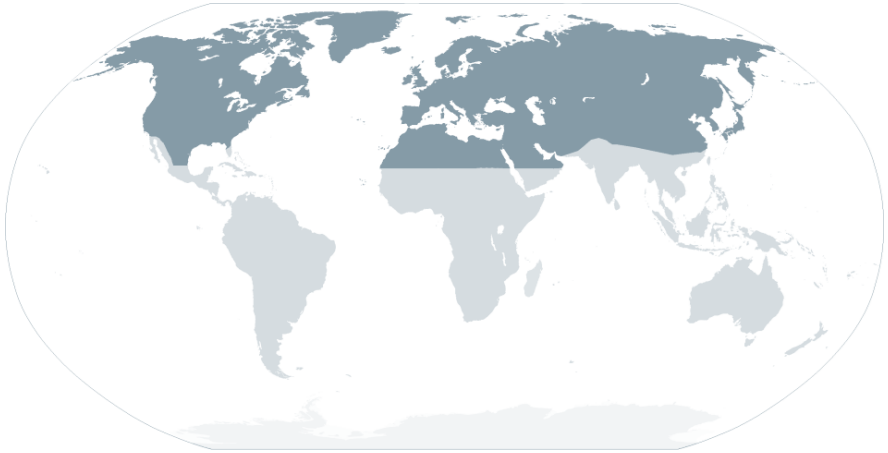
Palaeoclimate reconstruction

Stephens & Wiens, 2009; Gagnon *et al.*, 2019

Introduction

Holarctic tree genera and bioclimatic variables

Holarctic Realm



Picea (spruce)

Boreal forest

Quercus (oak)

Temperate forest

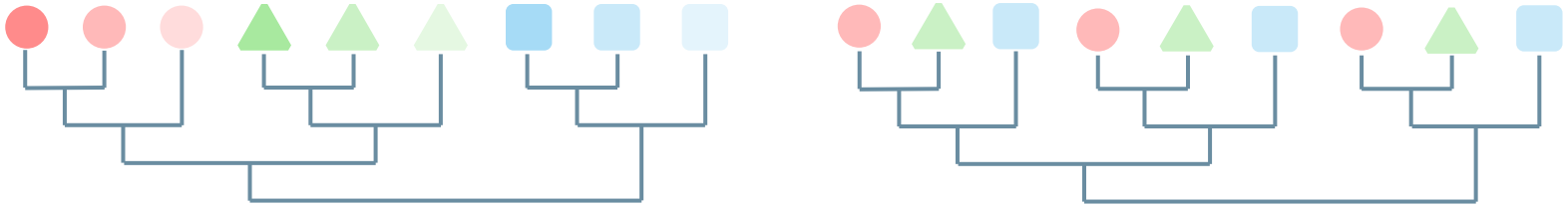
Three bioclimatic variables

- Moisture index (MI) → **plant-available moisture**
- Mean temperature of the coldest month (MTCO) → **winter cold**
- Growing degree days above a base level of 5 ℃ (GDD_5) → **summer warmth**

Takhtajan, Crovello & Cronquist, 1988; Farjon, 2001; Harrison *et al*., 2010; Fick & Hijmans, 2017; Prentice *et al*., 2017; Trabucco & Zomer, 2018

Methods

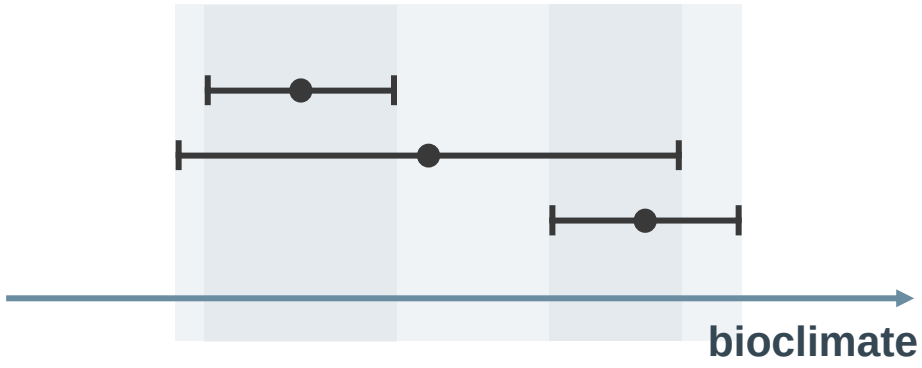
- Whether **more closely** related species have **more similar** climatic requirements?



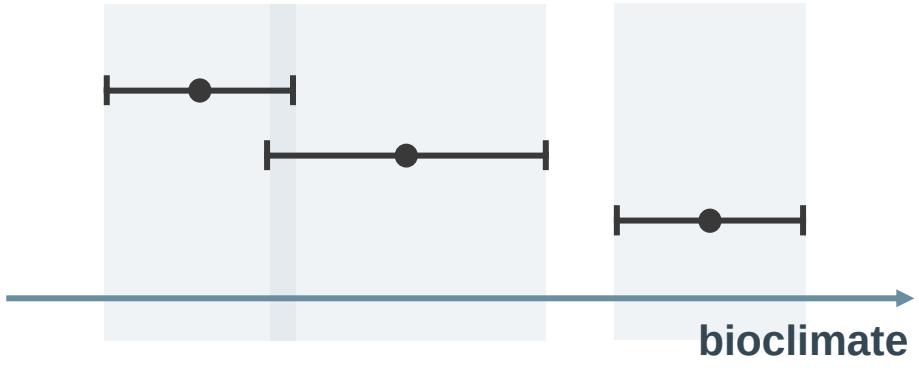
PNC

No PNC

- Whether the **combined climatic ranges** of species within each **genus** are **coherent**?



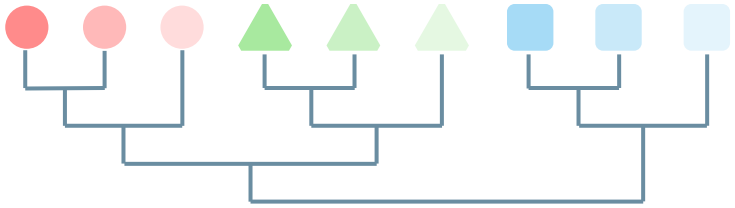
Coherent – PNC



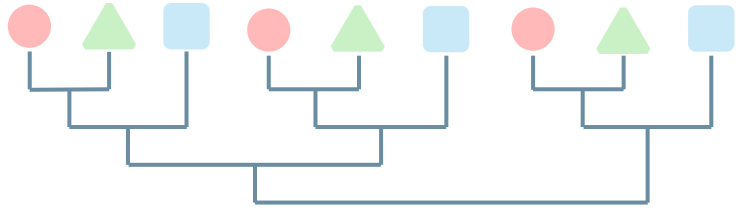
Not coherent – no PNC

Methods

- Niche characterisation for **each species**
  - Species Distribution Models (SDMs – GLMs and GAMs) → Optimum ($\boldsymbol{u}$) and Tolerance ($\boldsymbol{t}$)
- Whether **more closely** related species have **more similar** climatic requirements?
  - Mantel test
  - Phylogenetic signals
  - Evolutionary models

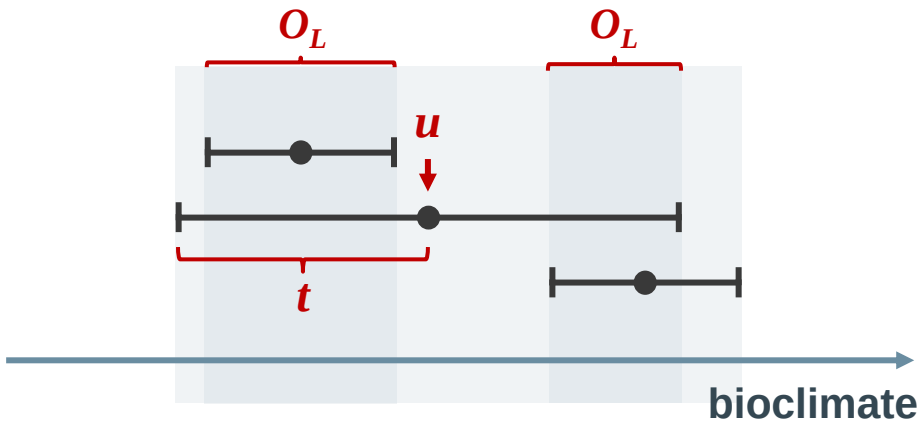


PNC

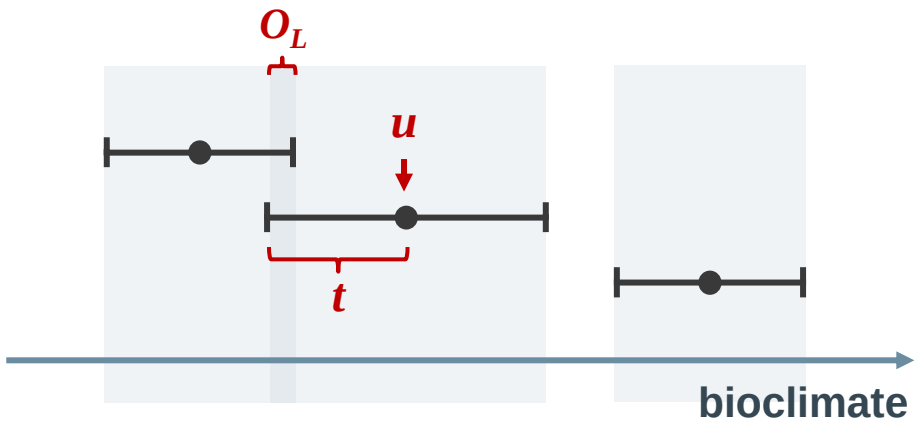


No PNC

- Whether the **combined climatic ranges** of species within each **genus** are **coherent**?
  - Designed an **R** function and developed an index of niche overlap ($\boldsymbol{O_L}$)



Coherent – PNC



Not coherent – no PNC

Results

MTCO: – 10 ~ 0

Picea abies

MTCO: – 10 ~ 10

Quercus robur

Deciduous oak

MTCO: 0 ~ 10

Quercus ilex

Evergreen oak

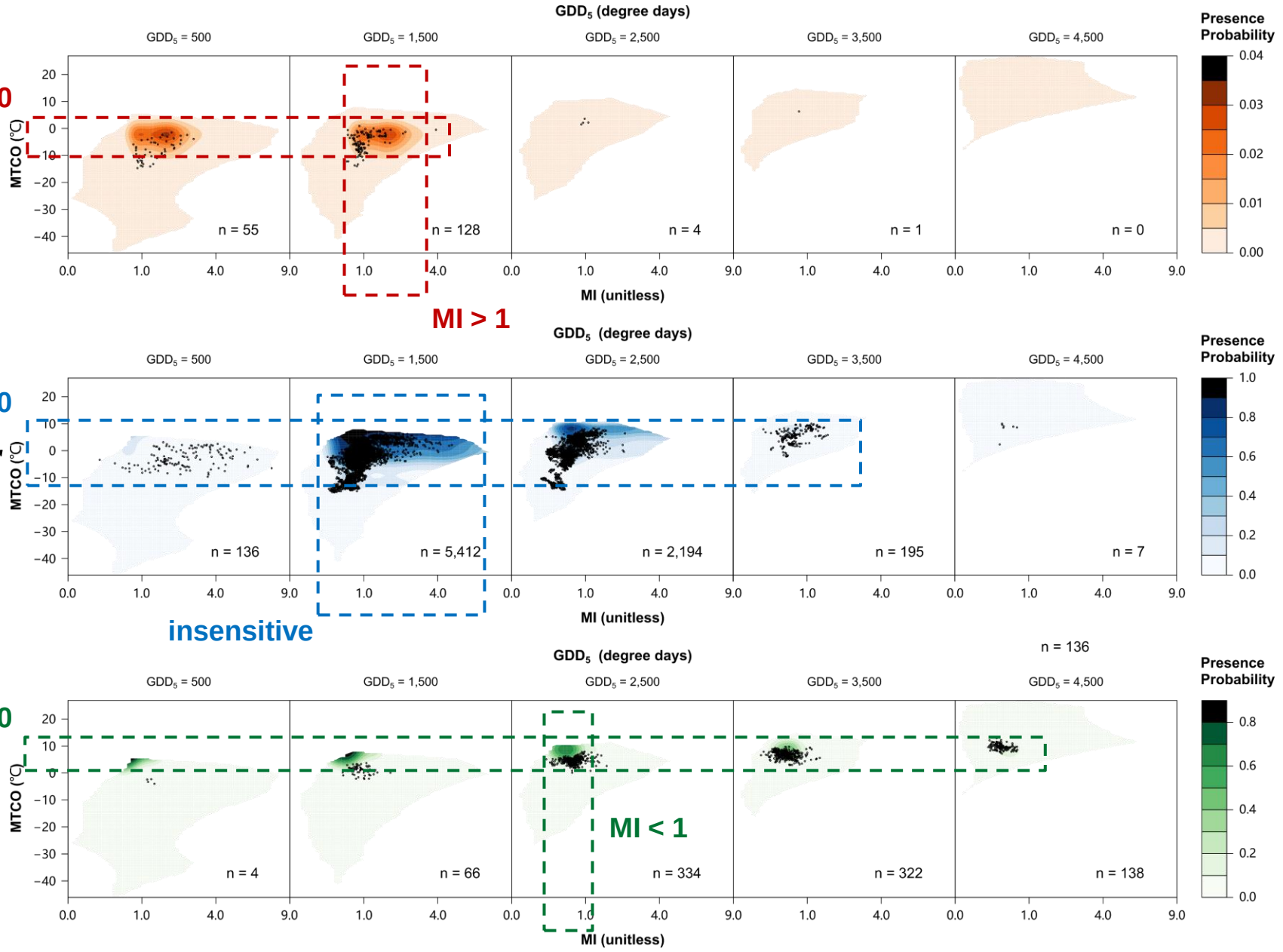


Fig. 1 Climate space diagrams. Contours show the presence probability of the species; black dots present species' actual distribution.

Results

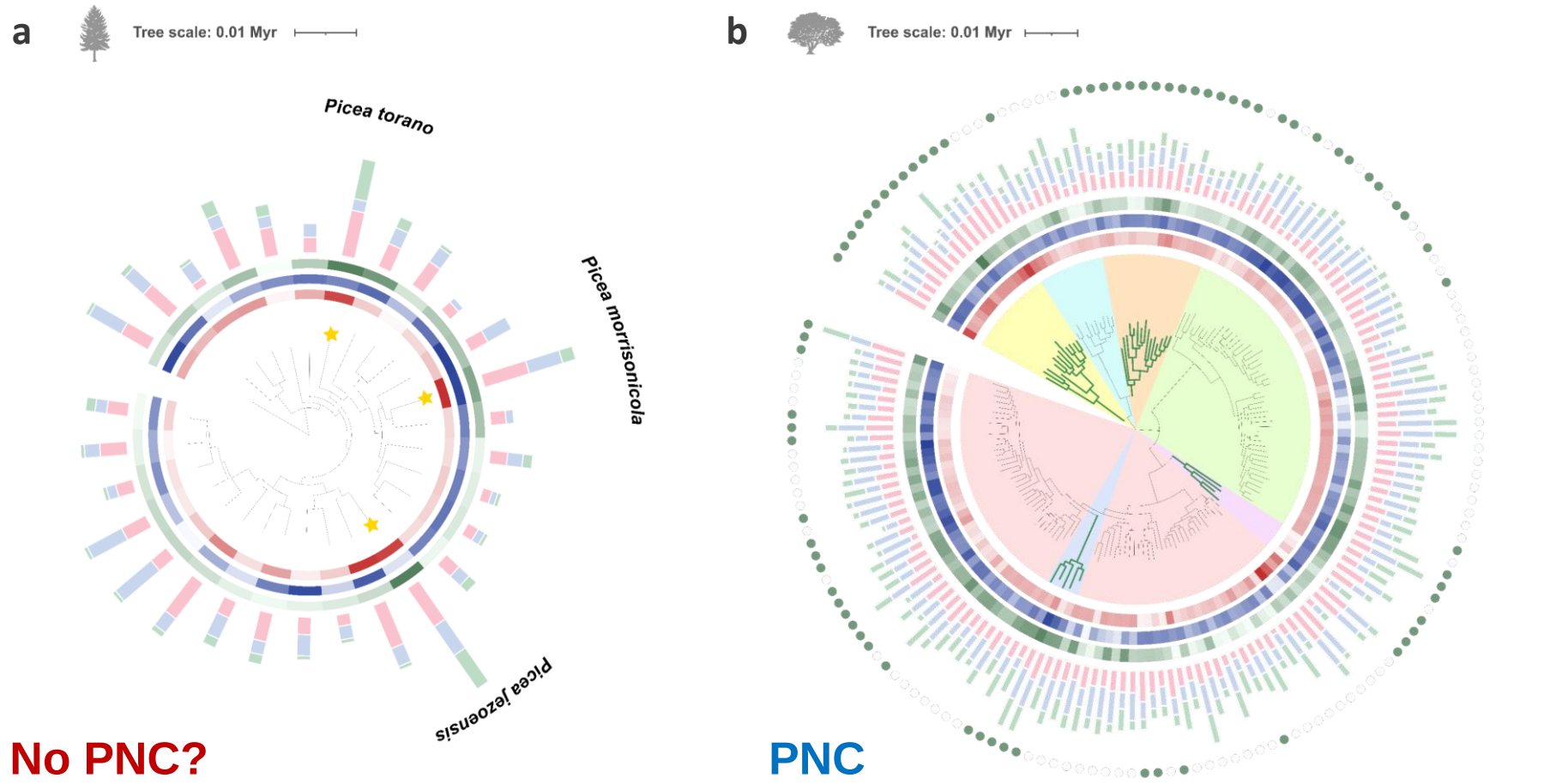


Fig. 2 Bioclimatic distributions across the phylogenetic trees of (a) *Picea* and (b) *Quercus*. The **multi-value bar chart** shows the number of species pairs with O_L **= 0**. Species with a **higher bar** means having a **more distinctive** climatic niche.

No PNC?

- Brownian motion model **without** phylogenetic signal
- White-noise model → **phylogenetic independent**
- Coherent

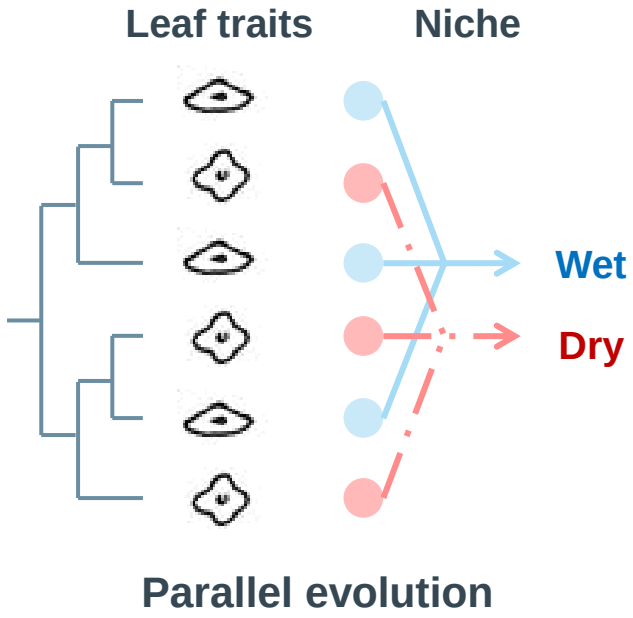
PNC

- Brownian motion model + **strong** phylogenetic signals
- Ornstein-Uhlenbeck model → **evolutionary stasis**
- Coherent (all, deciduous, evergreen clades)

Discussion

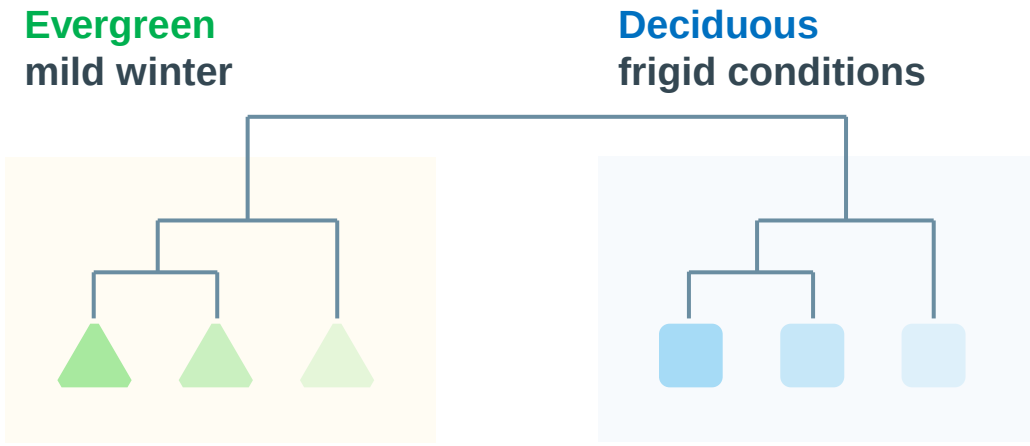
Potential PNC in *Picea*

- **similarity** among **distantly** related species ⟵ Parallel evolution
- **divergence** among **closely** related species ⟵ **Small** tree (29 species)



PNC in *Quercus*

- PNC within clades
- Niche stasis at the species level



Ackerly, 2003; Losos, 2008; Calatayud *et al.*, 2011; Denk *et al.*, 2017; Hipp *et al.*, 2018; Fallon & Cavender-Bares, 2018; Cavender-Bares, 2019

Thank you!

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LabPrentice:

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