

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

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# Riparian-Dependence: A Sliding Scale



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Populus tremuloides

Scientific Name

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***Populus tremuloides* Michx.**  
**quaking aspen**

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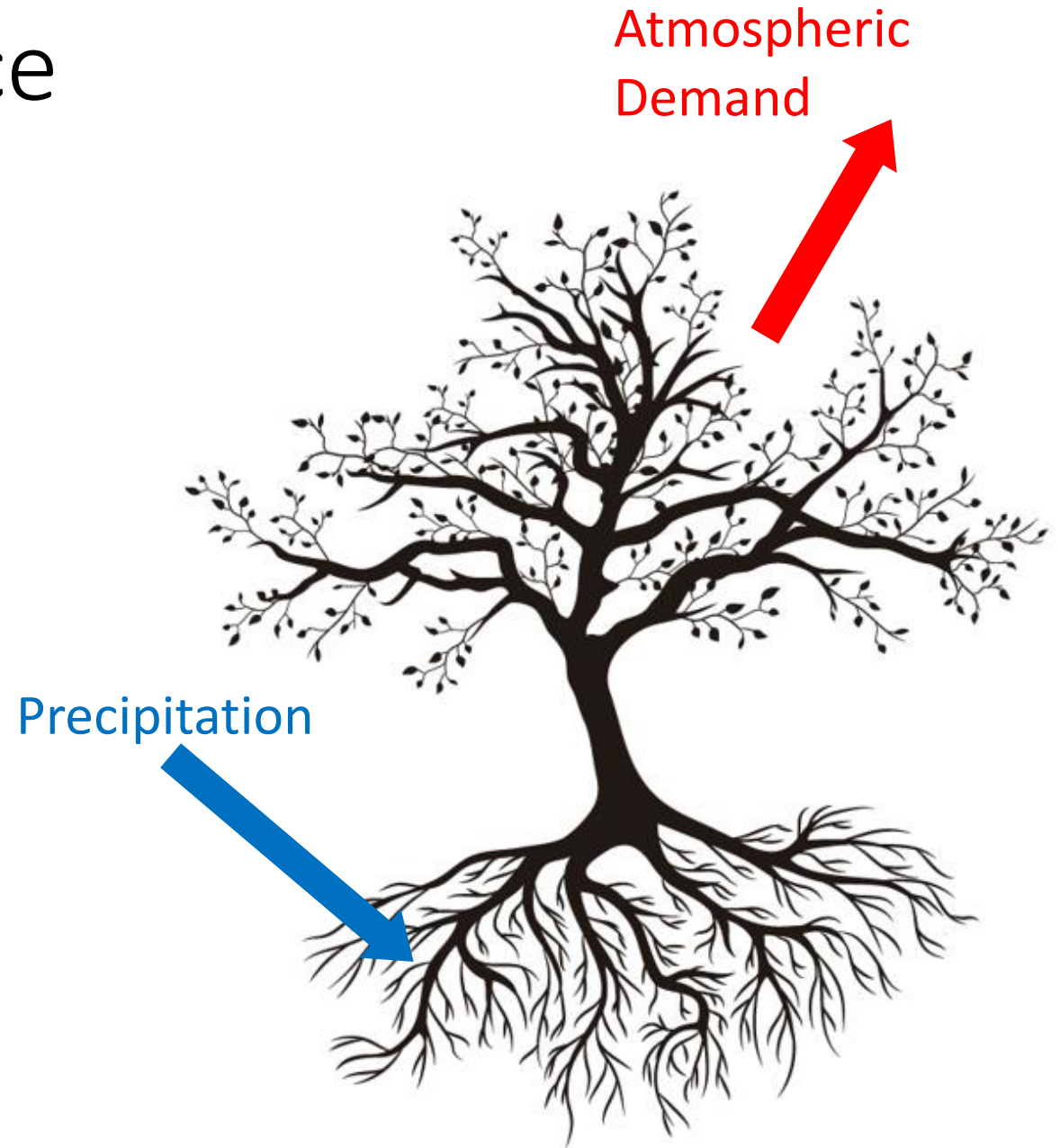
North America	
Alaska	FACU
Arid West	FACU
Atlantic and Gulf Coastal Plain	FAC
Eastern Mountains and Piedmont	FAC
Great Plains	FAC
Midwest	FAC
Northcentral & Northeast	FACU
Western Mountains, Valleys, and Coast	FACU

## Indicator categories

Indicator Code	Indicator Status	Designation	Comment
OBL	Obligate Wetland	Hydrophyte	Almost always occur in wetlands
FACW	Facultative Wetland	Hydrophyte	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Hydrophyte	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Nonhydrophyte	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Nonhydrophyte	Almost never occur in wetlands

# 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?



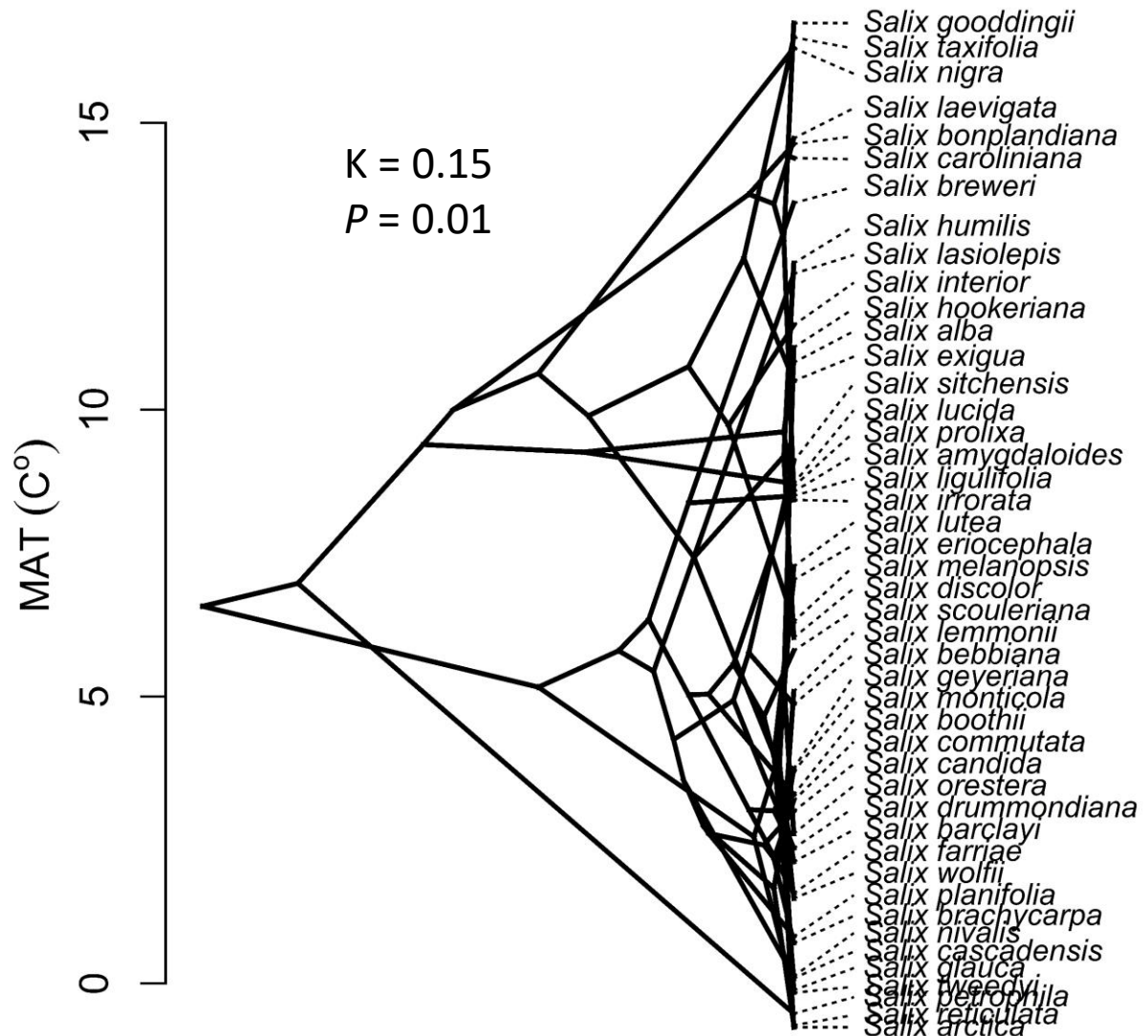
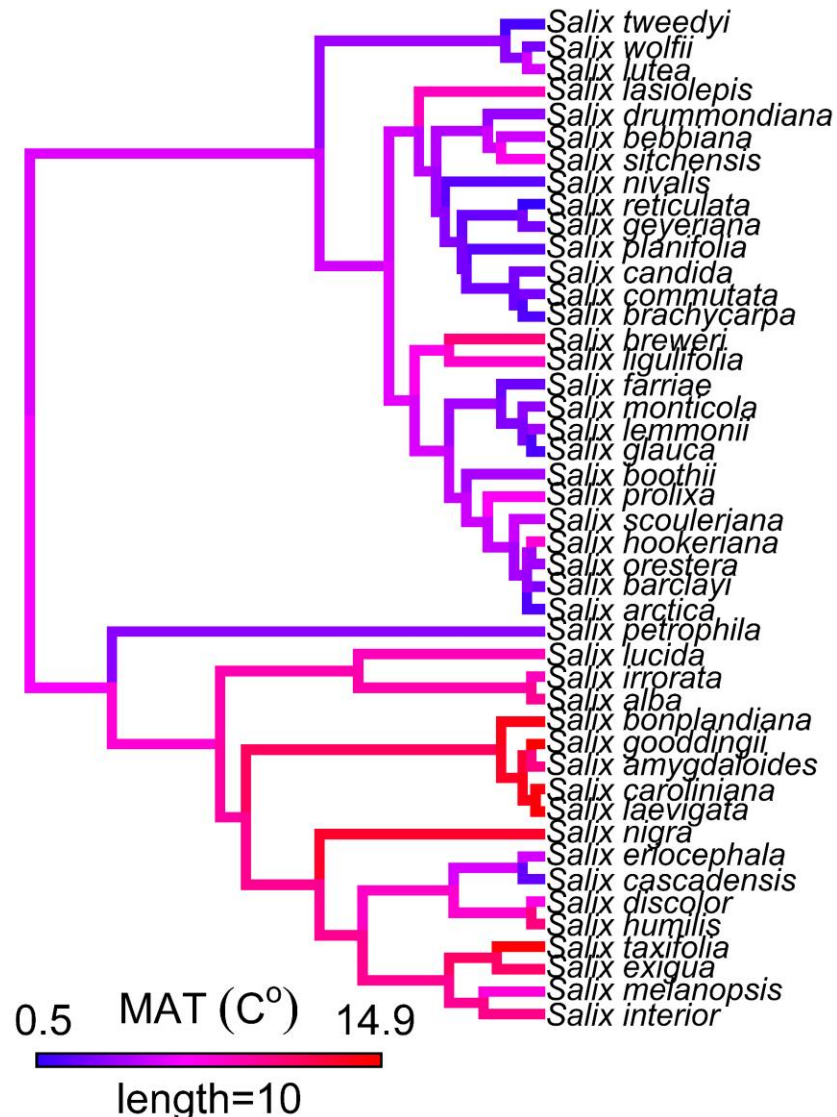


## Willows: A Model Clade for Riparian Ecosystems and River Management





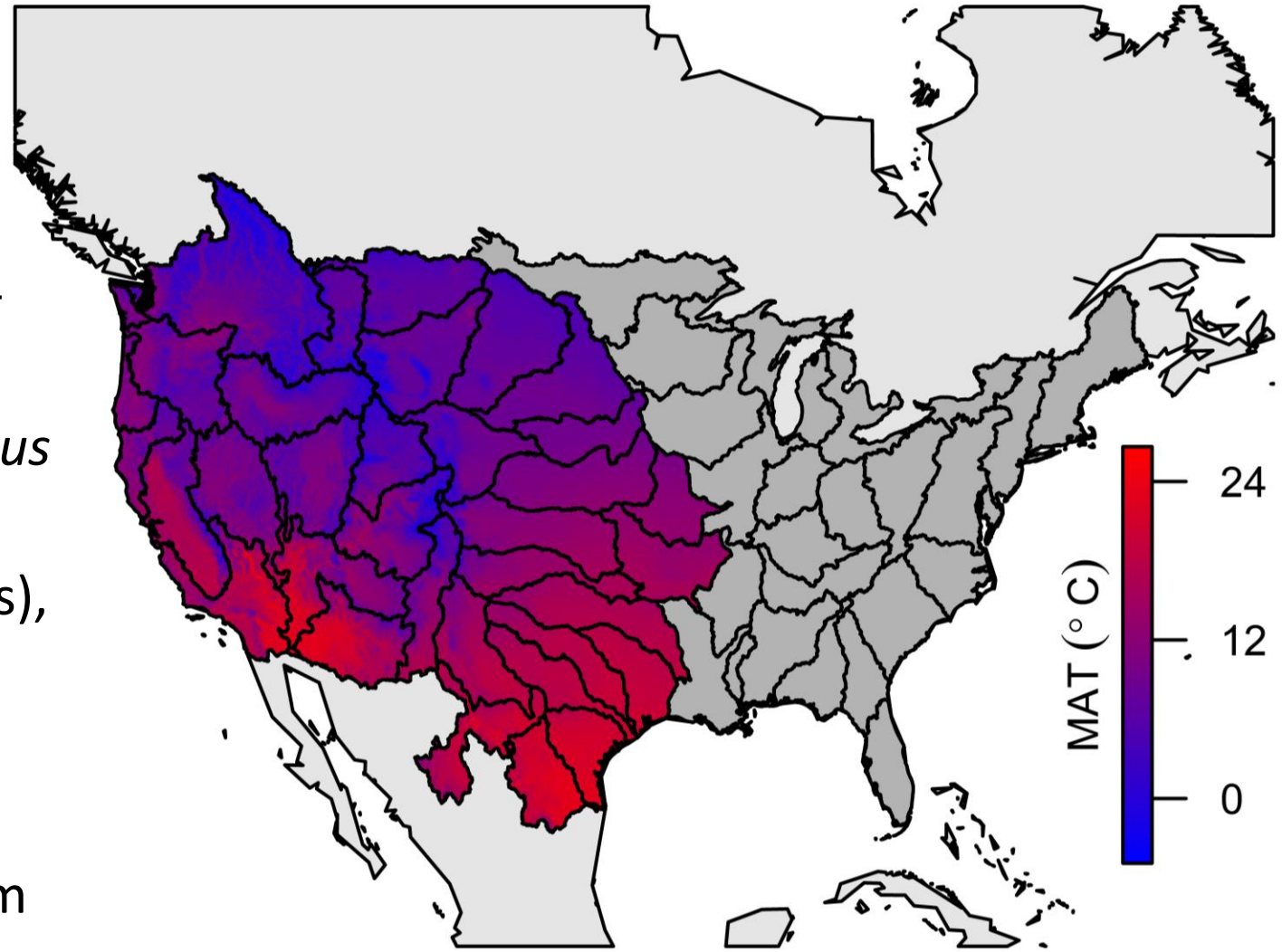
# Willows Cover an Impressive Range of Climates



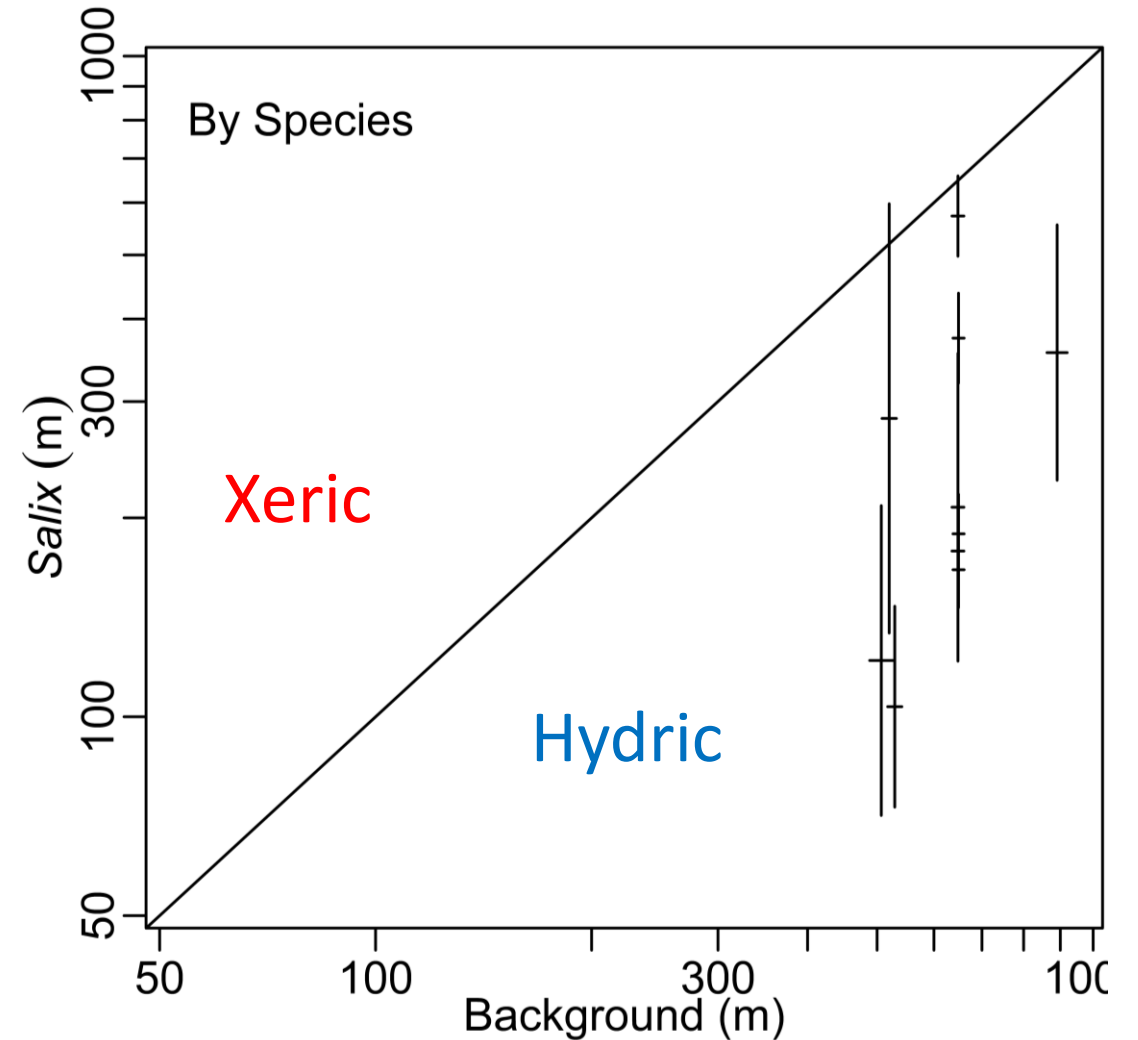
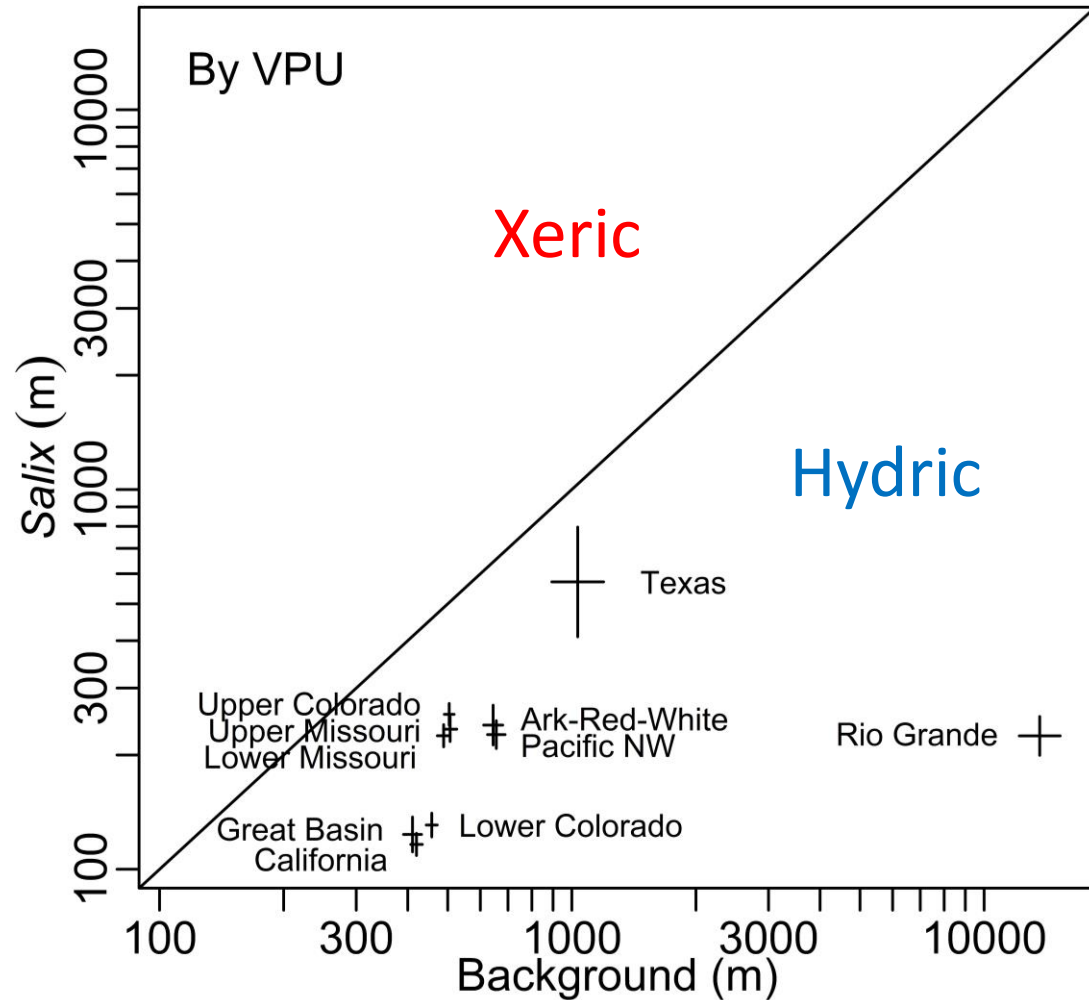
# Hydrological and Climate Niche Data

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- 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



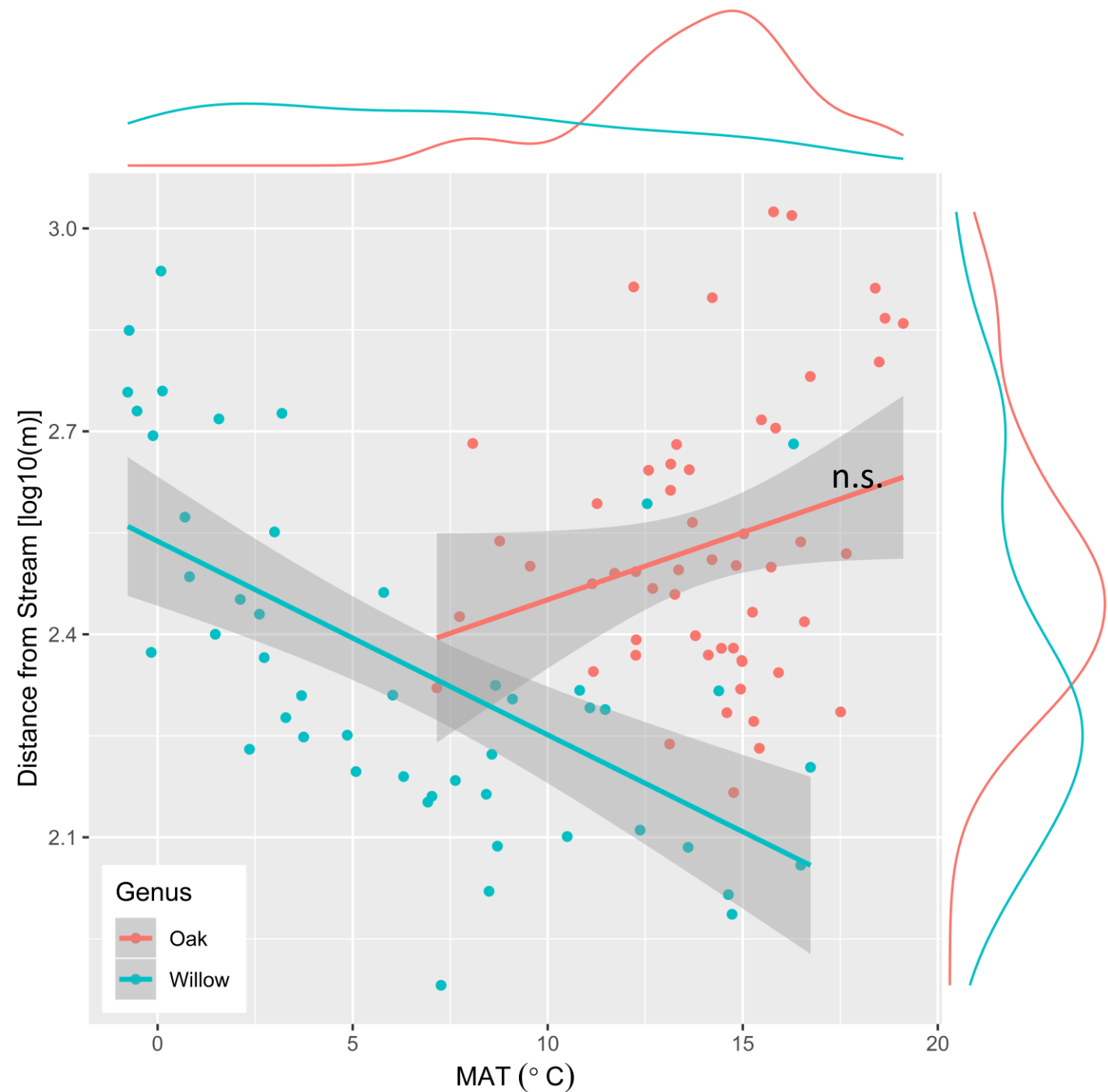
# Willows are Closer to Streams than Expected



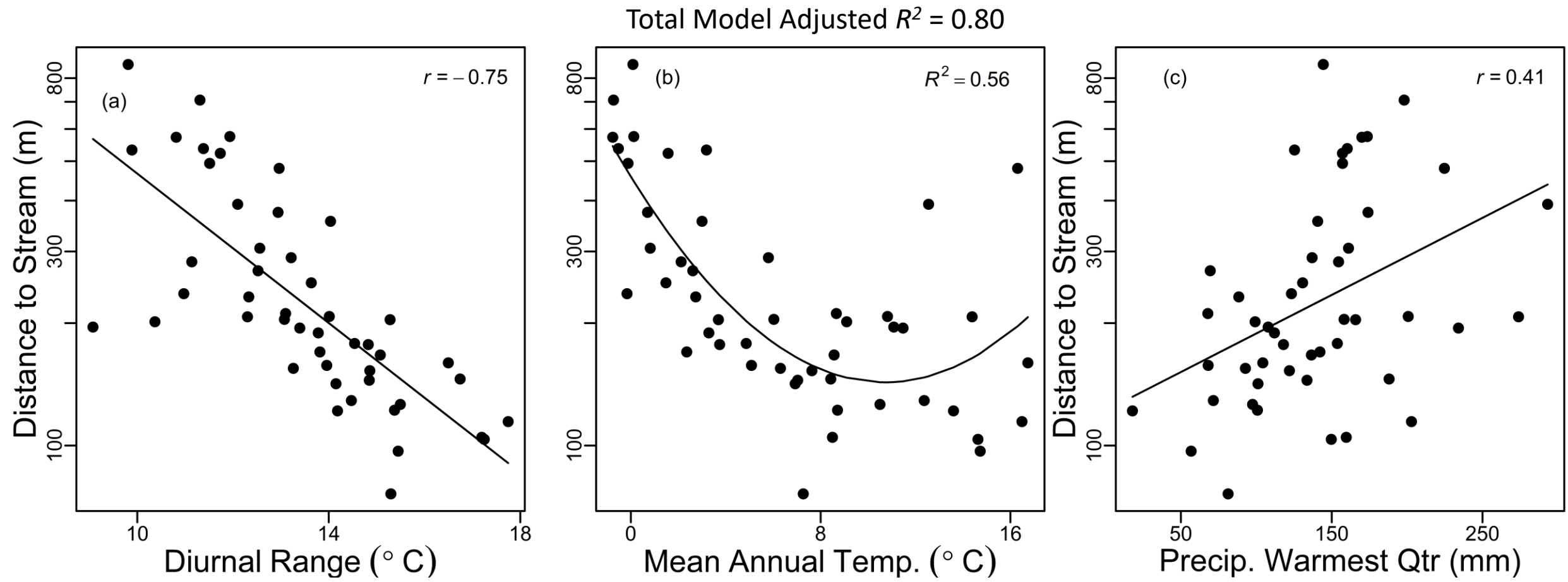


# Willows are Closer to Streams than Oaks

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

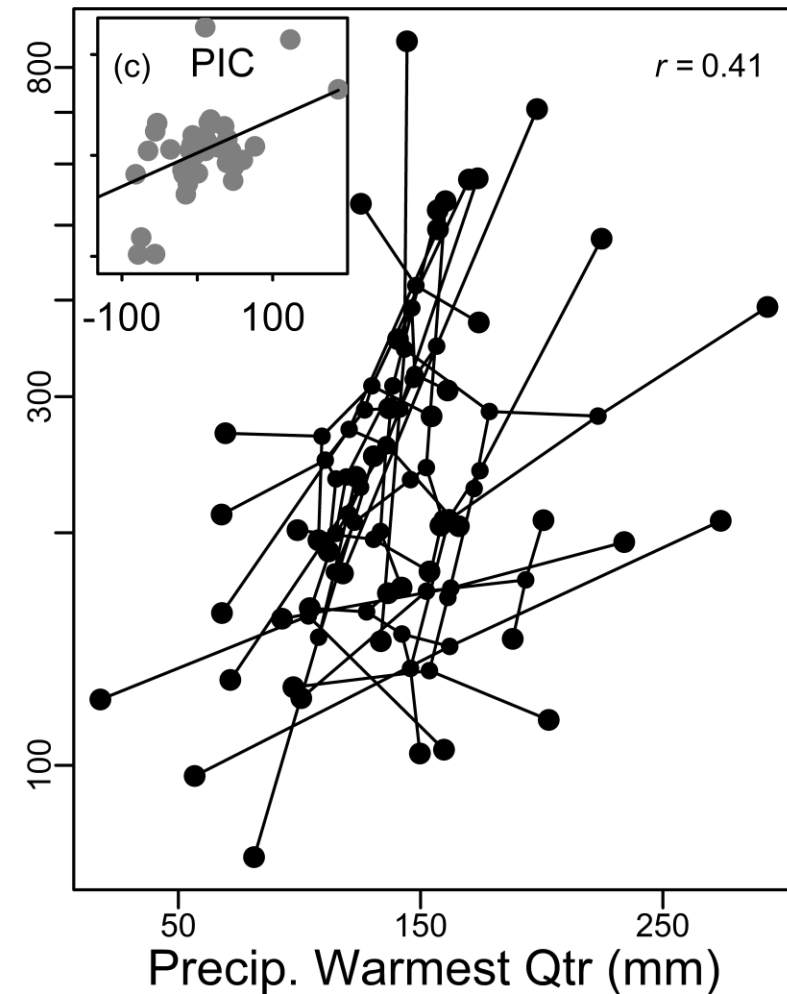
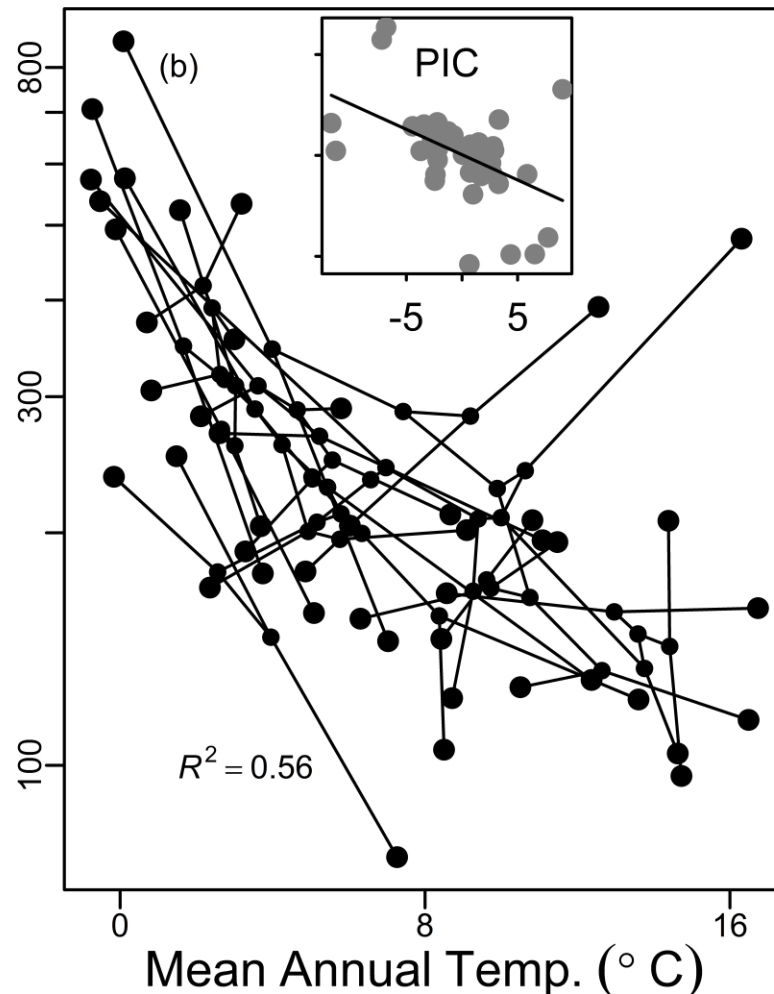
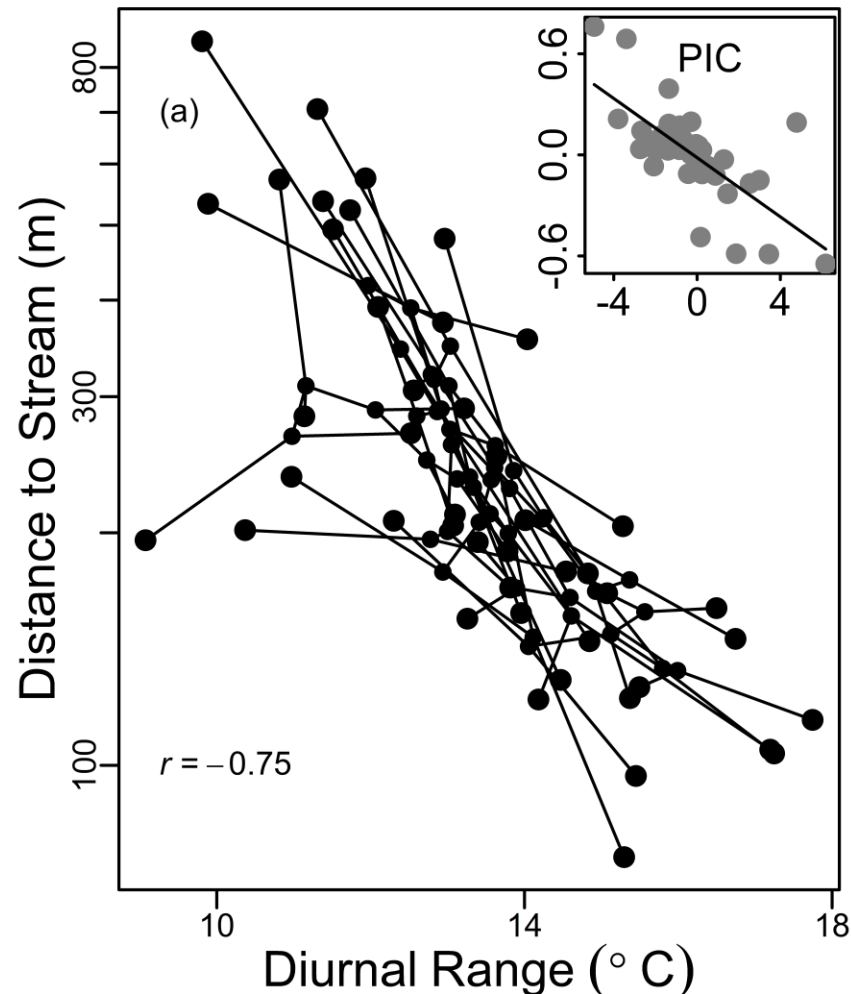


# Willow Riparian-Dependence Strongly Tied to Atmospheric Demand (And Summer Precip.)



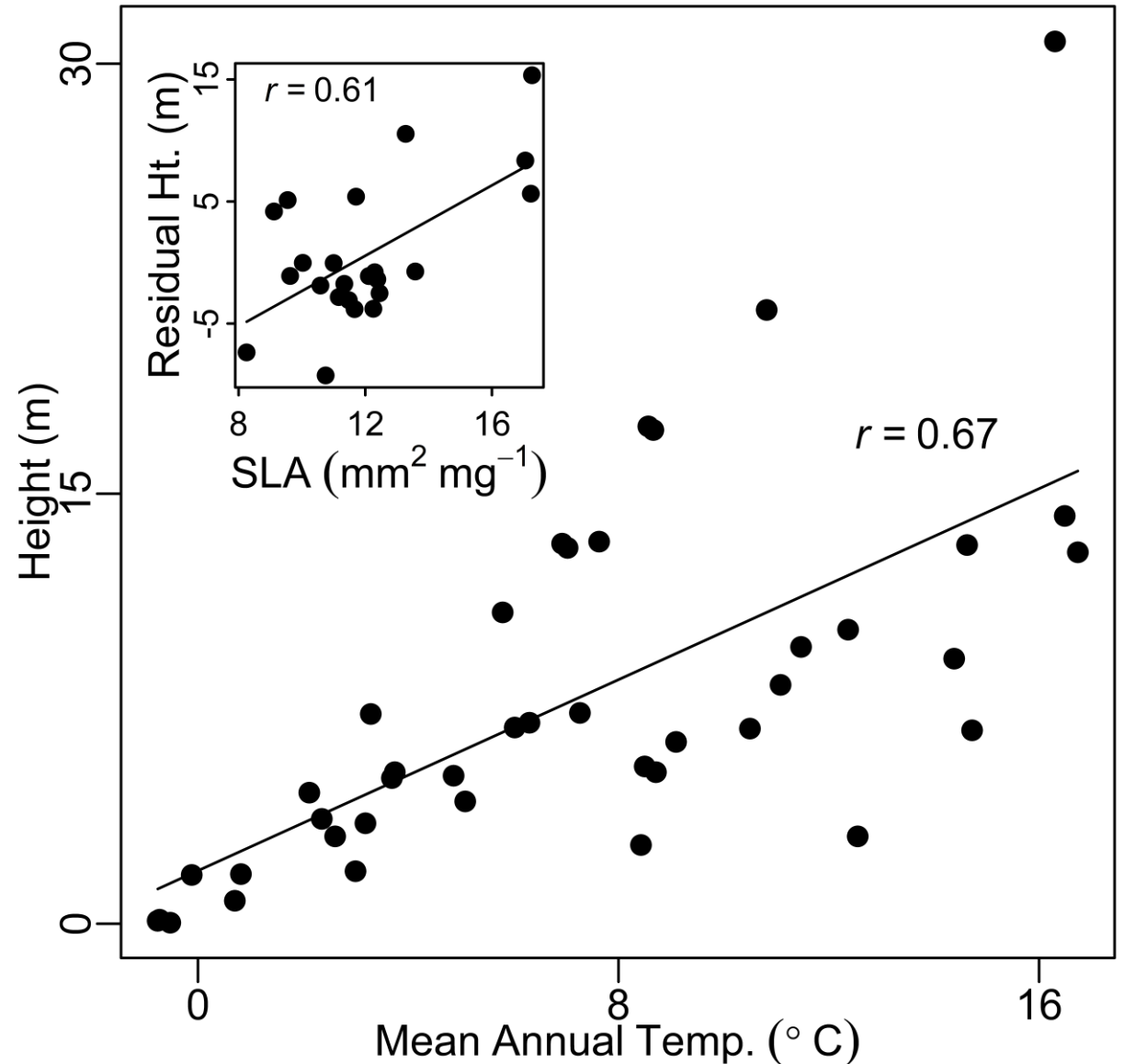


# These Niche Dimensions are Phylogenetically Correlated as Well



# 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



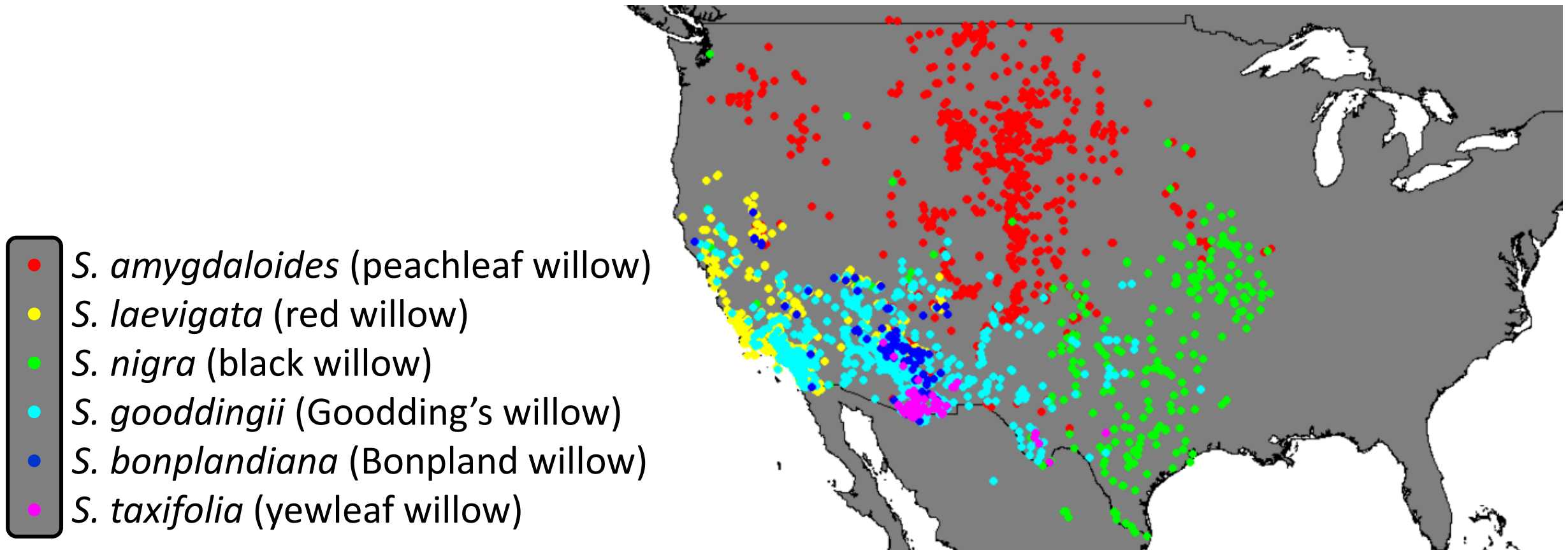
# Management Relevance

- 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





**ECOS<sup>s</sup>** Center for Ecosystem  
Science and Society at  
Northern Arizona University

Thanks! For more info:  
[butterfieldlab.weebly.com](http://butterfieldlab.weebly.com)

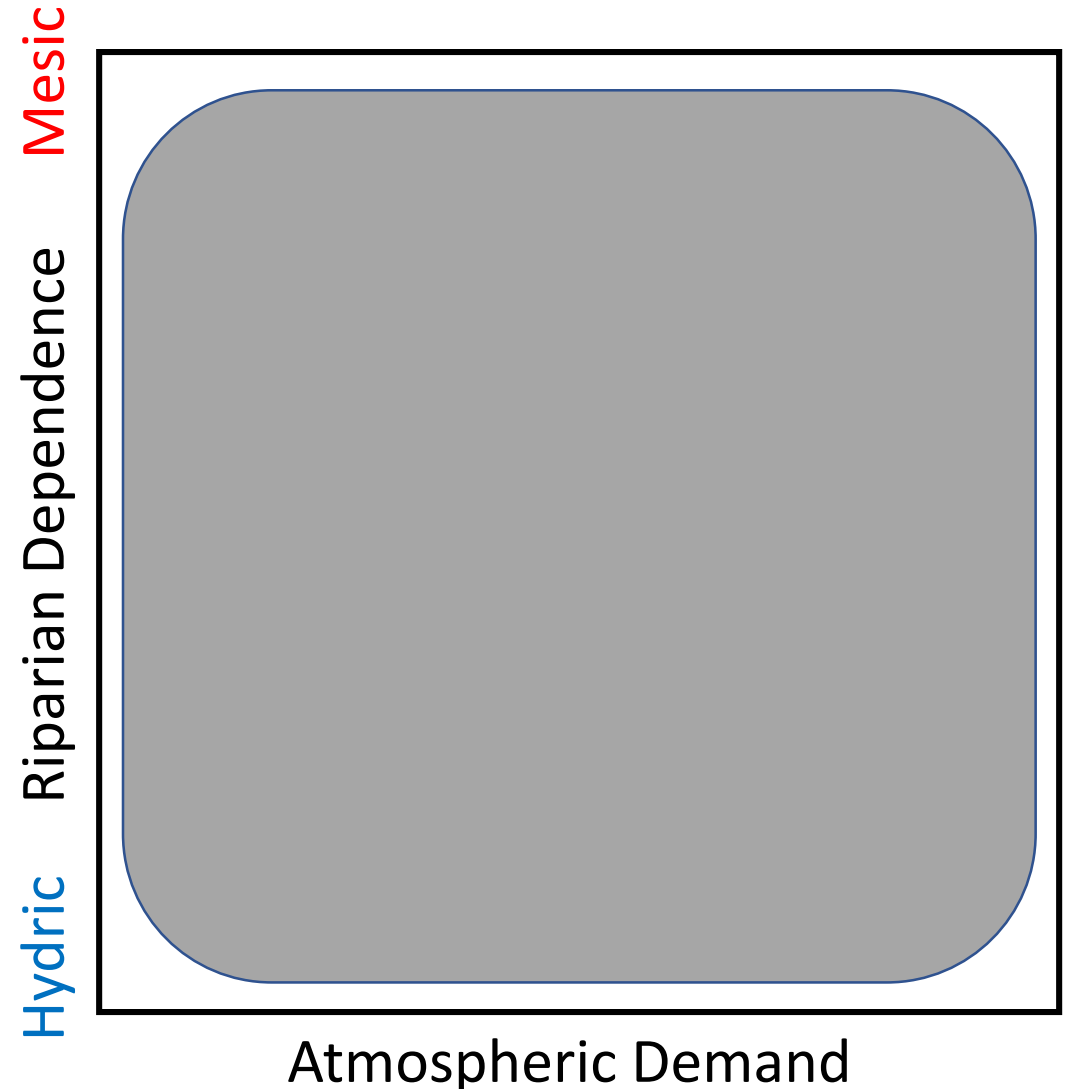
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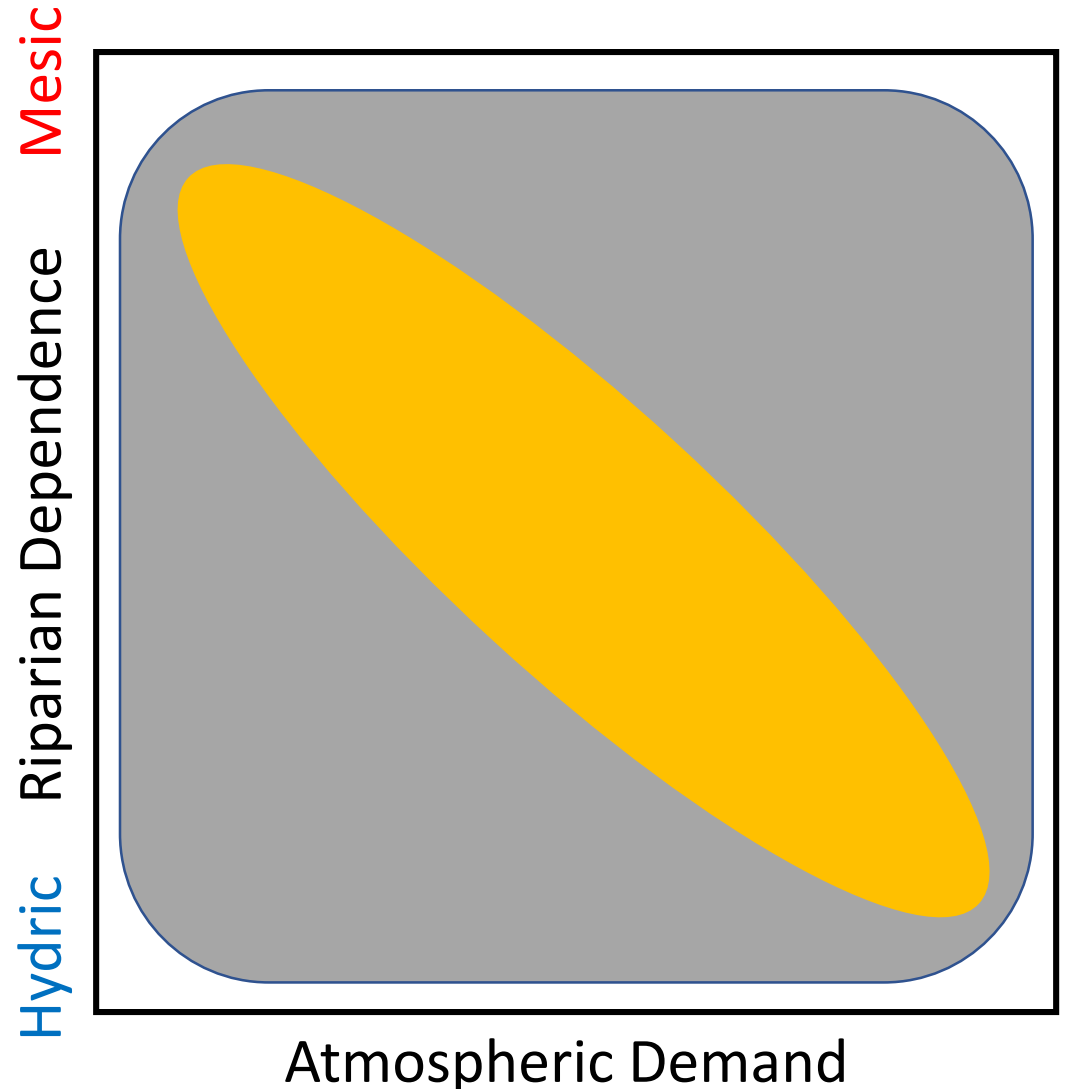
# A Universal Tradeoff for Hydric Trees & Shrubs?

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

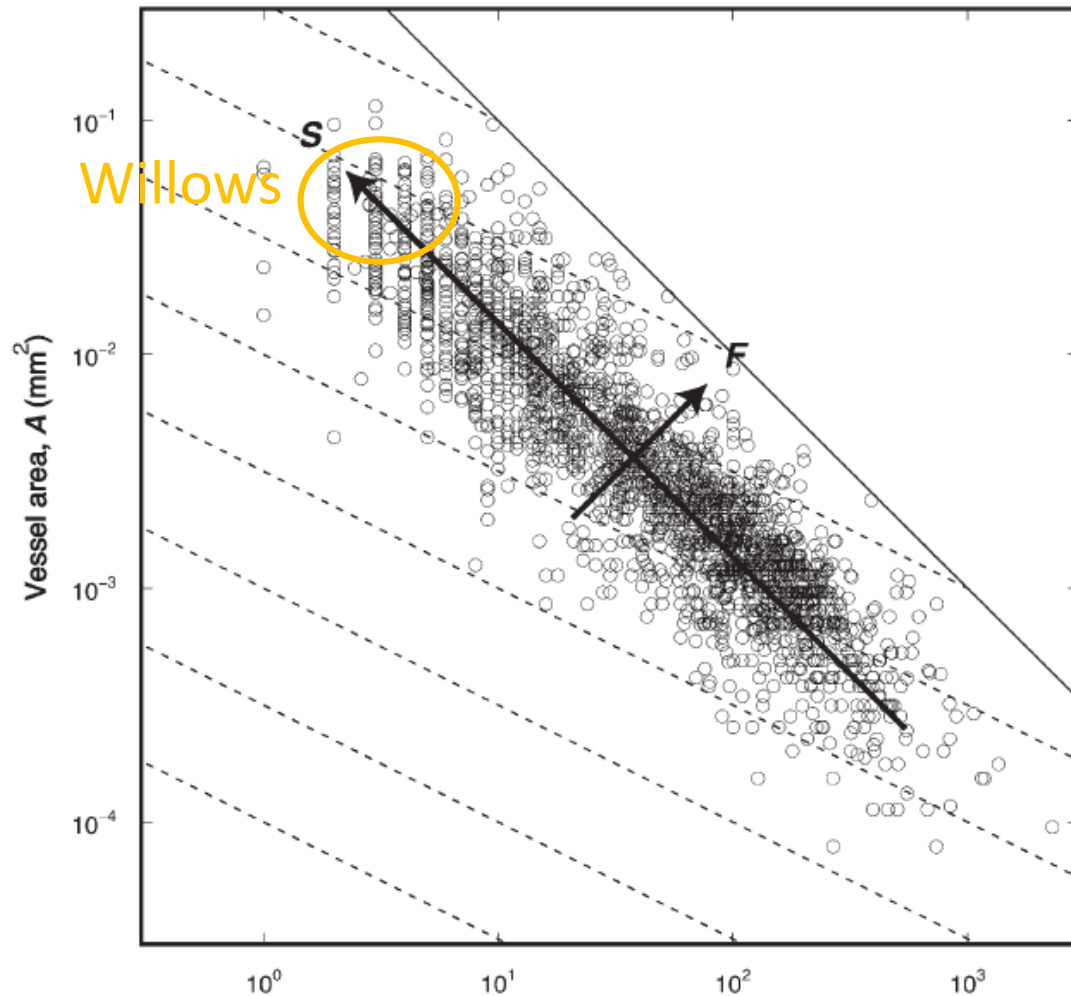


# A Universal Tradeoff for Hydric Trees & Shrubs?

- 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



# A Universal Tradeoff for Hydric Trees & Shrubs?



Zanne et al. 2010 *AmJBot*

