Regional Coordination between Riparian Dependence and Atmospheric Demand in Willows (*Salix*) of Western North America

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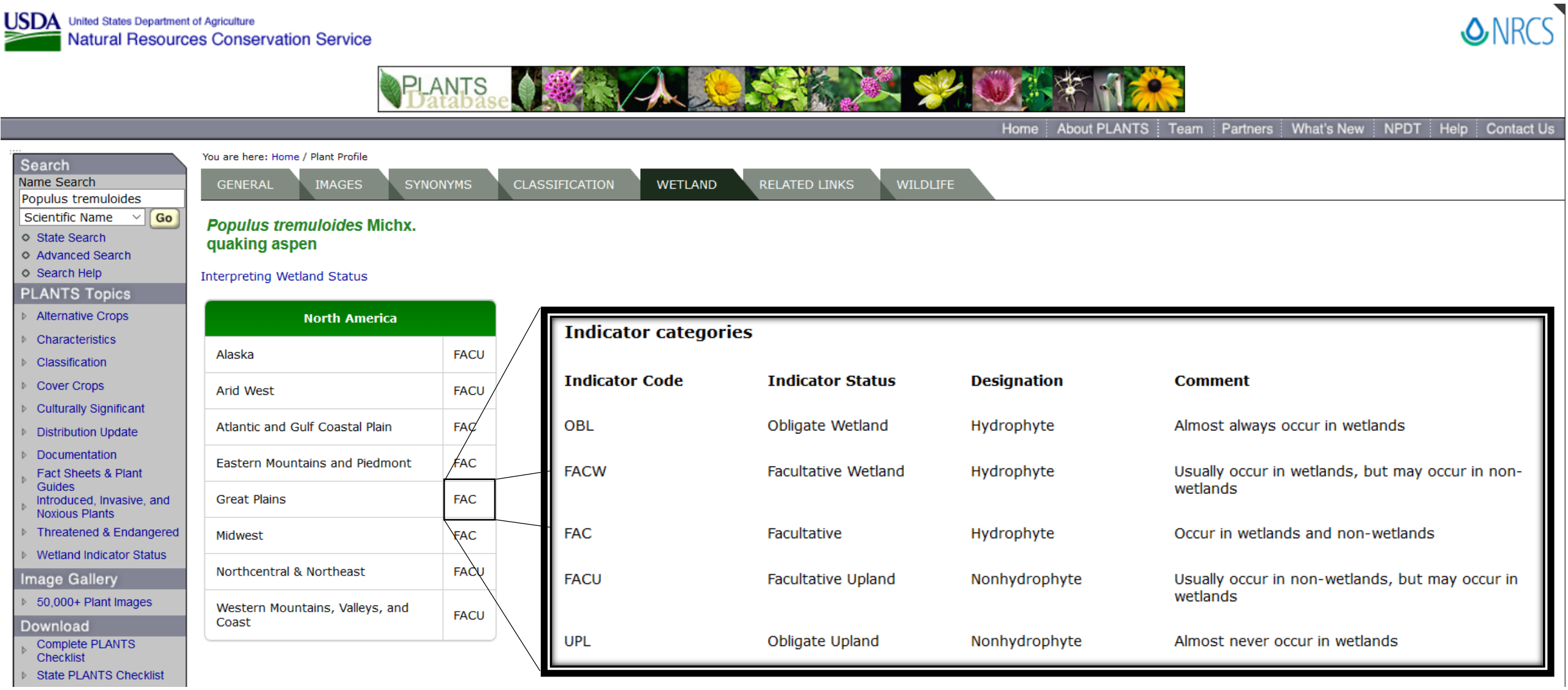
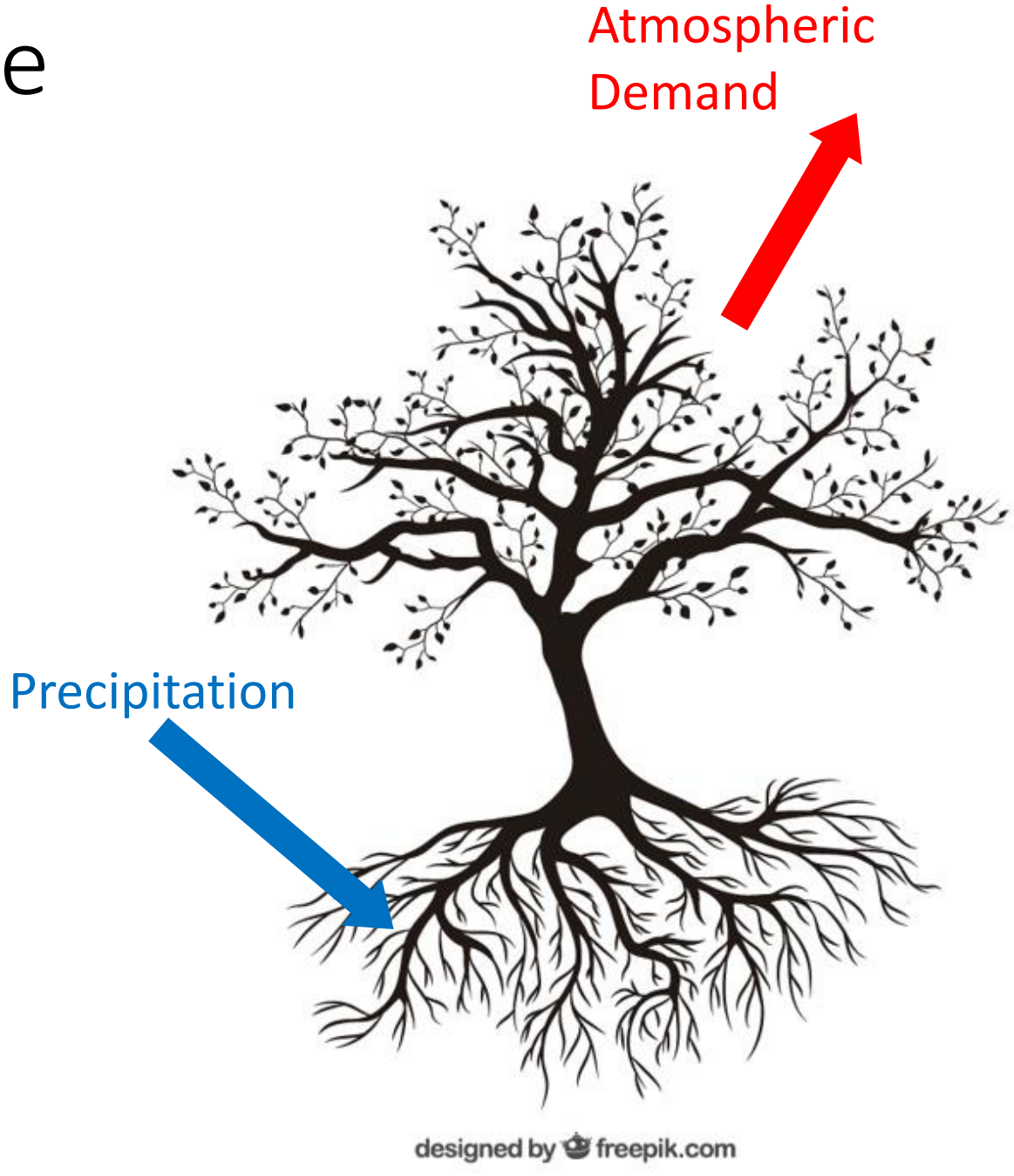
Riparian-Dependence: A Sliding Scale



Does Riparian-Dependence Vary with Climate?

- Direct Environmental Effects
  - Does more precipitation reduce dependence on stream water?
  - Does hotter, dryer air increase reliance on stream water?
- Indirect Eco-Evolutionary Effects
  - How do adaptations to aridity affect riparian-dependence?



How Do Hydrology and Climate Shape the Ecology and Evolution of Woody Riparian Plants?

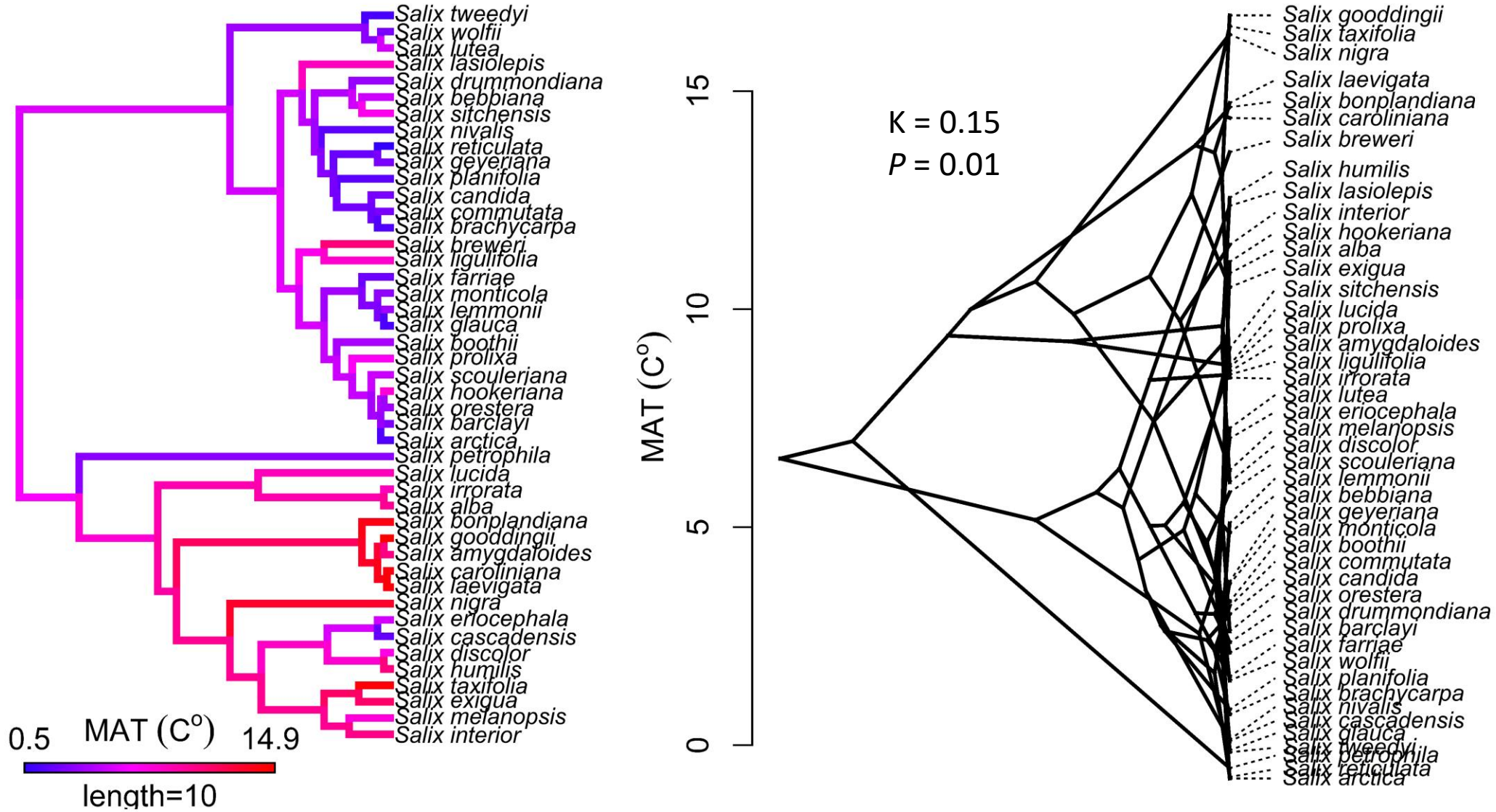
Are climatic and hydrological niches correlated across species?

If so, do they represent fundamental evolutionary tradeoffs?

What functional strategies are related to these tradeoffs?

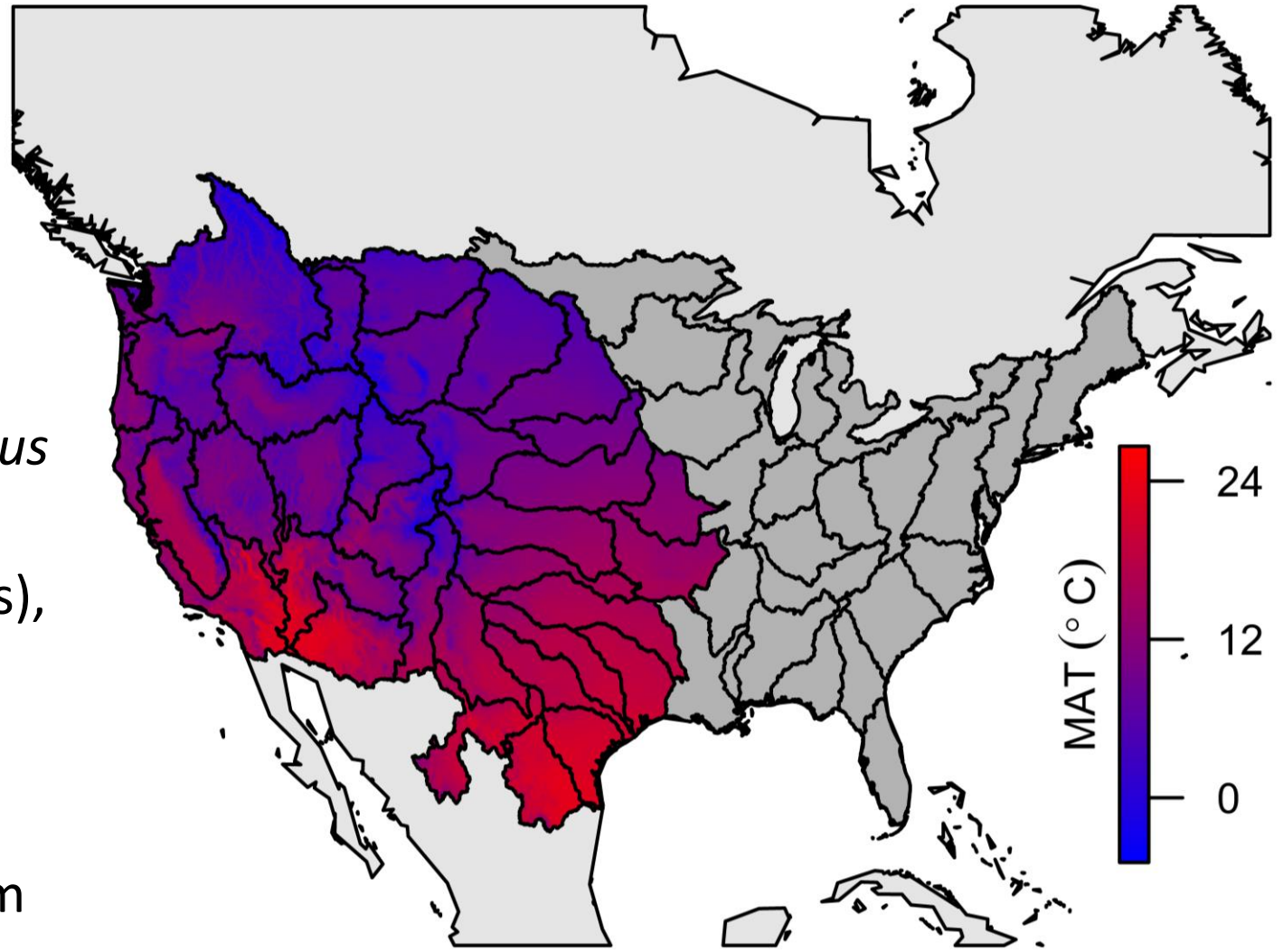
Willows: A Model Clade for Riparian Ecosystems and River Management

Willows Cover an Impressive Range of Climates



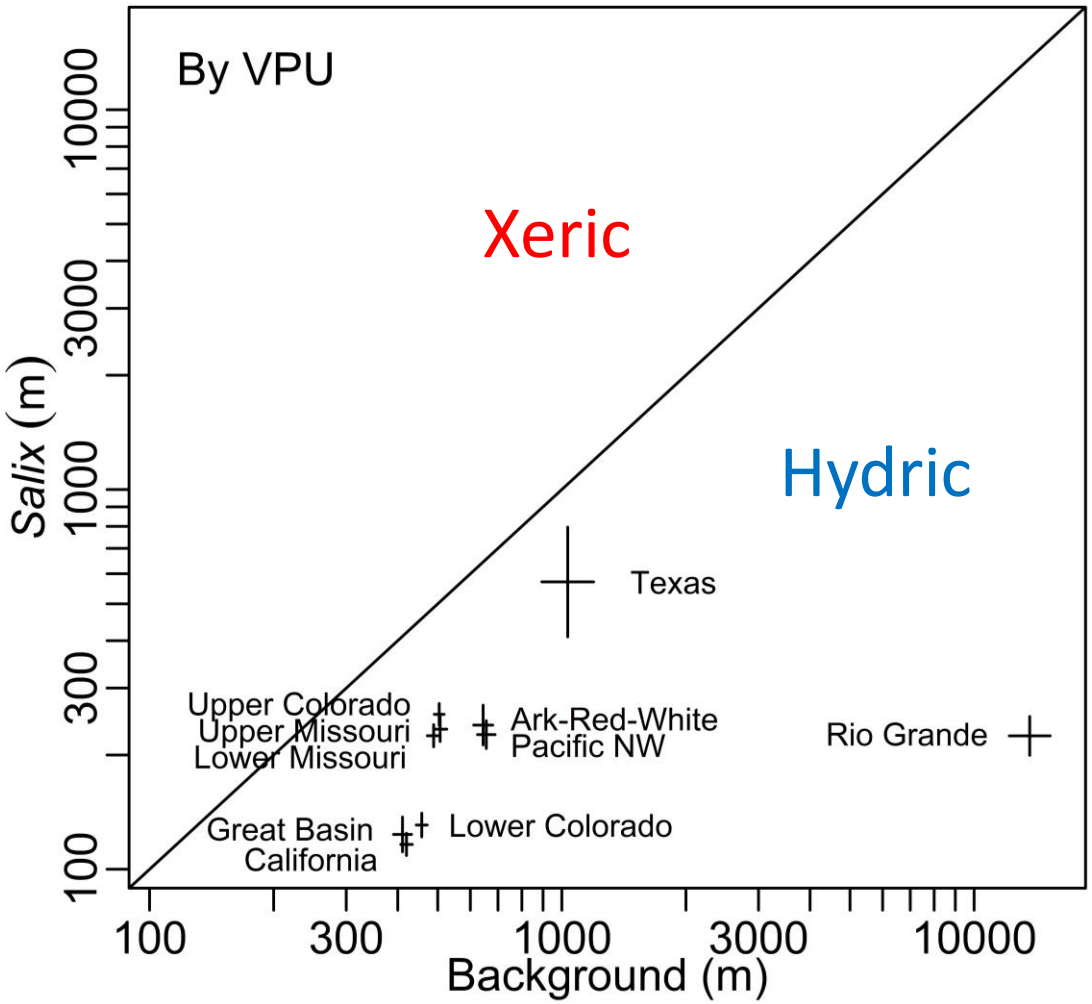
Hydrological and Climate Niche Data

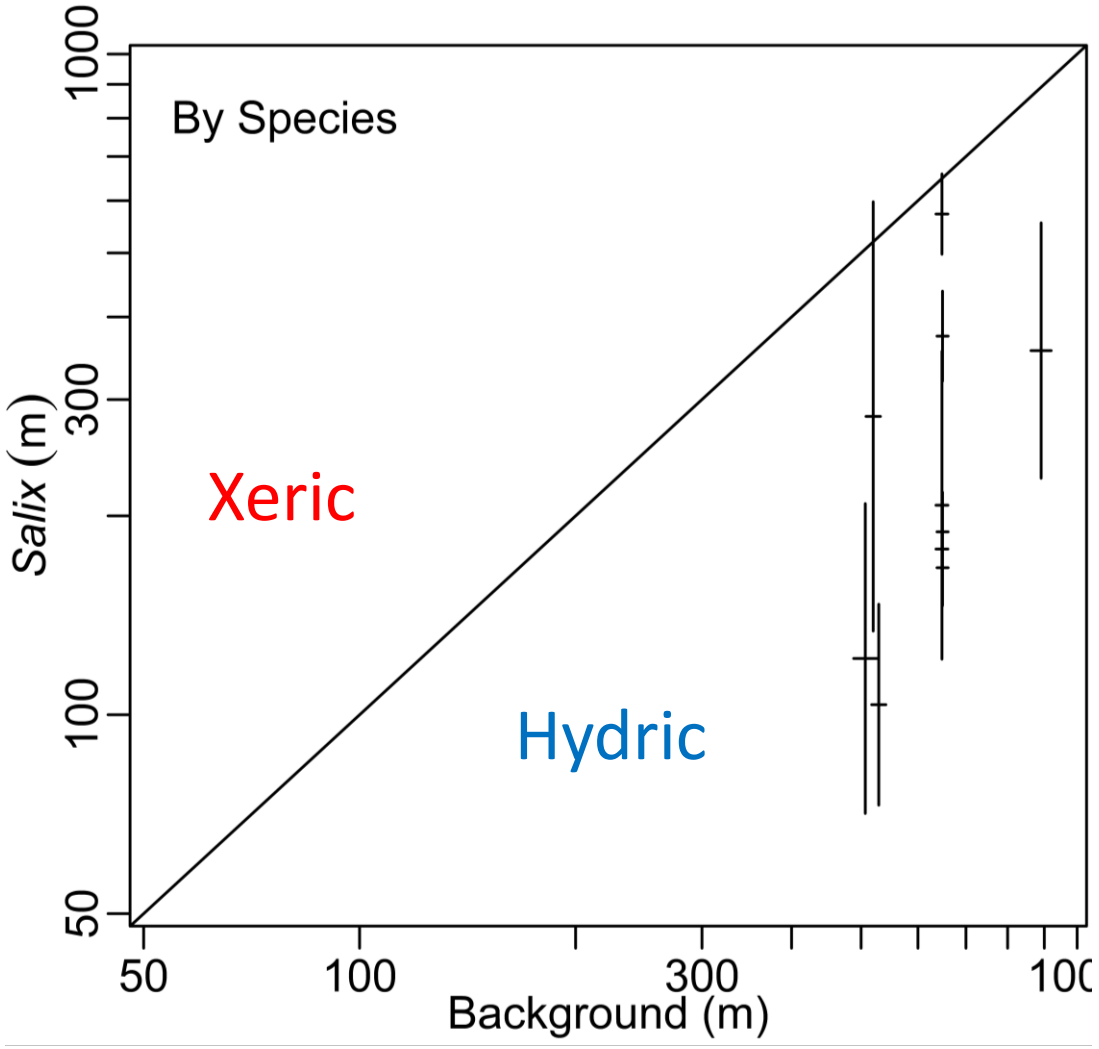
- Extracted georeferenced occurrence records for *Salix* (willows) and *Quercus* (oaks) from SEINET
- 48 species of willows (15,470 records), 54 oaks (17,209)
- Extracted climate values for each occurrence
- Calculated distance to nearest stream for each occurrence record



- Extracted functional trait data (specific leaf area, height, seed mass) from TRY database

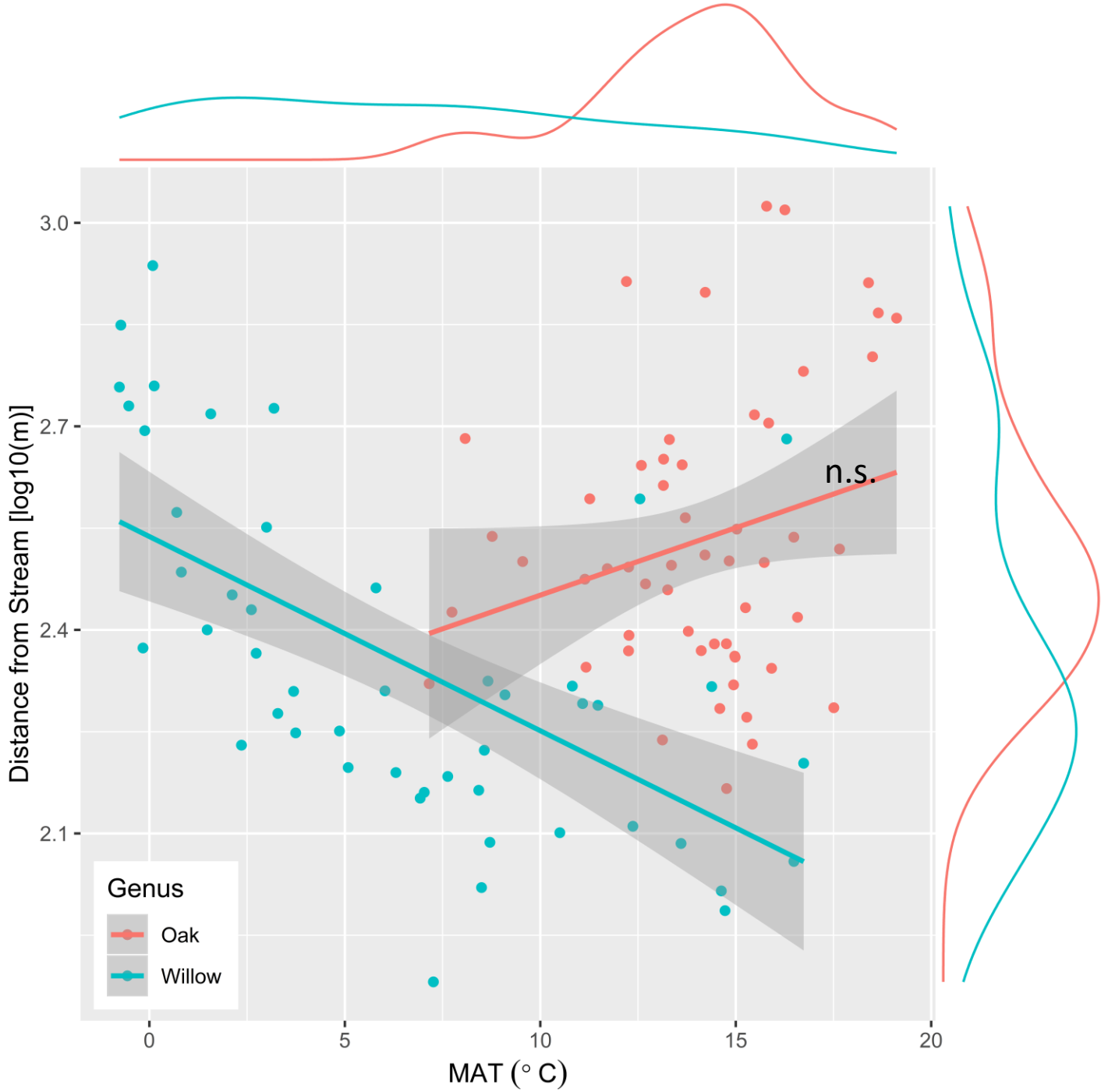
Willows are Closer to Streams than Expected





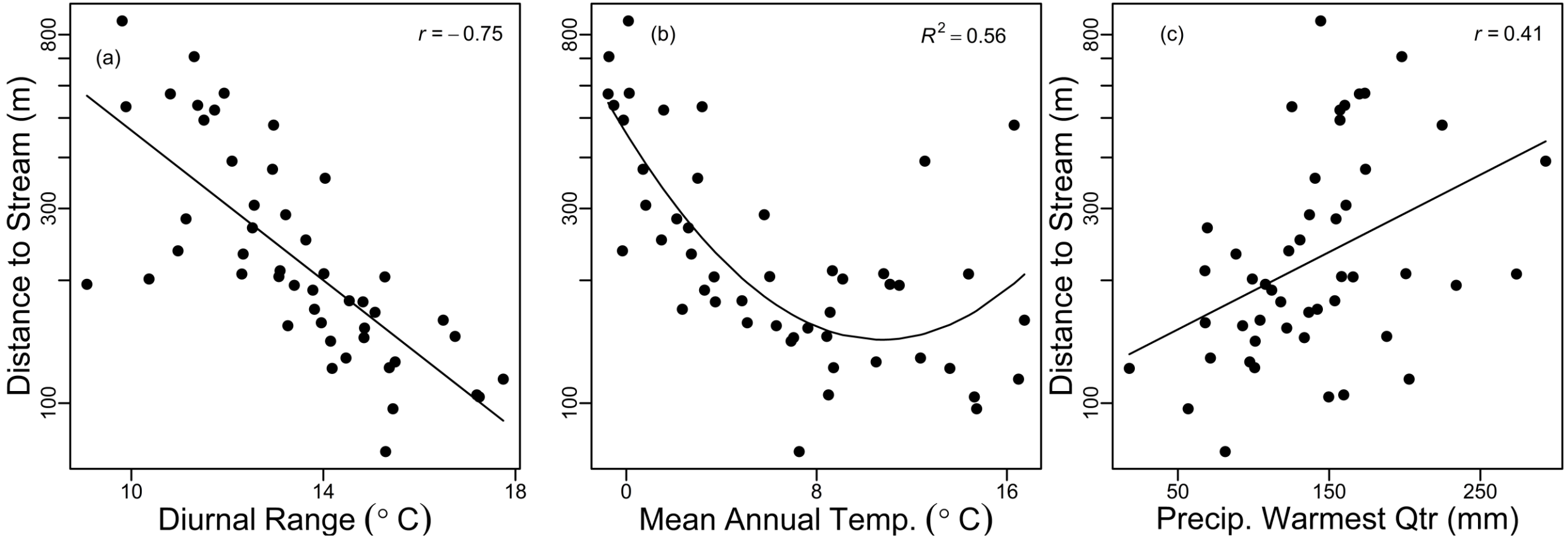
Willows are Closer to Streams than Oaks

- Also occur across a broader range of temperature conditions
- [Spoiler] Riparian dependence is linked to temperature niche

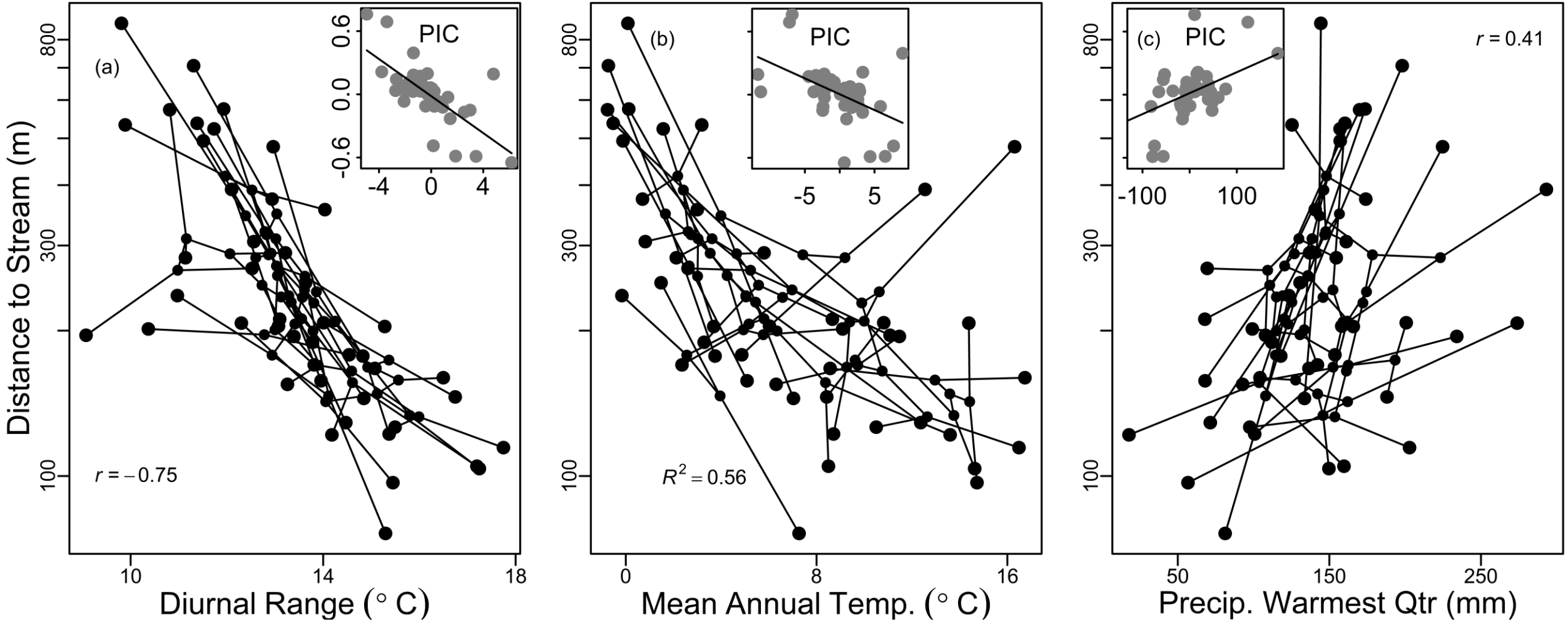


Willow Riparian-Dependence Strongly Tied to Atmospheric Demand (And Summer Precip.)

Total Model Adjusted $R^2 = 0.80$

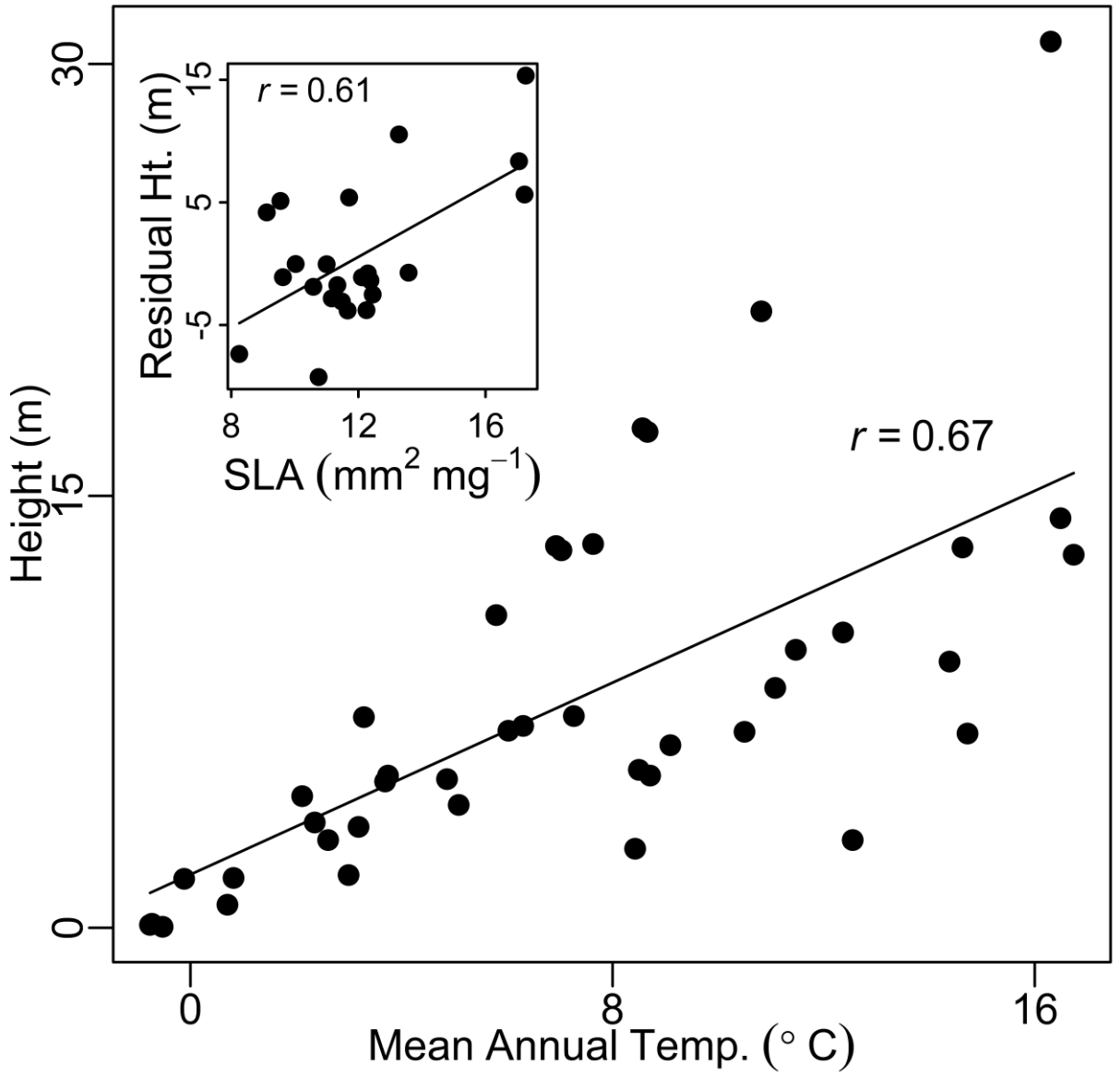


These Niche Dimensions are Phylogenetically Correlated as Well



Willow Height Increases with Temperature Niche

- Taller plants → larger stems → exponentially increasing sapwood area → increased water transport
- Two strategies in hot environments:
  - Tall, large-trunk species have cheap leaves with high water use and photosynthetic capacity
  - Short, multi-stemmed species with long-lived, water-use-efficient leaves



Summary

- Riparian-dependence is a quantifiable, continuous scale
- Riparian-dependence increases with atmospheric demand
- This represents a fundamental tradeoff in hydrophyllic plant form and function
- There are multiple functional strategies in arid environments

Management Relevance

- In cooler environments:
  - Maintain buffer zones in cooler climates to accommodate increasing riparian-dependence
  - Maintain connectivity to uplands for migration
- In hotter environments:
  - Reduce stream intermittency and groundwater drawdown, or shrink the channel to maintain function
  - Identify conditions suitable for alternative functional strategies (tall, water-inefficient species versus short, water-efficient species)

- Expand your restoration palette!

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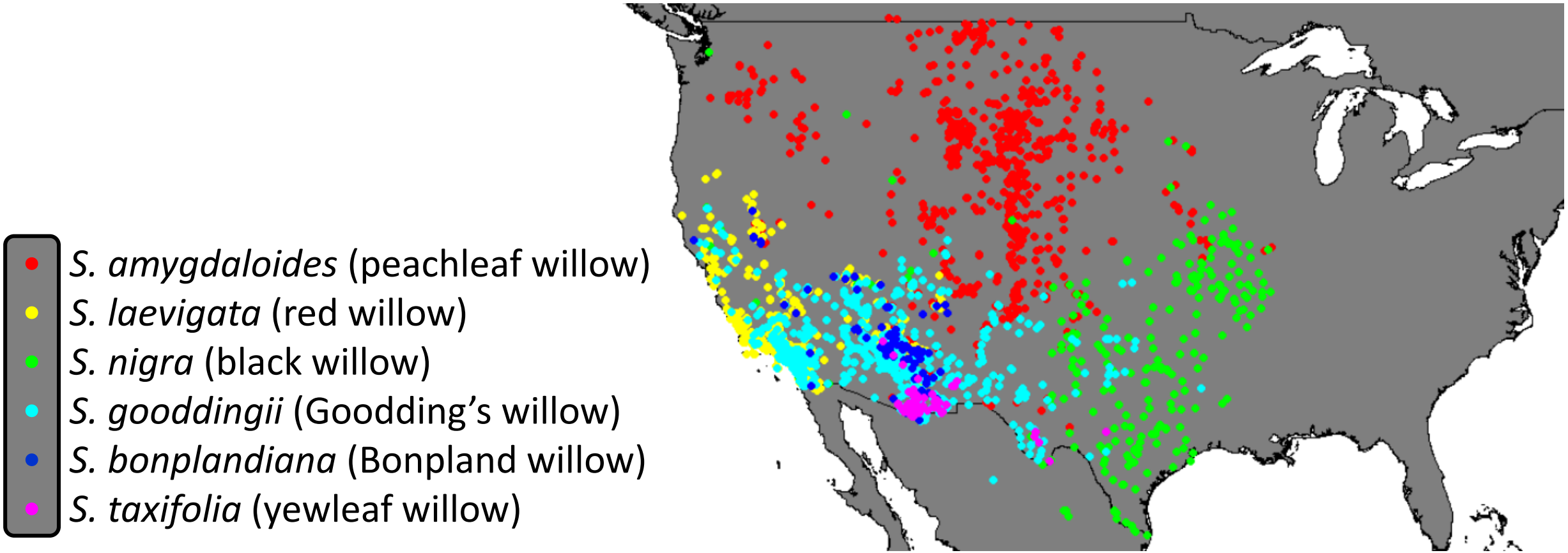
Prestoration: using species in restoration that will persist now and into the future



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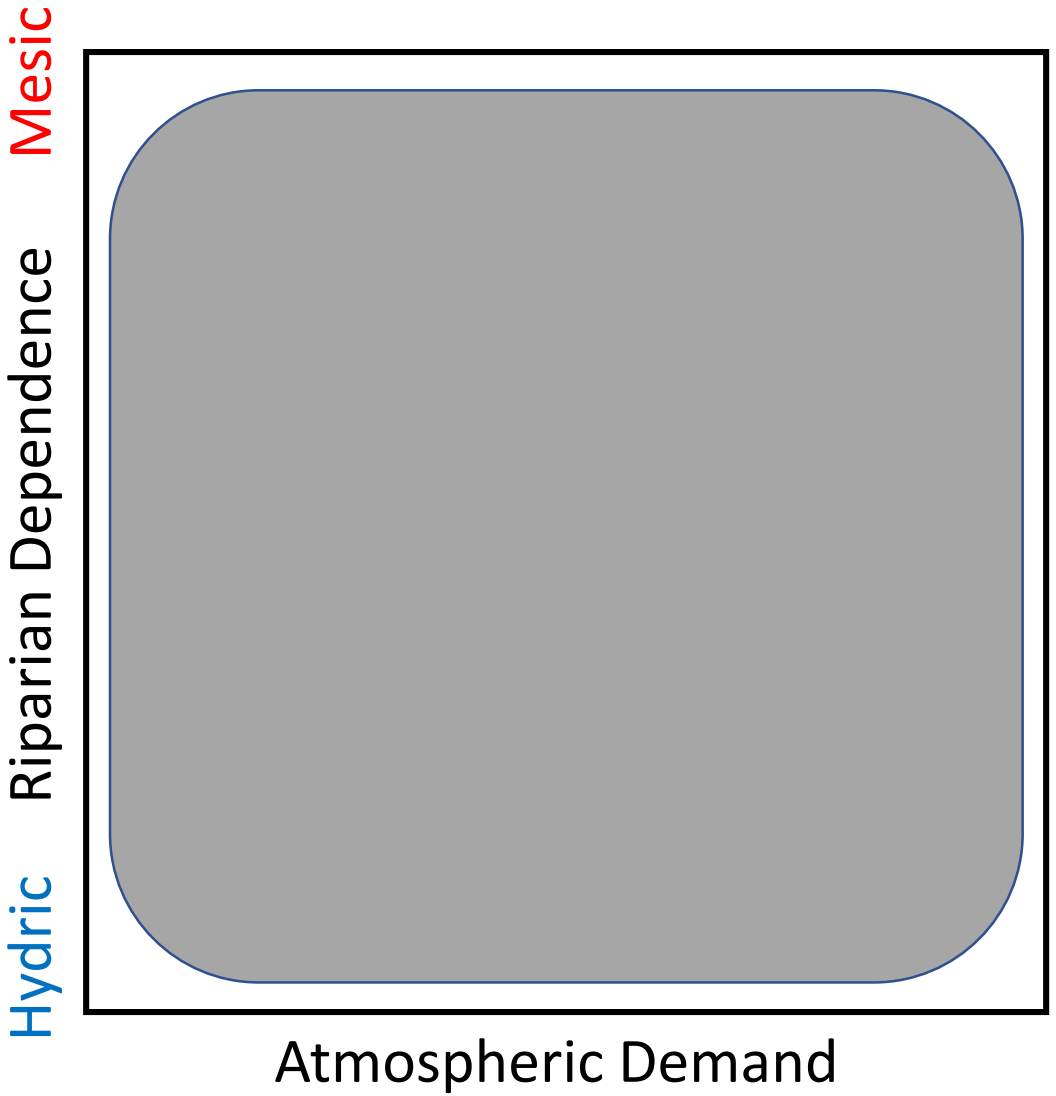
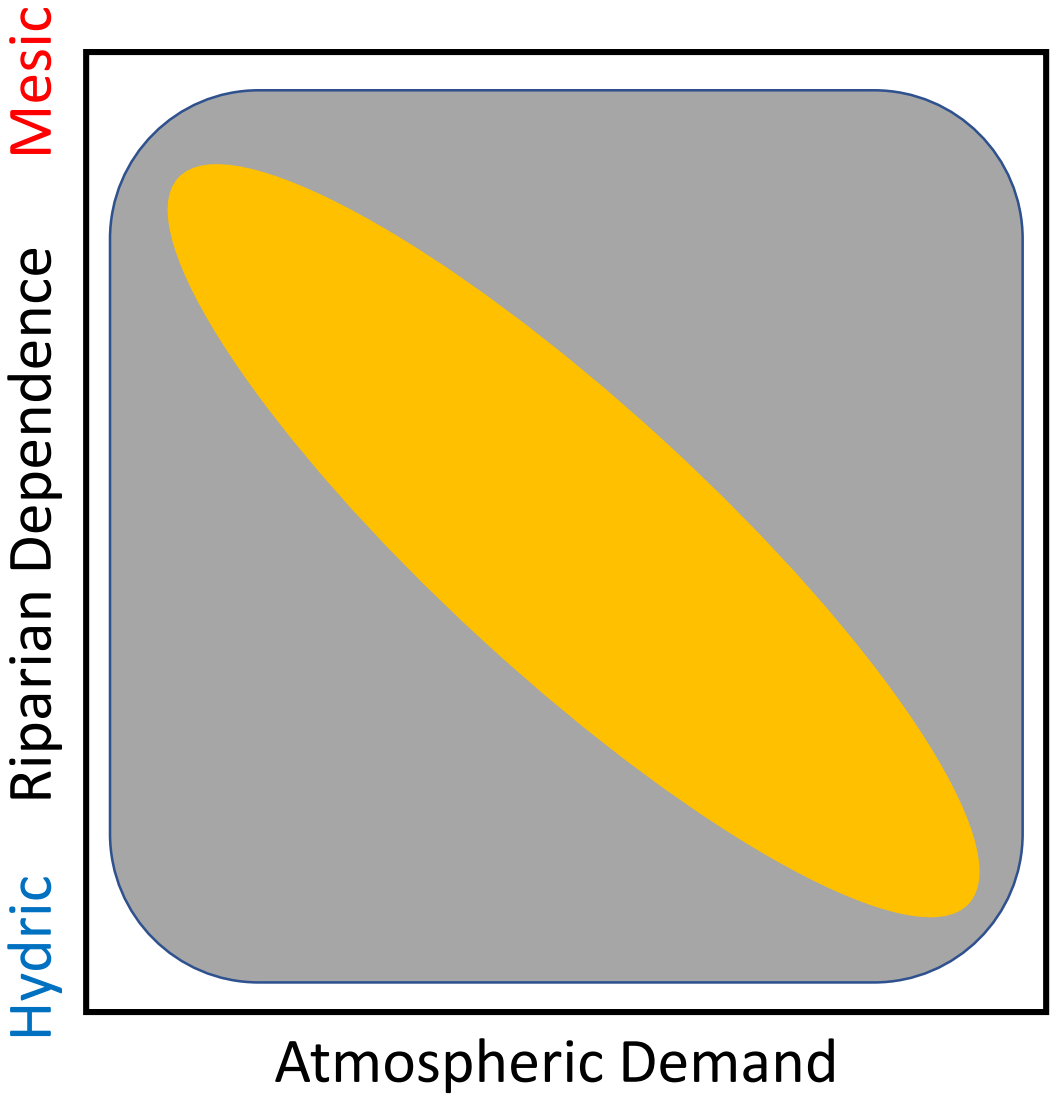
A Universal Tradeoff for Hydric Trees & Shrubs?

- All combinations of riparian dependence and atmospheric demand tolerance exist across the tree of life



A Universal Tradeoff for Hydric Trees & Shrubs?

- All combinations of riparian dependence and atmospheric demand tolerance exist across the tree of life
- Tradeoffs are revealed when we focus on a single group of closely-related species



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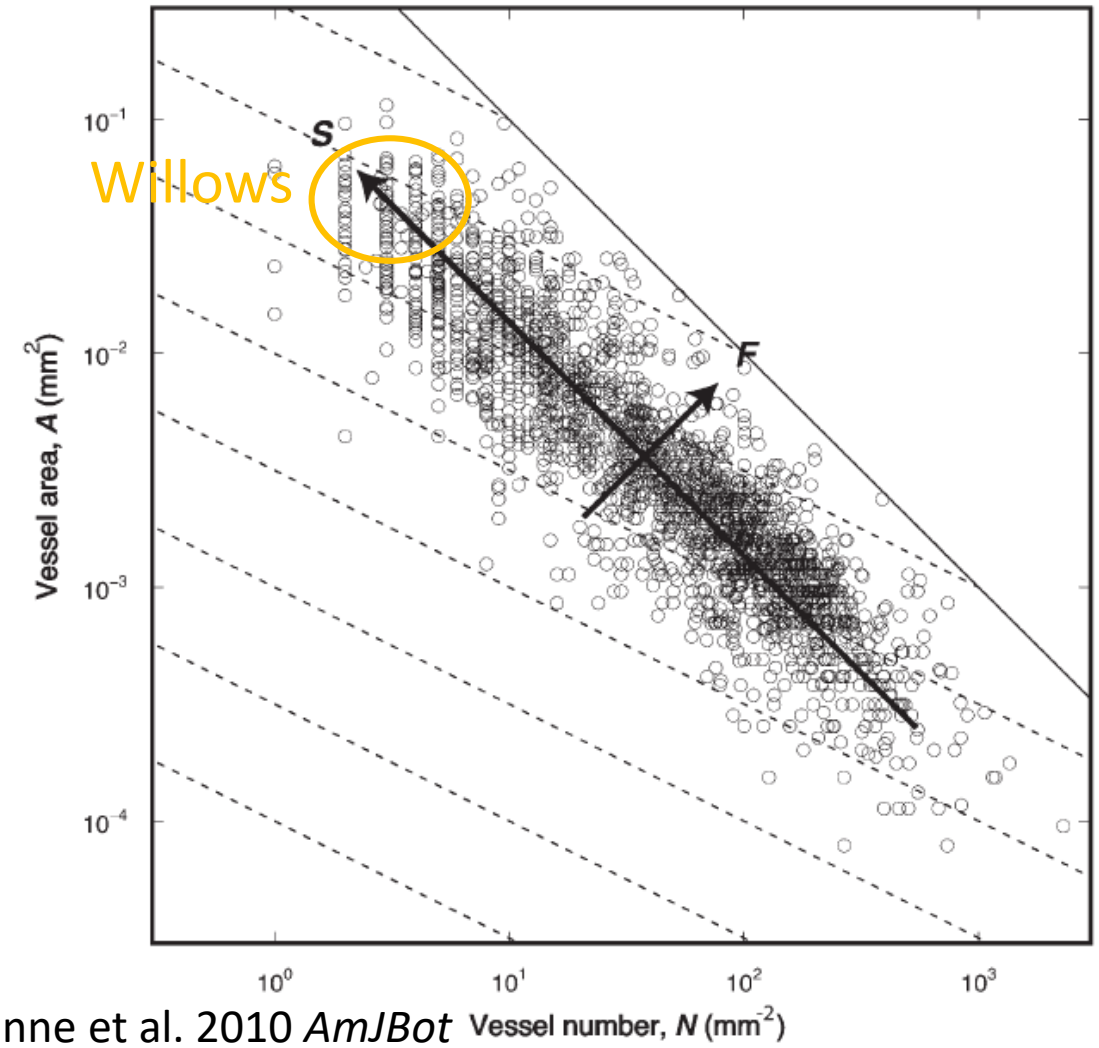

Zanne et al. 2010 *AmJBot*