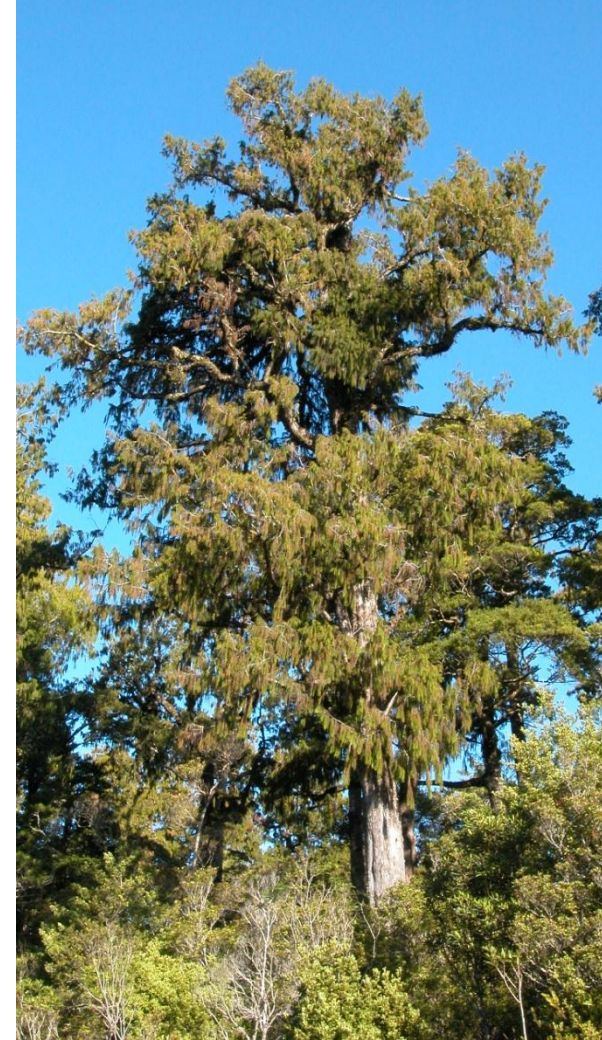


When conifers meet



Pinaceae

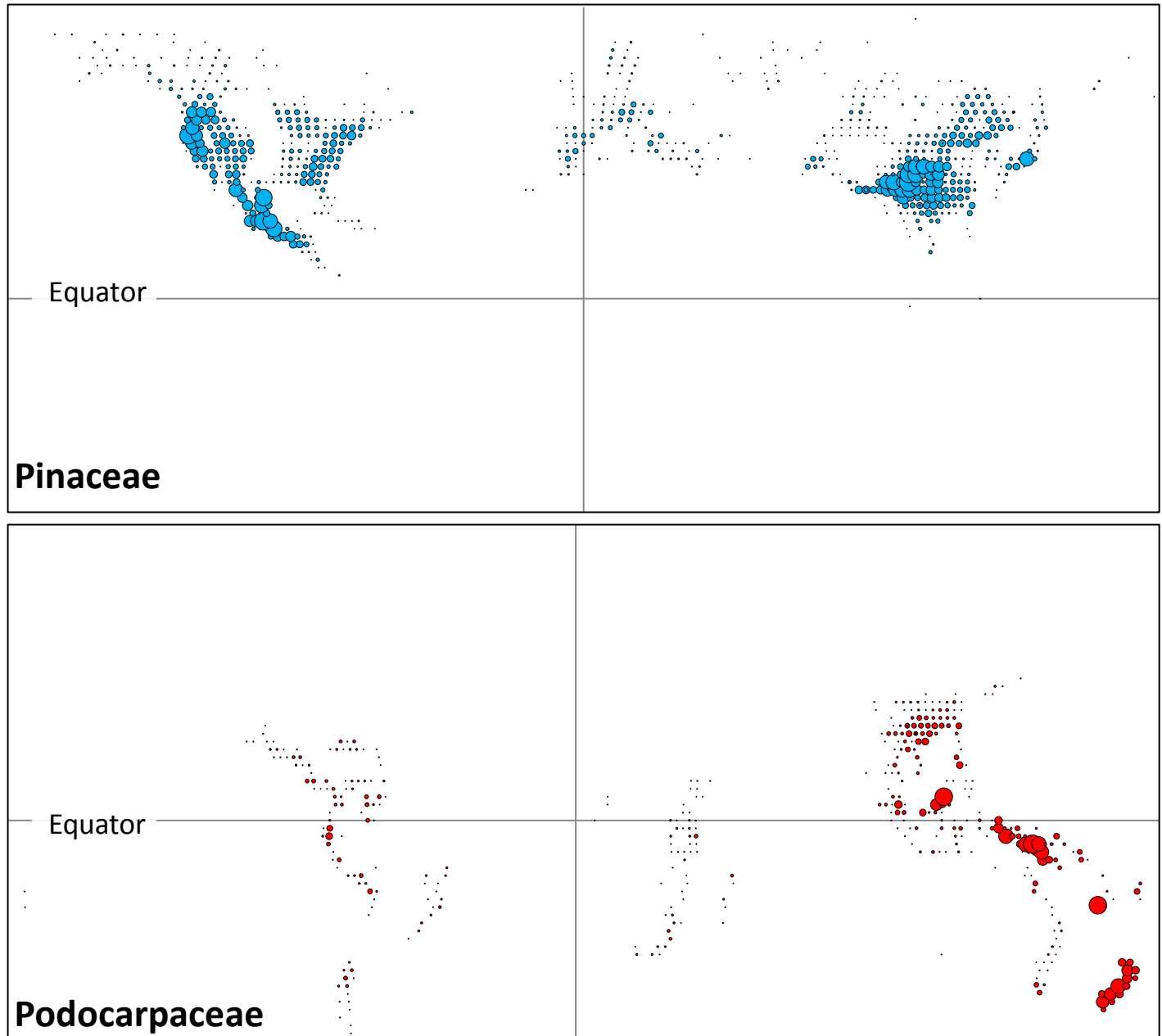
Greg Jordan
Tim Brodribb



Podocarpaceae

North versus South

Species
richness in
equal area
grid cells
(2° latitude)



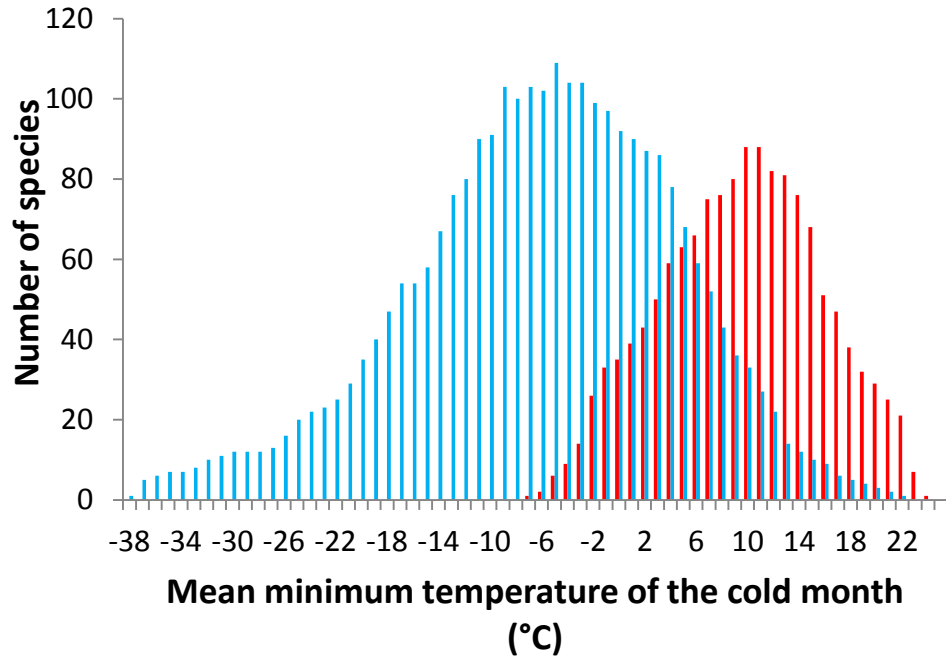
Dispersal limitation?

- evidence for "rapid" dispersal of some **Podocarpaceae** [at least]
 - long history at high southern latitudes [≥ 150 million years]
 - appeared in SE Asia ≤ 20 million years

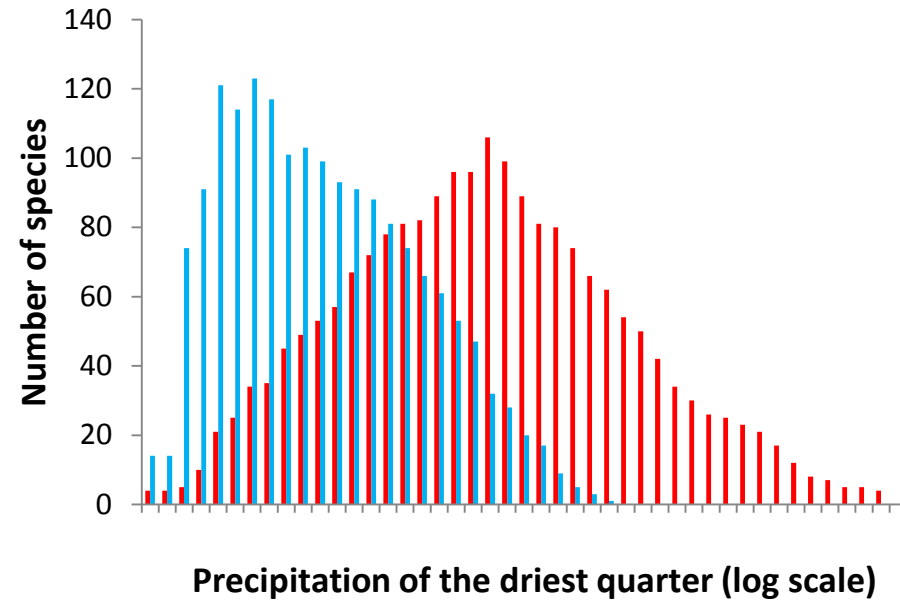
or niche constraints?

- Physiology
 - podocarps hate frost, dry climates & fire
 - pines hate closed forest
- is this true now?
- was it true in the past?

Pinaceae and Podocarpaceae occupy different climate spaces now

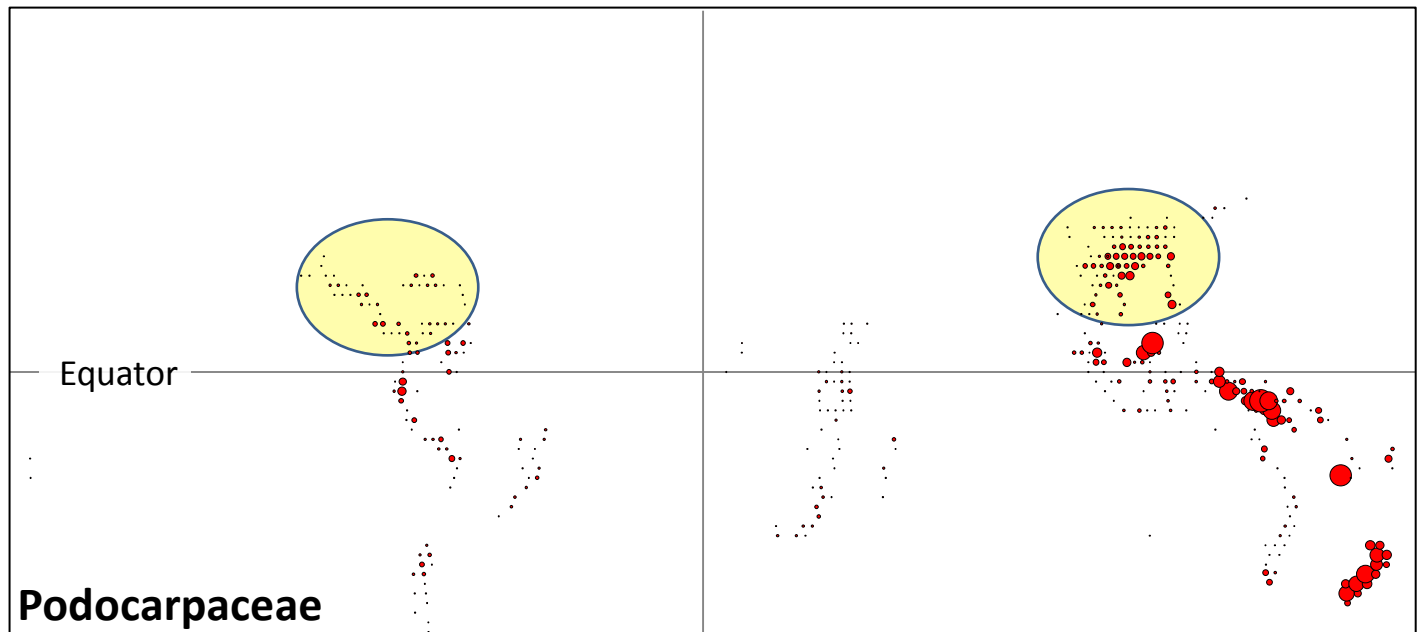
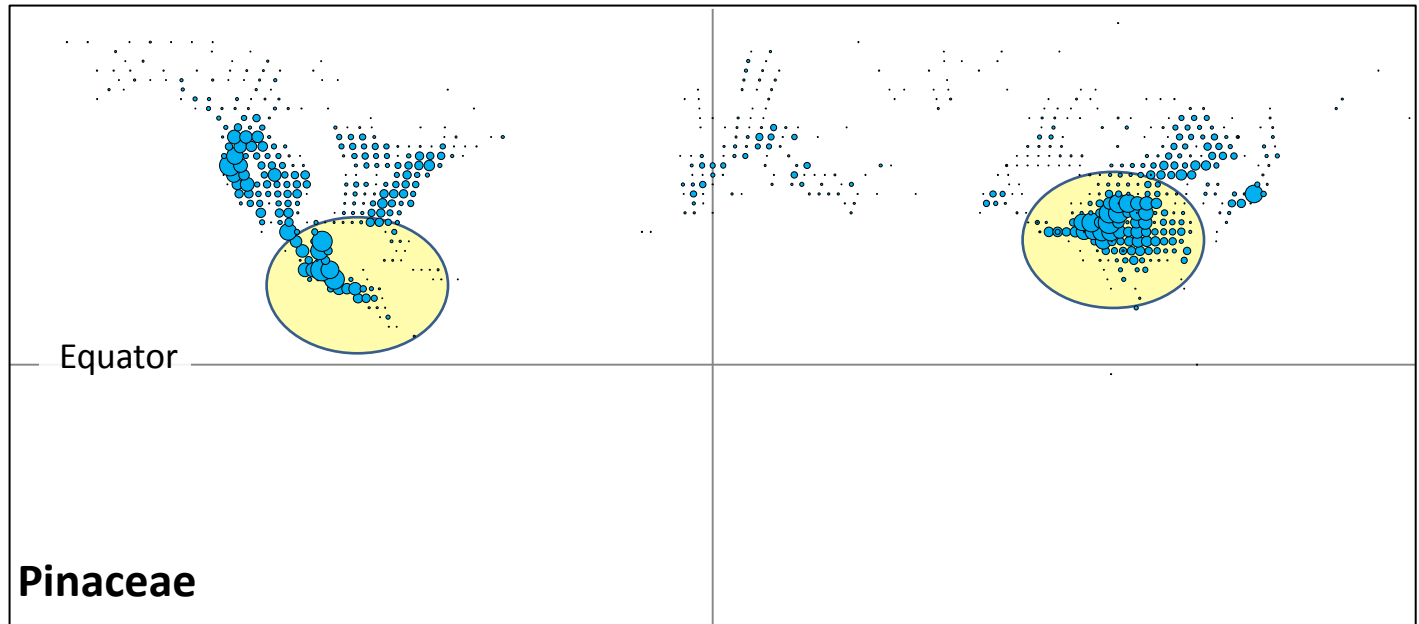


Podocarpaceae are absent from very frosty climates

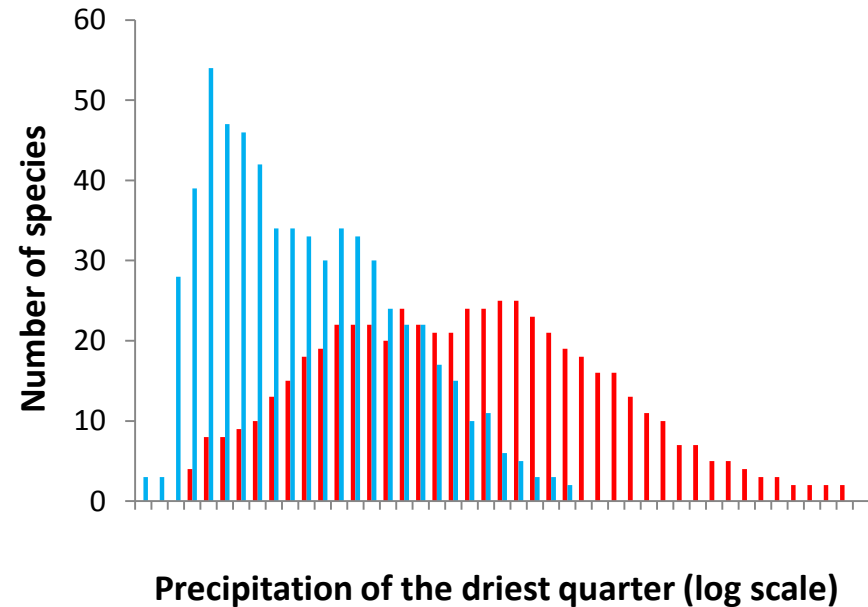
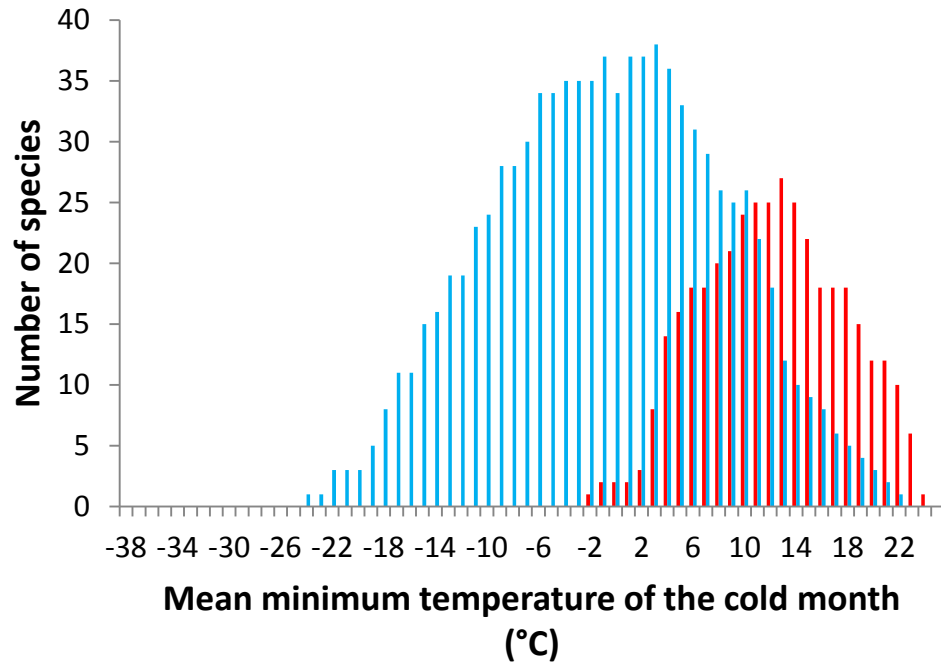


Podocarpaceae occupy wetter climates than Pinaceae

Two regions of overlap



Similar contrasts in the regions of overlap



The contrasting climates are not just because of the different climates in the SH & NH

Was this true in the past?

- Ancestral state reconstructions?
- Other ways?

extinction and directional selection in conifers poses problems for ancestral state reconstruction

- conifer phylogenies clades with very long stems^{1,2}
- extensive fossil evidence of climate driven extinction



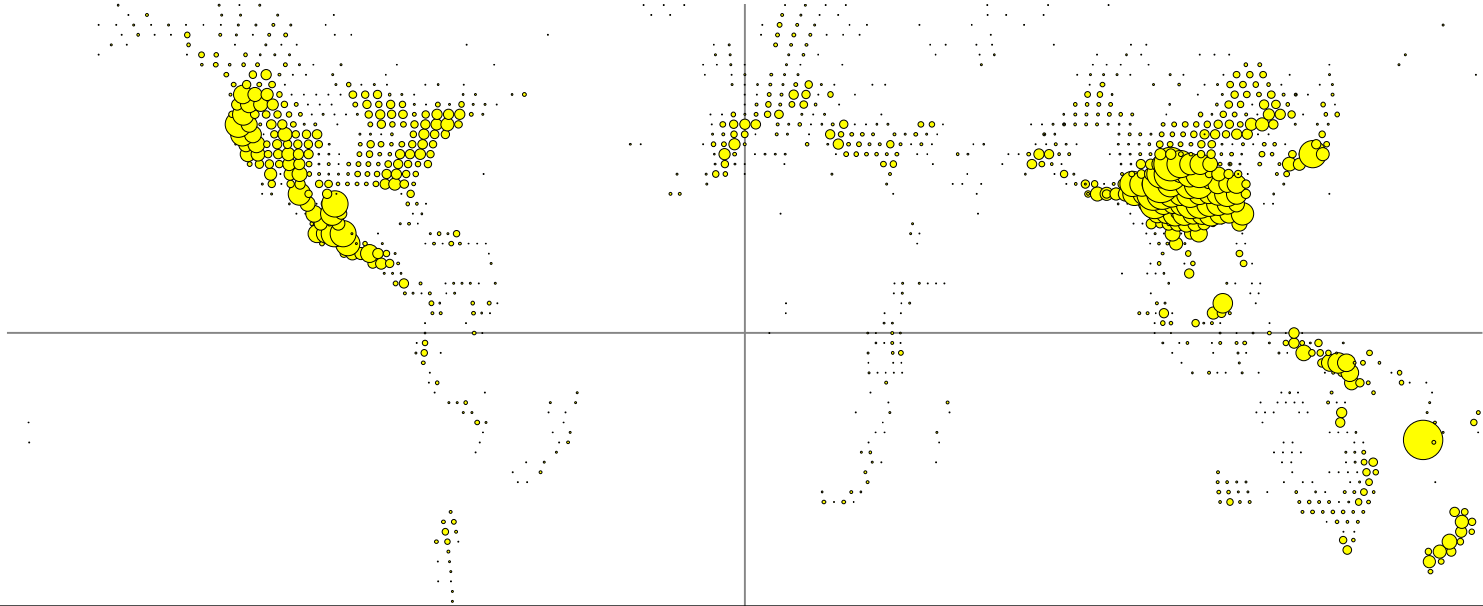
¹ **Crisp MD, Cook LG. 2011.** Cenozoic extinctions account for the low diversity of extant gymnosperms compared with angiosperms. *New Phytologist* **192**: 997-1009.

² **Nagalingum NS, Marshall CR, Quental TB, Rai HS, Little DP, Mathews S. 2011.** Recent synchronous radiation of a living fossil. *Science* **334**: 796-799.

Phylogenetic endemism

- weights diversity according to past selection
 - upweights rare old clades
 - i.e. ones that have been selected against...

species richness for all conifers



Phylogenetic endemism for all conifers

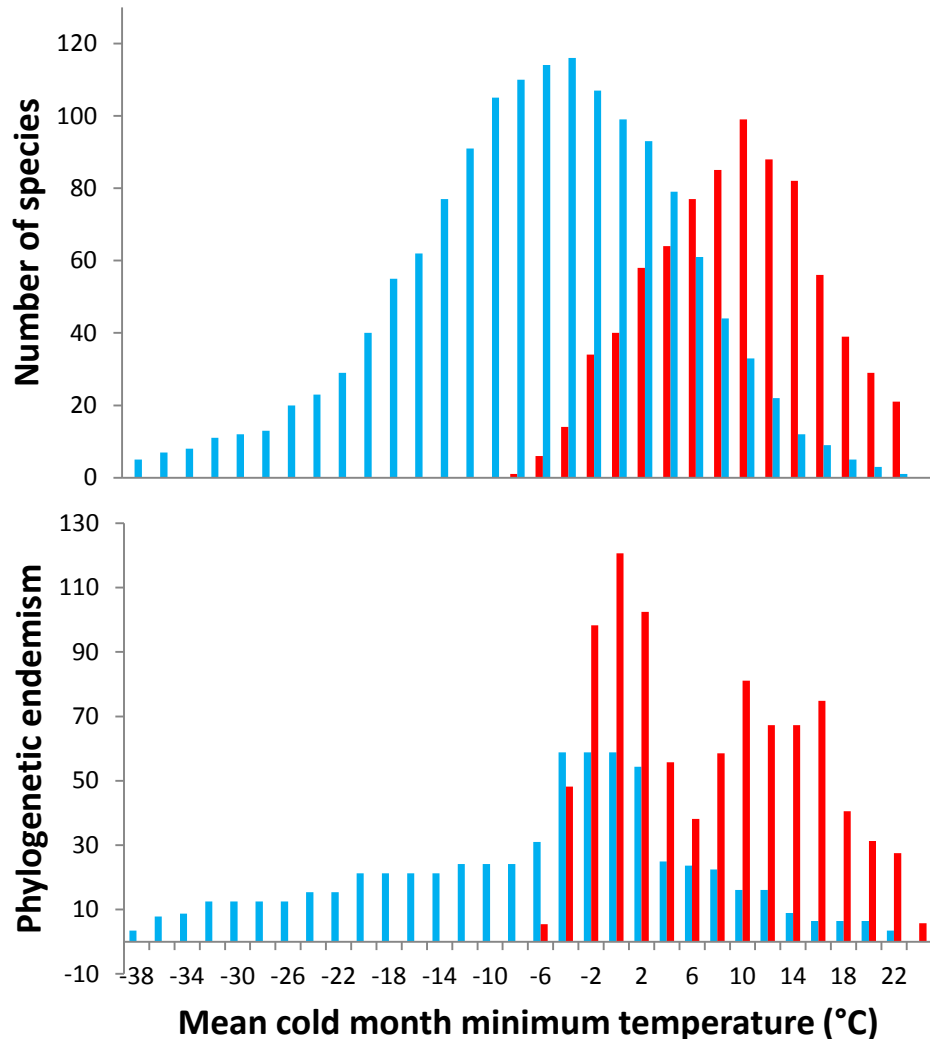


As a sign of past processes

- rare old clades are presumably rare because of past selection
- these clades tend to retain ancient, unfavoured physiology
- high phylogenetic endemism relative to species richness can indicate ancestral states

Phylogenetic endemism in climate space

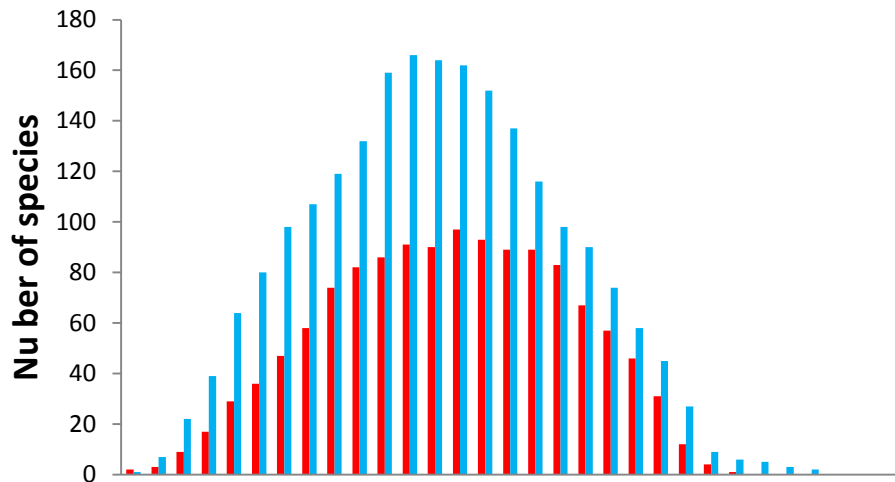
(**Pinaceae** vs **Podocarpaceae**)



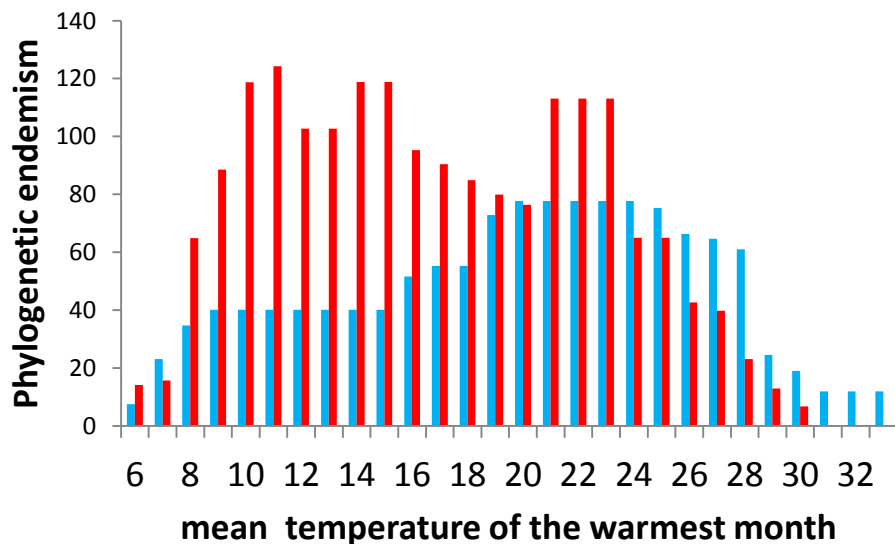
Both clades show a mode in phylogenetic endemism at a cold month minimum temperature of $\sim 0^{\circ}\text{C}$

Divergent radiations:
Pinaceae into frosty places
Podocarpaceae into tropical rainforest

Summer temperature (proximity to tree line)

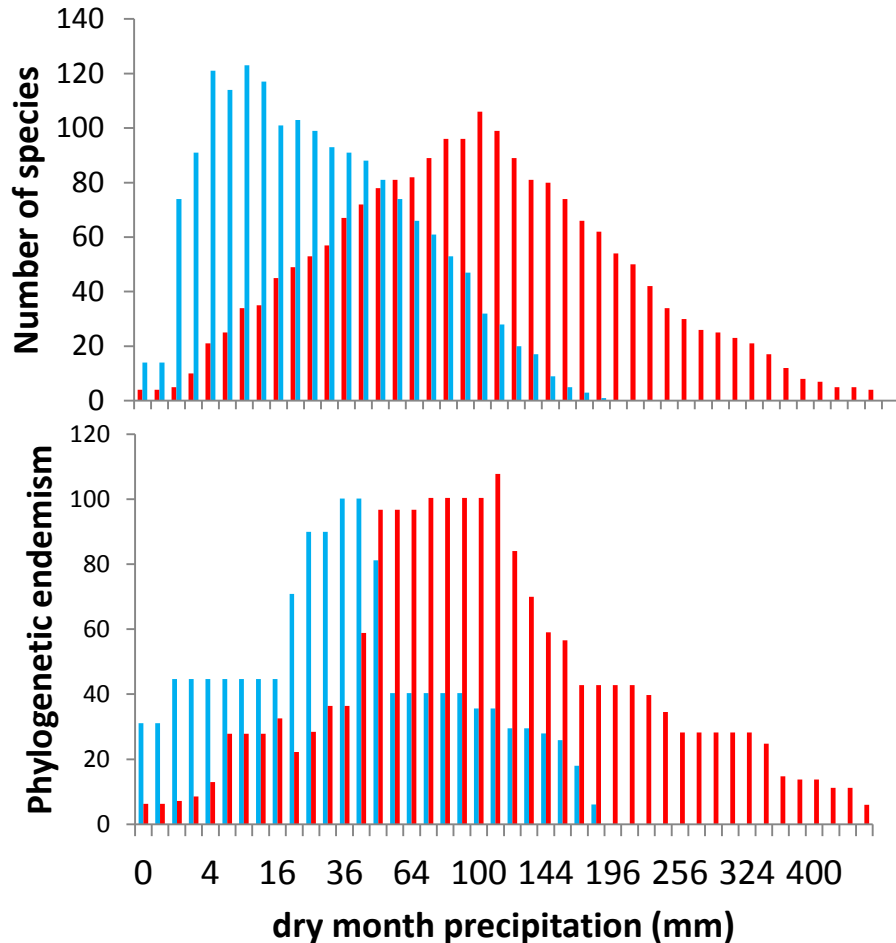


Podocarpaceae moved into warmer climates?



Pinaceae moved into colder climates

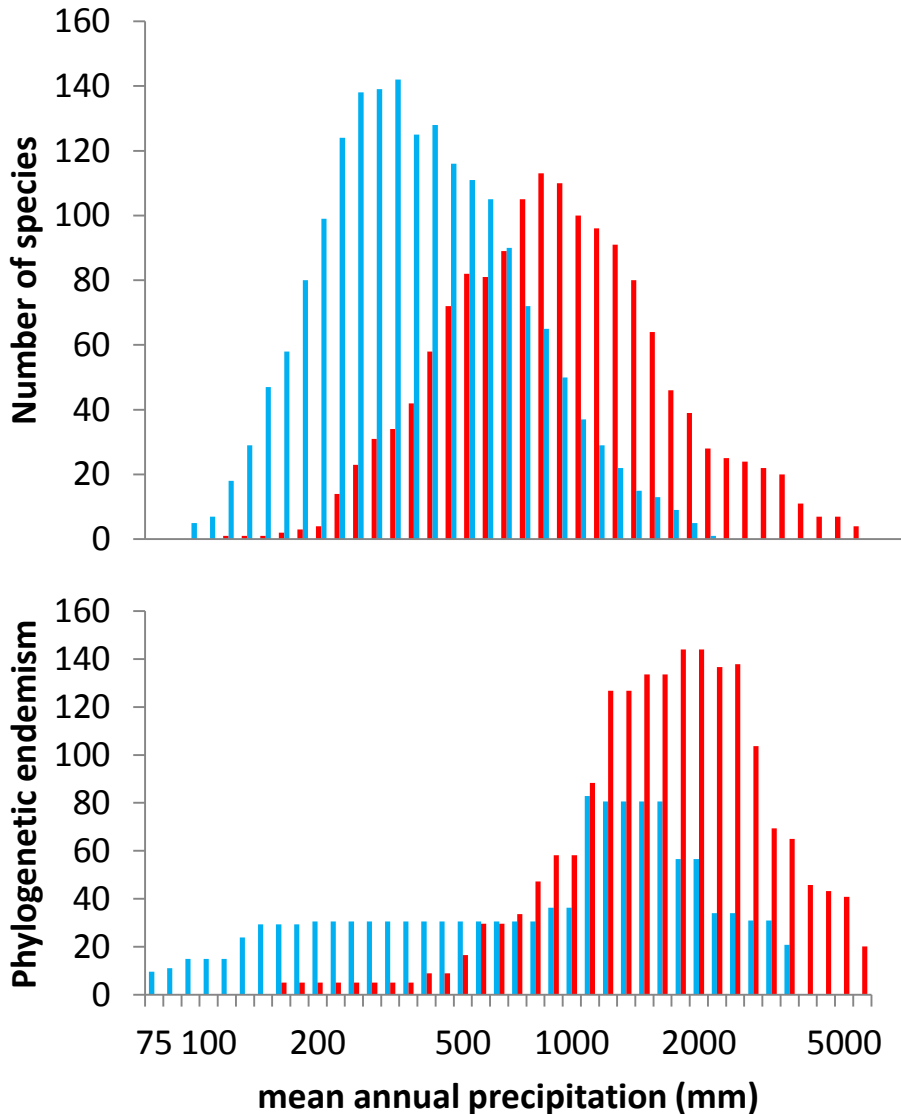
Dry climates



Podocarpaceae have not changed – always wet

Pinaceae were always drier than **Podocarpaceae**, but have radiated further into dry climates

Mean annual precipitation



Both clades have moved to drier climates, but especially **Pinaceae**

Overall

- **Podocarpaceae** and **Pinaceae** are strongly ecologically differentiated
- This appears to have always been the case
 - niche conservatism
 - especially for **Podocarpaceae**
- **Pinaceae** constrained by the Equator
- Phylogenetic endemism tells us about the past, not just the present