Assessing the Ecohydrological Response to Juniper Control

A collaborative effort between OSU, HSWCD, CCSWCD, Crook County, BLM, & multiple landowners in Crook County and Harney County

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Funding: Oregon State Legislature, BLM, OSU, OWEB, NFWF

OUTLINE

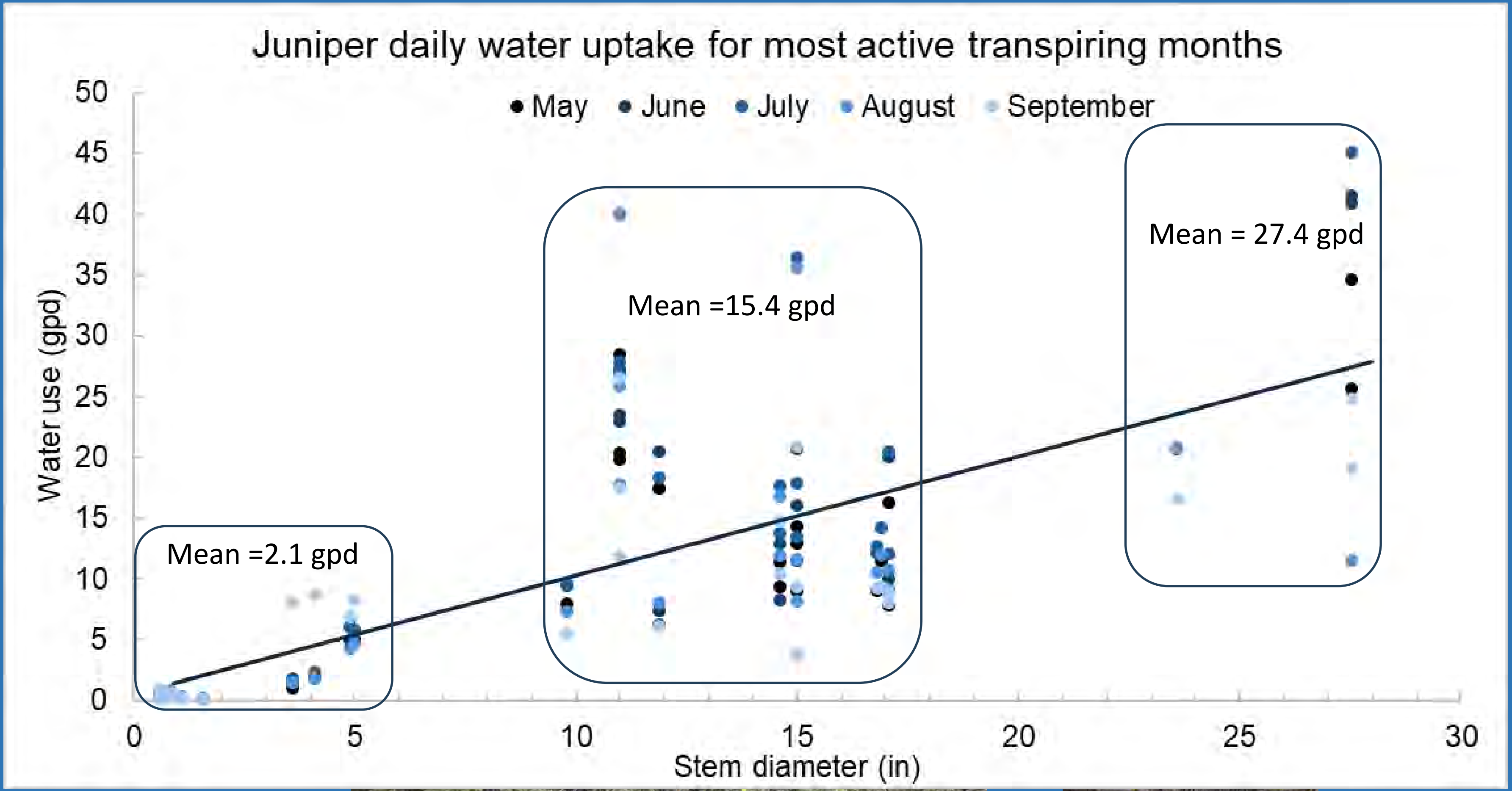
- Introduction - Doug Riggs and Tim Deboodt
- Ecohydrology of Juniper Control - Carlos Ochoa (OSU)
    - Ongoing Collaborations - Jason Kesling (Harney SWCD)
    - New monitoring projects – Carlos Ochoa (OSU) and Skyler Hickey (BLM)
        - Crook County – Crook County SWCD, OSU, Crook County, Landowners
        - The Drewsey Project – BLM, OSU, Harney SWCD, Landowners
- Closing remarks - Doug Riggs and Tim Deboodt
- Q&A

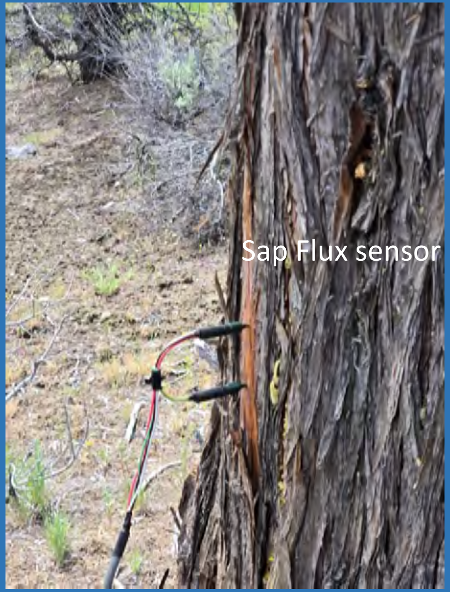
Background

- Woody vegetation species are expanding worldwide.
- When is juniper expansion a problem?
- Juniper control offers an opportunity to enhance or reestablish the ecohydrological function in rangeland ecosystems.

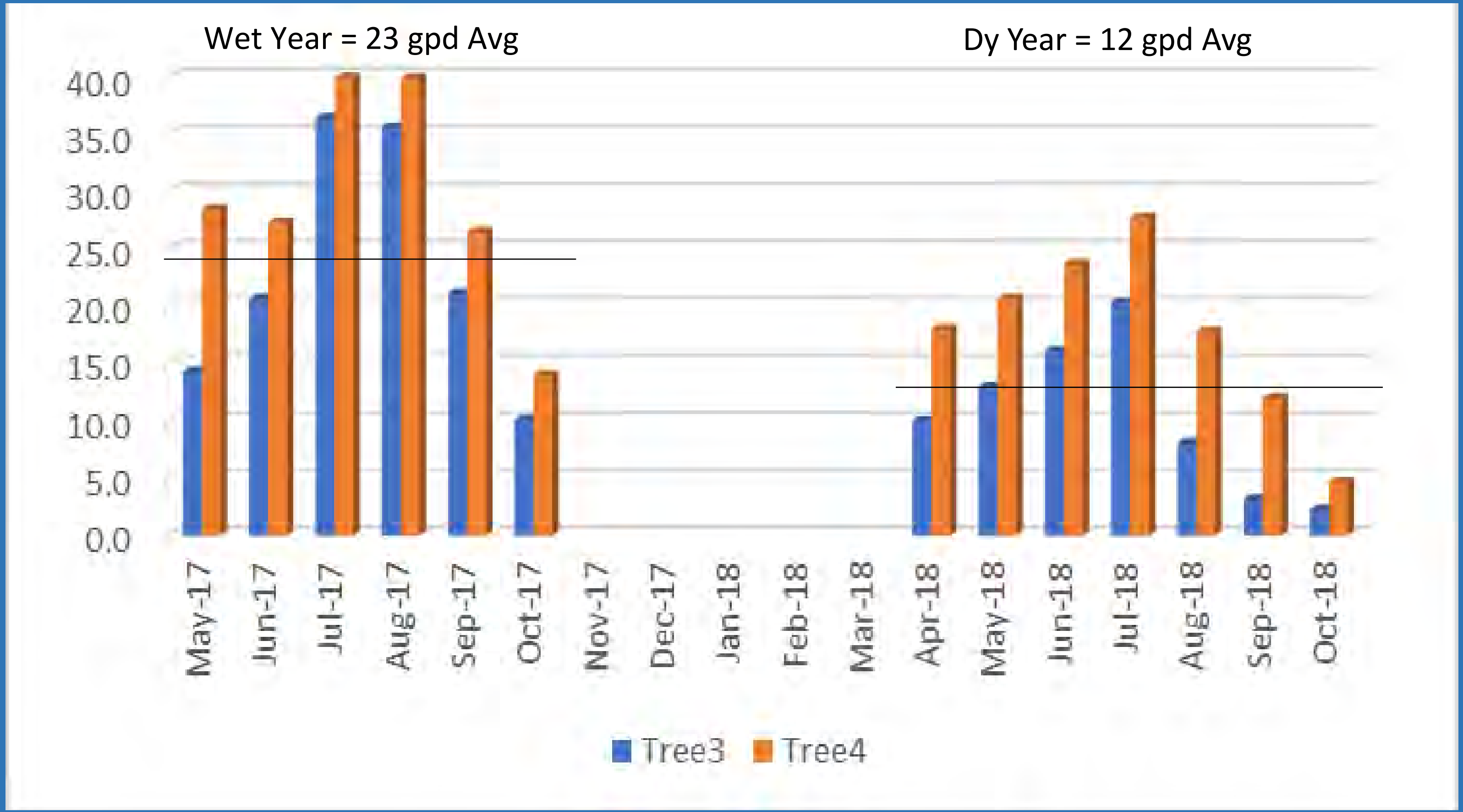
How much water does juniper use? – Results from our long-term project in central Oregon.

- Our previous and ongoing studies show that juniper water use varies widely with tree size and moisture availability.





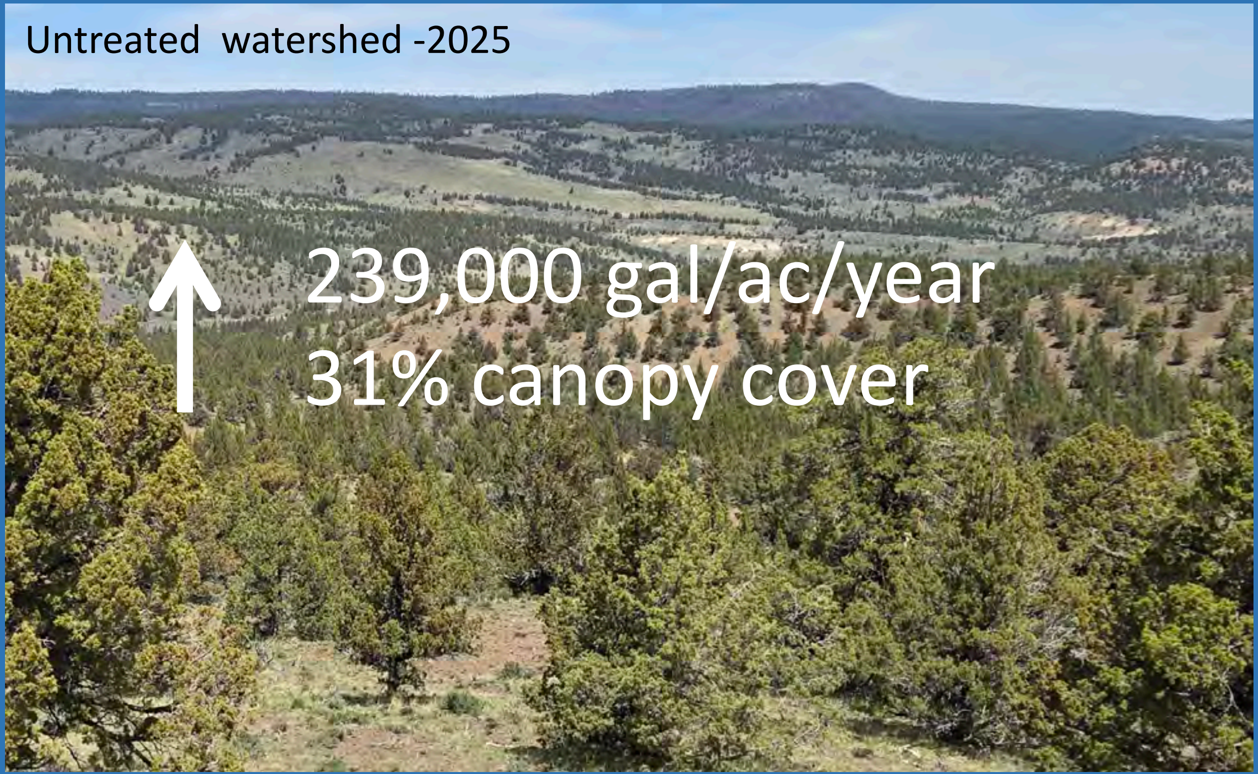
- Juniper is highly adaptable to the amount of available water – For example, the average of two mature juniper trees' water uptake was almost twice as much water in a wet year (15 in total ppt) as in a dry year (8 in total ppt).
- On average, one mature juniper tree can use 4700 gallons of water per year (spring-summer-fall); one sapling uses 70 gallons per year.

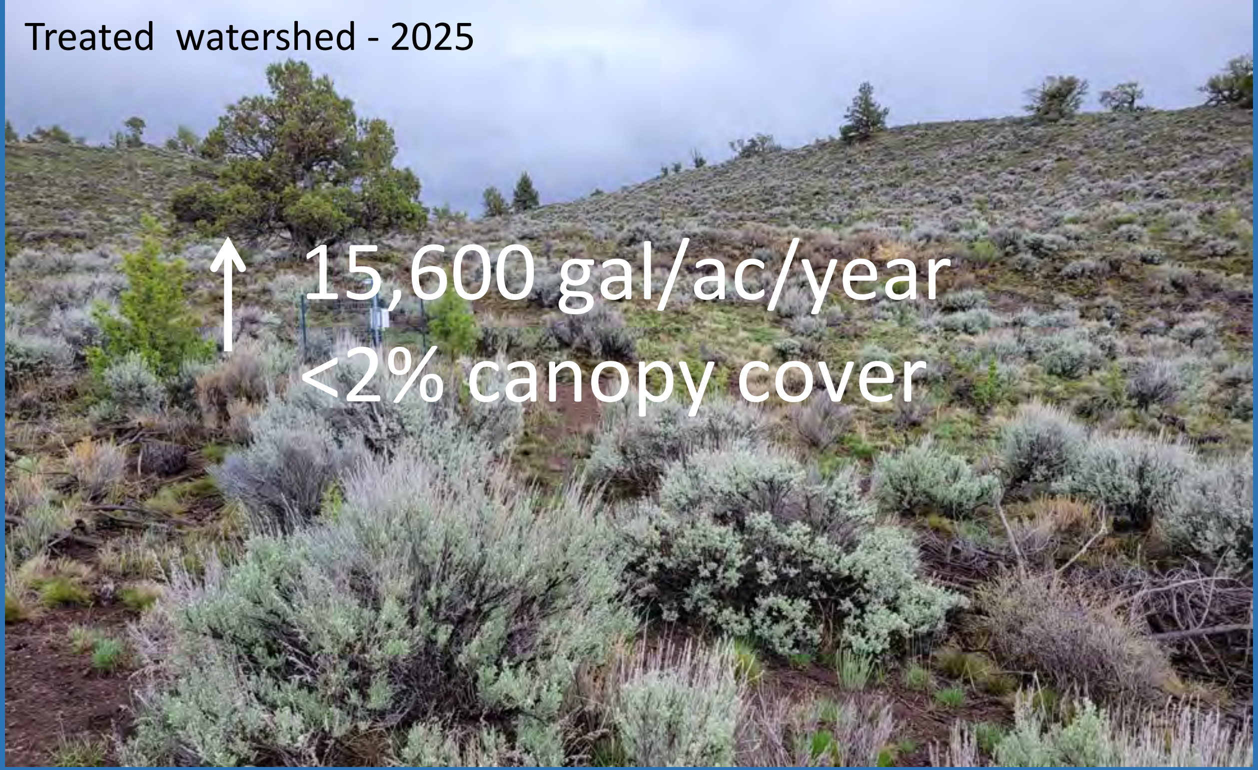


Sap flow sensor

Abdallah et al. 2020, Ochoa et al. 2023

- Juniper water use is 15.3 times higher in the untreated watershed.





*Calculation based on previous and ongoing studies on tree water uptake and juniper stand cover and structure (small, medium, large trees) in each watershed.

Abdallah et al. 2020, Durfee et al. 2019, Ochoa et al. 2023

- Where does the water go following juniper removal?
- It follows two main paths: Green Water (vegetation & soils) and Blue Water (surface water & groundwater).

Green Water

Vegetation

- Vegetation cover
- Plant species diversity
- Herbaceous yield (i.e., forage production)
- Plant water use

Soils

- Soil moisture
- Soil carbon, nitrogen, and organic matter
- Water transport through the soil profile
- Soil erosion

Blue Water

Surface water

- Streamflow levels
- Channel stability
- Sediment transport
- Evaporation

Groundwater

- Hydrogeology (shallow and deep aquifers)
- Springflow rates
- Aquifer recharge
- Groundwater flow timing and duration

Benefits & Ecosystem Services

- Water availability (within & downstream watershed)
- Improved rural economies (ranching, farming)
- Reduction of wildfire risk
- Wildlife habitat (e.g., mule deer, sage grouse)
- Helps carbon, water, & nutrient cycling
- Healthier upland and riparian areas

- Significant recovery of sagebrush and perennial grasses following juniper removal in 2005.

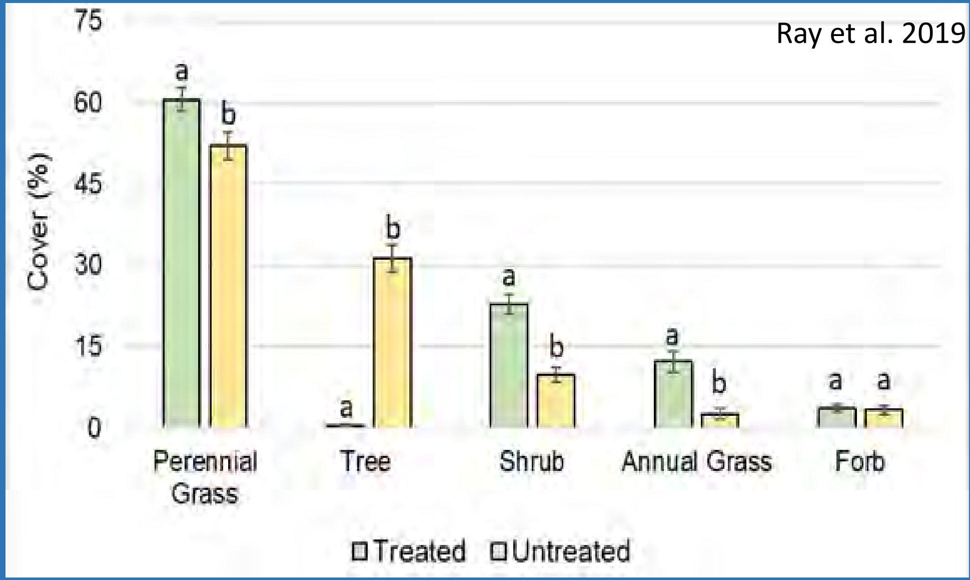
- Improved vegetation and soil conditions are still observed in the treated watershed at 20 years post-juniper removal.

Management practices	Root carbon
Untreated	3.57(0.30)[b]
Treated	9.23(0.83)[a]
P value	< 0.05

- Higher root carbon content due to increased establishment of shrubs and perennial grasses (Abdallah et al. 2020).

- Higher soil C, N, & OM content in the effective root zone (top 12 inches) (Ochoa et al. 2026).

- Herbaceous yield ratio of treated vs untreated 3:1

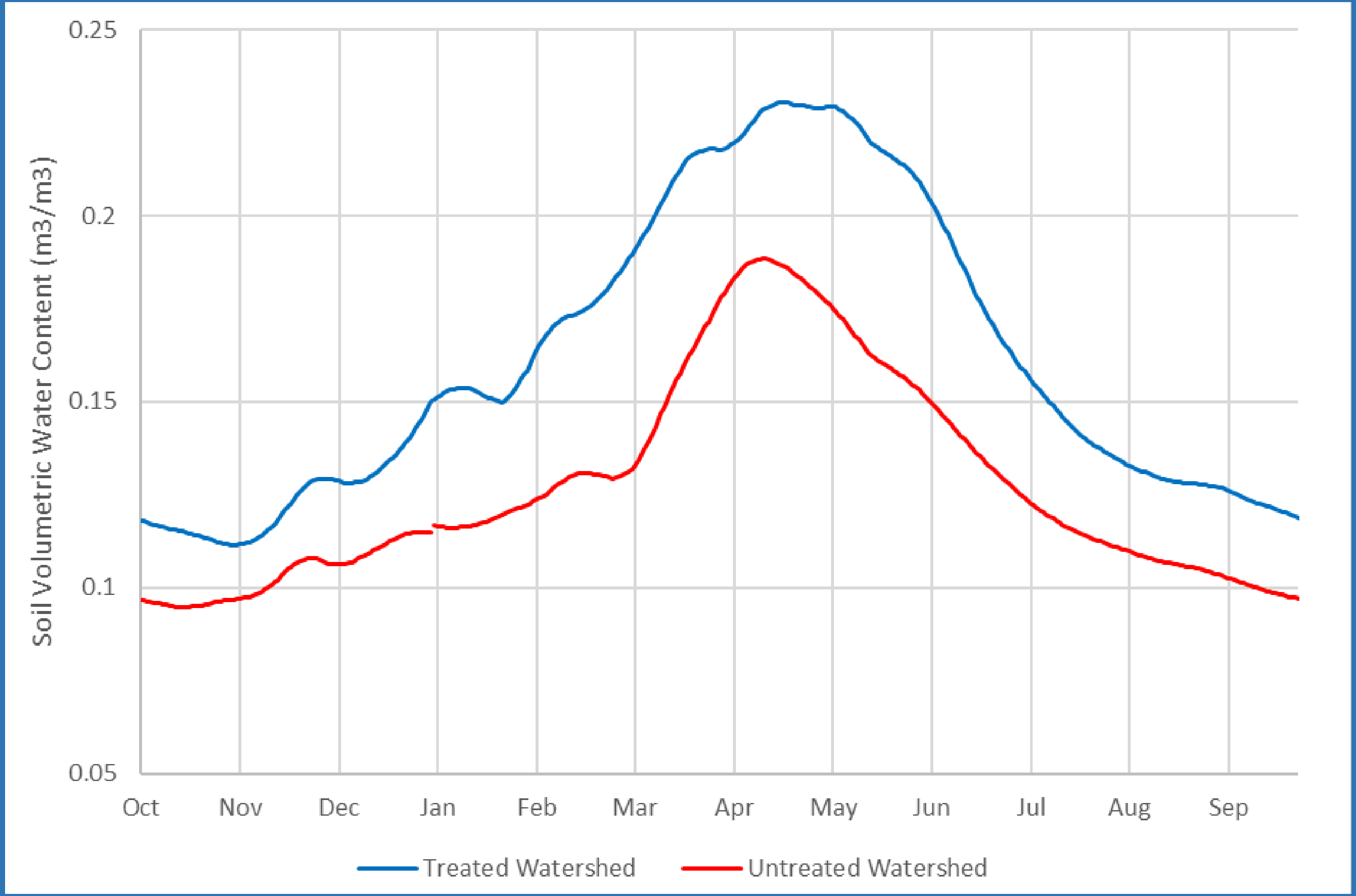


- More grass and shrub cover in the treated watershed.

Soil moisture

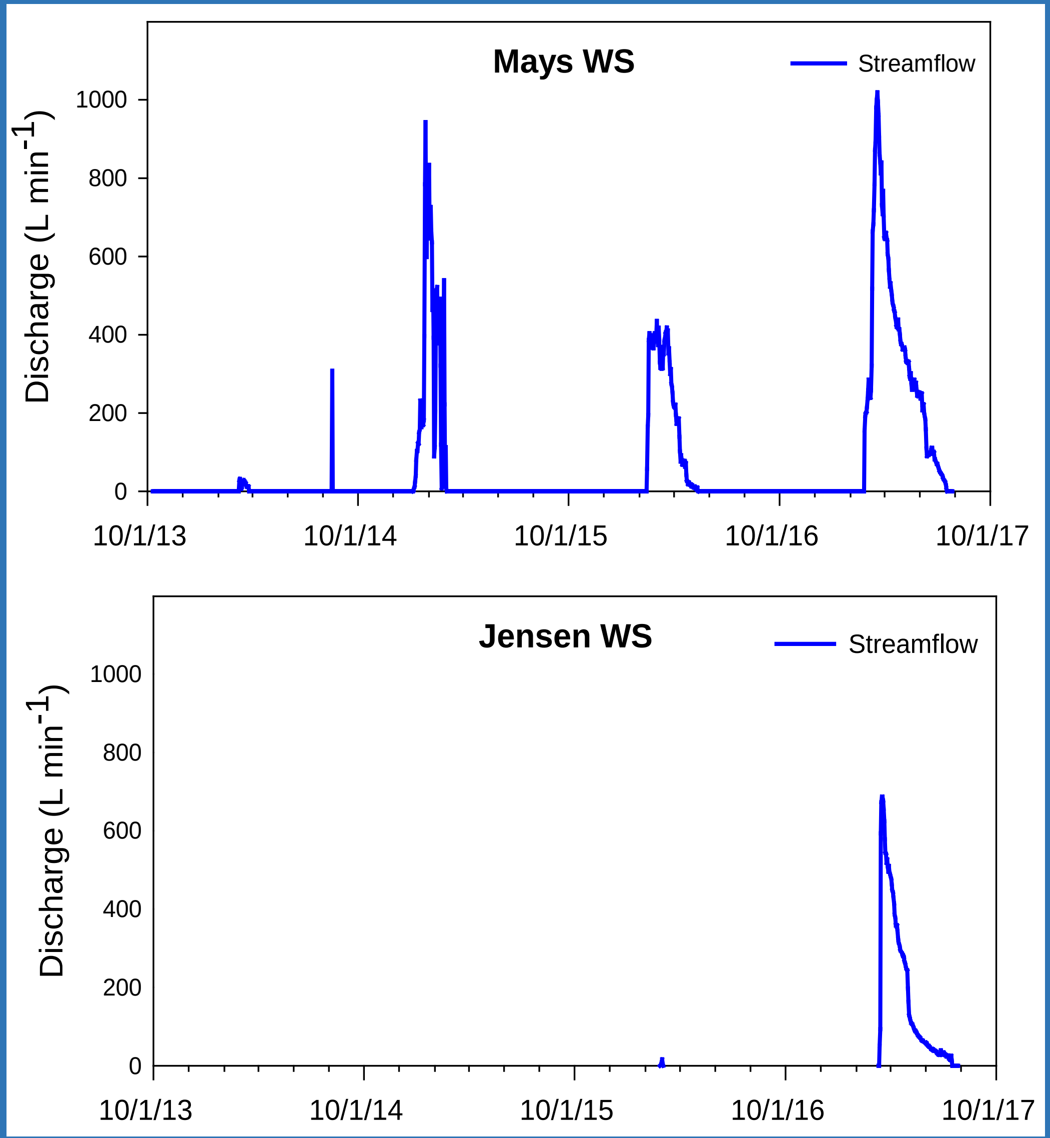
- Ten-year averaged data from upstream and downstream locations in each watershed show consistently higher soil moisture levels in the treated watershed.

- Year-long higher soil moisture in the treated watershed, with a 5% difference between the treated and untreated watersheds during peak soil moisture conditions in April for the entire 32-inch soil profile.



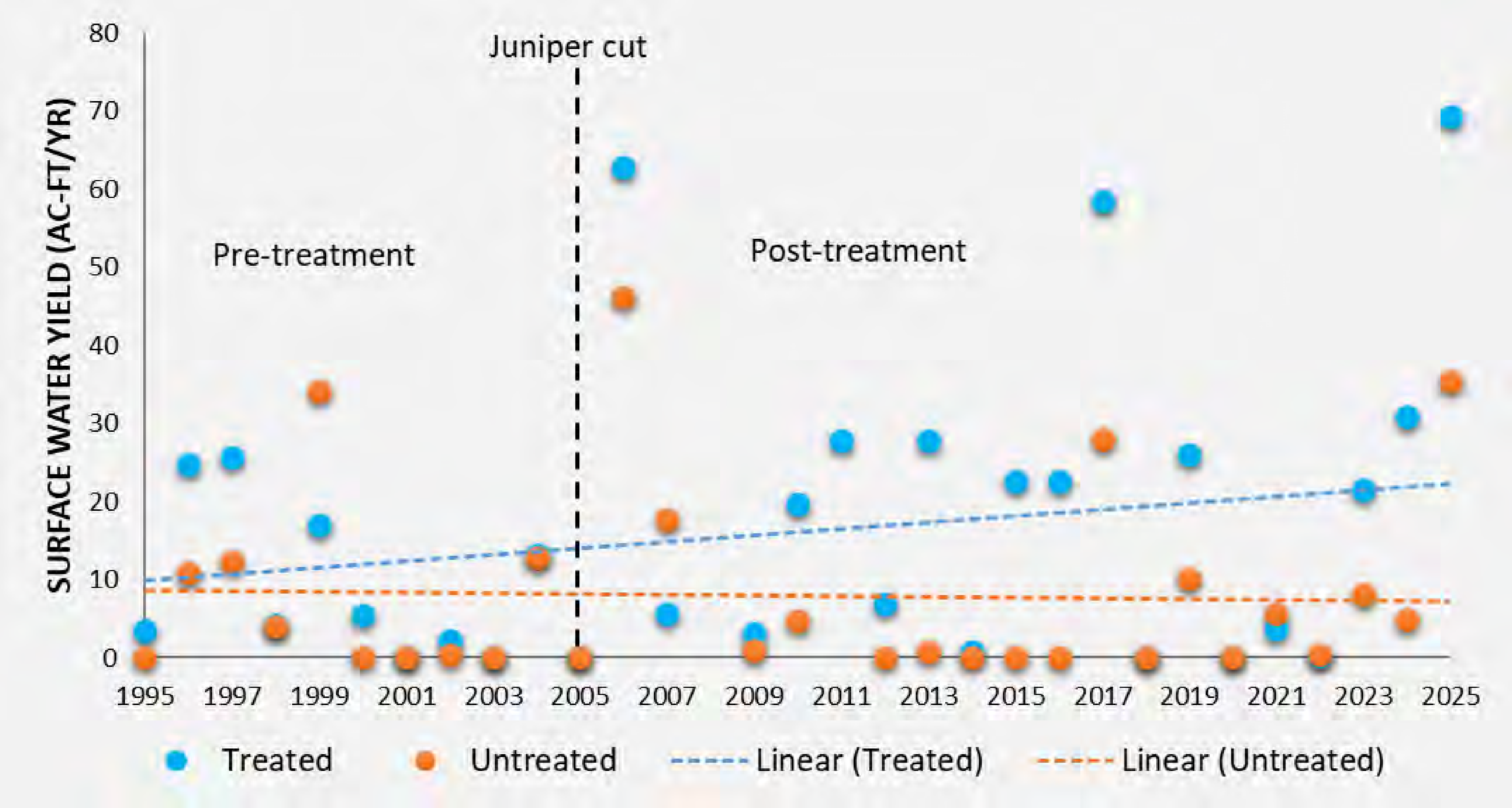
Surface water-groundwater interactions.

- Improved vegetation and soil moisture conditions in the treated (Mays) watershed have resulted in an increased water residence time, augmenting surface and subsurface water flows (Ochoa et al. 2018).



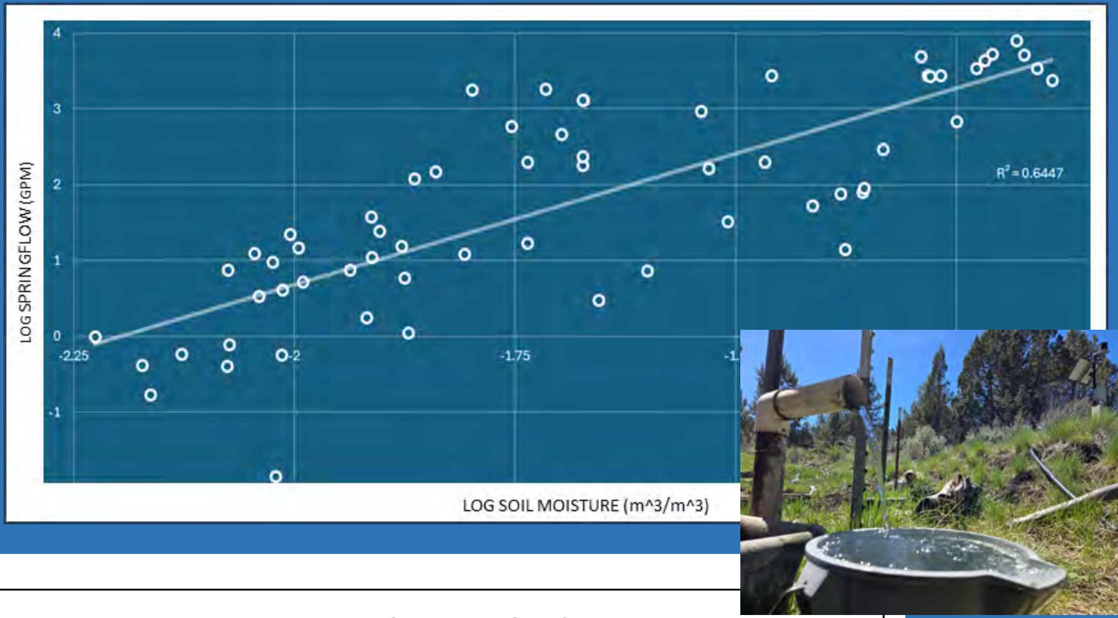
Streamflow

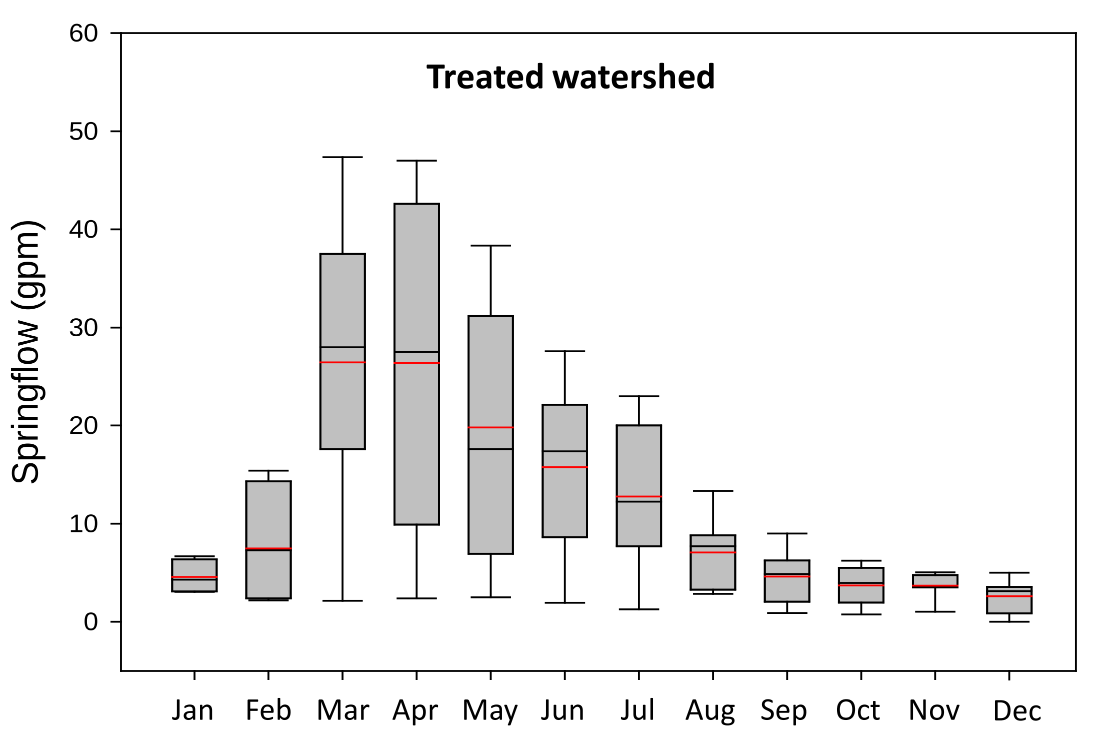
- The 30-yr study shows that, on average, yearly surface water yields in the treated watershed are more than double (21 ac-ft/yr) than in the pre-treatment years (9 ac-ft/yr). Annual water yields for the untreated watershed have remained relatively the same.

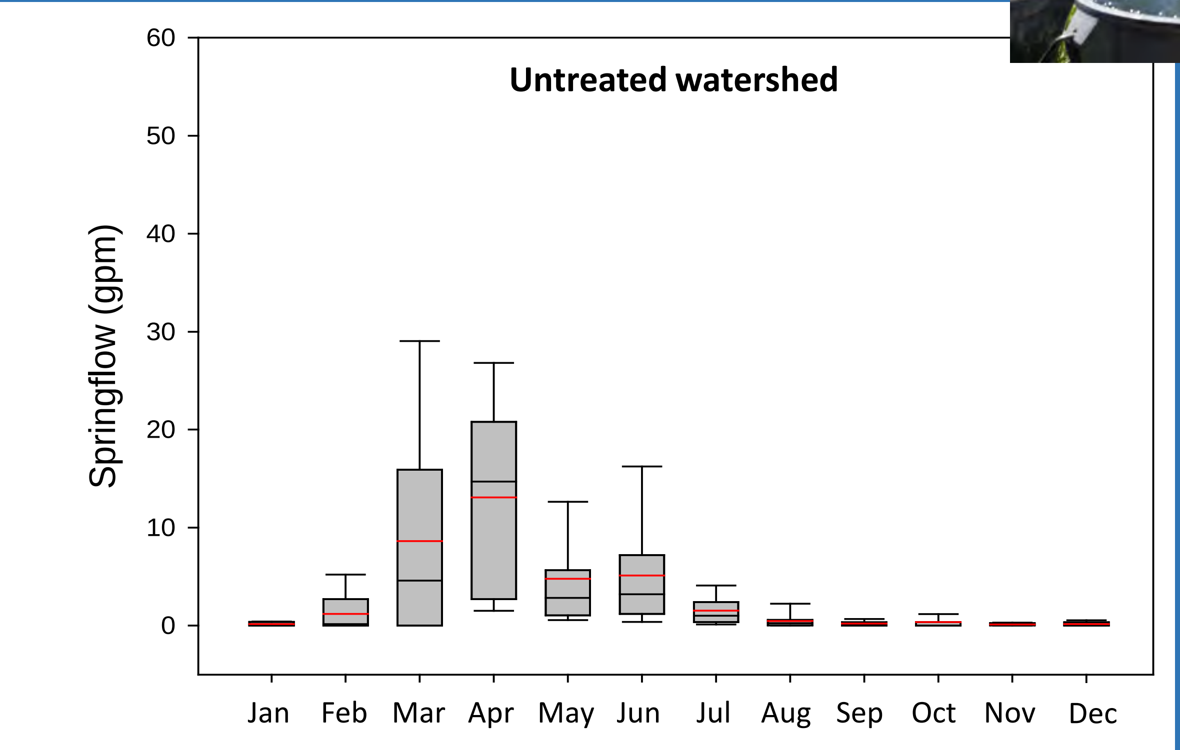


Springflow

- There is a strong correlation between soil moisture and springflow.
- The monthly averages of 20 years of post-treatment data below show springflow rates are consistently higher and last year-long in the treated WS than in the untreated WS, where flows are negligible by midsummer.

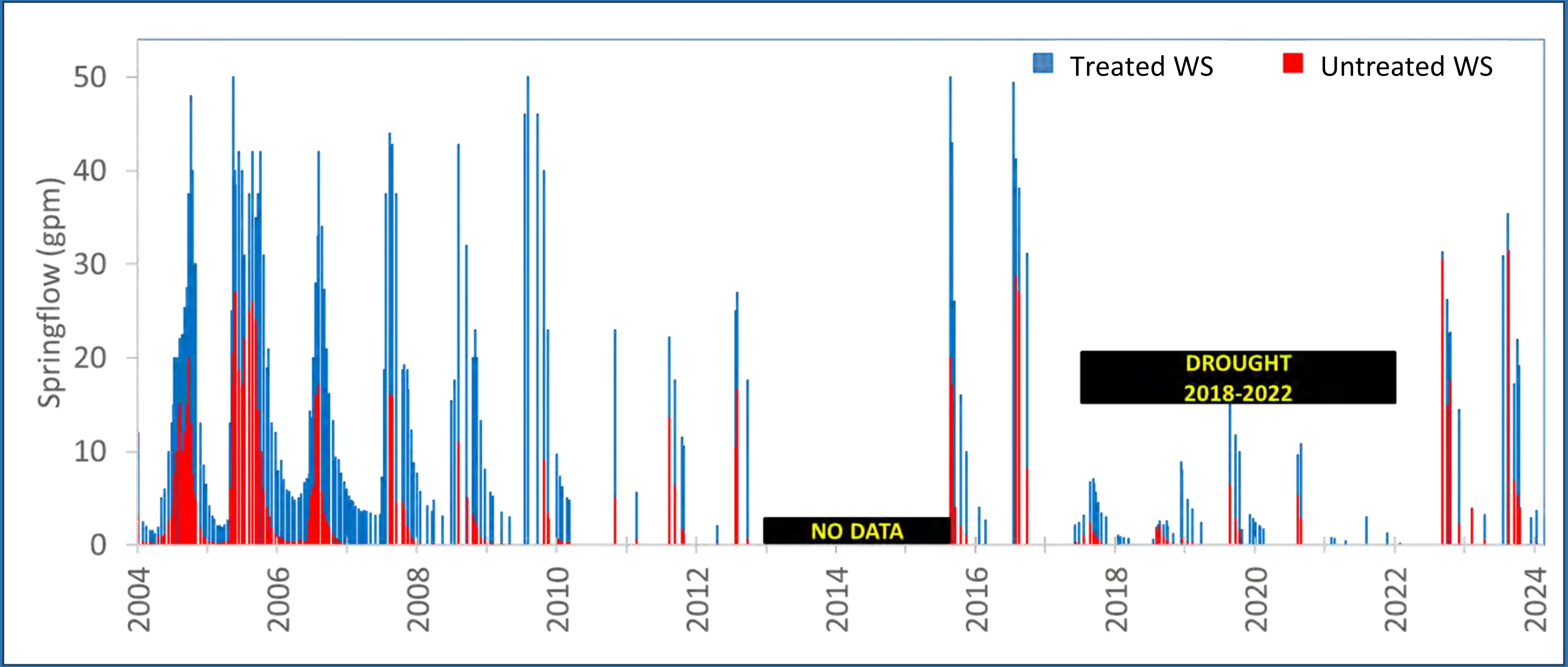






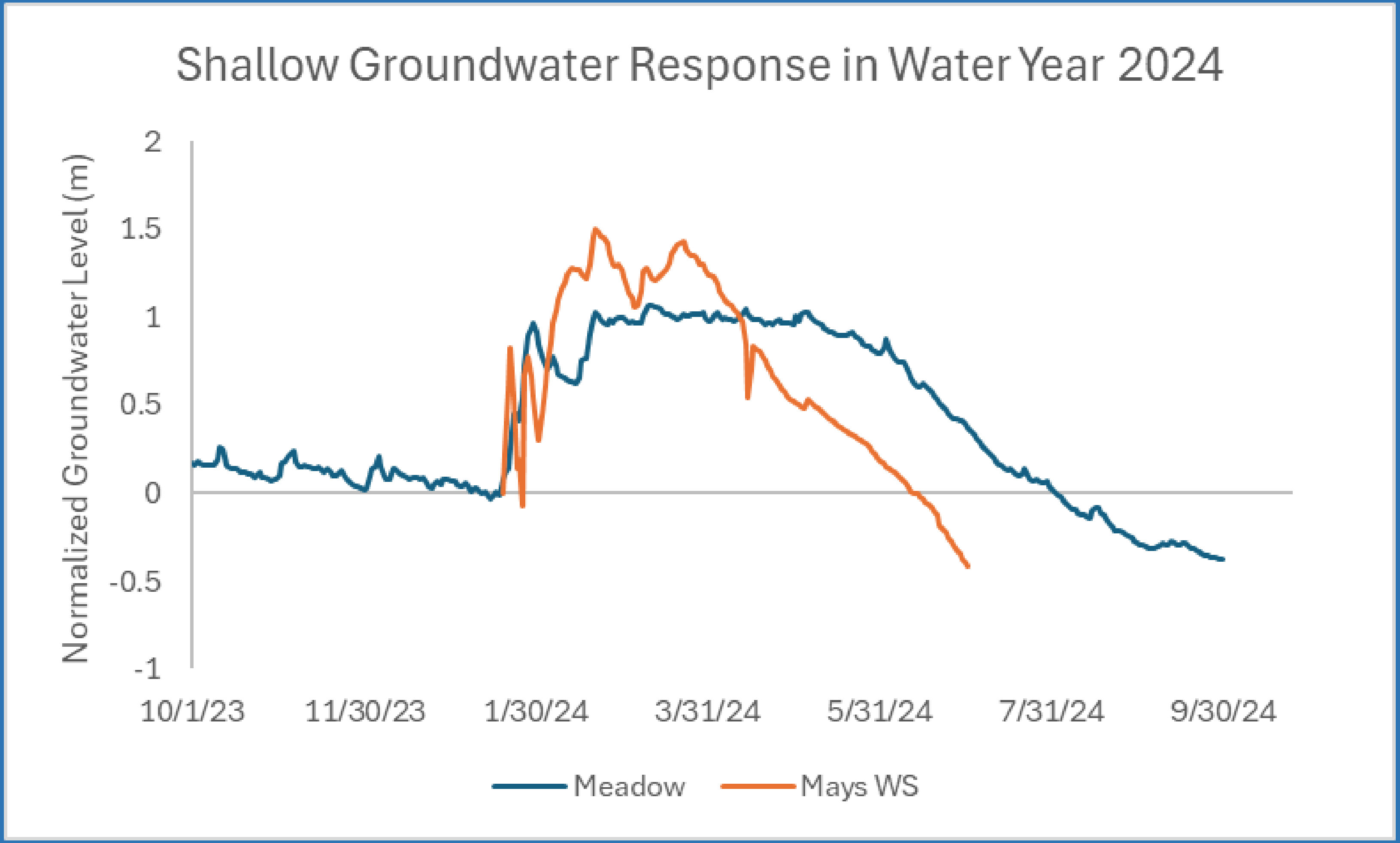
- Springflow levels in both watersheds are highest in April, consistent with moisture release from winter precipitation-saturated soils and peak snowmelt runoff.

- Groundwater and springflow fluctuations are dominated by seasonal moisture availability, including timing, magnitude and precipitation type (snow vs. rain).
- The drought conditions from 2018 through 2022 and the corresponding reductions in springflow levels exhibit this relationship.



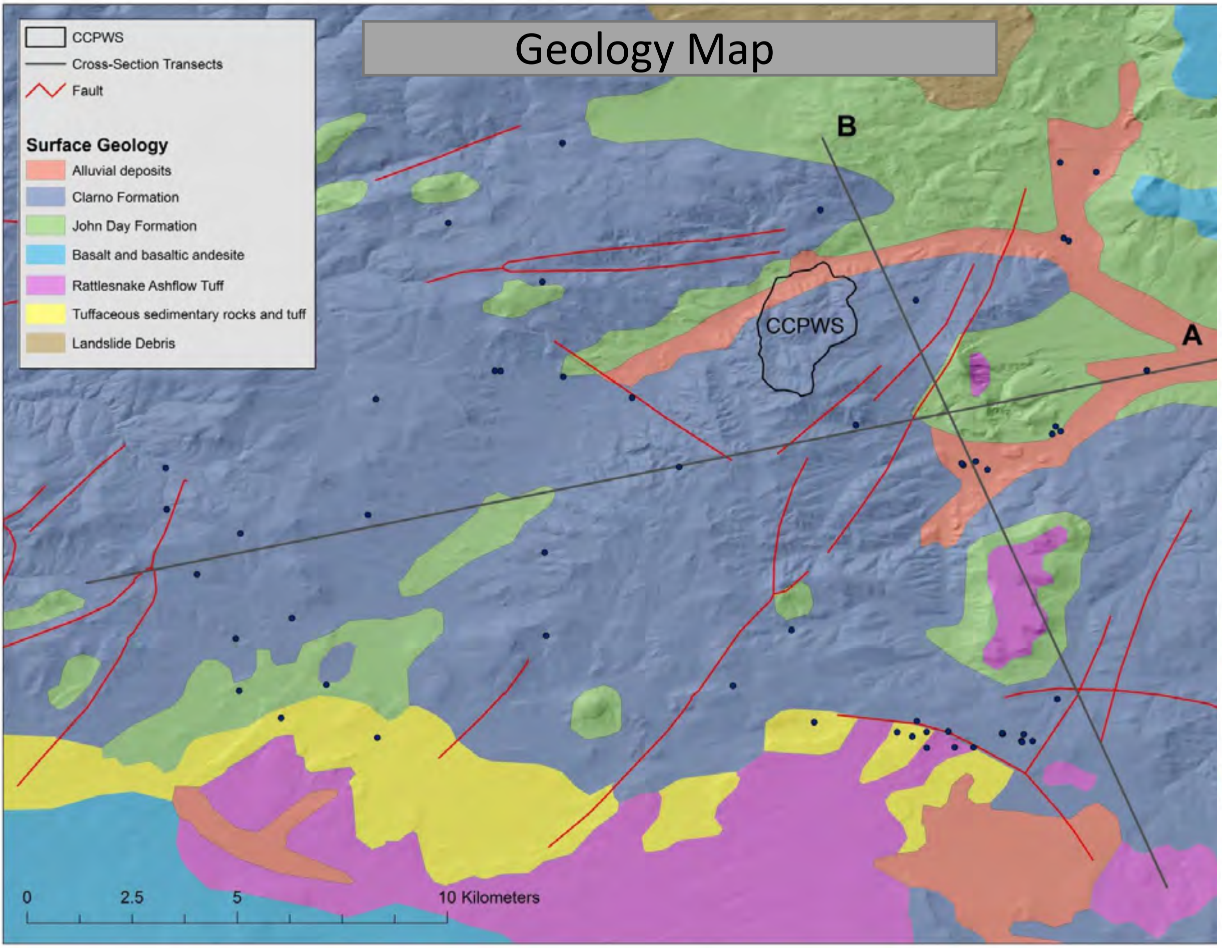
Groundwater and riparian areas

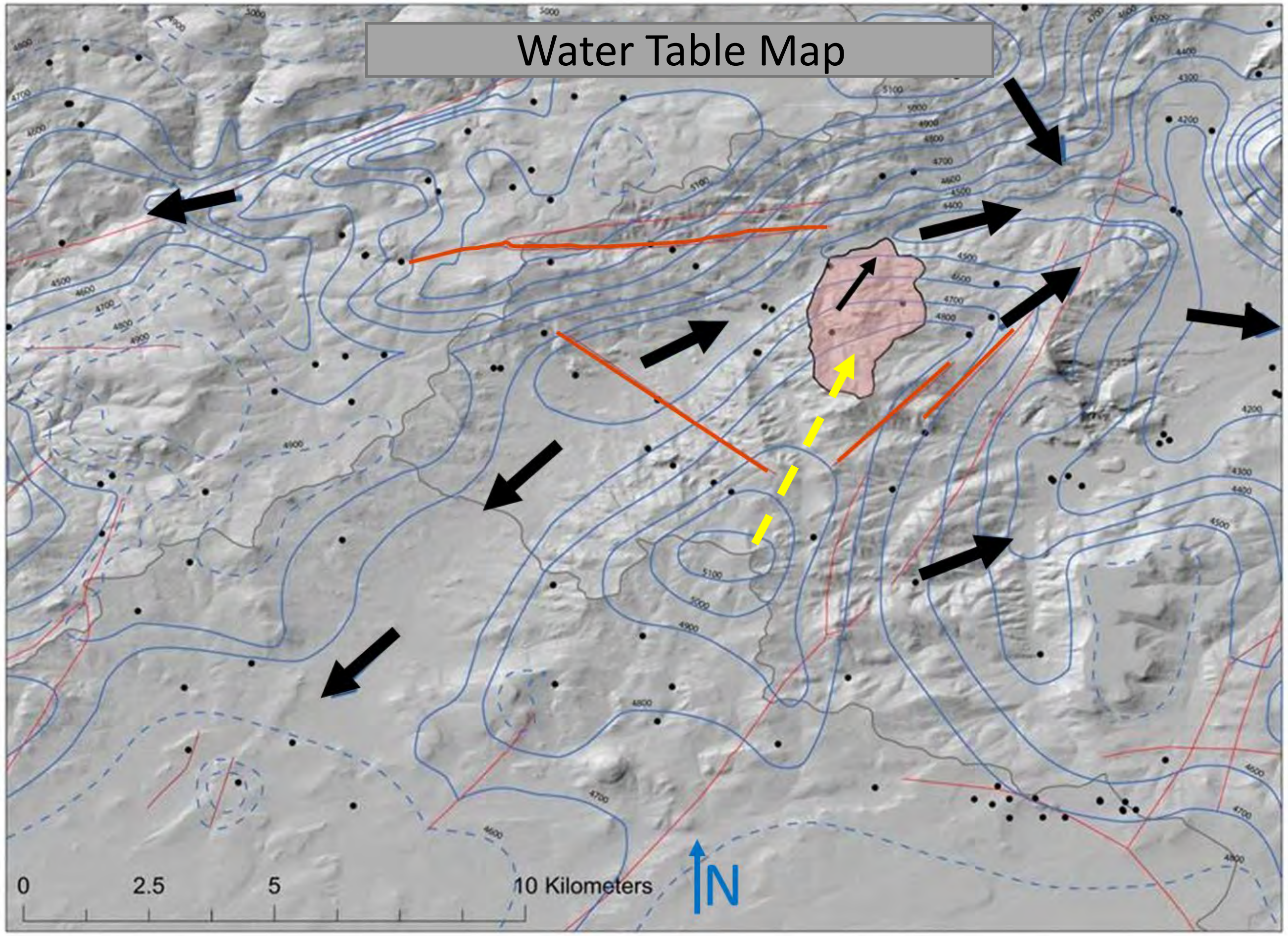
- Shallow aquifer (< 30 ft) response in the meadow area generally extends beyond that in the upstream WS due to the upland springflow contributions to downstream subsurface flow entering the meadow.



Hydrogeological framework

- Underlying geology typically influences springflow and shallow aquifer recharge at scales beyond local catchments.
- The relationships between juniper control and groundwater need to be studied at a larger scale.





References & Project Info: OSU Ecohydrology

Caruso et al. 2019

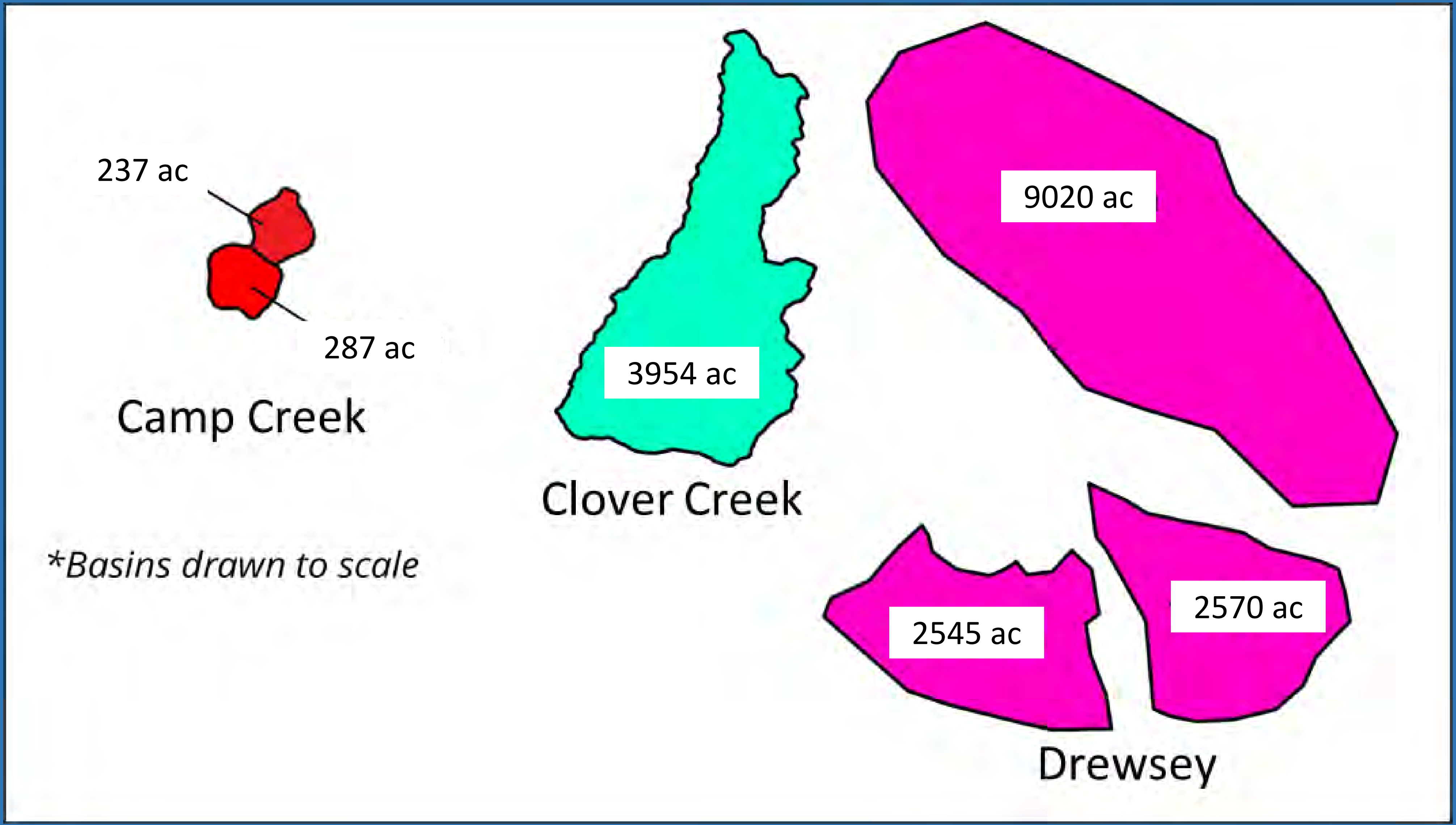
ONGOING COLLABORATIONS – Jason Kesling

Drewsey Field Day 2026 – Harney County.

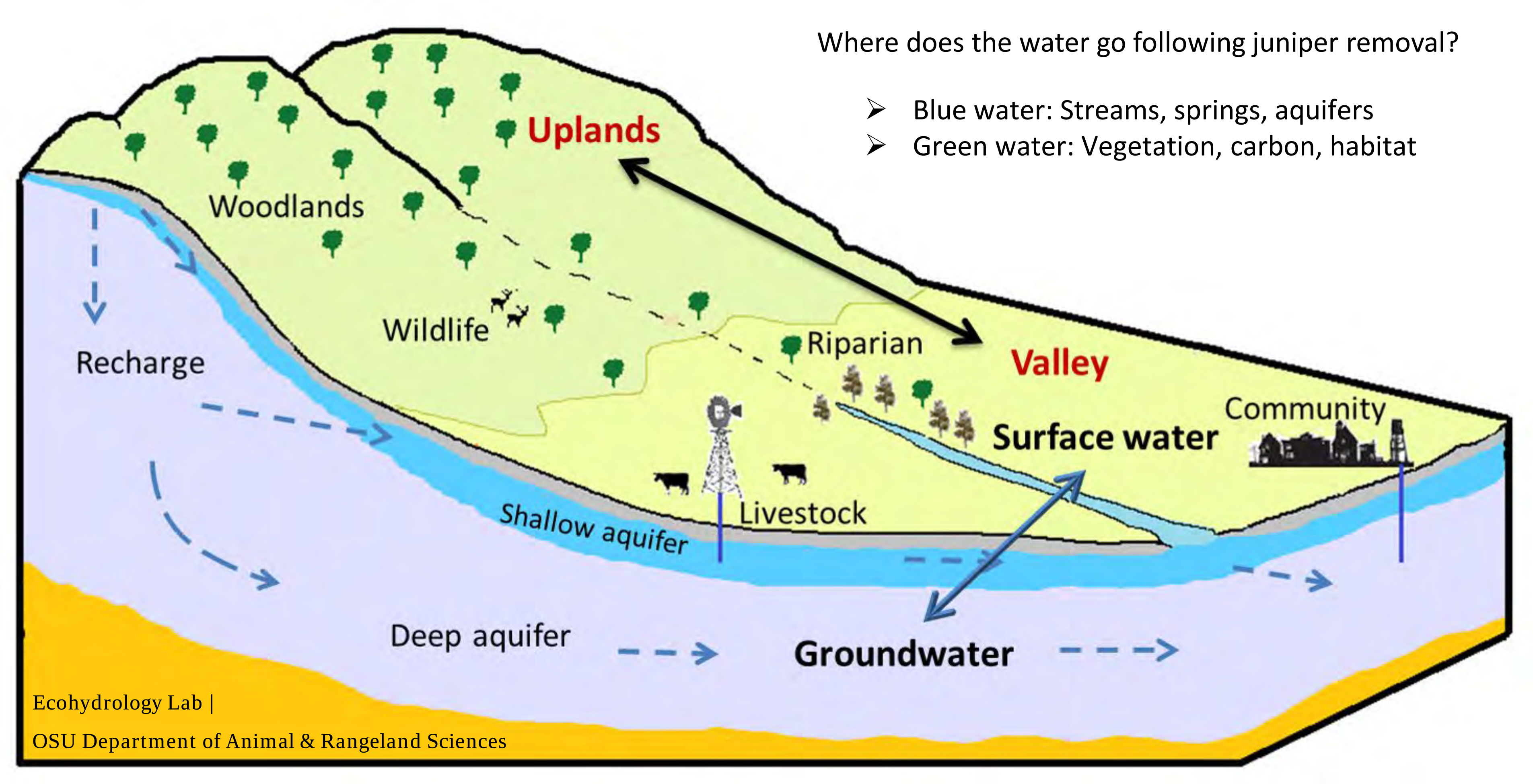
Camp Creek Field Day 2025 – Crook County.

New juniper studies at larger scale – in partnerships with BLM, Harney County SWCD, Crook County SWCD, and local landowners.

- Ongoing projects range from ~ 500 acres (Camp Creek) to ~4,000 (Clover Creek) to ~14,000 acres (Drewsey).

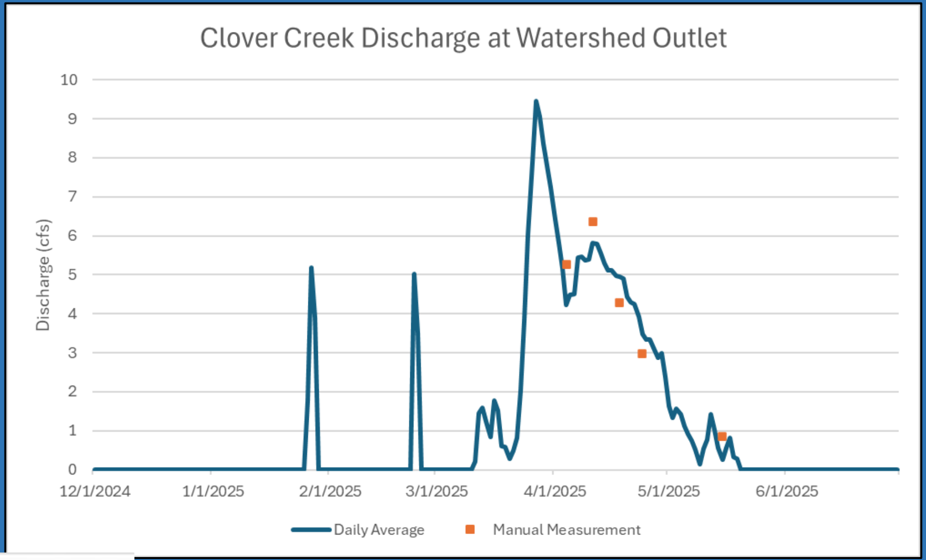


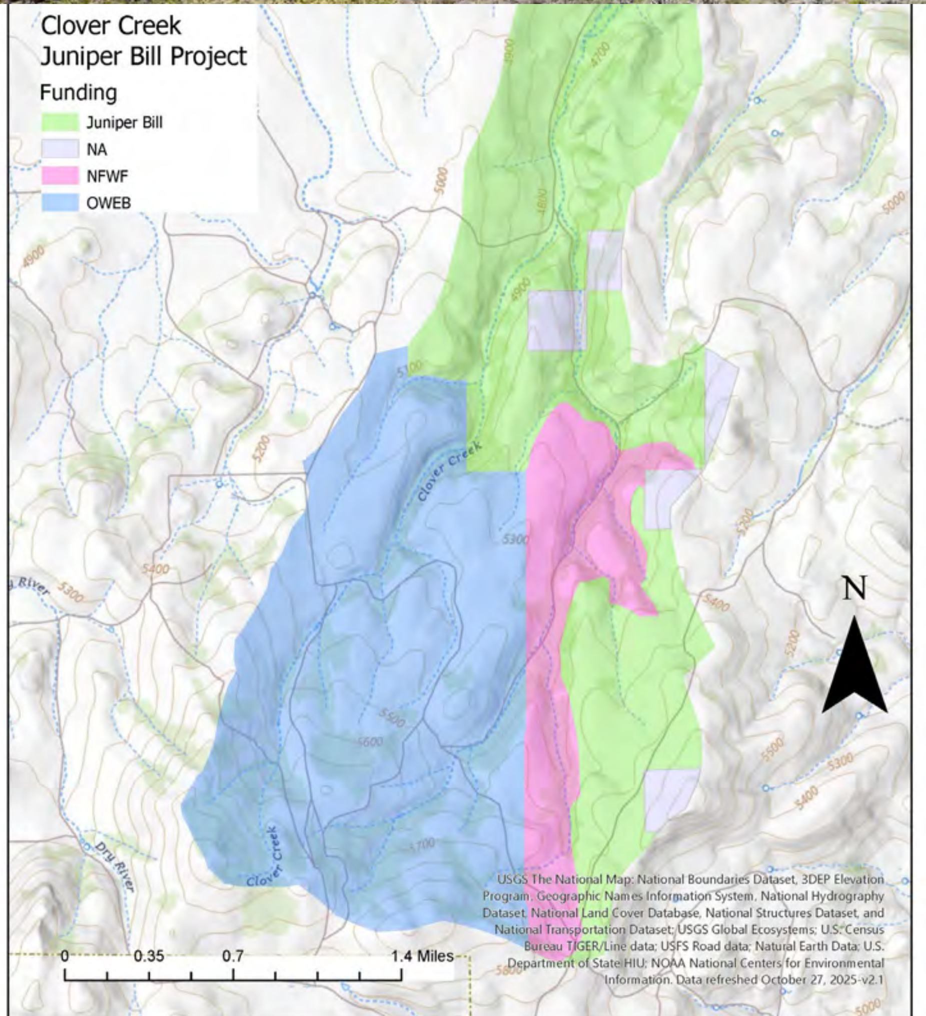
- We use a systems approach to evaluate the effectiveness of large-scale juniper removal efforts in improving water, soil, and vegetation conditions.
  - Intensive on-the-ground monitoring of multiple water budget components and ecological indicators.
  - Numerous tools, including GIS, remote sensing, AI, and statistical analyses, to assess the relationships between geology, soils, hydrology, and vegetation.



Clover Creek Project – Crook County (4000 acres, 5-year project). OSU, CCSWCD, Crook County, landowners

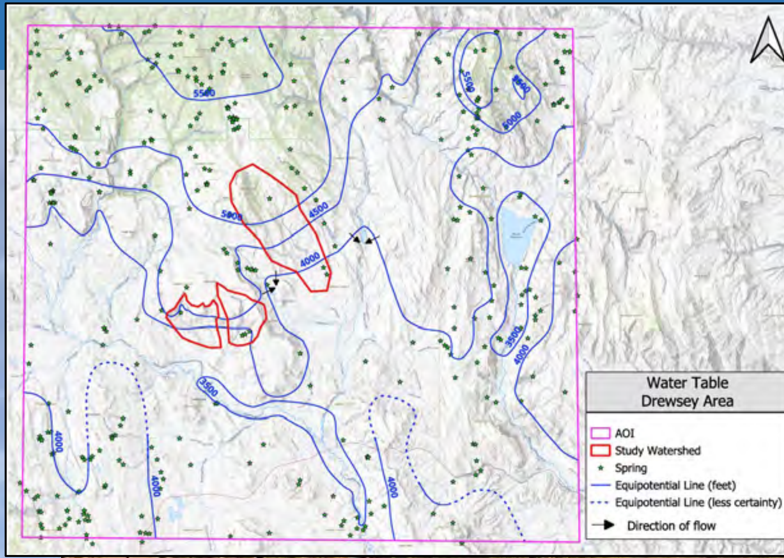
- Two streamflow monitoring stations, two weather stations, five soil moisture stations, and three monitoring wells.
- Also, data for vegetation features such as canopy cover and forage yield are being collected.

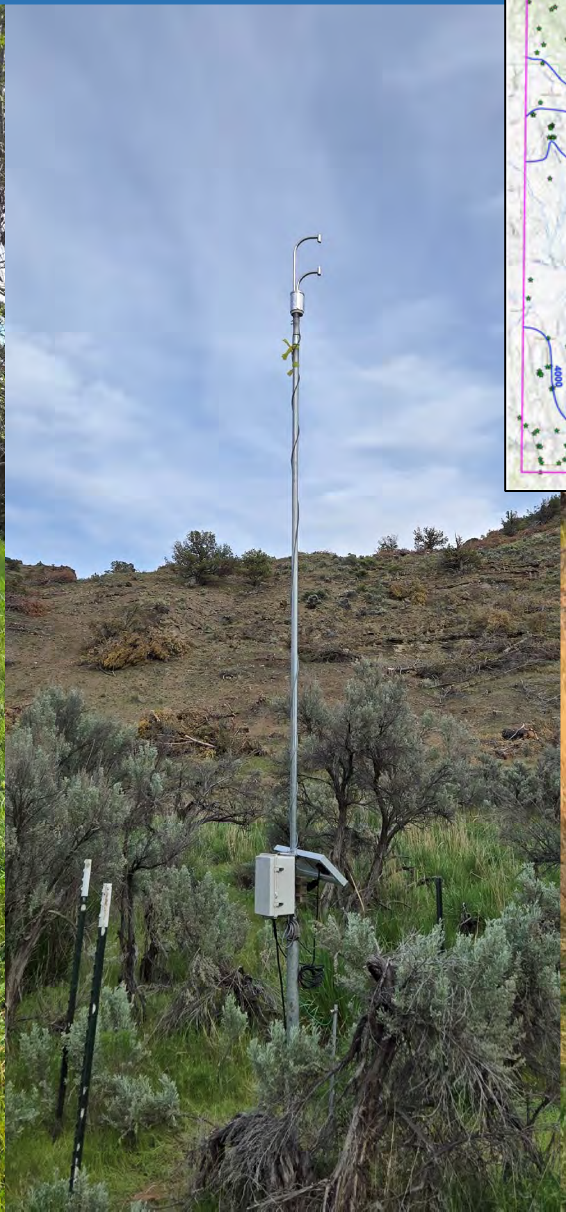




Drewsey Project – Harney County (14,000 acres, 10+ year project). OSU, BLM, HSWCD

- Three watersheds instrumented to monitor weather and hydrology variables of interest (e.g., groundwater, streamflow).
- Soils and vegetation data, groundwater and geology assessments are ongoing.

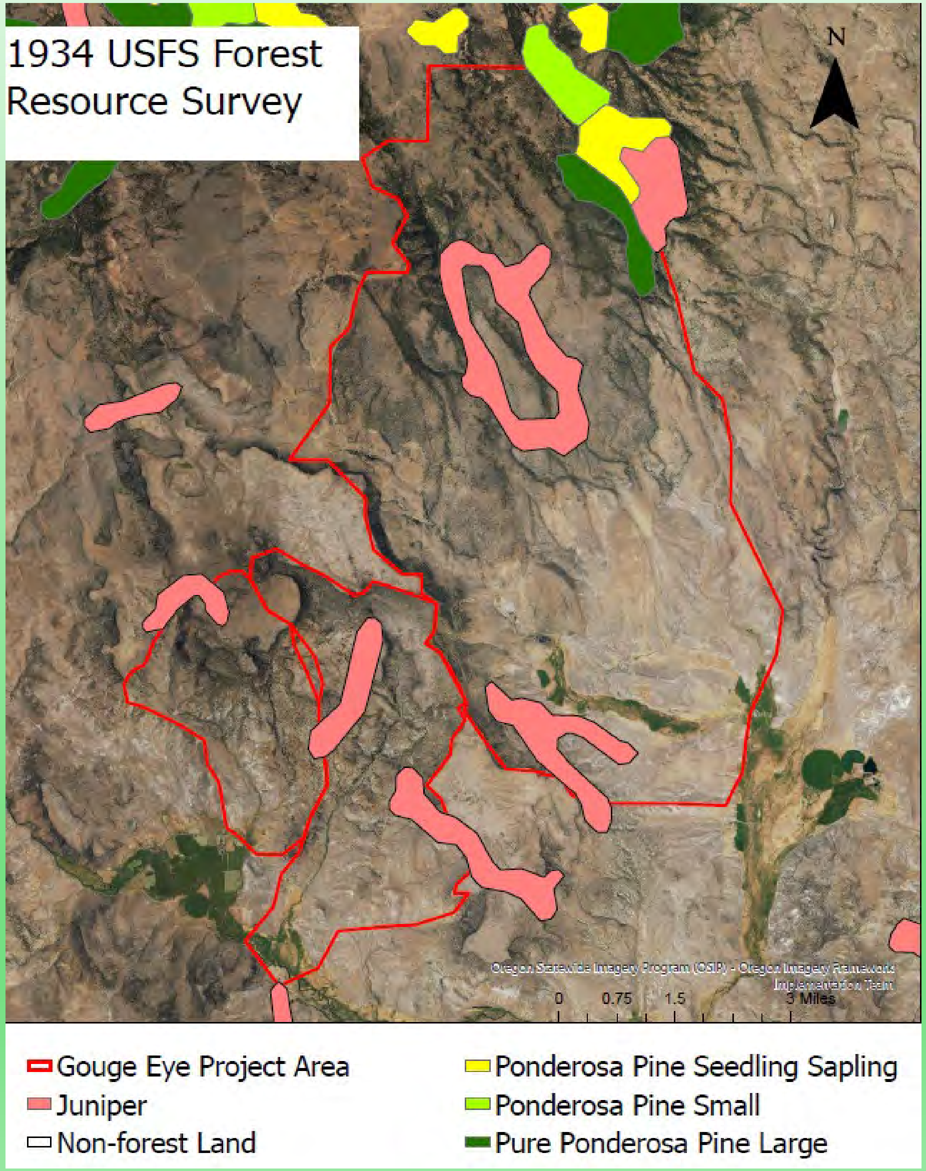




Using remote sensing technology to estimate juniper water use

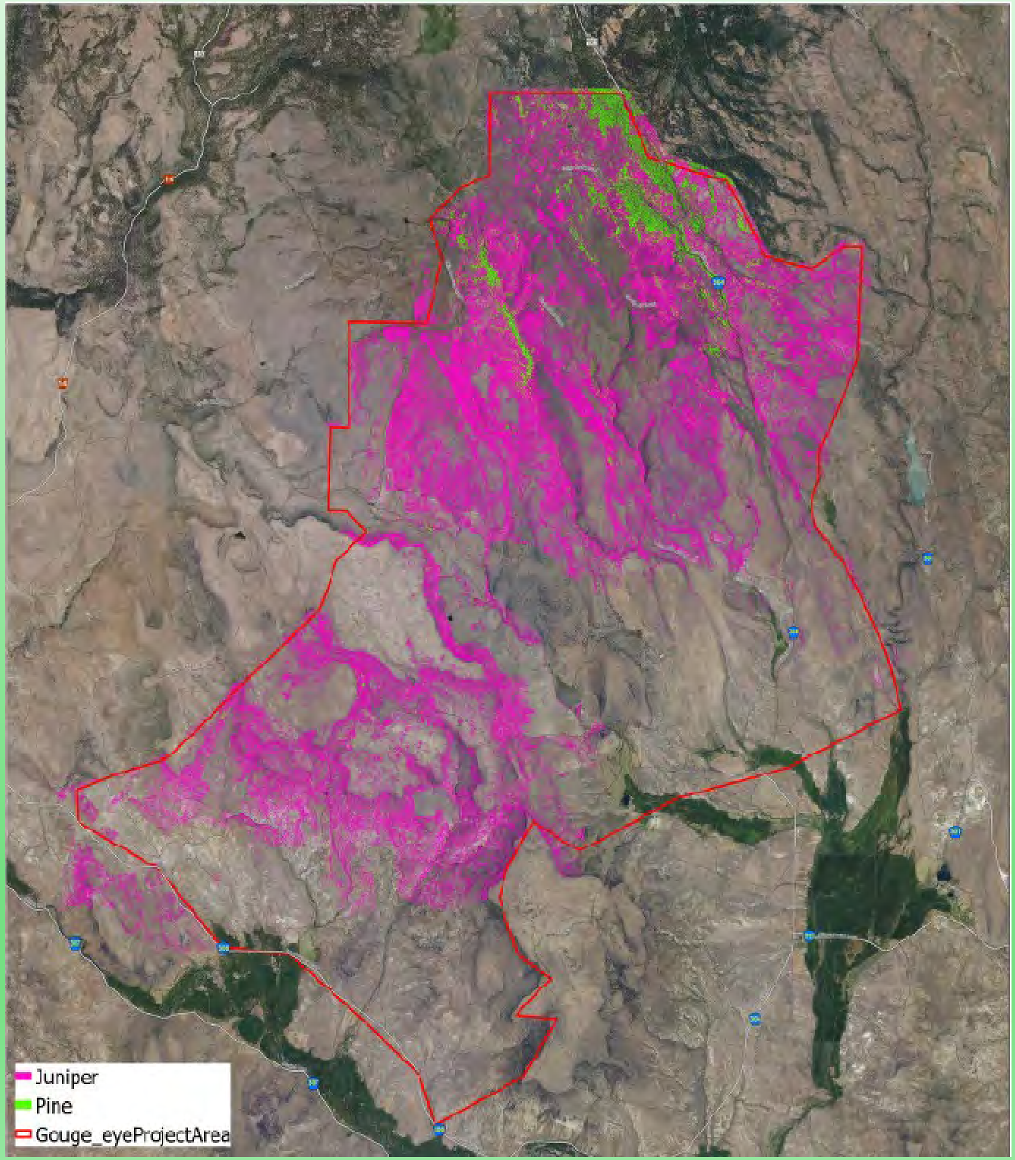
By: Skyler Hickey
BLM Assistant Field Manager

1934 to 2025 Tree Comparison



Map 1: USFS Forest Resource Inventory Survey

- 1934 Forest inventory
  - 3,839 acres Juniper
  - 1,388 acres Pine
- 2025 Open Range Consulting
  - 21,657 acres juniper
  - 2,213 acres pine
- Approx 22% increase conifer expansion Since 1934



Map 2: Tree Report; Open Range Consulting 2025

Otis Mountain: Total Annual Water Consumption

Transpiration + Canopy Interception — All 884,900 Western Juniper Trees

Average Year

13,632

ac-ft / yr

Wet Year

16,343

ac-ft / yr

Dry Year

~10,271

ac-ft / yr

Component	Average Year (ac-ft/yr)	Wet Year (ac-ft/yr)	Dry Year (ac-ft/yr)
Transpiration — all 884,900 trees	6,482	9,193	4,371
Canopy interception (20% cover, 13" precip)	7,150	7,150	~5,900 (10" eff.)
COMBINED (Transpiration + Interception)	**13,632**	**16,343**	**~10,271**

Source: Abdallah et al. (2020); Eddleman (1986) via Deboodt (2023). These figures represent total plant-atmosphere water flux, not recoverable streamflow.

What Does 14,000 Acre-Feet of Water Look Like?

Putting juniper water consumption into perspective

Olympic Pools

17,300+

An Olympic pool holds ~660,000 gallons. The junipers consume the equivalent of over 17,300 Olympic swimming pools — every single year.

City of Burns

~5× annual use

Burns (~2,700 people) uses roughly 2,700 ac-ft/yr. Juniper water consumption is equivalent to supplying the city of Burns for ~5 years.

Irrigation Season

40 days

14,000 ac-ft equals the entire flow of the Silvies River for 40 consecutive days — more than a full month of irrigation-season flow.

Livestock Water

5.5 billion gal

At 30 gal/day per cow, this is enough water to sustain 500,000 cattle for an entire year — across Harney County's rangeland.

**14,000 ac-ft/yr approximates the combined transpiration + interception under average-to-wet conditions. Actual recoverable water yields are substantially lower.*

Where Does The Water Go After Treatments?

- If treated all juniper within project area how much would go to…
  - Other vegetation
  - Springs and seeps
  - Creeks
  - Deep and shallow aquifer recharge

Trees using approx 5 billion gallons on 22,000 acres

Understanding how 1,023,000 acres of juniper encroachment is affecting water resources across Harney County

WRAP UP & QUESTIONS?

Camp Creek, Treated WS – April 2026 – Crook County.