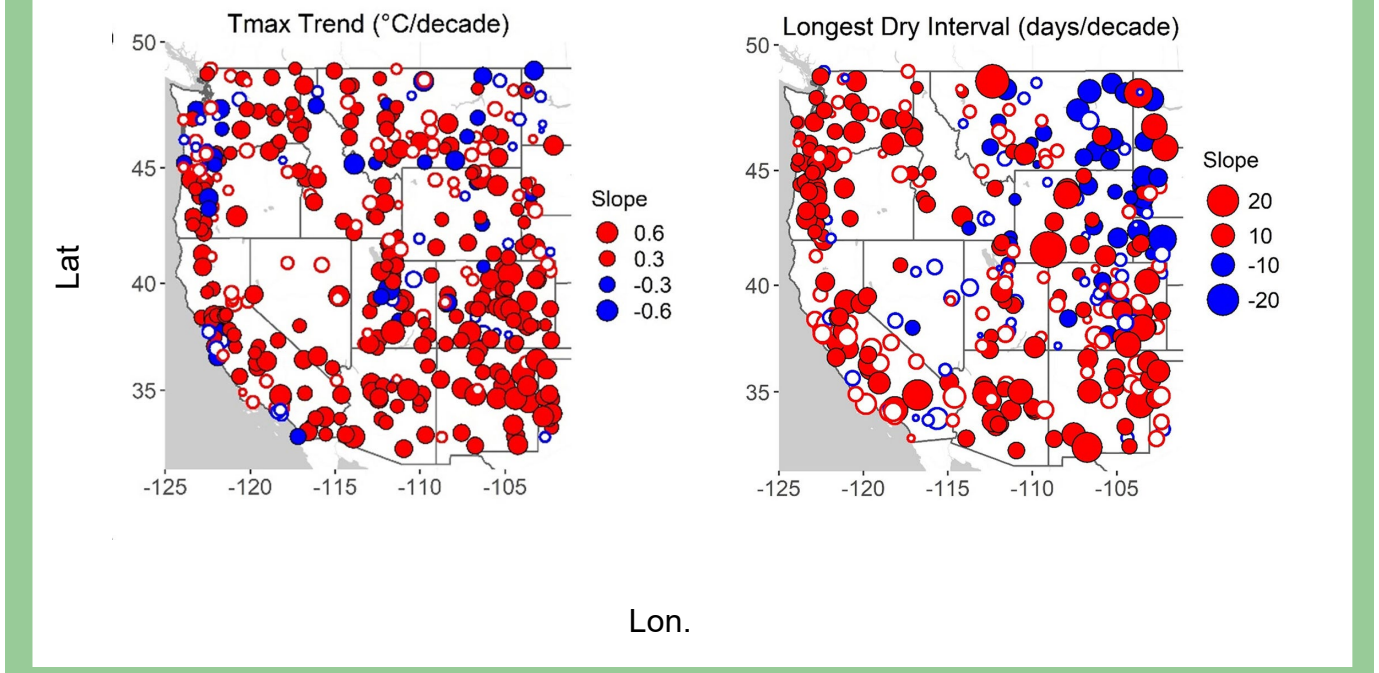
Climate-Driven Shifts in Vapor Pressure Deficit Tolerance May Favor Russian Olive Over Fremont Cottonwood

Rebecca Senft, Brandt Winn, Susan Bush, Kevin Hultine, Luiza Aparecido

The Western US is getting hotter and drier, which has a strong effect on plant health.

Mean maximum temperature is increasing in most areas.

More dry days are occurring.



Zhang, et al. (2021) *Geophysical Research Letters.*

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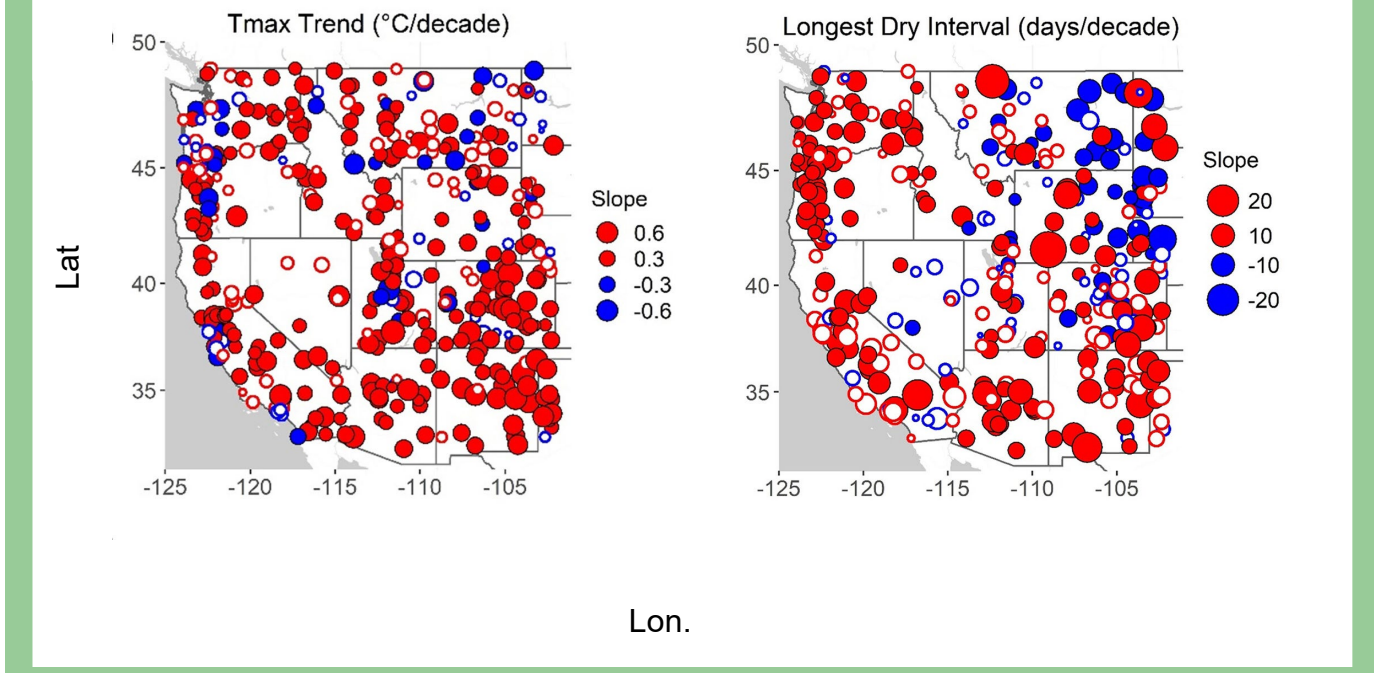
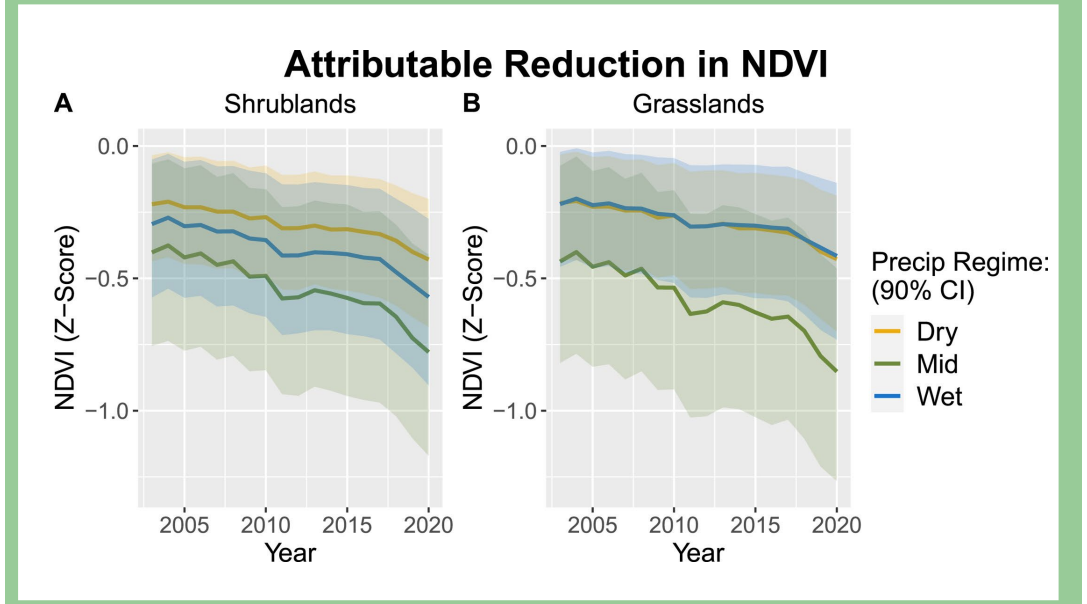


Zhang, et al. (2021) *Geophysical Research Letters.*

NDVI in the US Southwest is declining.



William, et al. (2023) *Earth's Future.*

Native species, Fremont cottonwood is facing widespread mortality.

Photo credit: Hillary Cooper, Tom Whitham

Loss of Fremont cottonwood would affect many areas of the Southwest.

Little, 1971. *Atlas of United States trees.*

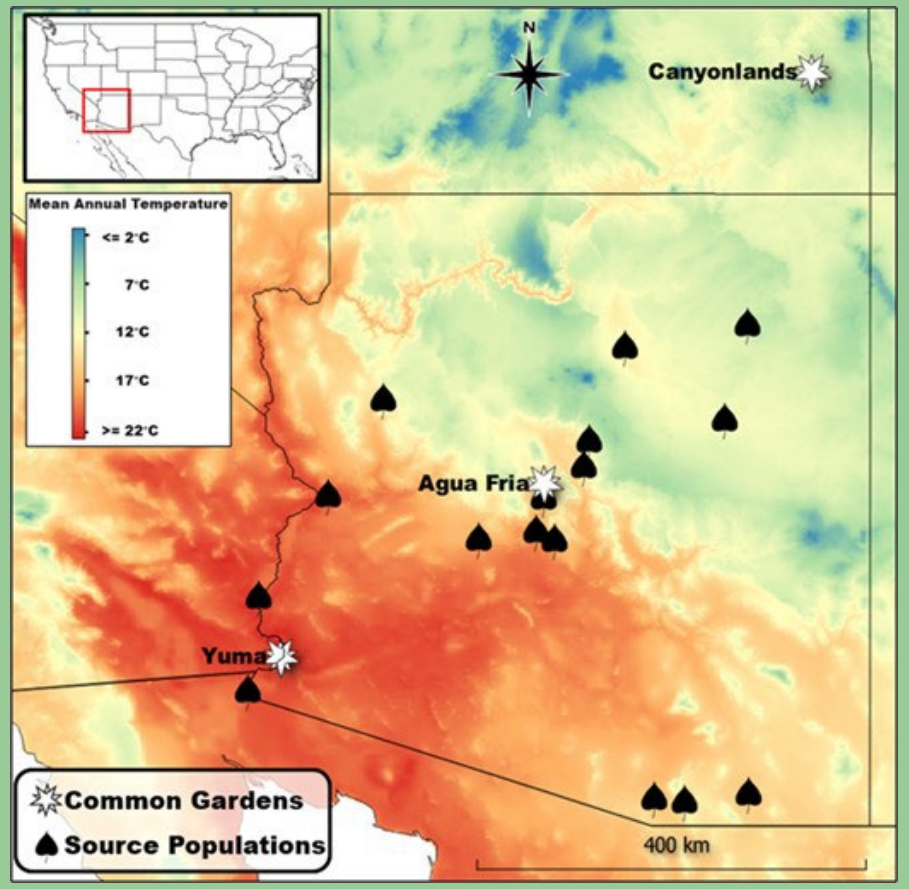
Fremont cottonwood provides ecosystem services such as:

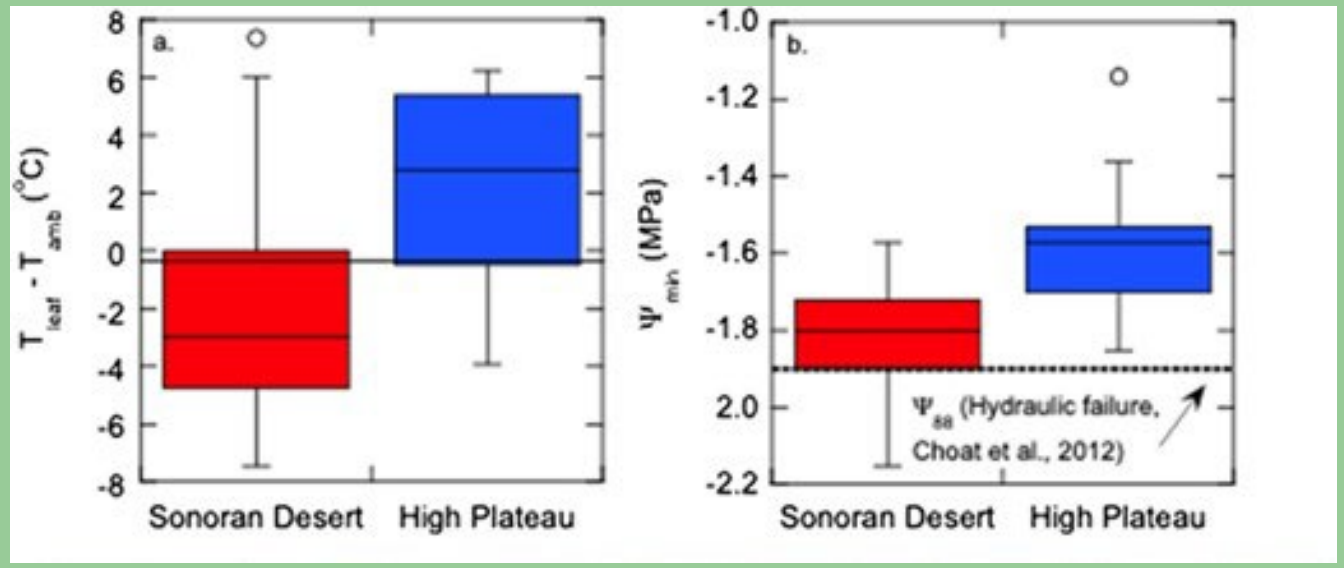
- Contributing to nutrient and water cycles
- Assisting with bank stabilization
- Creating habitat for endangered species
- Serving as a culturally significant species

Why do some individuals survive?

Photo credit: Hillary Cooper, Tom Whitham

Phenotypic plasticity may confer resistance to heat and drought

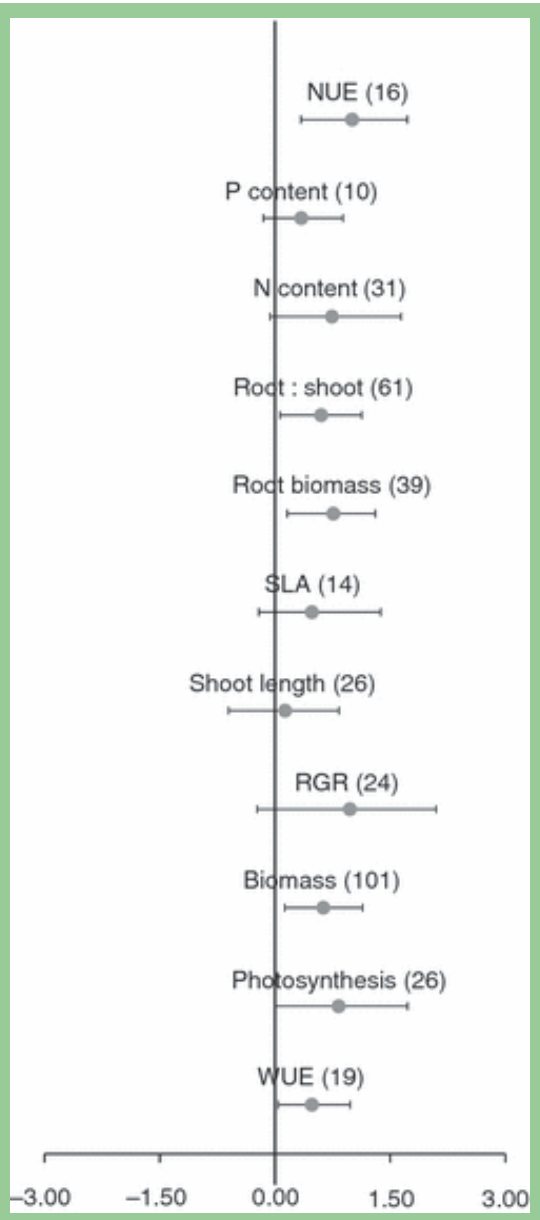




Hultine, et al. (2020) *Conservation Physiology.*

Invasive species are also believed to be highly plastic.

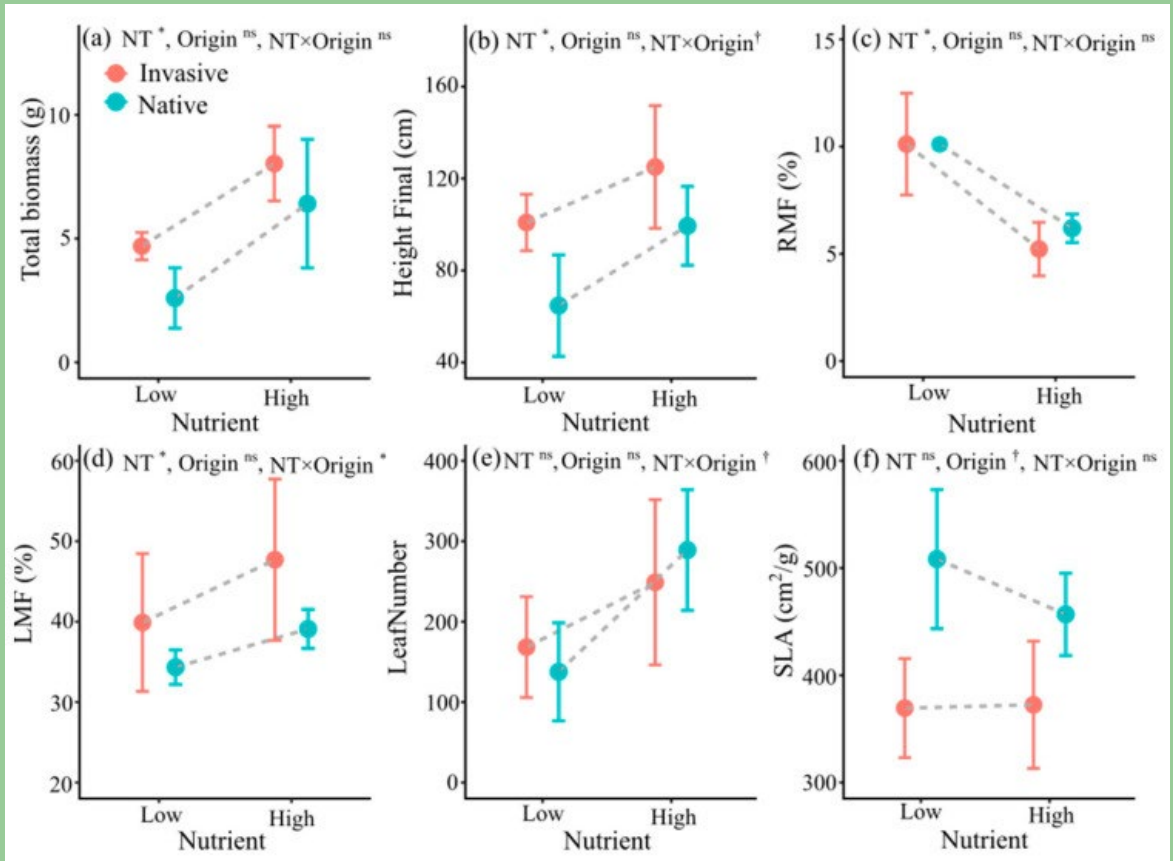
Mean difference in trait plasticity between invasive and native species.



Davidson, et al. (2011)
Ecology Letters

Invasive species are also believed to be highly plastic.

Native herbaceous species more plastic than invasive herbs.



Zhang, et al. (2022) *Life.*

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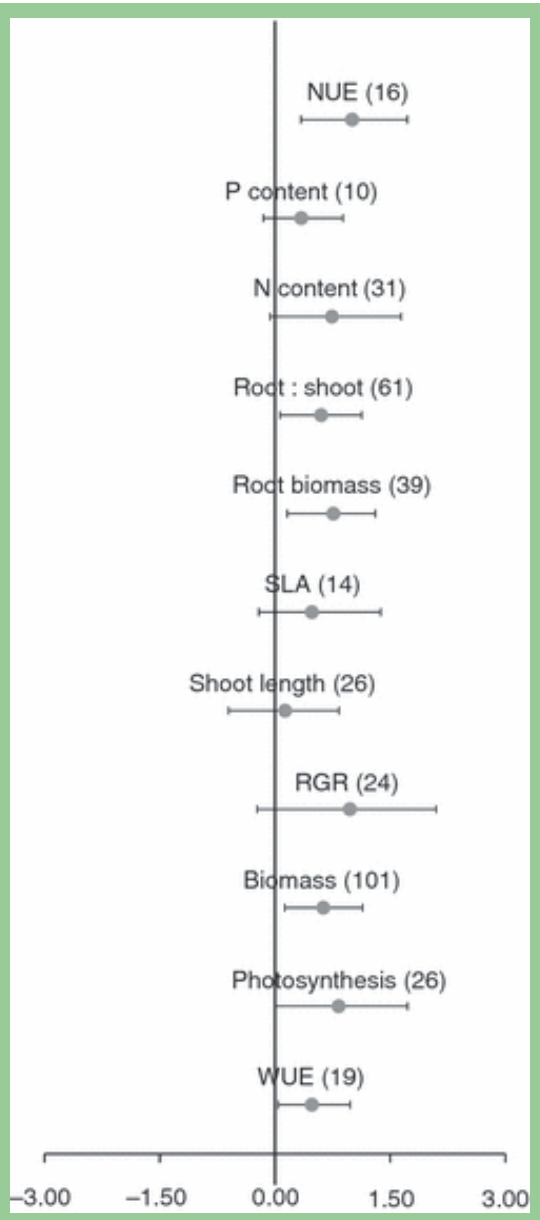


Davidson, et al. (2011) *Ecology Letters*

Additional threats from invasion, like Russian olive may exacerbate these risks.

Pre-restoration

Post-restoration

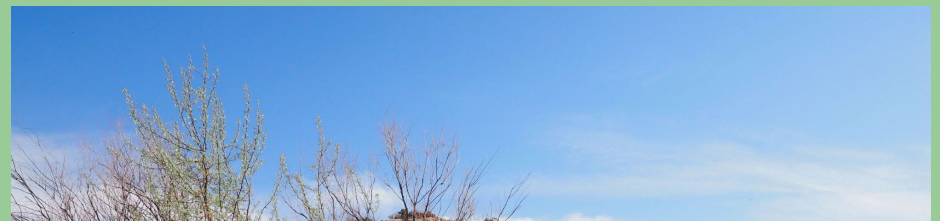
Photo credit: Bill Wolverton

Large removal efforts throughout the West

The Durango Herald

The Colorado Sun

Large removal efforts throughout the West



Little physiology work on Russian olive is available in its invaded range.

The Durango Herald

The Colorado Sun

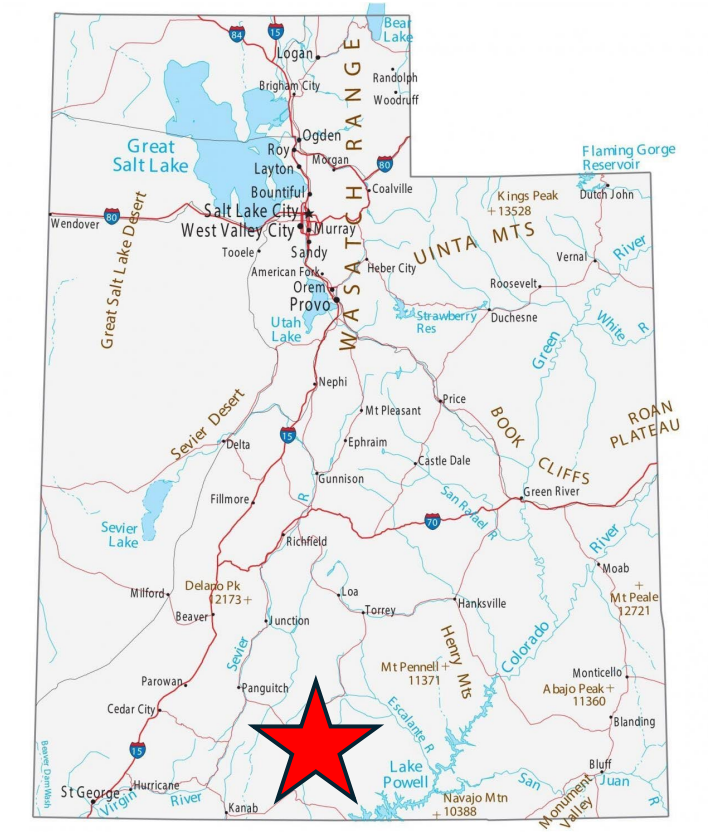
Differences between Russian olive and Fremont cottonwood

1. **Is Russian olive also able to acclimate to climate stress?**

2. **Which species is better suited to increases in heat and drought (represented as VPD)?**

Study Area: The Paria River

Paria River in the Grand Staircase Escalante National Monument



Three sites along an elevation gradient (1800 meters, 1451 meters, and 1400 meters)

Methods

Study period: May through September in 2024 and 2025

Leaf gas exchange: Photosynthetic rate and stomatal conductance with LICOR LI6800 portable photosynthesis machine.

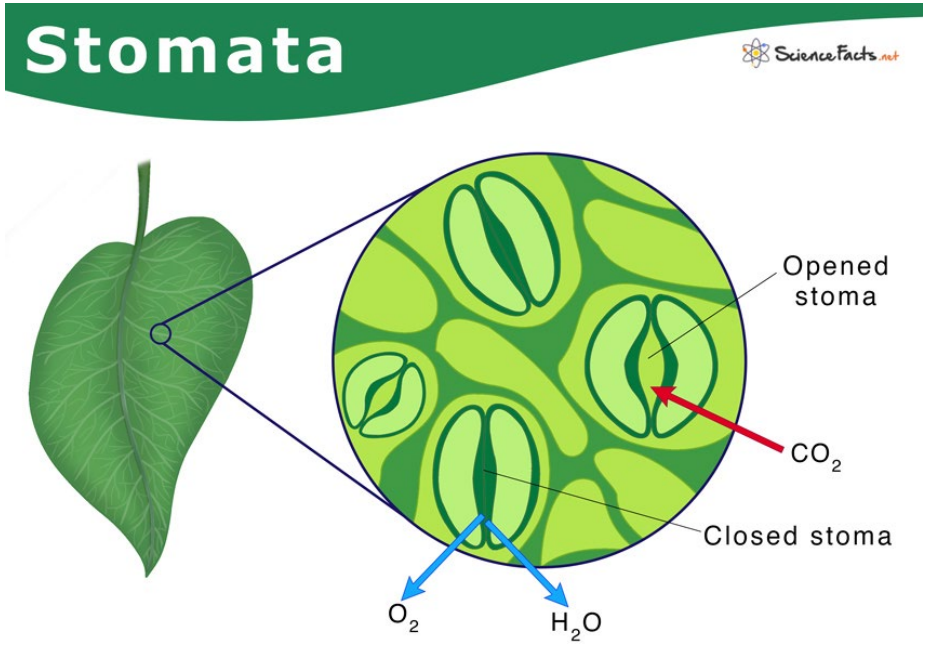
Leaf water potential: Predawn and midday leaf water potential values taken using Scholander pressure chamber.

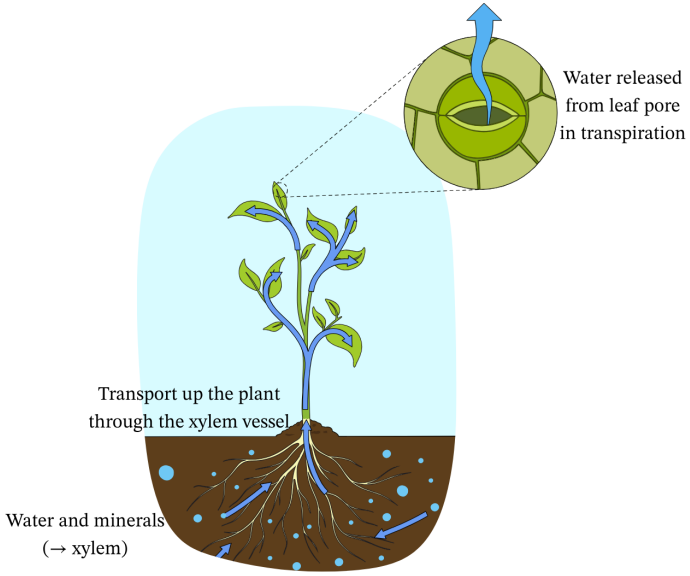
Sapflow: Trees instrumented with sensors using the Granier heat dissipation method.

Site Climate Data: Meter ATMOS 41 weather station installed in the center of the site in July 2024.

Undergraduate, Brandt Winn

What are we measuring?





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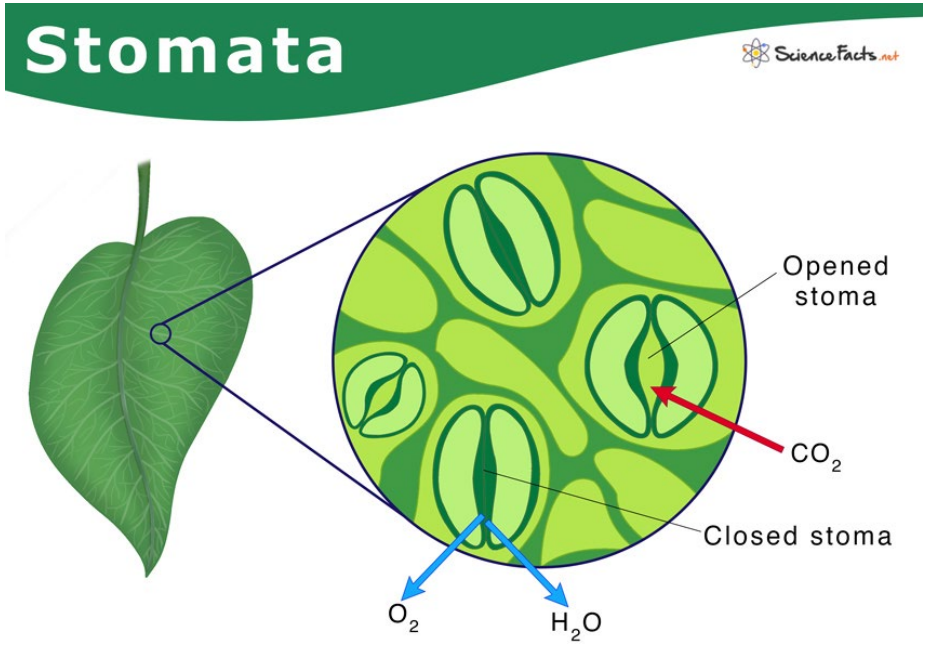
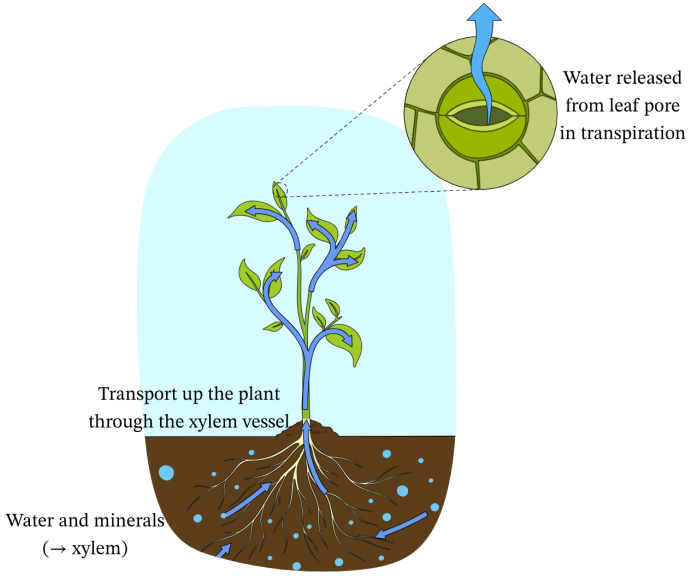
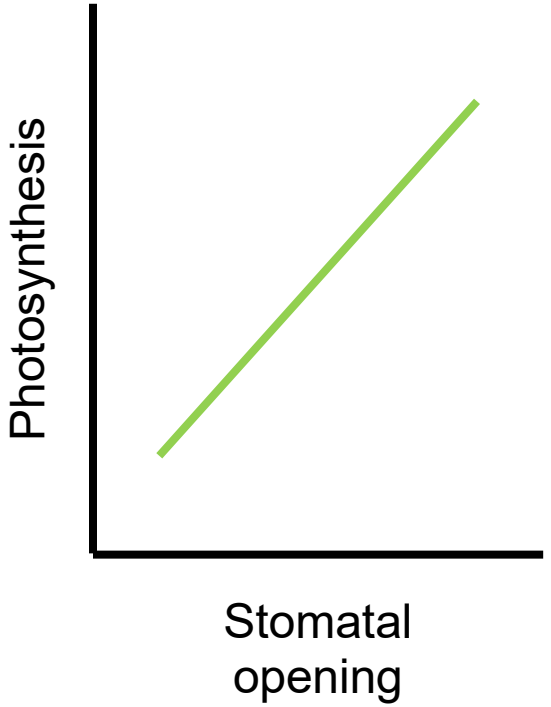
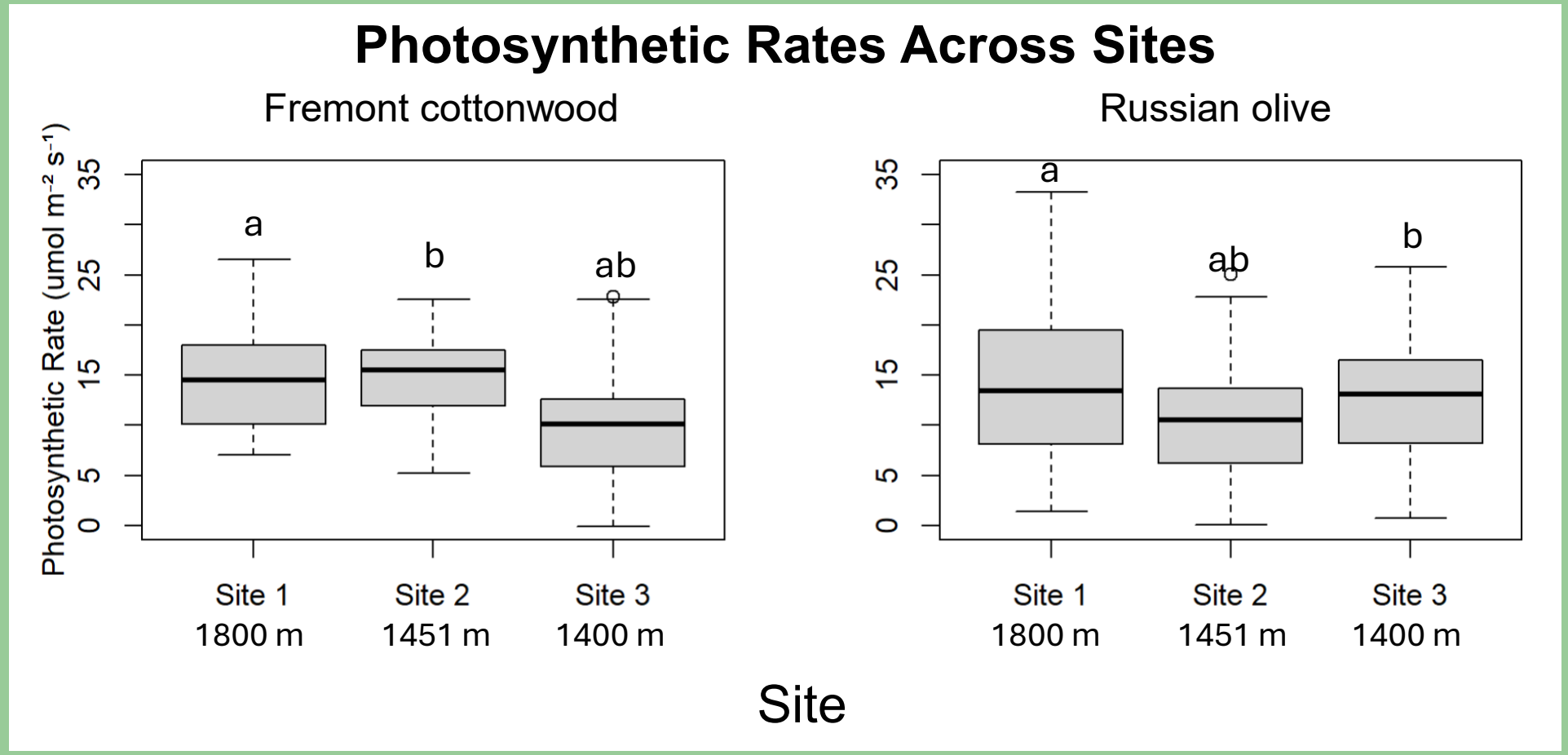






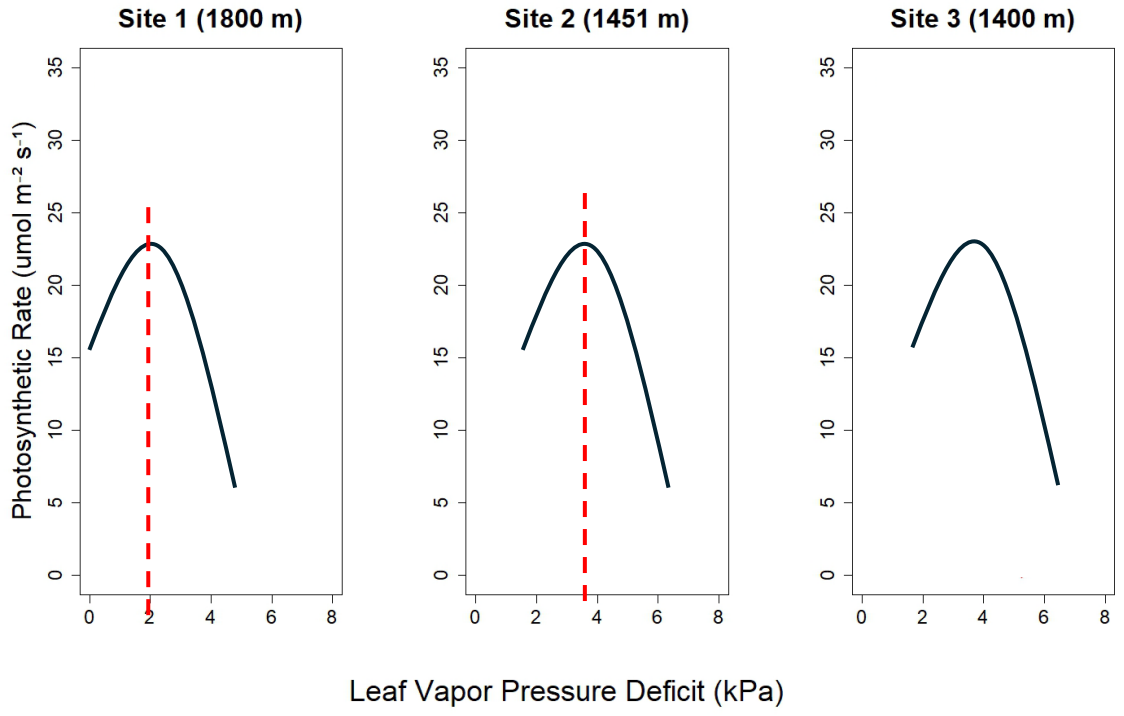
Does photosynthetic rate vary across sites?



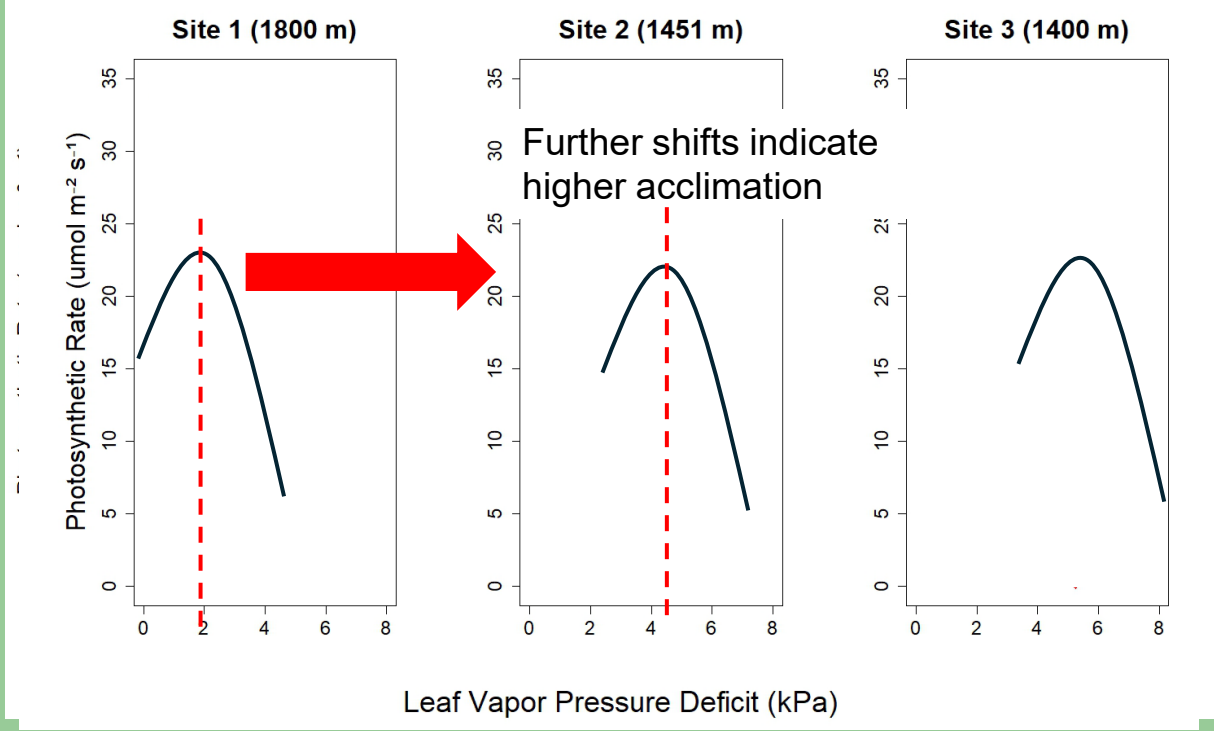
Does response vary by elevation?

Photosynthetic Rate at Different Elevations

Fremont cottonwood



Russian olive



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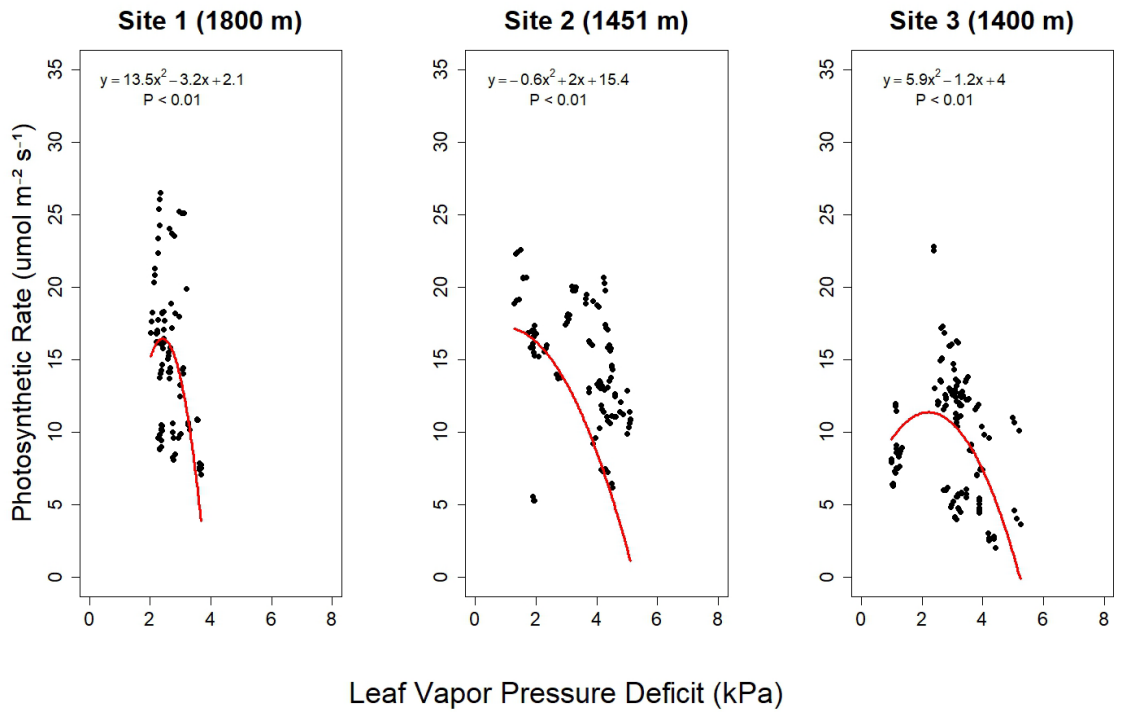
Photosynthetic Response to VPD at Different Elevations

Fremont cottonwood



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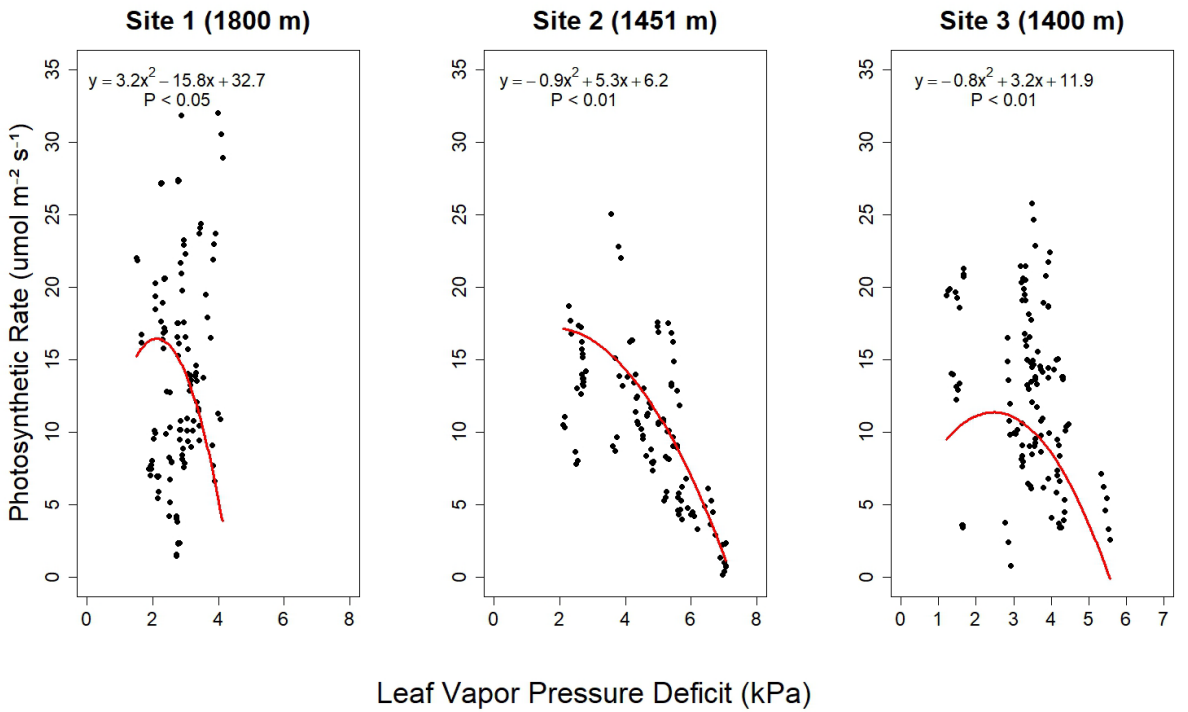

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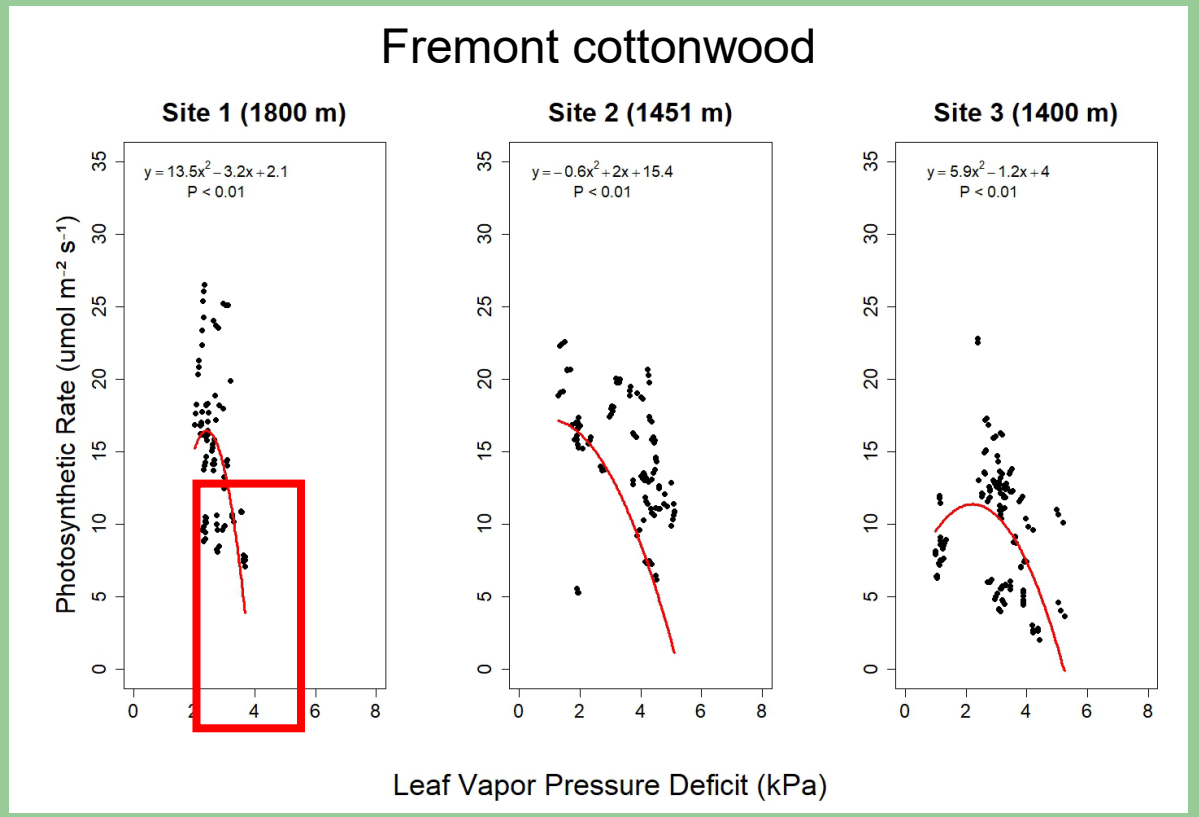

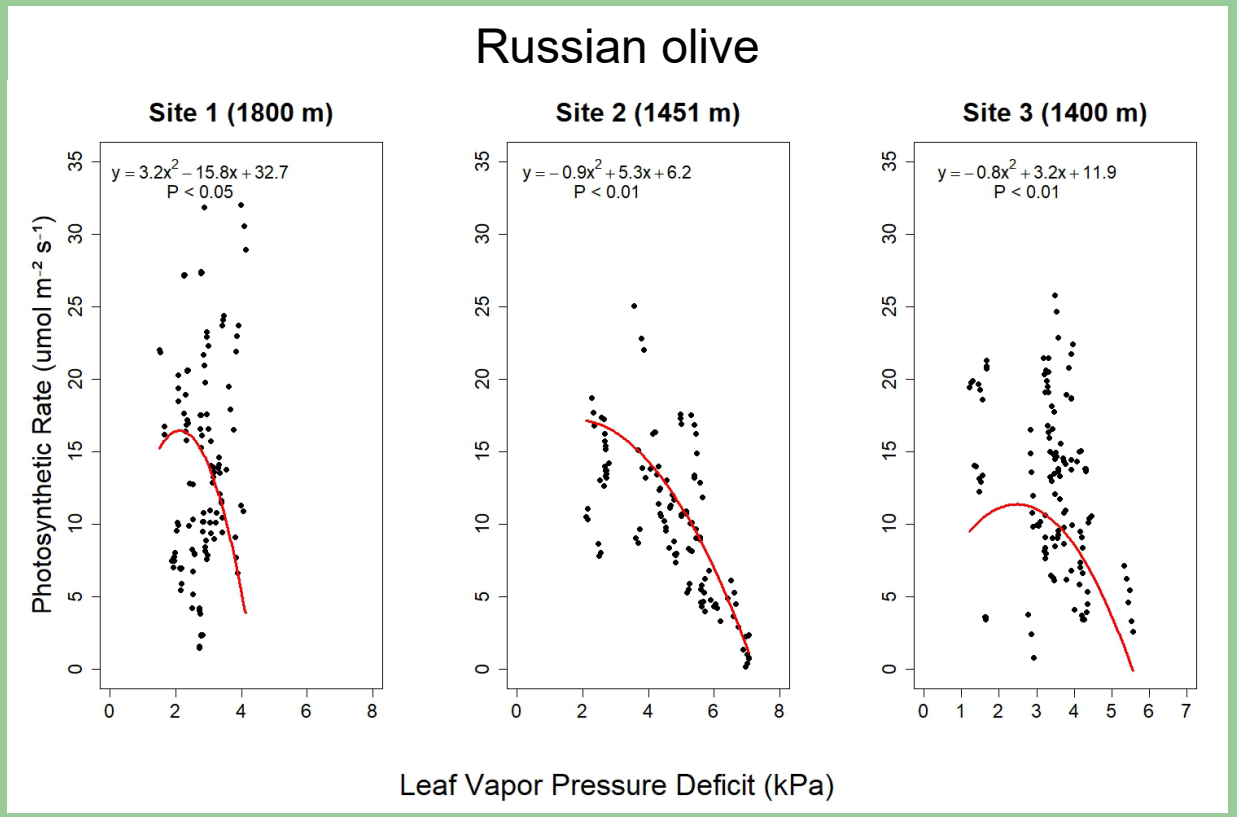

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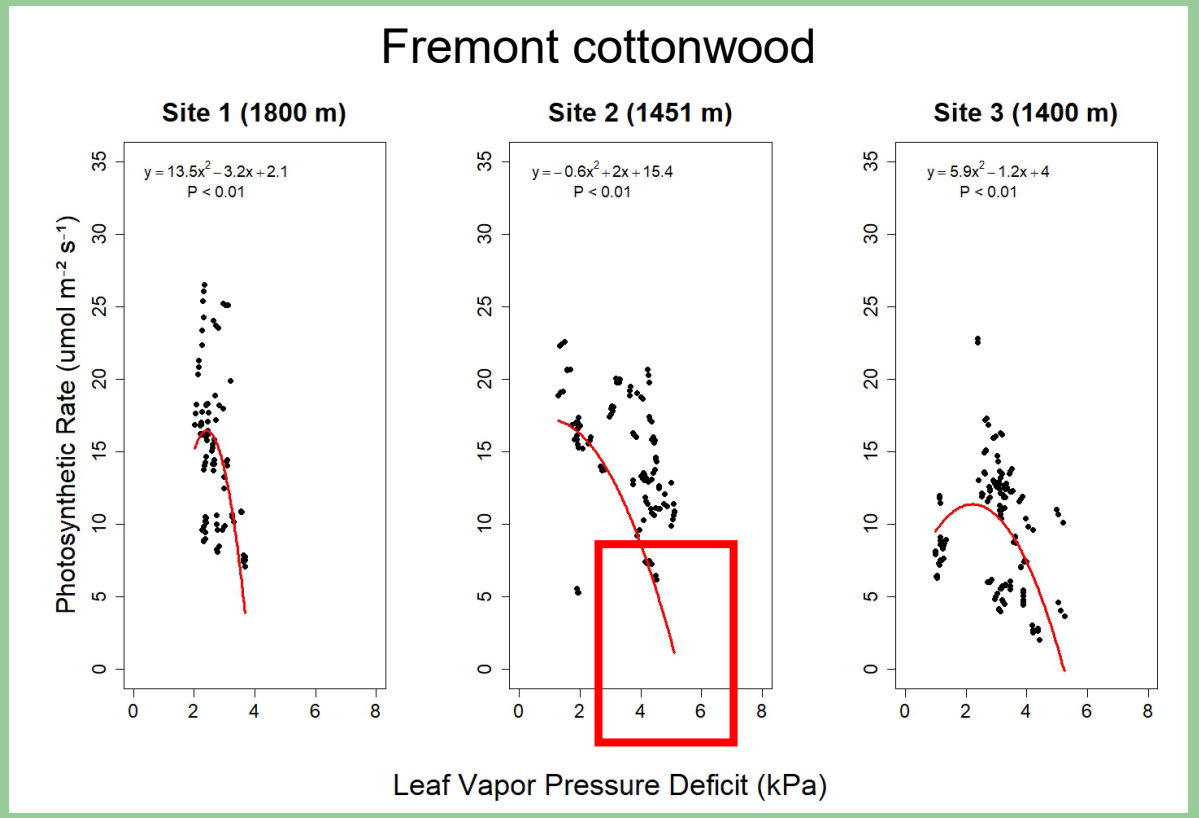
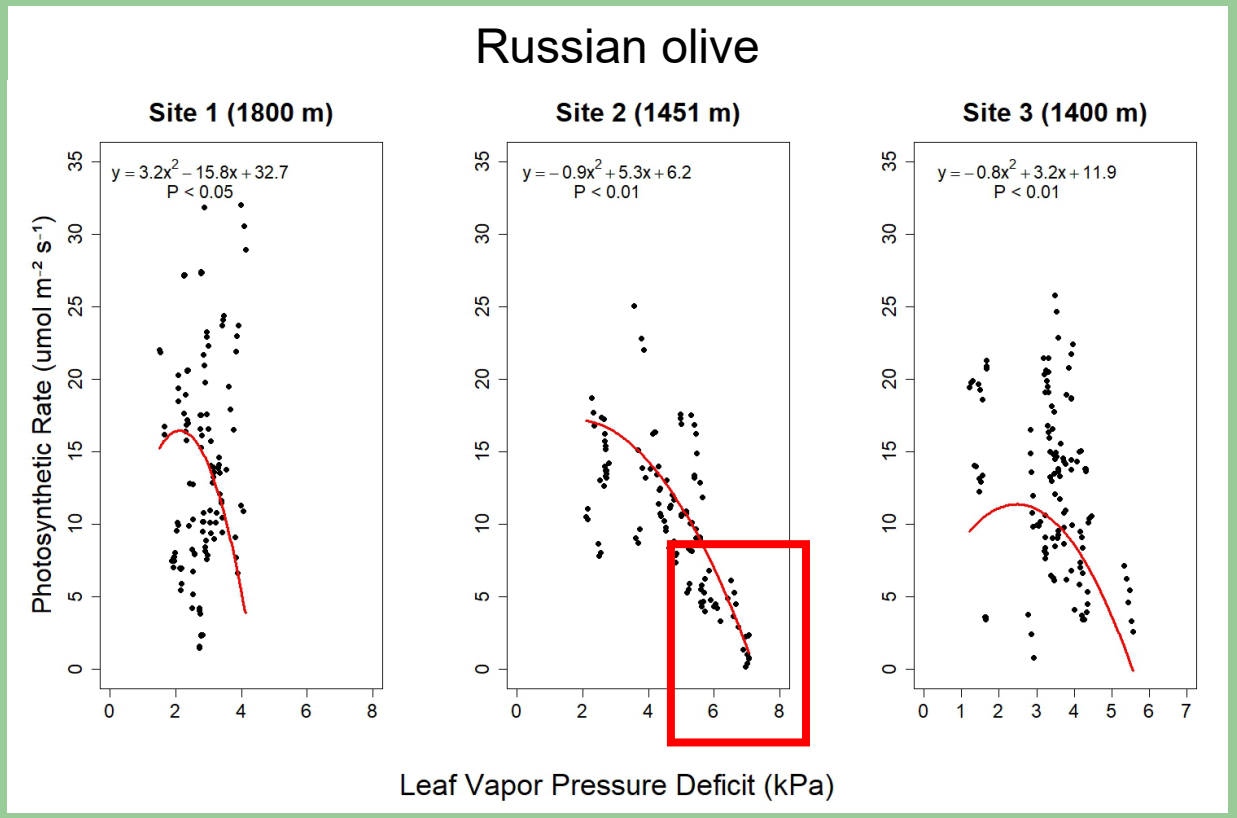
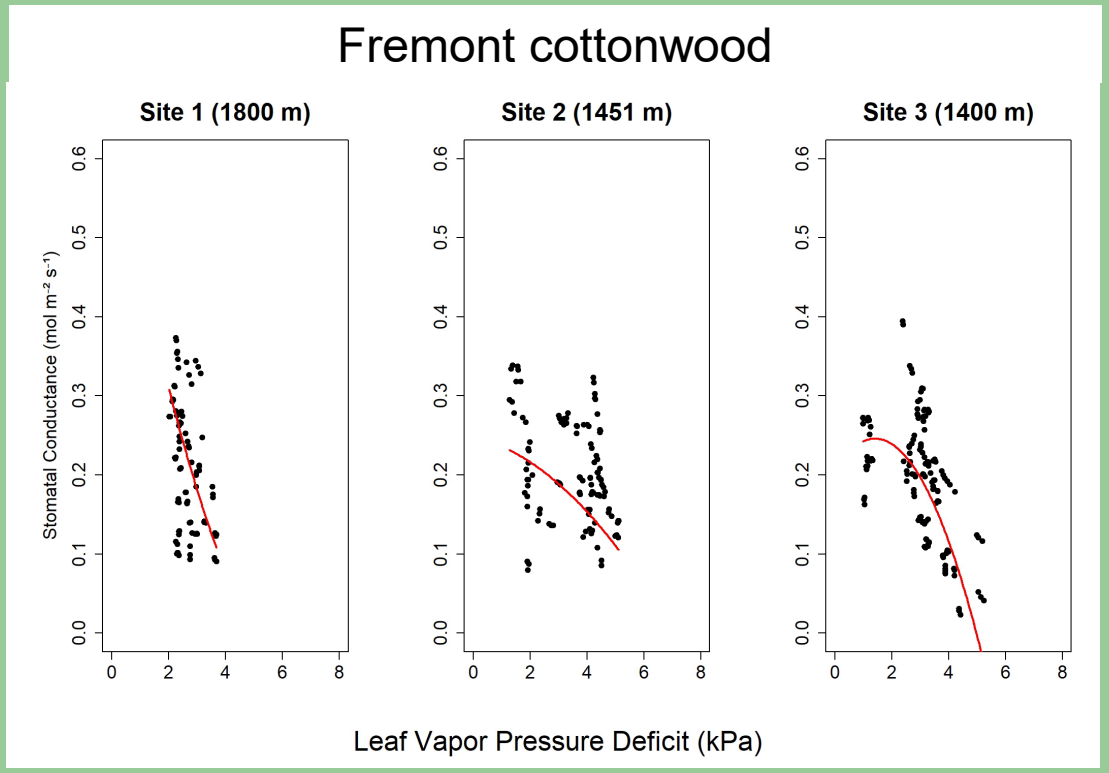
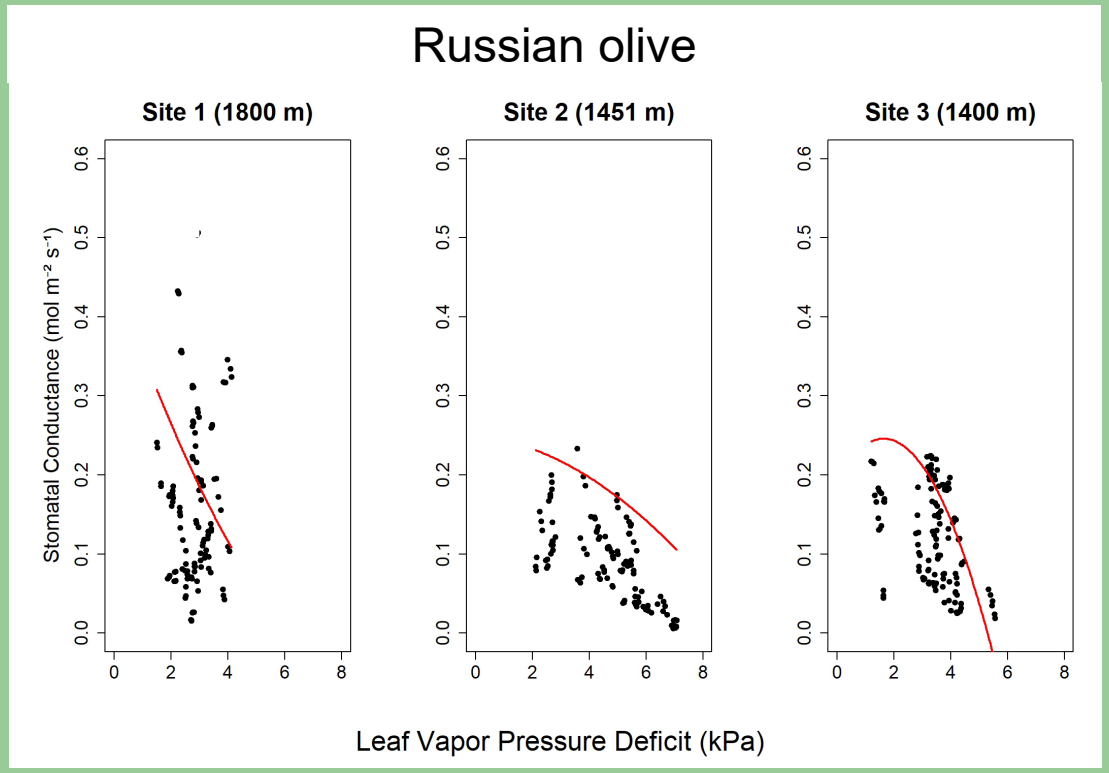




Does response vary by elevation?

Stomatal Response to VPD at Different Elevations





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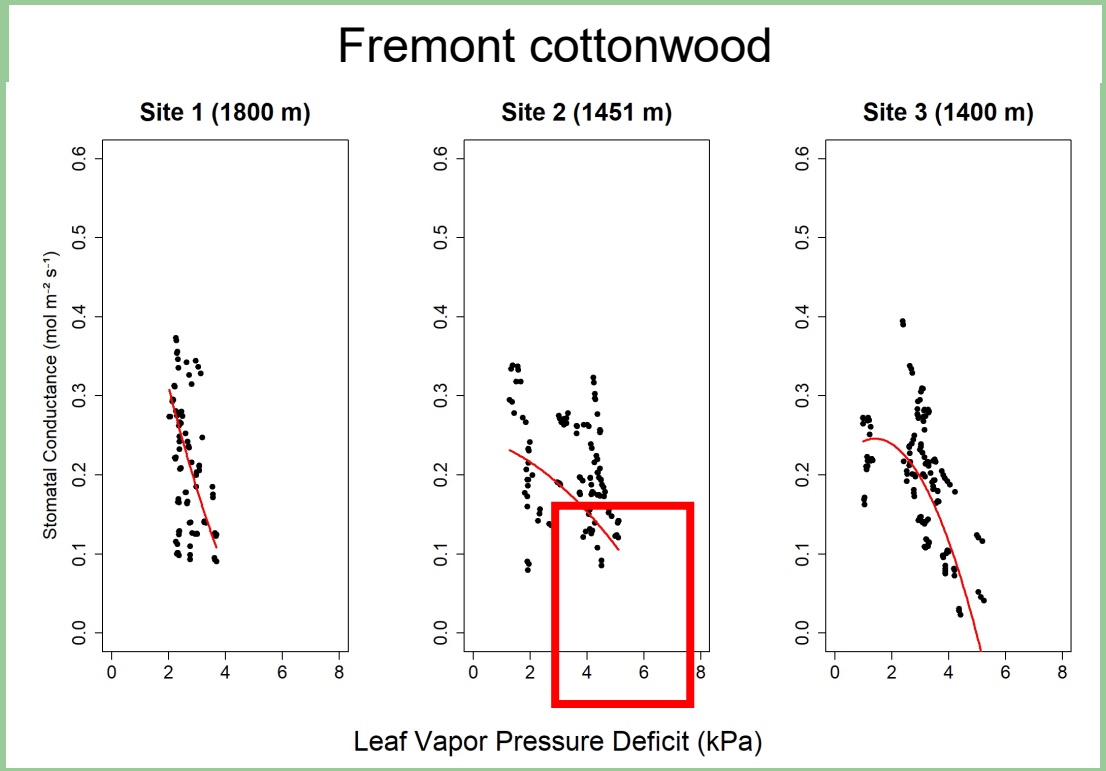
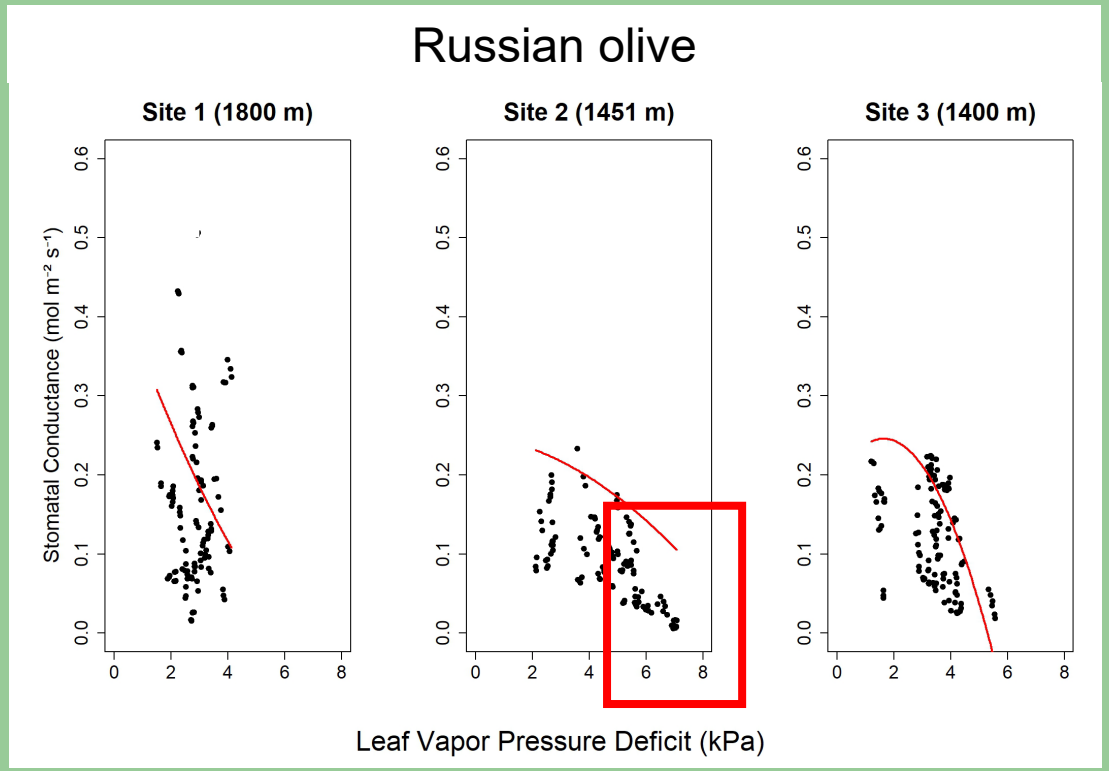
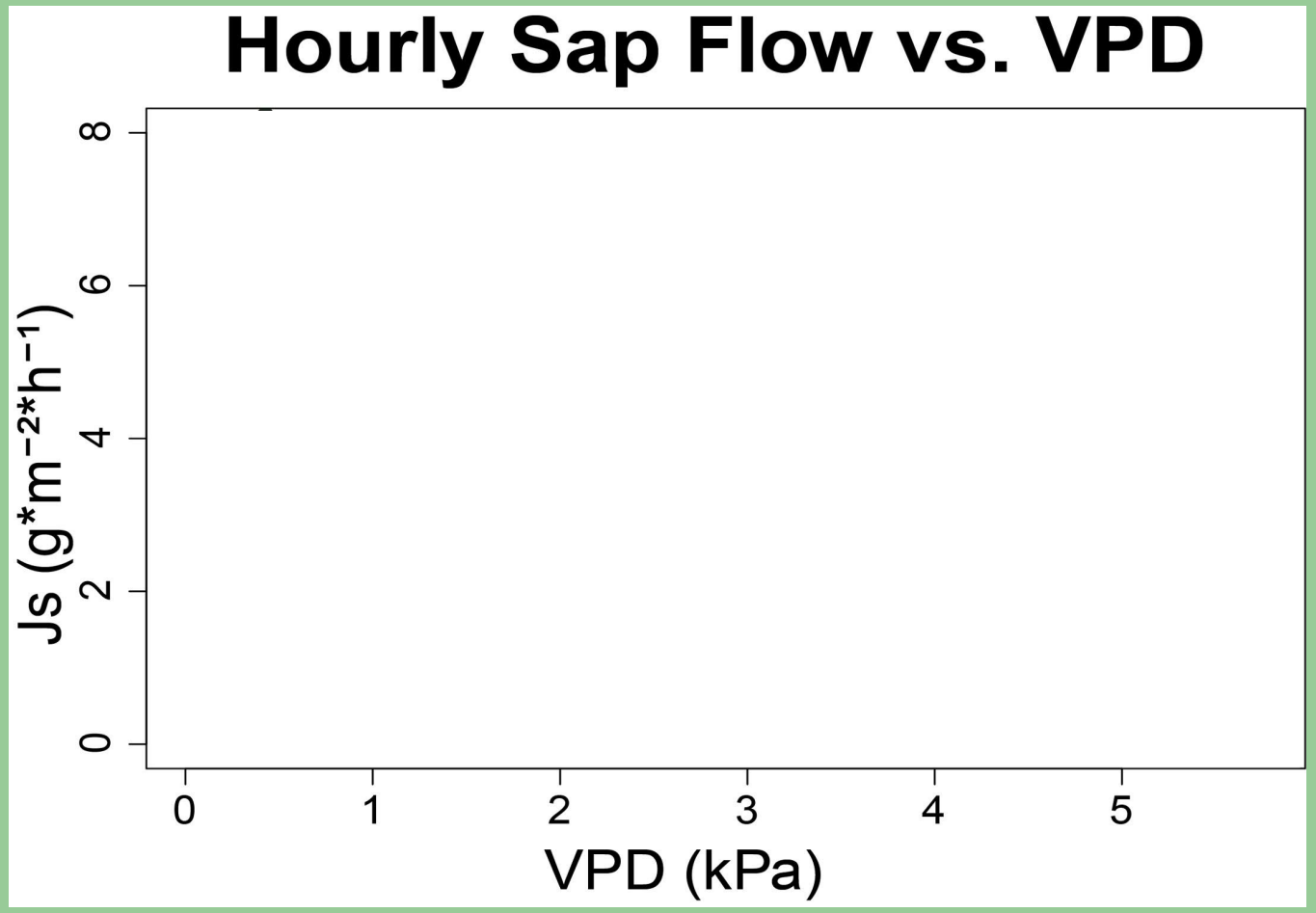
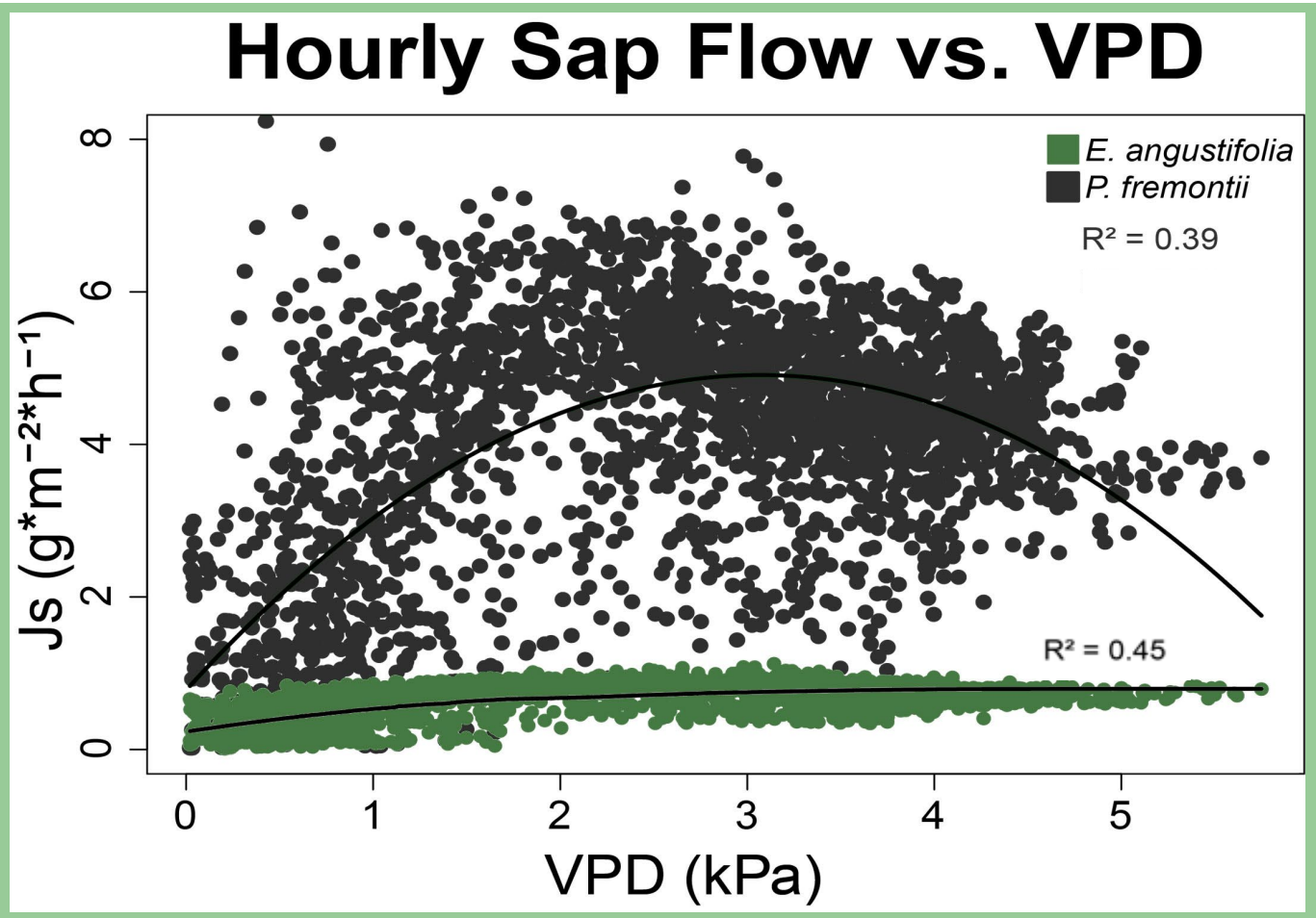




Hydraulic Sensitivity to VPD



Russian olive is less sensitive to VPD than Fremont cottonwood.



Differences between Russian olive and Fremont cottonwood*:*

1. **Is Russian olive also able to acclimate to climate stress?**

   Both species shift photosynthetic rate and stomatal regulation, depending on site conditions. Russian olive is similarly plastic compared to Fremont cottonwood.

2. **Which species is better suited to increases in heat and drought (represented as VPD)?**

   Russian olive seems to be more resilient to increases in VPD, leaving stomata open at higher VPDs, allowing photosynthesis and sap flow to continue.

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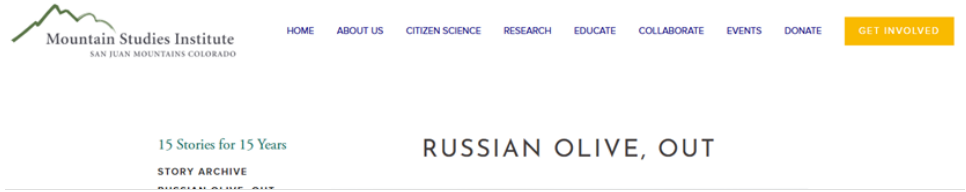
3. **Which species utilizes more water at the individual and stand level?**

Large removal efforts throughout the West

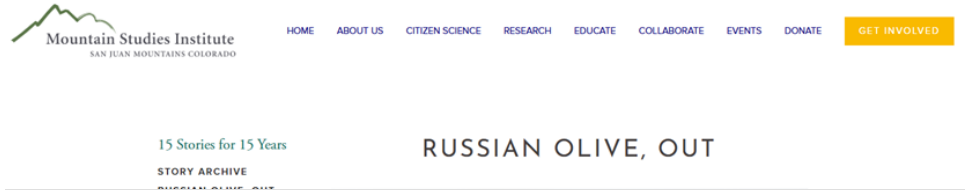
The Durango Herald



"These silvery leafed trees gulp up **75 gallons of water a day** and eagerly push out native trees, including willows and cottonwoods."

"Russian olives drink around 1.6 acre-feet of water each year, according to some sources, and up to **200 gallons per day** per plant according to others."

Large removal efforts throughout the West



No tree-level study validates that water use of Russian olive in its invaded range.

The Durango Herald

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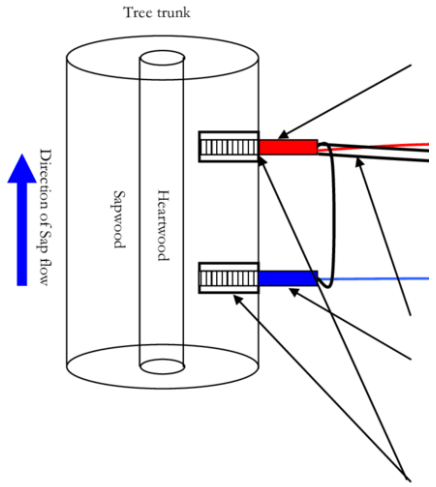
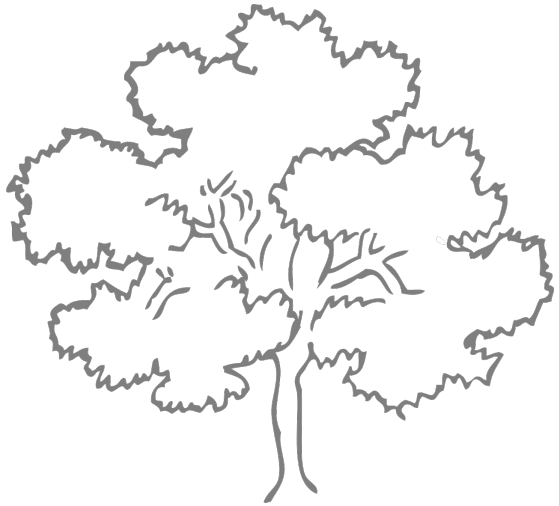
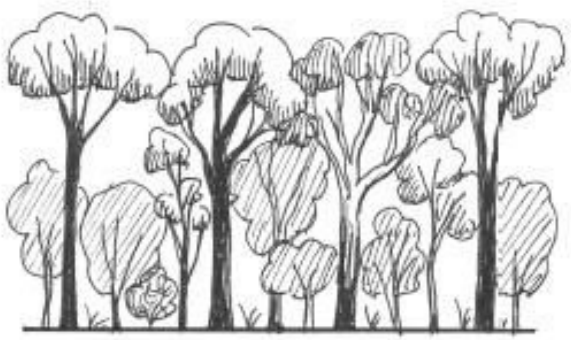
Upscaling sapflow



Point Measurement:
Obtained from the sensor

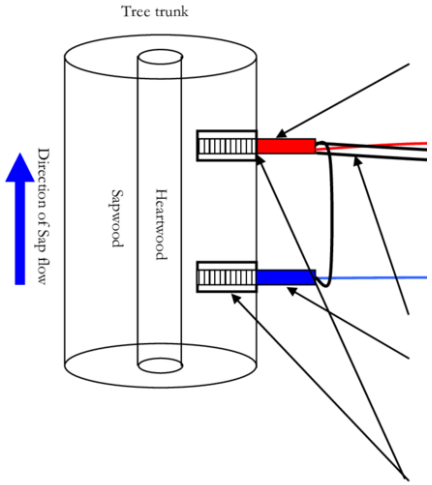


Tree Level:
Uses the size of the tree and total active sapwood area



Stand Level:
Uses the number and size of trees in stand

Upscaling sapflow



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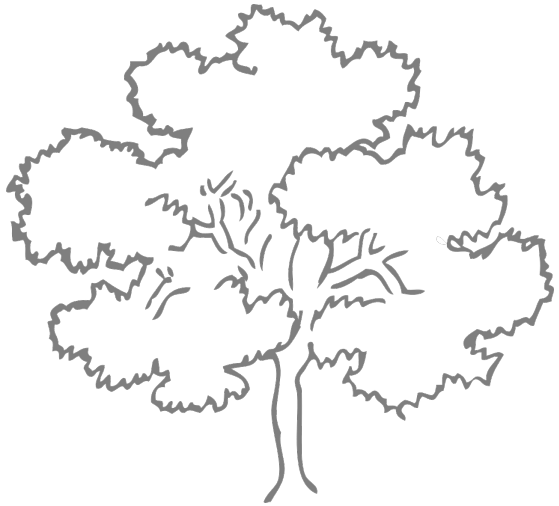

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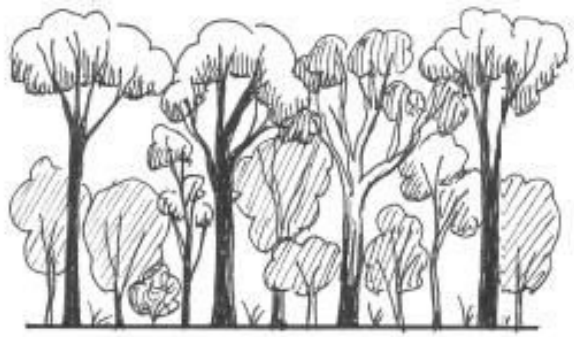

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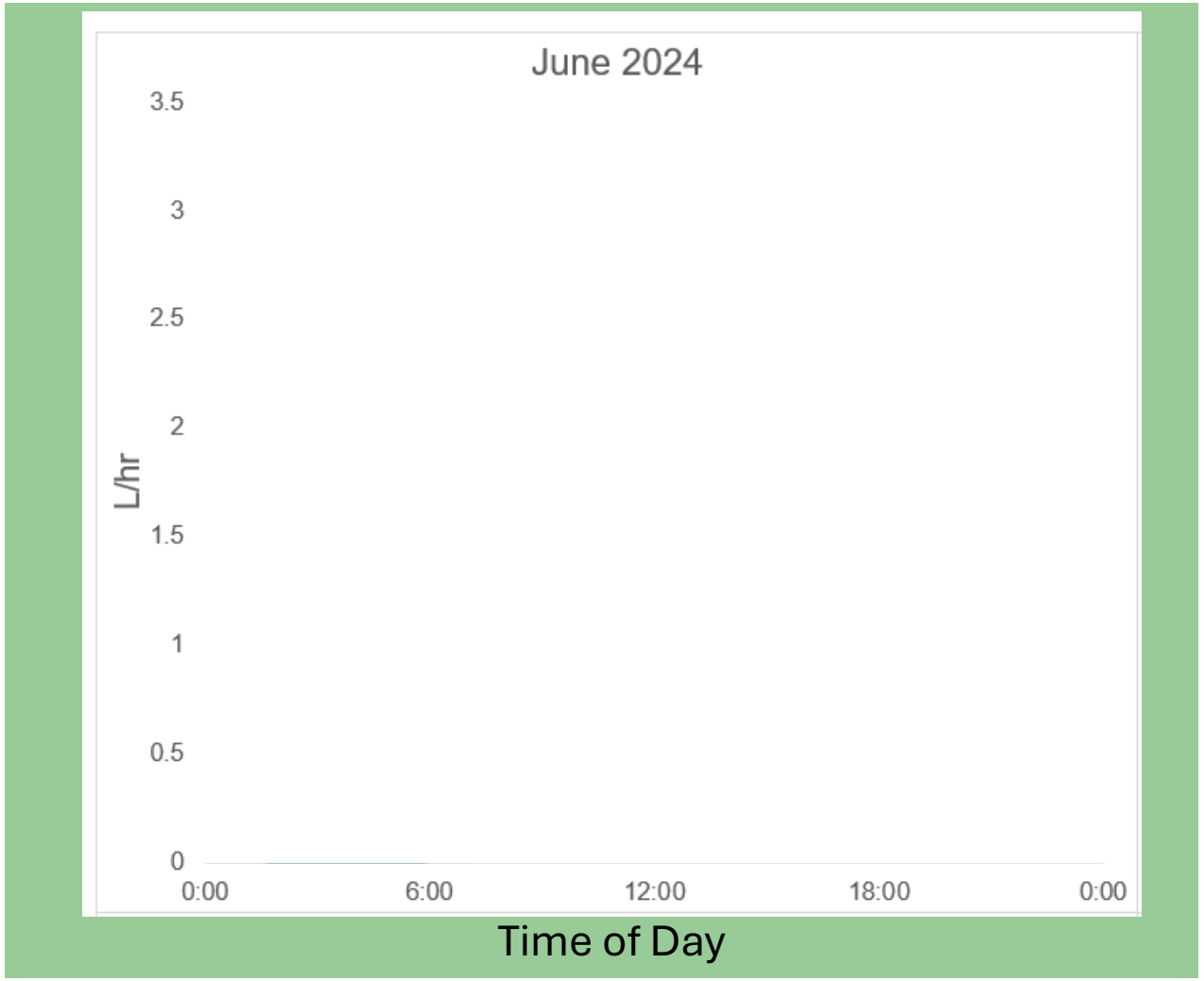
Does *Russian olive* use more water than *Fremont cottonwood?*

Tree Level Sapflow

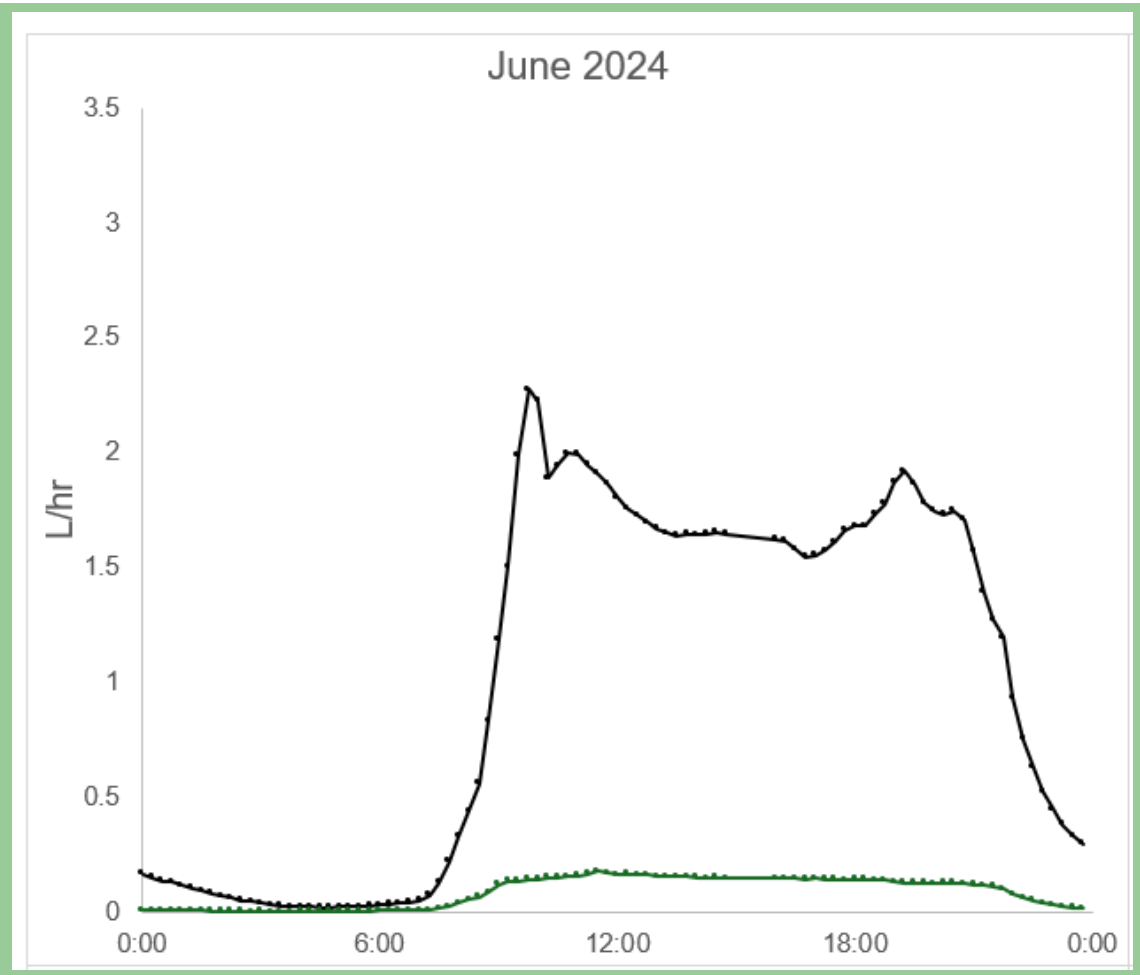


Fremont cottonwood (native)

Russian olive (invasive)

Does Russian olive use more water than Fremont cottonwood?

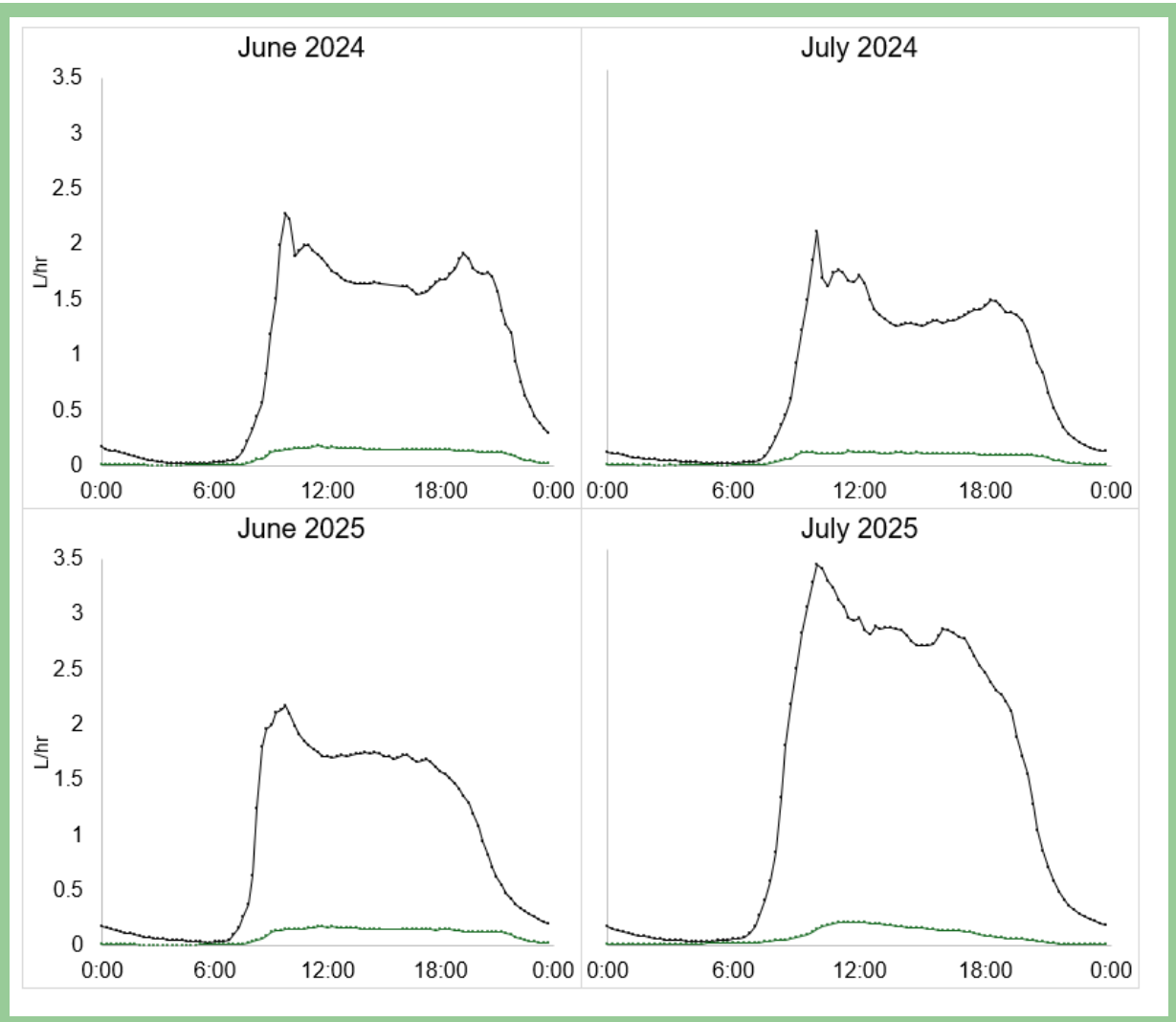
Tree Level Sapflow



Fremont cottonwood (native)

Russian olive (invasive)

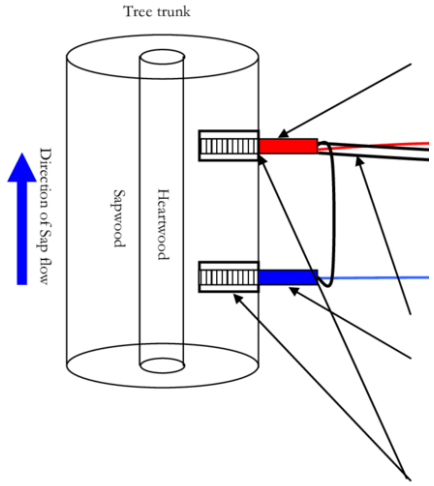
This is consistent across hottest months.



Fremont cottonwood (native)

Russian olive (invasive)

Stand level sapflow:



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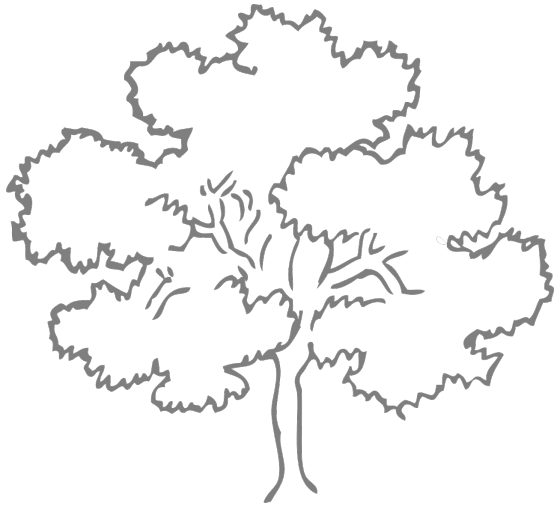

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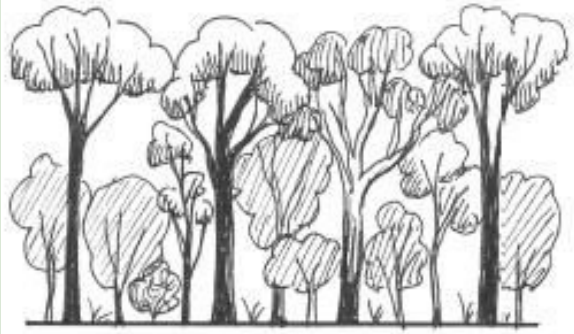
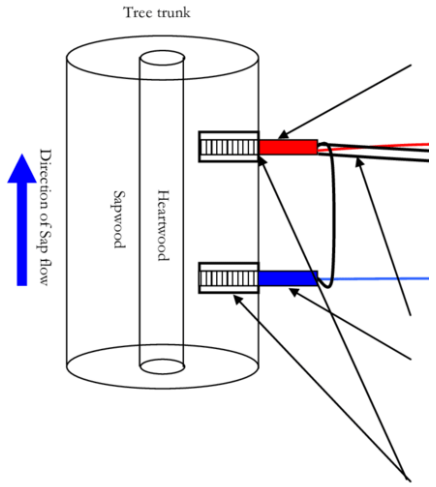


Stand Level:
Uses the number and size of trees in stand

Stand level sapflow:

Fremont cottonwood = 63; Russian olive = 64



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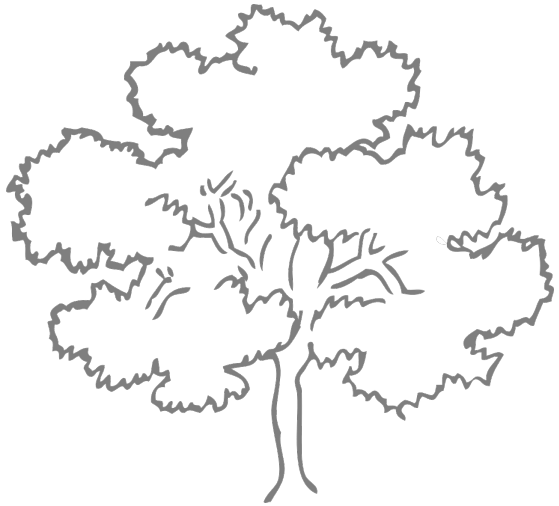

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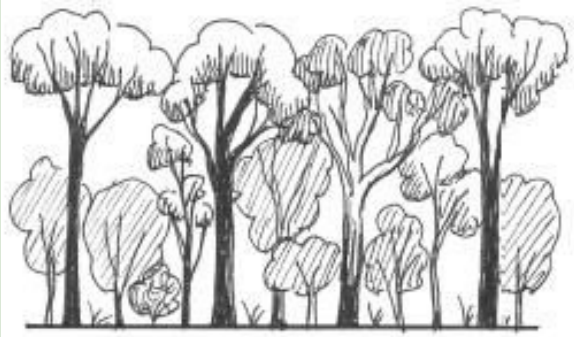

Stand Level:
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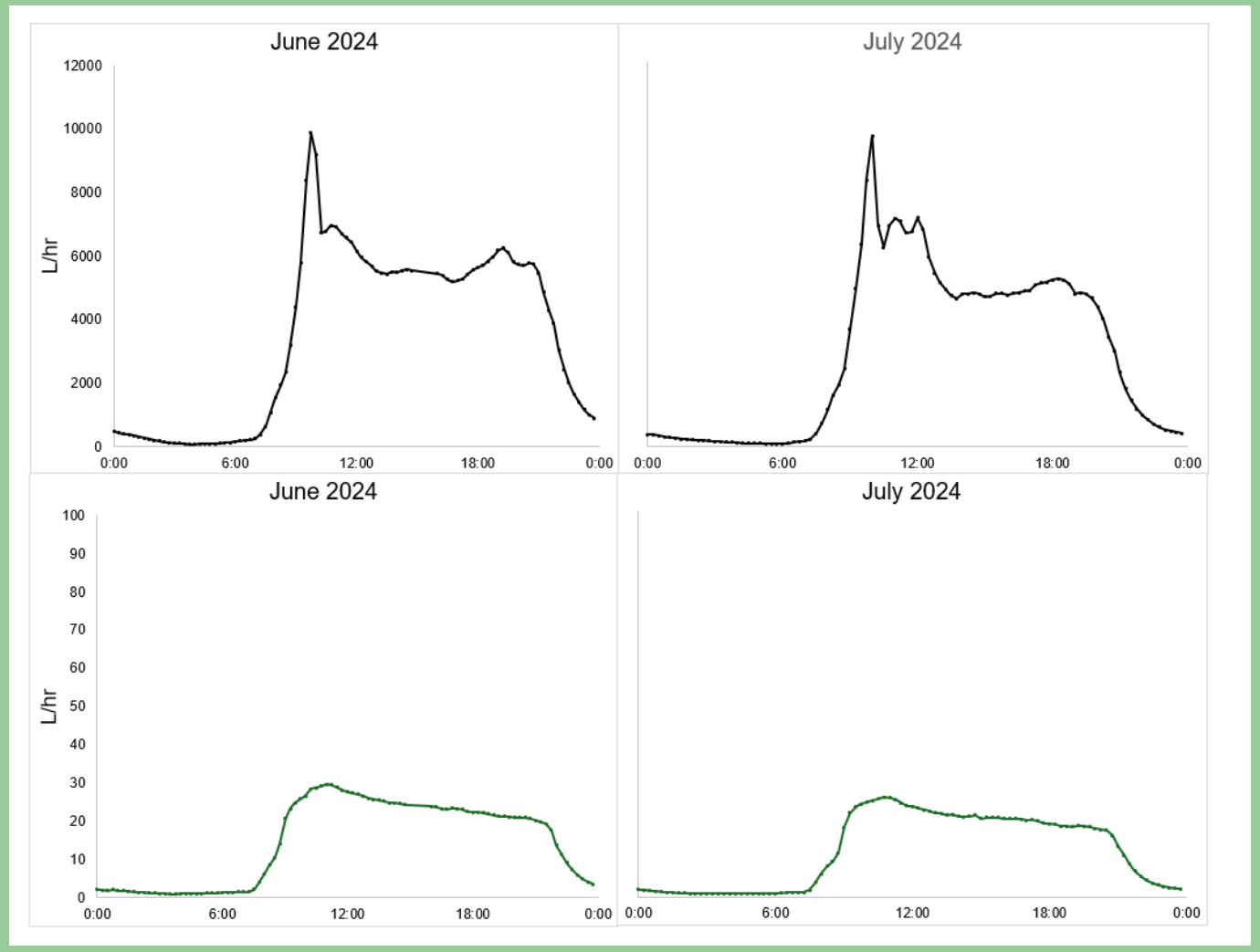
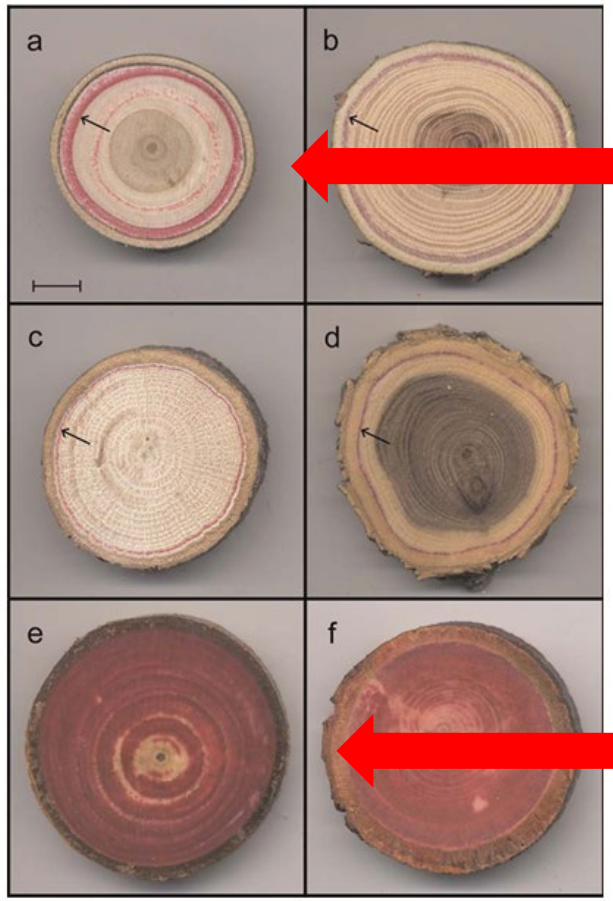
At the stand level, Russian olive utilizes even less water compared to Fremont cottonwood.



Fremont cottonwood (native)

Russian olive (invasive)

This may be driven by differences in wood anatomy.



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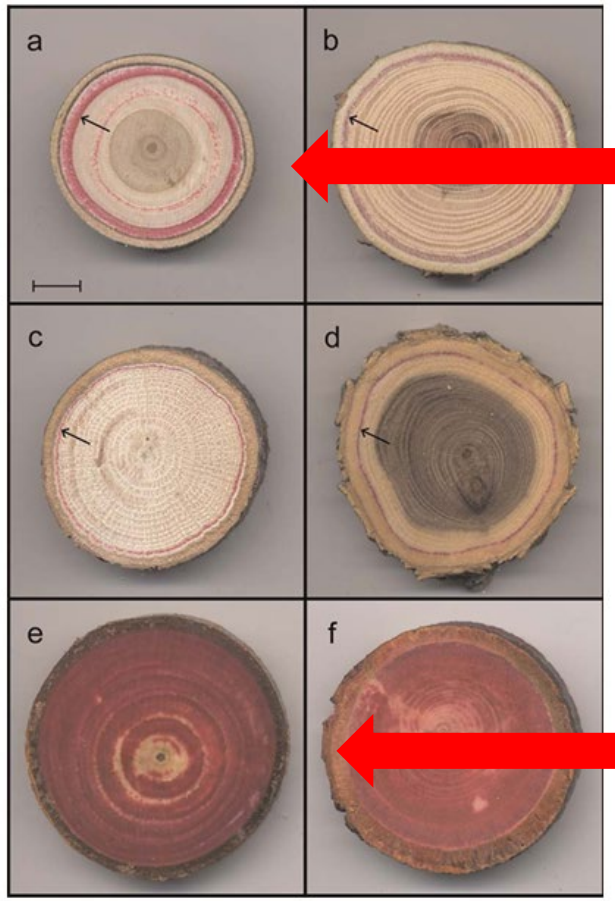

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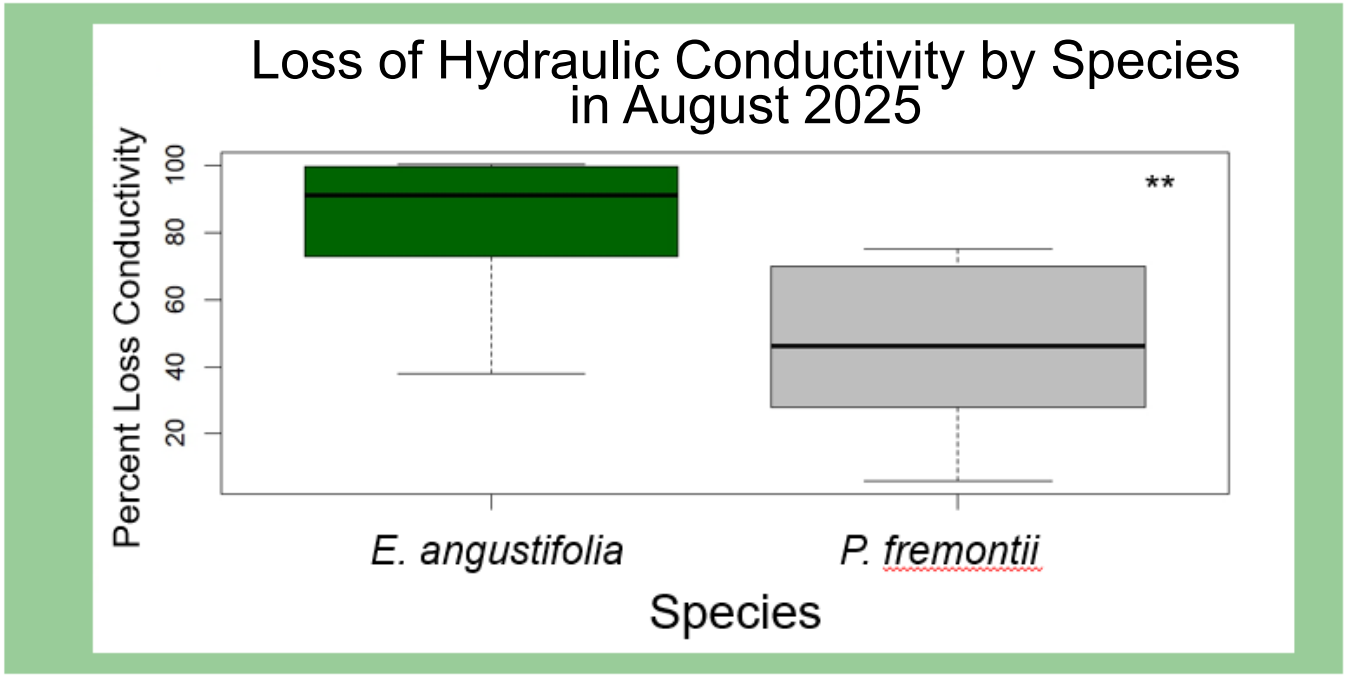
Fremont cottonwood



n = 12 *E. angustifolia*; 11 *P. fremontii*

Differences between *Russian olive* and *Fremont cottonwood:*

1. **Is *Russian olive* also able to acclimate to climate stress?**

   Both species shift photosynthetic rate and stomatal regulation, depending on site conditions. Russian olive is similarly plastic compared to Fremont cottonwood.

2. Which species is better suited to increases in heat and drought (represented as VPD)?

Russian olive seems to be more resilient to increases in VPD, leaving stomata open at higher VPDs, allowing photosynthesis and sap flow to continue.

3. Which species utilizes more water at the individual and stand level?

Russian olive utilizes less water when compared to Fremont cottonwood. This is likely due to differences in wood anatomy.

Invasion affects more than just water availability…

How do plant communities change when Russian olive is present?

Repeat photography project led by undergraduate Maddie West

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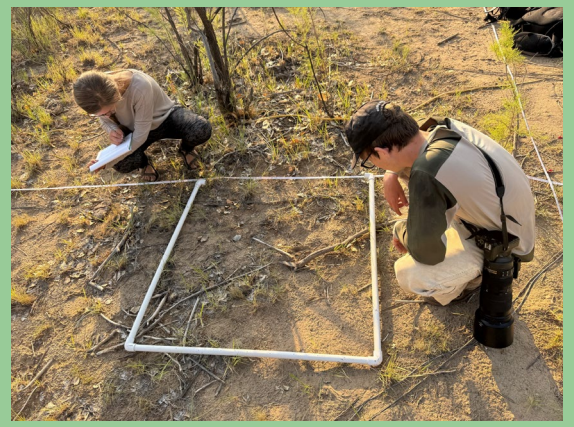
Can native biodiversity be restored post-removal?



Biodiversity surveys led by (previous!) undergraduate Tucker Hastings

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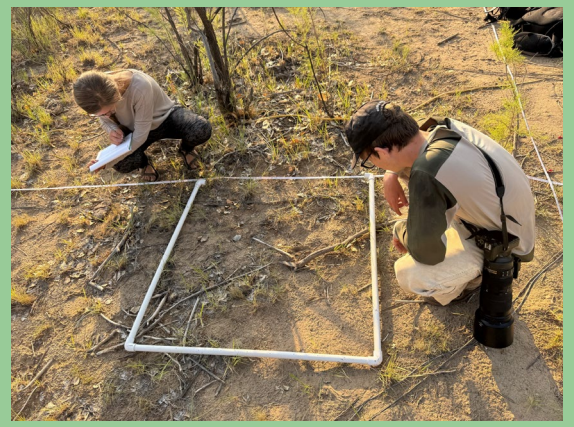

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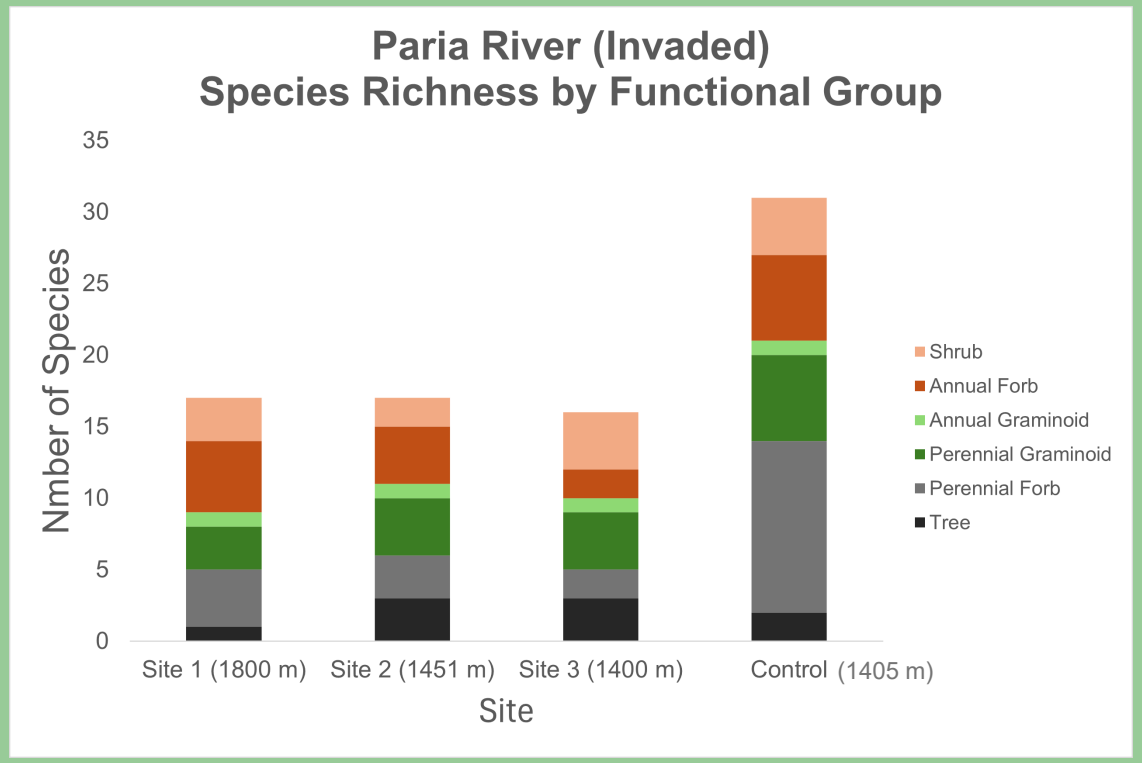
How does removal affect water availability?

Water table monitoring project starting this year.

What does this mean for future removal?

- Removal of Russian olive may not lead to a massive increase in water availability (however more validation is needed.)
- Russian olive may be better suited to survive increasing environmental stress.
- Russian olive does decrease native biodiversity.



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