Evolution of Soil Hydraulic Properties following Industrial Reforestation in Chile

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Background and Research Q's

Figure 1. Satellite imagery showing a site transitioning from traditional wheat cultivation to silviculture. Native forest is shown in blue.

Central Chile is at the end of a major land use transition, shifting from tilled agriculture (primarily wheat) to industrial forestry [1]. Much of this farmland has been severely degraded by over 200 years of intensive tillage.

This shift from annual cropping to silviculture, combined with Chile's unique geography, offers a rare opportunity to study the natural evolution of soil structure [2] (e.g., bioturbation, organic matter deposition, aggregate formation) and its effects on soil hydraulic properties (SHP).In addition to *in situ* infiltration measurements, we measured air permeability to evaluate whether soil air pathways are also evolving with the transition from wheat to forestry.

Our research questions are:

1) Does industrial silviculture improve the SHP over time?

2) What is the effect of climate on the evolution of SHP?

3) Is there a relationship between air and water permeabilities?

Site Locations and Rainfall Gradient

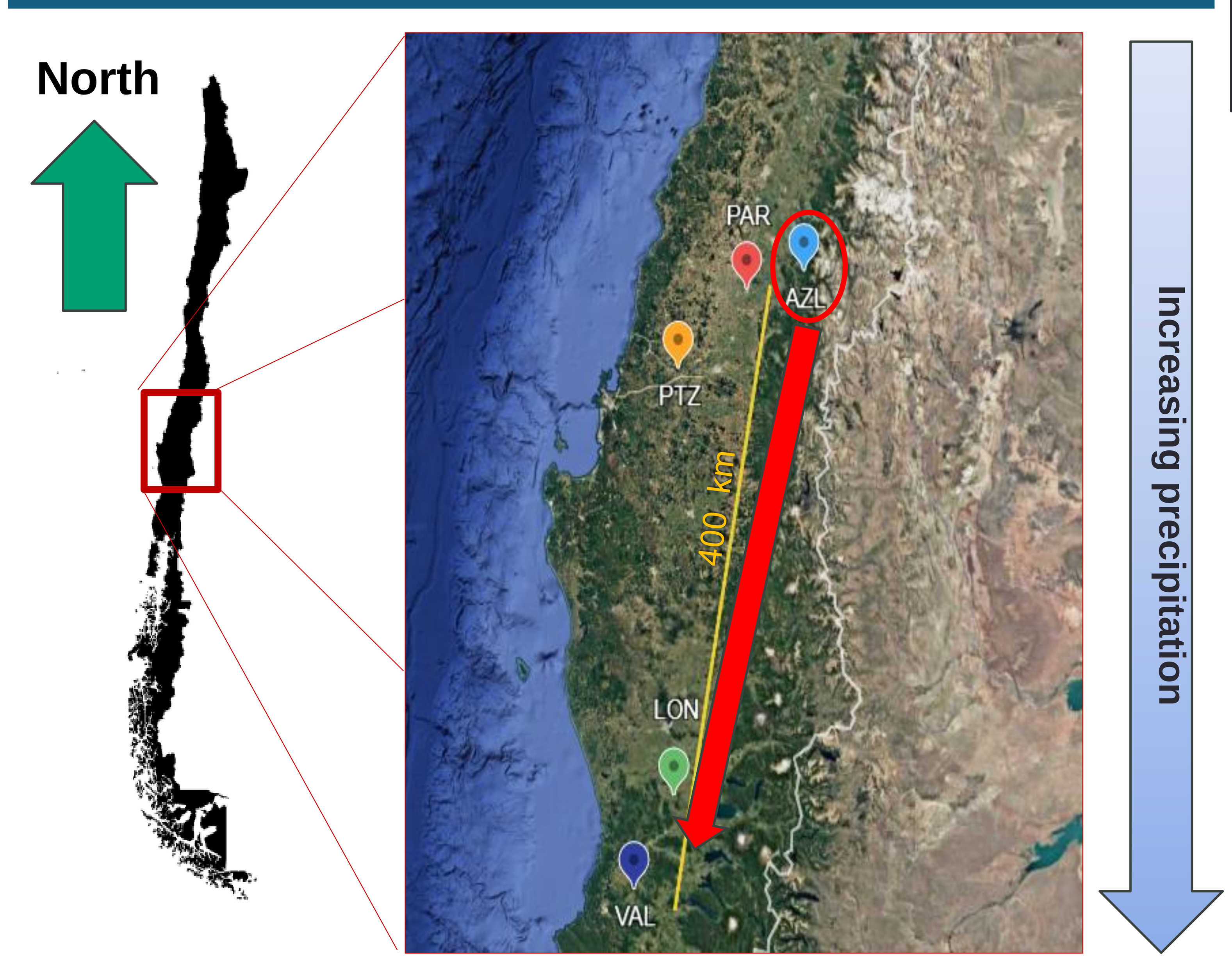

Figure 2. Locations of measurement sites along a 400 km transect spanning a ~1000 mm/year precipitation gradient. Note the AZL site (shown in light blue) is higher in elevation and, despite its position, receives greater precipitation.

Methods

To study this transition, we conducted over <u>280 collocated measurements</u> of air permeability and infiltration across two seasons at five sites. Plots of Native Forest (for reference), wheat, and pine plantations were selected for each site.

Air measurements were taken, followed by water infiltration measurements in the exact same ring. Additionally, we gathered over <u>50 undisturbed cores</u> and disturbed samples for laboratory analyses of soil physical and biological properties, including the water retention curve.

Our equation for air permeability (ka) was:

$$k_a = Q_a \frac{\mu_a}{\nabla p_a}$$

Where Q_a is the air flow $[\frac{m^3}{s}]$, μ is the dynamic air viscosity $[Pa * s]$, and ∇p_a is the gradient of the air pressure $[Pa]$.

And for water permeability (kw):

$$k_w = K_{sat} \frac{\mu}{\rho g}$$

Where μ is the dynamic viscosity $[Pa * s]$, ρ is the density of the fluid $[\frac{kg}{m^3}]$, and g is the acceleration due to gravity $[\frac{m}{s}]$. Ksat is the saturated hydraulic conductivity and is calculated using the Wu et al. (1999) method [3].

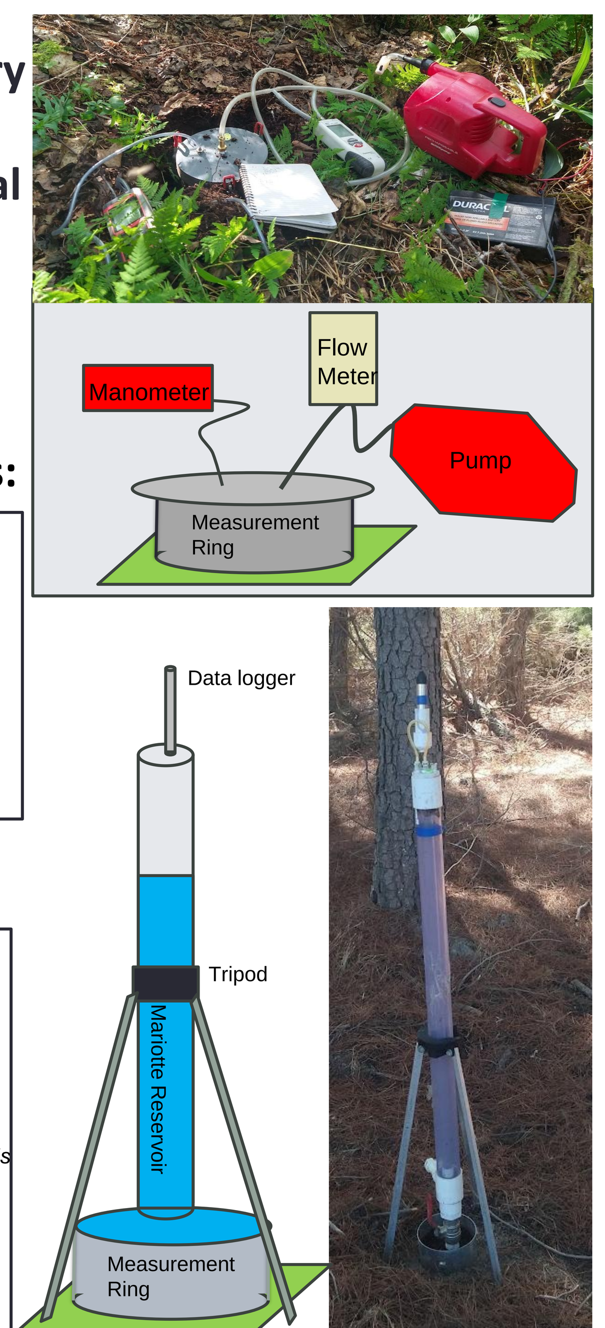

Figure 3. Diagrams and photos showing out field measurement devices (Air Permeameter above and in infiltrometer below).

Preliminary Results Air and Water field measurements

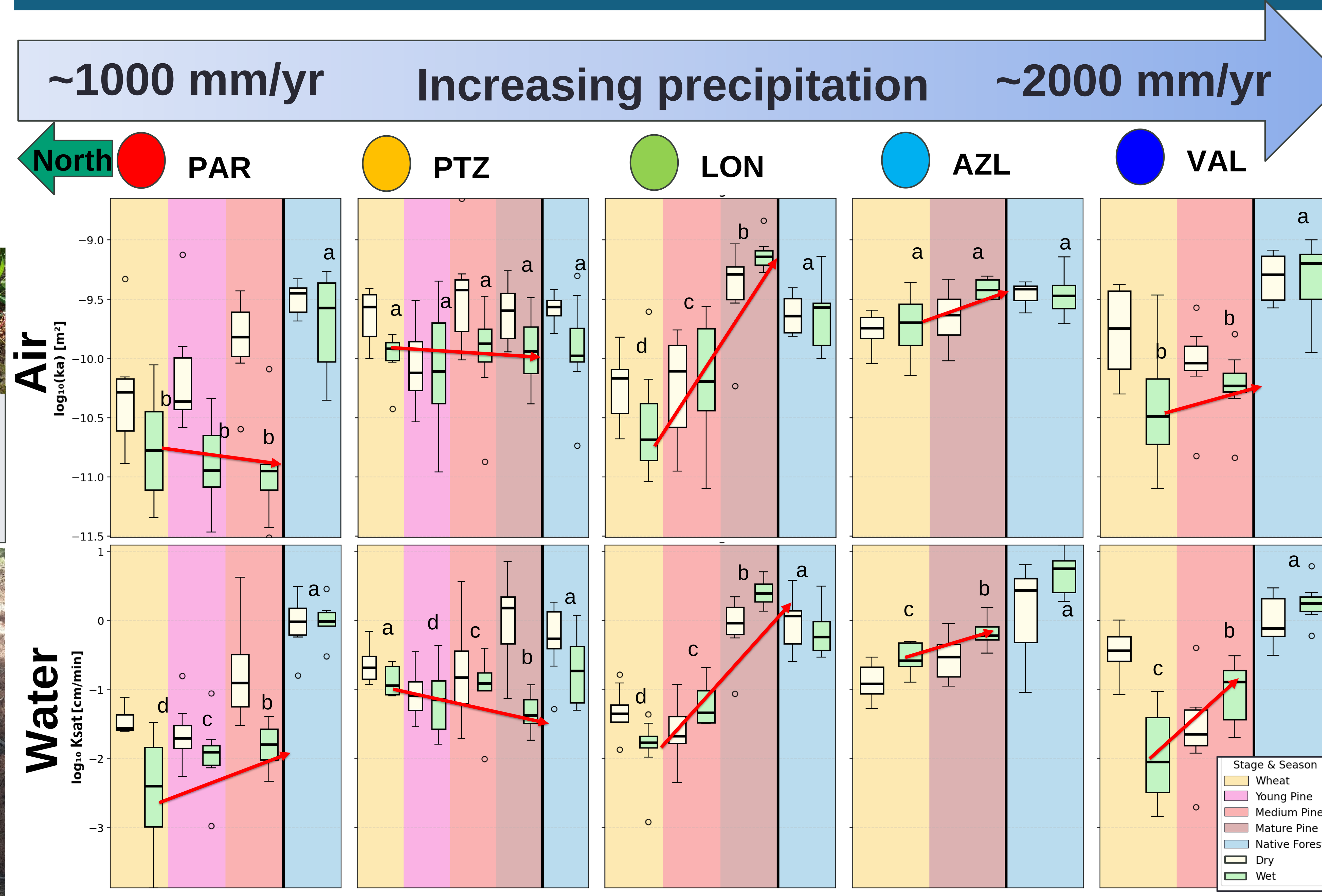

Figure 4. Results from our field measurements of air permeability (above) and water saturated hydraulic conductivity (below) for each of our five sites. The yellow bars indicate plots still in wheat cultivation, the pink to red colors represent sites which are first rotation pine plantations of progressing ages, and the light blue is native forest. The green bars are wet season measurements, and the tan are dry season. The red arrows are drawn from wheat to oldest pine plantations for the wet seasons. The letters indicate statistically significant differences (or lack thereof) within a site during the <u>wet</u> season only.

Air and Water Combined

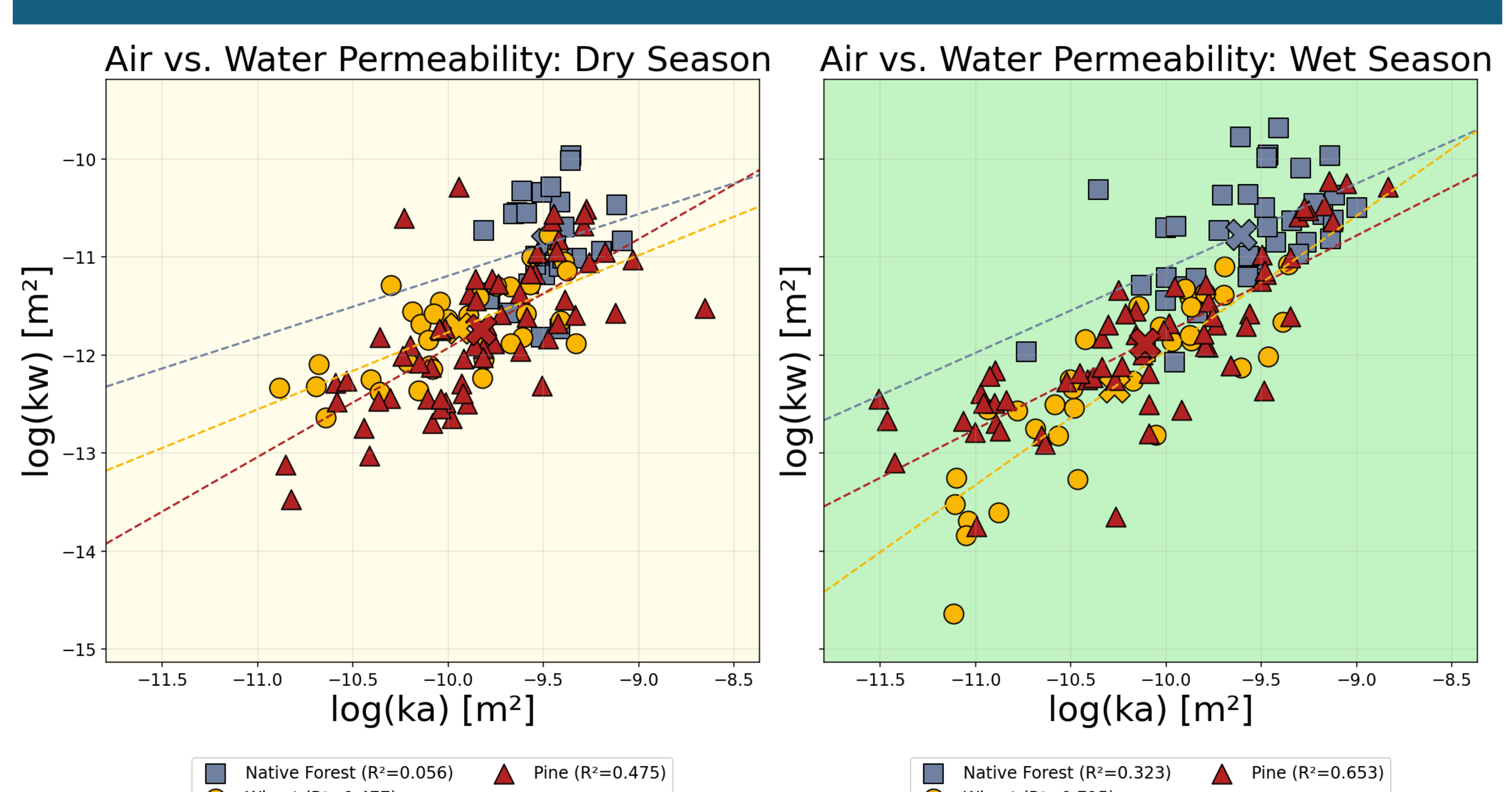

Figure 5. Relationship between air permeability and water permeability, grouped by cover type. All relationships are significant except for the native forest during the dry season.

Conclusion and Future Directions

While these results are still preliminary, our data suggest:

1) SHP (or at least Ksat) does improve following the transition to silviculture; however….

2) This improvement is limited to sites with higher precipitation, indicating a potential role of climate. Similar trends are seen in each season.

3) Air and water permeabilities show a relationship, but it is stronger in soils with less developed natural structure.

Moving forward we will analyze our samples in the laboratory, including texture, soil water retention curve, lab ka and Ksat tests, soil organic matter, aggregate stability , etc.

Acknowledgements

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