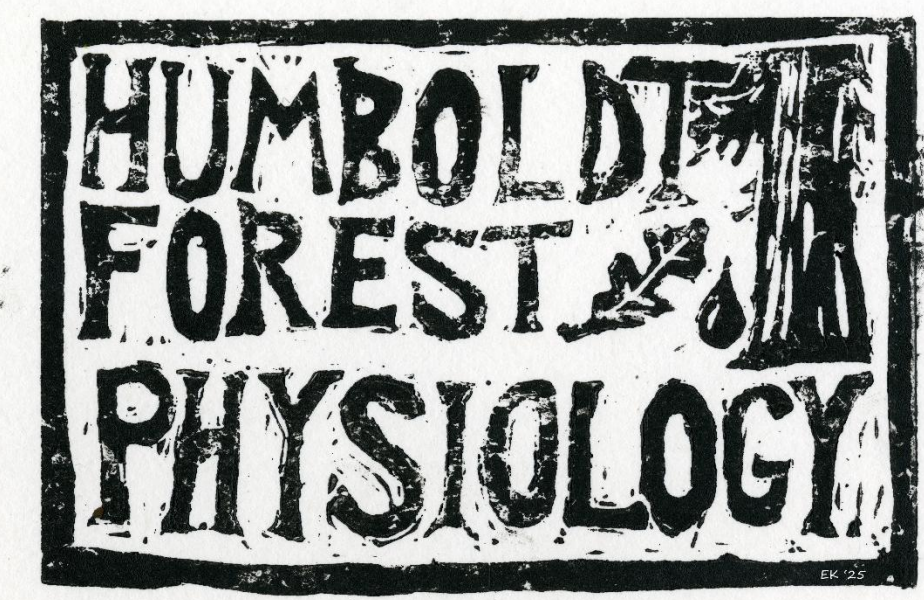


Physiological Responses of Oregon White Oak to Thinning in the East Cascades

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Abstract

Oregon white oak (*Quercus garryana*) ecosystems are frequent targets of regional restoration thinning treatments to relieve conifer encroachment. Previous work reports positive responses in oak growth to these treatments, but the physiological mechanisms driving this growth and the effects of altered microclimates on these responses remain poorly understood. This study explores these knowledge gaps at three encroached oak stands in the East Cascades region of Oregon. We are monitoring physiological responses (water sources, water status, and gas exchange) to thinning treatments and investigating the influences of encroachment, tree characteristics, and environmental variables on these responses.

Xylem water isotopic signatures suggest niche partitioning of soil water between oaks and conifers at two of our three sites, with oaks using deeper water sources than conifers. In the first post-treatment year, physiological responses varied among sites. At one site, treatment plots had significantly higher productivity and lower water stress than control plots, another site showed no significant differences between treatment and control plots, and our third site had lower productivity and higher water stress in treatment plots compared to control plots, with variation across the site suggesting location-dependent responses. Findings from this work will improve understanding about the effects of thinning treatments on physiological growth mechanisms and inform management activities at the eastern edge of this species' range.

Introduction

Oregon white oak (*Quercus garryana*) ecosystems have experienced widespread stand densification due to fire exclusion and conifer encroachment and are frequent targets of restoration thinning treatments. While previous work indicates that thinning generally improves oak growth, most studies rely on long-term structural metrics such as diameter, height, and crown ratio; the short-term physiological mechanisms driving these responses, particularly in water-limited systems, remain poorly understood. Studies in mesic climates suggest increased light, rather than release from water limitation, may drive post-thinning growth, and isotopic evidence indicates limited direct competition for soil moisture between oaks and conifers. However, the effects of increased solar radiation and altered microclimates on oak responses to thinning in more arid systems have not been well studied.

This study assesses short-term physiological responses to thinning at site and tree levels in three encroached Oregon white oak stands in the semi-arid East Cascades of north-central Oregon. We use measurements of soil and xylem water isotopic signatures, water potential, and gas exchange (i.e., productivity) to research the following questions:

- What is the influence of thinning treatments on oak physiology across sites and at the individual tree level?
- What are the primary biotic and abiotic variables influencing oak physiological responses to treatments?
- How do the physiological responses of oaks vary in the first and second years after treatment?
- Do oaks and conifers compete directly for soil water in these arid habitats and are there differences in soil water evaporation rates among sites?

Methodology

- 3 Study sites (Compadre, Gate, and Warm Springs) in semi-arid oak-pine ecosystems of the East Cascades bioregion (Figure 1).
- Oregon white oak naturally co-occurs with conifer species in this transitional zone between higher elevation conifer-dominated areas and shrubsteppe-grassland (Figure 2).
- Annual rainfall < 500 mm per year.
- Pre-treatment measurements in 2024, 2 years of post-treatment measurements in 2025 and 2026. All data were collected in the last week of August, a time of high hydraulic stress for trees.

Each site contains 6 plots (3 control, 3 thinned) with 12 study oaks per plot (216 trees total).

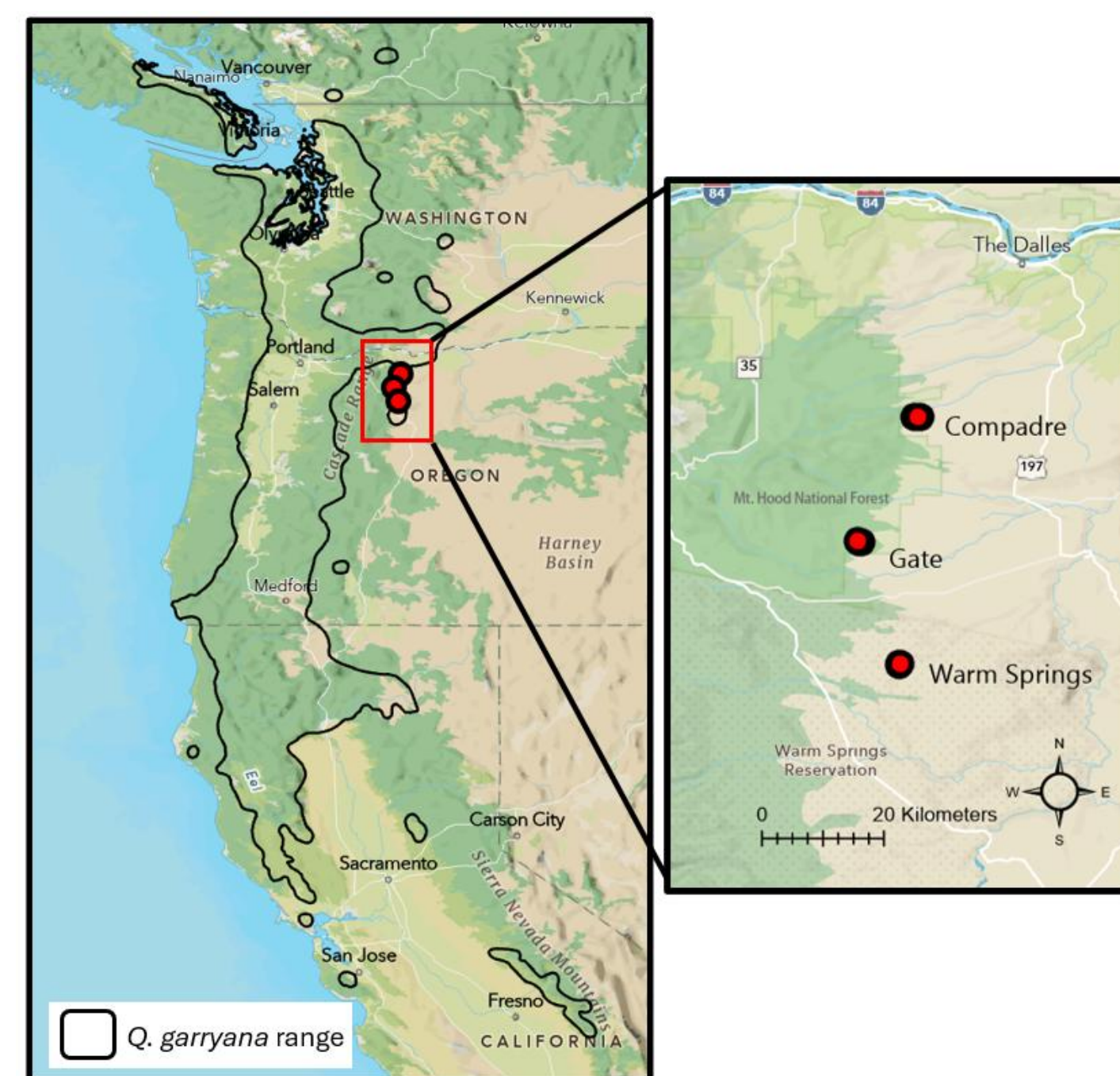


Figure 1. *Quercus garryana* range and location of study sites in the East Cascades. From north to south, sites are Compadre, Gate, and Warm Springs.

Physiological measurements

- Predawn water potential (Ψ_{PD}) and midday water potential (Ψ_{MD}):** Predawn (0200-0600) and midday (1100-1600) are the times of highest hydration and water stress, respectively, for a tree in a daily period. Measured with a pressure chamber.
- Stomatal conductance (g_s):** Strongly positively correlated with photosynthesis and regulated by plant water potential as well as environmental factors like temperature, humidity, and light. Measured with leaf porometers.

Isotopic analyses

In 2024, pre-treatment water stable isotope signatures were measured in trees and soil. Twig xylem samples were collected from each study oak and its nearest coniferous neighbor. Soil samples were collected in the center of each plot quadrant at 3 depths (5, 25, and 45 cm).



Figure 2. A thinned project area at the Gate study site in Mt. Hood National Forest showing the mixture of Oregon white oak and conifer typical of the region.

Results- Physiology

Water potential (Ψ_{PD} & Ψ_{MD}): Post-treatment Ψ varied among sites and between treatments (statistical analyses = Welch's *t*-test) (Figure 3).

- Compadre:** In first post-treatment year, Ψ_{PD} and Ψ_{MD} were significantly higher in thinned plots compared to control plots, indicating lower water stress in thinned stands. For oaks in control plots, Ψ_{PD} was substantially lower in 2025 compared to 2024, indicating higher depletion of plant-available water.
- Gate:** Similar water potential values in 2025 as measured in 2024 and comparable Ψ_{PD} and Ψ_{MD} measurements between treatments
- Warm Springs:** Ψ_{PD} was significantly lower in treatment plots, indicating higher water stress in thinned plots. However, these differences were variable between pairs of control and treatment plots, suggesting location-dependent responses.

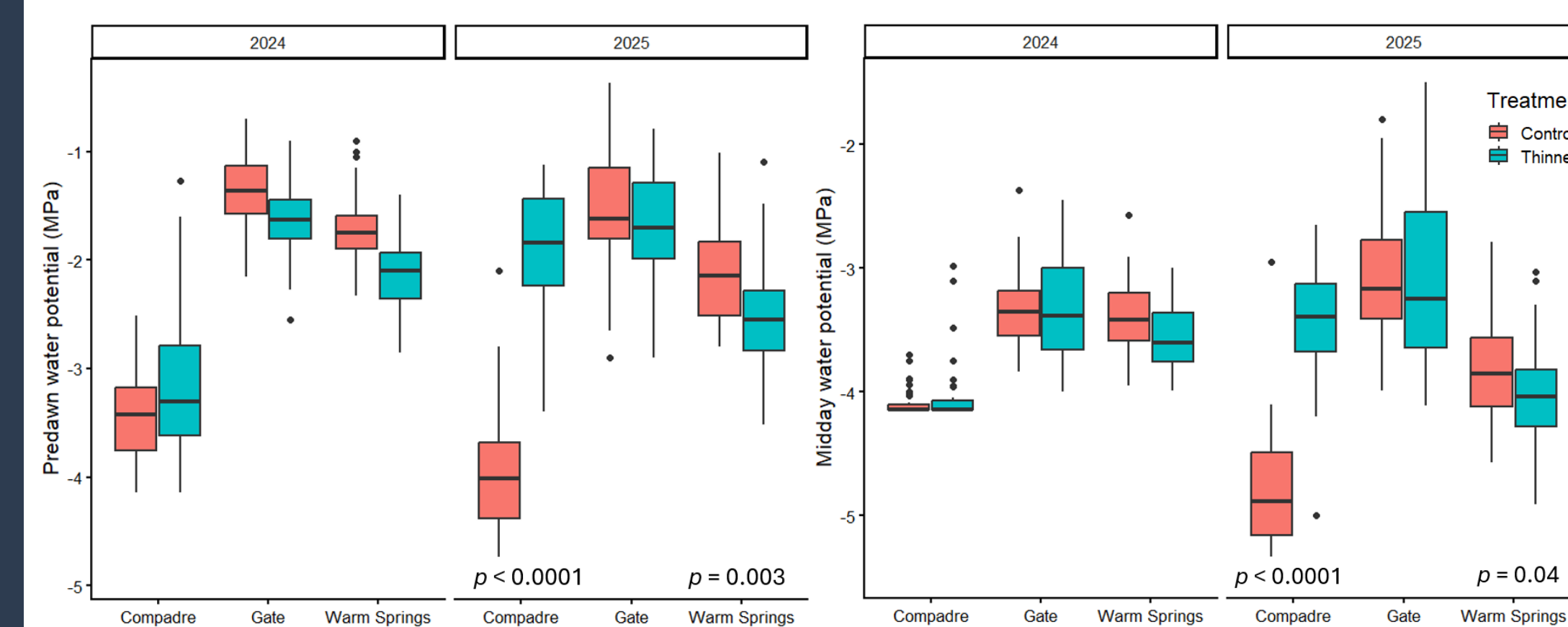


Figure 3. Mean (\pm SE) pre- (2024) and post-treatment (2025) predawn (left) and midday (right) water potential for Oregon white oak trees at the three study sites.

Stomatal conductance (g_s): Treatment enhanced g_s in residual oaks at two sites and had no measurable effect on g_s at one site (Figure 4). In both years, g_s was most strongly explained via its positive correlation with Ψ_{PD} (Figure 5).

- Compadre:** Treatment significantly increased gas exchange in residual oaks; in 2025, g_s was significantly low in Compadre control oaks compared to oak g_s in all other sites and treatments.
- Gate:** Oak g_s did not significantly differ between control and thinned plots. However, oak g_s in control plots was significantly lower in 2025 (relatively dry year) compared to 2024 while in thinned plots oak g_s was stable between 2024 and 2025, indicating that thinning enhanced productivity during dry conditions for residual oaks.
- Warm Springs:** In 2024 and 2025, stomatal conductance did not significantly differ between control and treatment plots and rates were comparable between years.

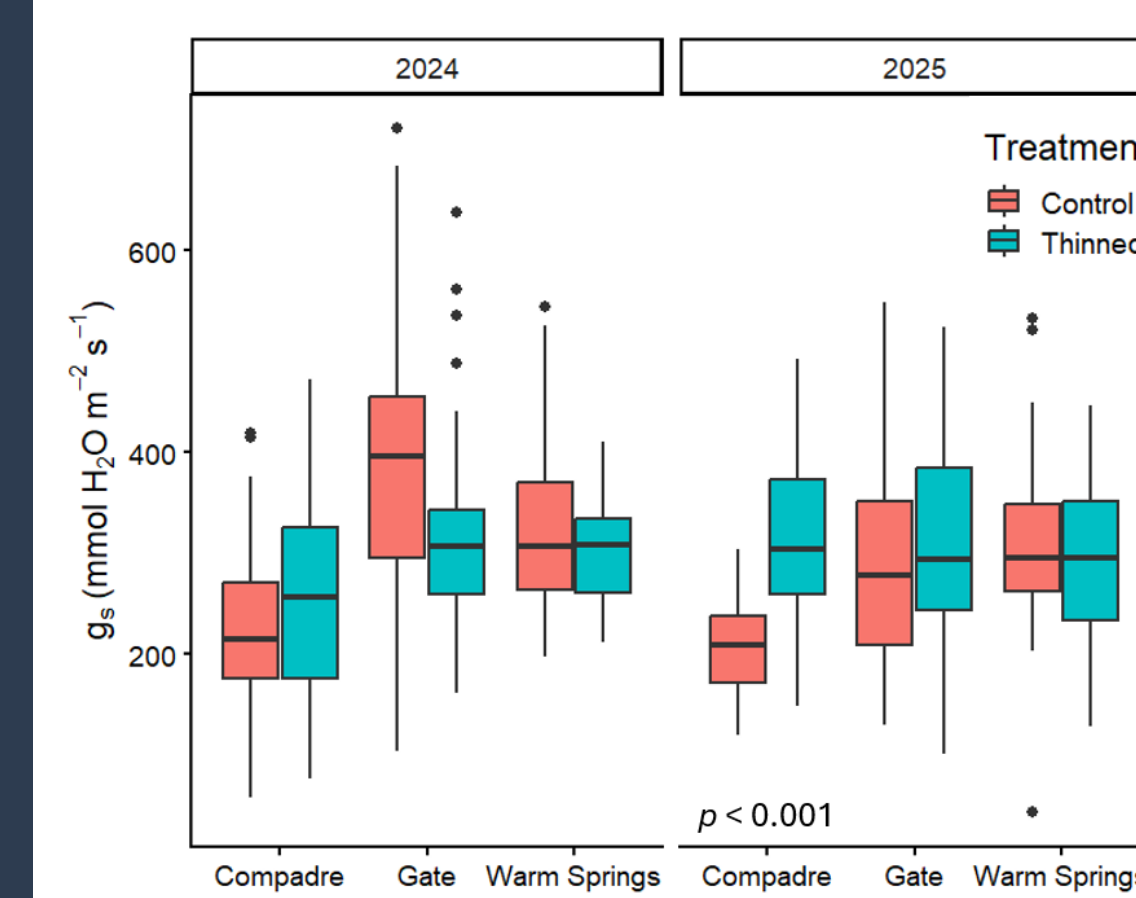


Figure 4. Mean (\pm SE) pre- (2024) and post-treatment (2025) midday stomatal conductance (g_s) for Oregon white oak trees at the study sites.

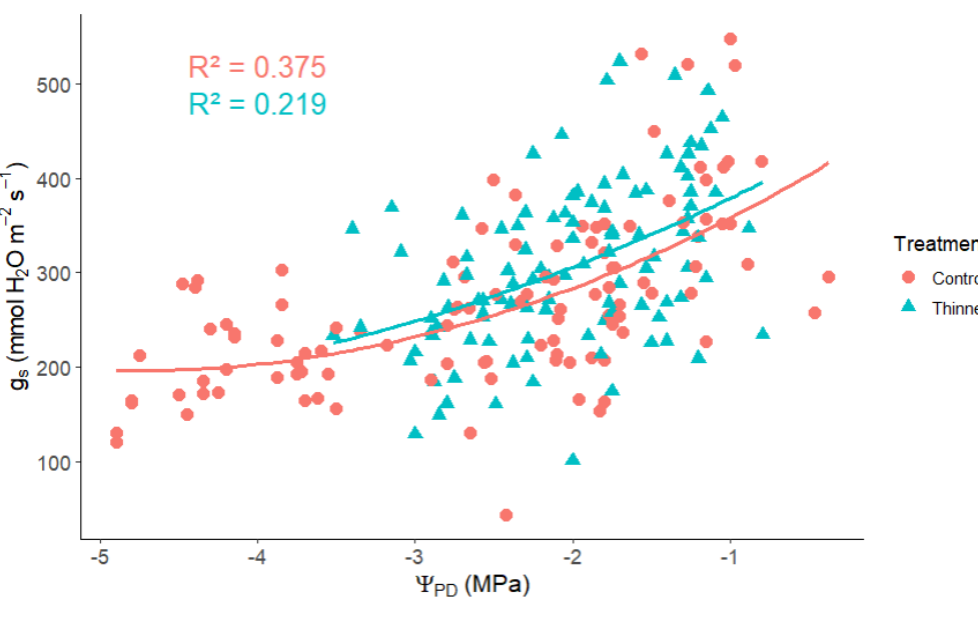


Figure 5. Post-treatment (2025) midday stomatal conductance (g_s) predicted by predawn water potential (Ψ_{PD}) for Oregon white oak trees in control and treated plots across the study sites.

Results- Isotopes

Soil: Isotope signatures varied slightly among sites but were generally comparable across the three depths, indicating similar evaporative enrichment rates across sites. The data confirm that isotopic signatures deplete with depth, offering insights into the rooting depths of individual trees (Figure 6).

Xylem: Water isotopic signatures indicated that at Compadre and Warm Springs, oaks primarily used water from deeper soil depths than conifers. At Gate, oaks and conifers appeared to more directly compete for water from comparable soil depths. The greatest difference in oak and conifer isotopic signatures was at Warm Springs, suggesting a high degree of niche partitioning for water between hardwoods and softwoods.

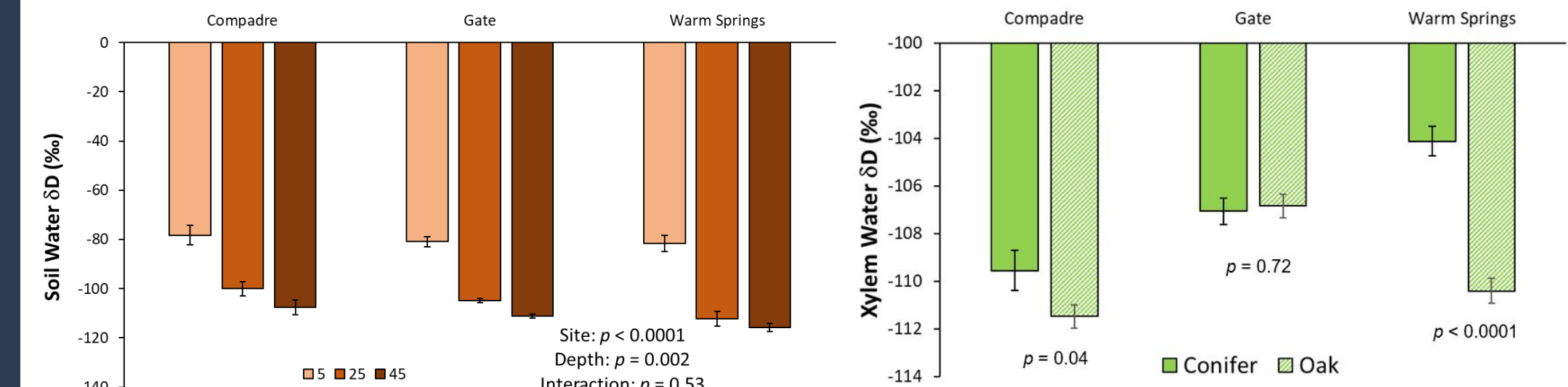


Figure 6. Mean (\pm SE) hydrogen (δD) isotopic signatures of water samples collected in August 2024 (pre-treatment). Left: soil water samples collected from three soil depths (cm). Right: twig xylem water samples collected from study oaks and their nearest conifer neighbors.

Conclusion, future analysis

Our first year of post-treatment data indicate that Compadre oaks responded positively to thinning while responses at Gate and Warm Springs were more muted. At Compadre, Ψ_{PD} in thinned plots was substantially higher in 2025 compared to 2024, indicating that thinning prolonged plant-available water. Similarly, thinning increased g_s at Compadre, despite drier post-treatment conditions. Notably, at Warm Springs, thinning seemed to enhance g_s , as treated plots had comparable rates between years while control plots experienced a drop in g_s during the drier 2025 conditions.

Isotopic data indicated that oaks and conifers do not directly compete for soil water at two of our three sites. At Gate, our densest site, oaks and conifers appeared to use water from similar soil depths, highlighting the potential for conifer removal treatments to benefit oaks, as competition for water between these taxa could exacerbate tree drought stress.

Future work includes collecting data in the second post-treatment year (2026) and then creating mixed effects models to describe the effects of biotic and abiotic predictor variables on oak physiology. Our examination of the physiological mechanisms underlying oak responses to thinning strengthens the scientific basis for restoration in water-limited landscapes and informs management in a warming climate.

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