Fierce urgency: on-the-fly development of a coast redwood drought-response monitoring program on a college campus

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Introduction

Vegetation transitions happened in the past over geological time scales.

Vegetation transitions are predicted in much of California with climate change, and changes are already in motion.[1,2]

Twentieth-century shifts in forest structure in California: Denser forests, smaller trees, and increased dominance of oaks

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Coast redwoods are resilient after fire[3] and flood, but coast redwoods are also predicted to see significant range shifts with climate change.[4.] Monitoring of change among planted, urban and semi-urban redwoods may give us insights into the future.
What factors might result in stressed redwood forest?

Global Change Biology

Primary Research Article

Back to the future: using historical climate variation to project near-term shifts in habitat suitable for coast redwood

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In 2019 we began seeing (presumed) drought effects in redwoods on our campus – and did not know how or whether this might signal the onset of transitional loss of redwood forest – or if redwoods suffering from extreme drought are able to recover. Work on drought in redwoods has focused on seedlings[5], growth effects[6], and genomic analysis[7], not on resilience in mature trees.

What might transition look like?

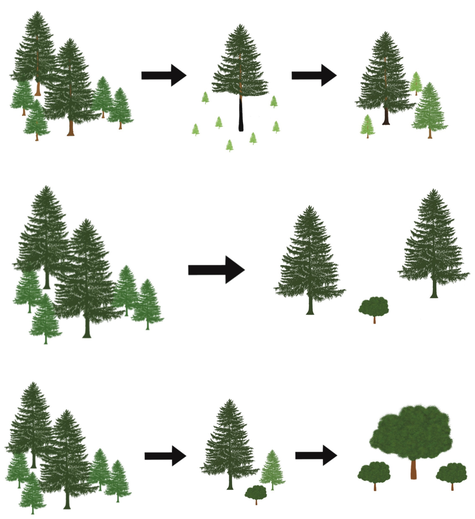

Fig.1: potential responses to disturbance

Artwork by Madi Tatar 2024

Coast redwoods in California are iconic, a critical foundation species ecologically, and important in carbon sequestration

Redwoods are resilient post-fire and post-flood but climate change is also expected to increase intensity and frequency of drought

Our results show coast redwoods were able to recover from the recent series of droughts after a good rainfall year but we do not yet know how they recover or the limits of their resiliency in the face of higher intensity droughts

Mechanisms of recovery may include epicormic bud sprouting and changes in stomata and wax coverage on new needles

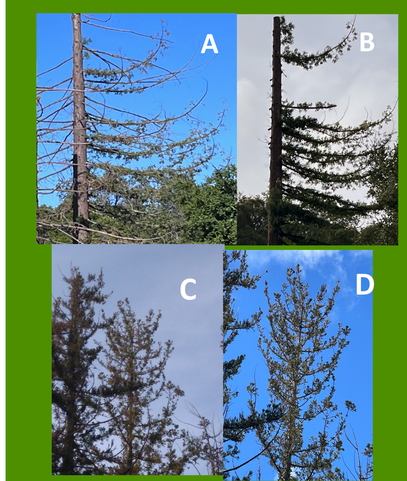

Fig.6 A B C D: *A and B are same tree Mar 2022 and Dec 2023. C and D are same tree Nov 2022 and Mar 2023. E and F are drone photos of canopy tops of the more stressed and less stressed trees whose needles were used in the stomatal and wax fraction analyses in Figs. 3 and 4*

Abstract link: SCAN ME

References link: SCAN ME

Methods

Our methodologies shifted after fall 2019: students evaluated "healthy" or not (2019) or % green from distance
Xylem conductivity evaluation used a modification of Jacobson et al[8]
Stomatal analysis and wax fraction calculations for assessing hydraulic character of needles were based on Chin et al[9]

Results

During the course of the drought, tree health/greenness declined. After the rainfall of 2022-2023, individual trees showed recovery.
Brown dry-looking stems had green epicormic buds and maintained potential for xylem function.

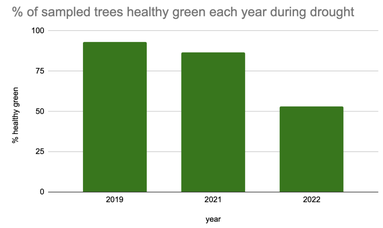

Fig.2: *Tree evaluations by student groups; from 2021 and 2022 (two semesters in 2022) were classified as healthy green if assessed as at least 75% green*

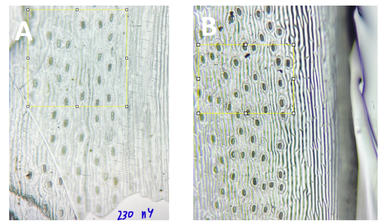

Fig.3 A and B: *Stomatal density in needles from less stressed trees (A) was significantly lower than stomatal density in more stressed trees (B).*

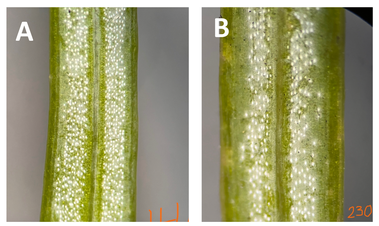

Fig.4 A and B: *Abaxial wax fractions on needles from less stressed trees (A) were significantly higher than those in stressed trees (B).*

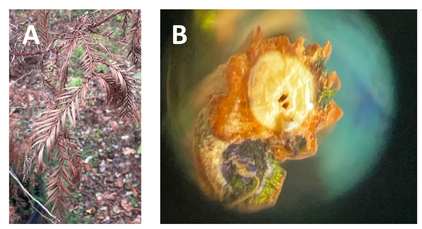

Fig.5 A and B: *Redwood stems and leaves can seem entirely brown (A) but still have functional xylem (stained in purple) and epicormic bud tissue (green).*

Conclusions/next steps

Our first-step conclusion is that although coast redwoods grew increasingly stressed under the most recent drought, they were able to begin to recover once rainfall returned. The stem dissections and xylem tests show that dead-looking drought-stressed trees may be ready to sprout epicormic buds.
The wax fraction and stomatal bed analyses suggest stressed trees are making new needles that are less hydraulically protected but better able to take up moisture from fog than those of non-stressed trees.
We are continuing the monitoring project, expanding our photo database with drone surveys, and doing more microscopic hydraulic analysis.

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