Is Soil Generalist *Erysimum capitatum* Differentially Adapted to Serpentine Soils Across California Serpentine Exposures?

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BACKGROUND

- Serpentine only covers 1.5% of the state but houses ~9% of CA endemics [1].
- Serpentine soil is stressful for plants because it contains heavy metals and is high in Mg and low in Ca [2].
- It has been used as a model system to study evolution for decades [3].
- Serpentine formations can be highly variable in heavy metals, physical properties, and parent material [3] but most studies treat all serpentine as homogeneous environments [4, 5].
- Few studies have addressed how differences in serpentines may cause plants to locally adapt to their soil of origin [4].
- *Erysimum capitatum* (Brassicaceae) is widespread in western North America, categorized as a soil generalist, and found in patchy populations [6, 7].
- *E. capitatum* occupies numerous distinct serpentine formations with nearby populations inhabiting non-serpentine soil.
- This makes it an ideal system to see if local adaptation is occurring between pairs of serpentine and non-serpentine populations and to test if serpentine populations are adapted to their specific serpentine soil.

Figure 1. Serpentinite, the parent material for serpentine soil in New Idria, CA.

Figure 2. *E. capitatum* growing in serpentine soil in New Idria, CA.

QUESTIONS

Q1. Are *E. capitatum* populations growing on serpentine soil locally adapted to serpentine soil as compared to nearby non-serpentine populations?

Q2. Does a serpentine ecotype of *E. capitatum* exist?

Q3. Do *E. capitatum* populations experience differential success when grown in their home serpentine vs other serpentine soils?

METHODS

Greenhouse Reciprocal Transplant

- Seeds collected from *E. capitatum* populations found on paired serpentine (n=4) and non-serpentine soil sites (n=4) across CA latitudinal gradient (Fig 3.)
- Soil was collected from the four serpentine sites.
- Seeds from 6-8 mothers at each site were germinated and planted into each of the soils plus a control sandy loam soil (43 seeds x 8 pops x 5 soils =1720 plants).
- Planting occurred in Dec 2022.
- Monthly data collected on longest leaf length, leaf count, and mortality.
- After 6 months of growth, shoot and root biomass were weighed.
- All data analyzed in R.

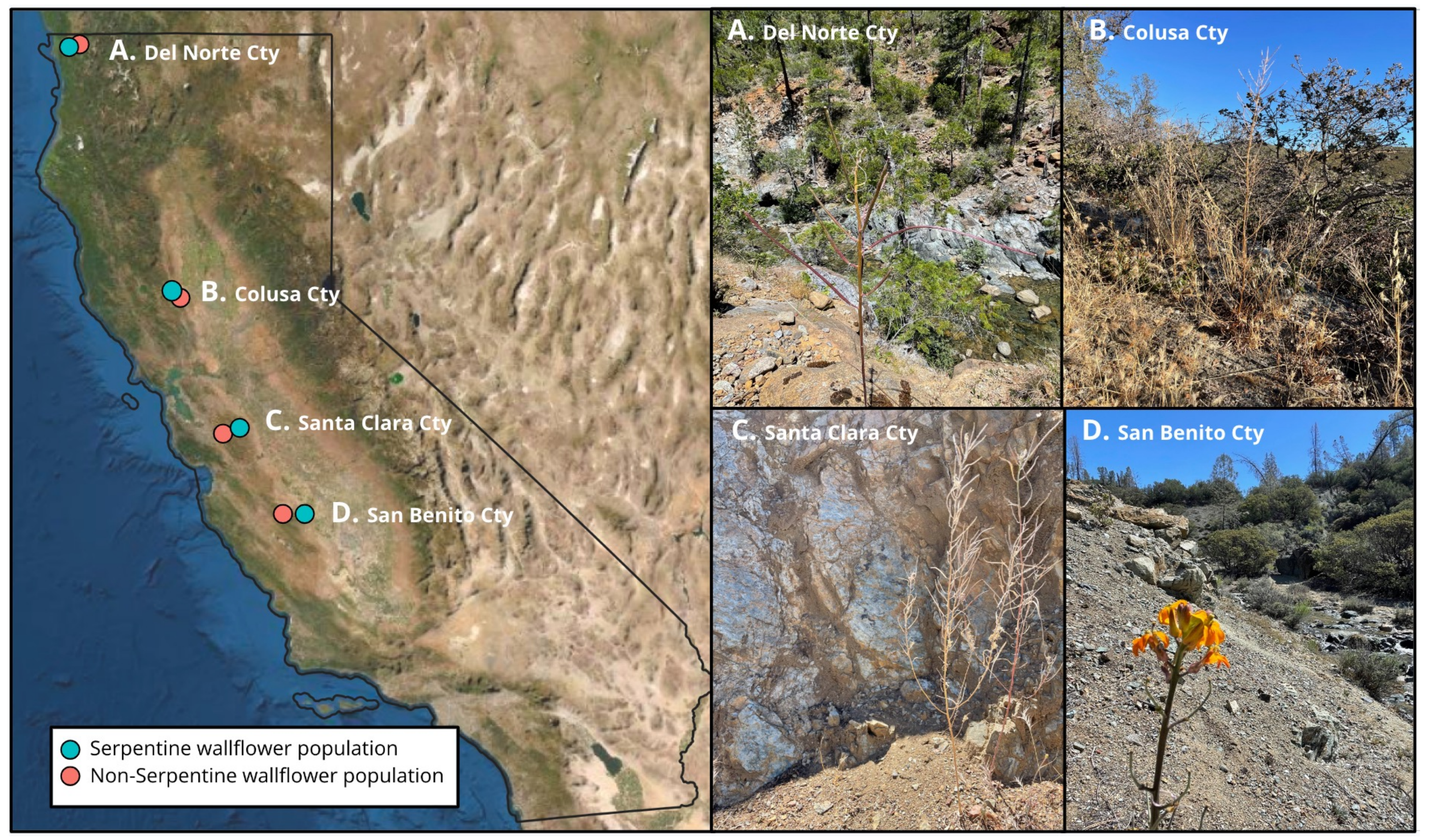

Figure 3. Map of *E. capitatum* serpentines and non-serpentine field site locations across CA with photos of individuals from each serpentine population. Map created using QGIS.

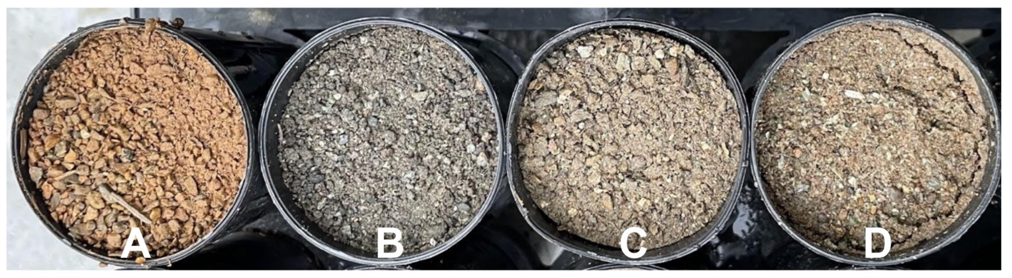

Figure 4. Cone-tainers of serpentine soils.

RESULTS

Q1 Results: Local Adaptation Found in 2 Serpentine Populations

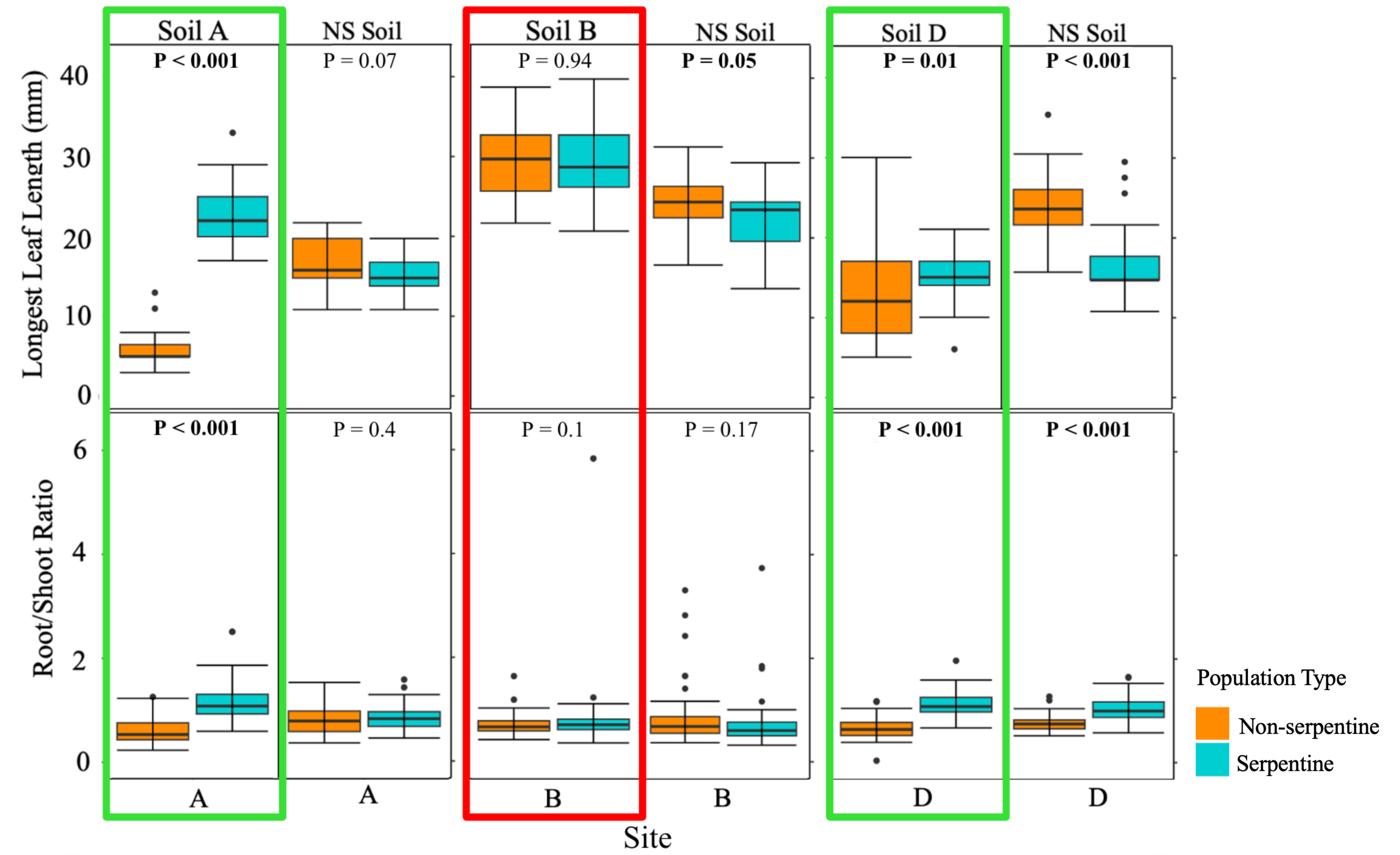

Figure 5. *E. capitatum* populations growing in home serpentine soils and non-serpentine soil. Top row showing longest leaf length comparisons and bottom showing root:shoot ratios. Soil C excluded due to total mortality. Analyzed using Wilcoxon rank sum test with continuity correction. Significant p-values bolded.

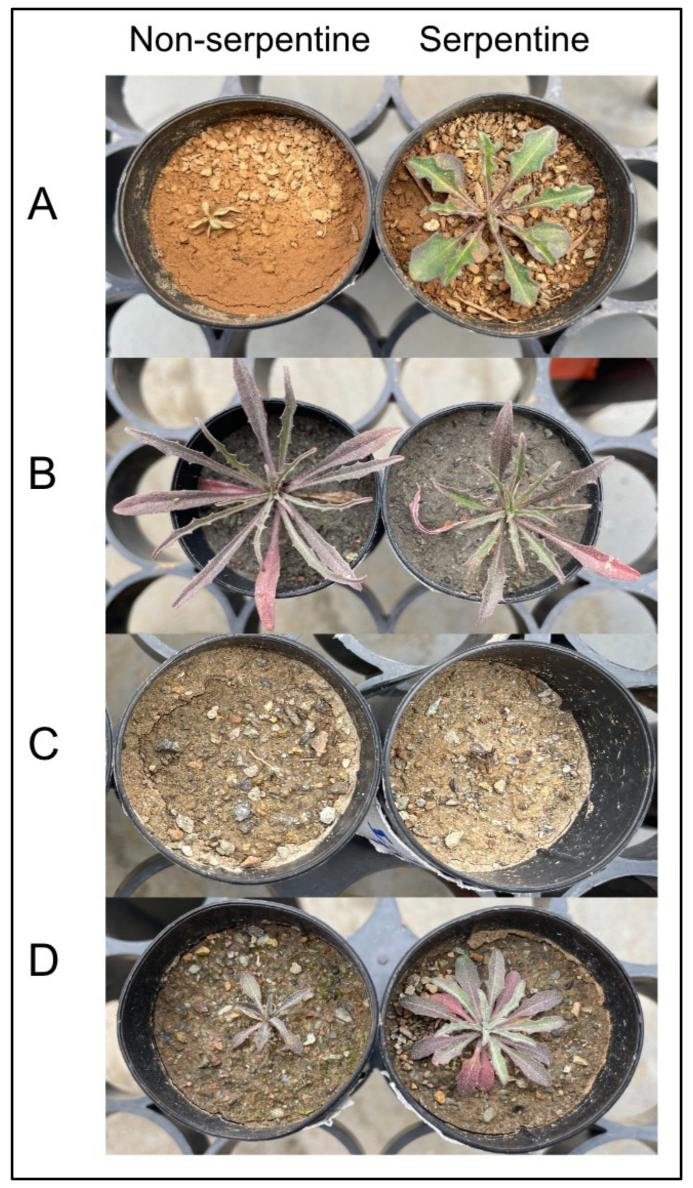

Figure 6. Population pairs after 6 months.

Q2 Results: No Serpentine Ecotype

- Evidence for an ecotype was not seen because not all serpentine populations were locally adapted.

Q3 Results: No Home Serpentine Advantage

- Serpentine populations did not exhibit any preference to growing in their home serpentine soil.

Other Results: Trend on Soil A

- All serpentine populations on serpentine Soil A outperformed the non-serpentine populations.
- **Conserved trait shared across serpentine populations for serpentine tolerance.**
- Soil analyses revealed high amounts of heavy metals: Fe, Ni, Mn, and Co in this soil only. Soil parent material dominantly Peridotite and Harzburgite.
- Heavy metal tolerance well known in other serpentine Brassicaceae.

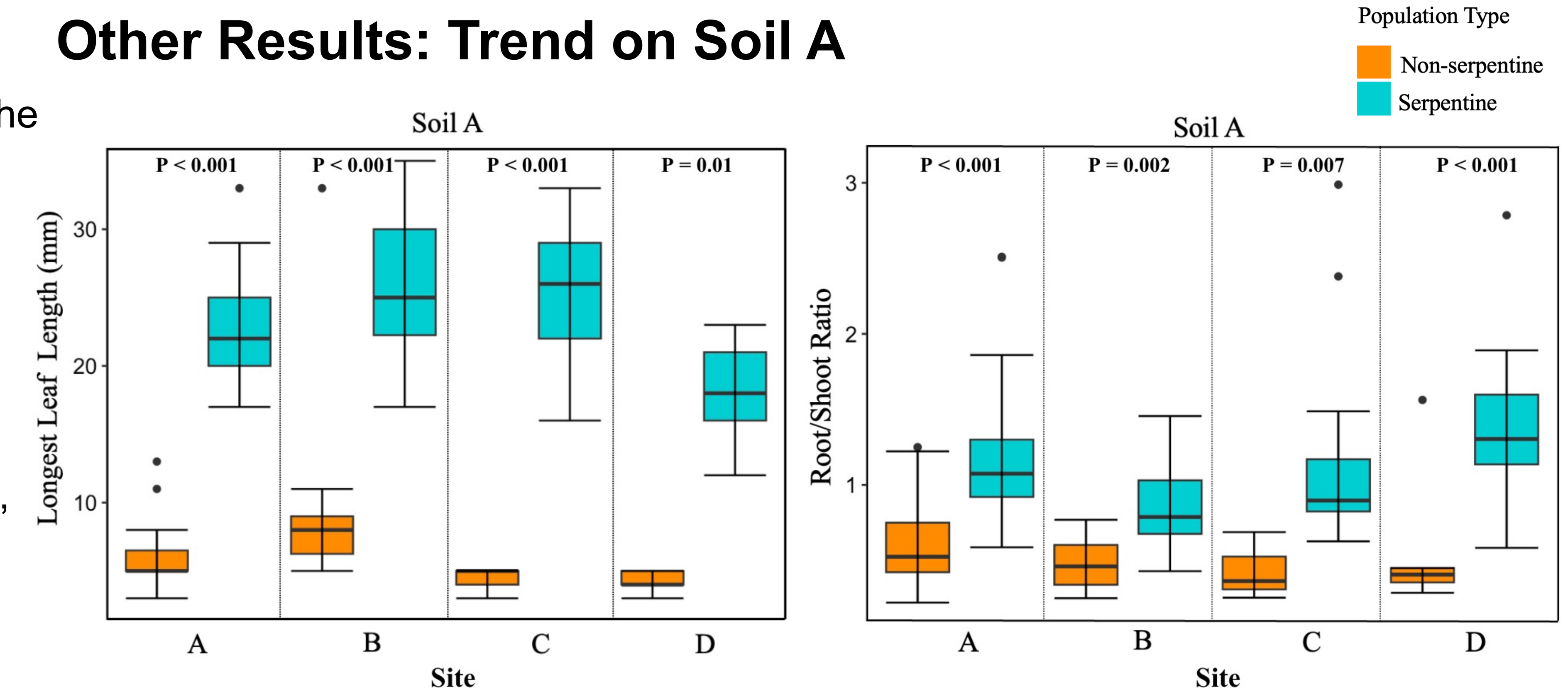

Figure 7. All *E. capitatum* populations growing in Serpentine Soil A. Left graph showing longest leaf length comparisons and right graph showing root:shoot ratios. Analyzed using Kruskal Wallis rank sum test with post hoc Dunn Test. Significant p-values bolded.

CONCLUSIONS

- There is a conserved trait for serpentine tolerance within *E. capitatum* serpentine populations possibly linked to heavy metal tolerance. More experiments testing populations on other high heavy metal serpentines is needed.
- Serpentine soils are diverse and the variation between exposures should be considered in botanical studies. Therefore, conducting experiments including serpentines from varying exposures is important to identifying differing adaptation.

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