Mortality of California shrubs: The roles of climate change and pathogens

R. Brandon Pratt
Biology Professor
CSU Bakersfield

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- Anna Jacobsen
- Stephen Davis
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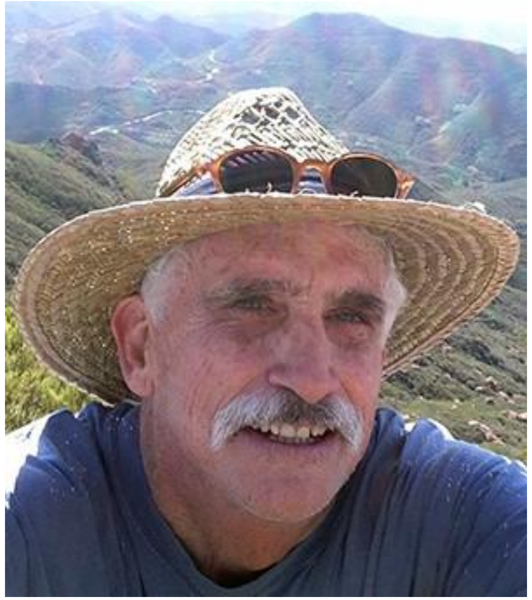
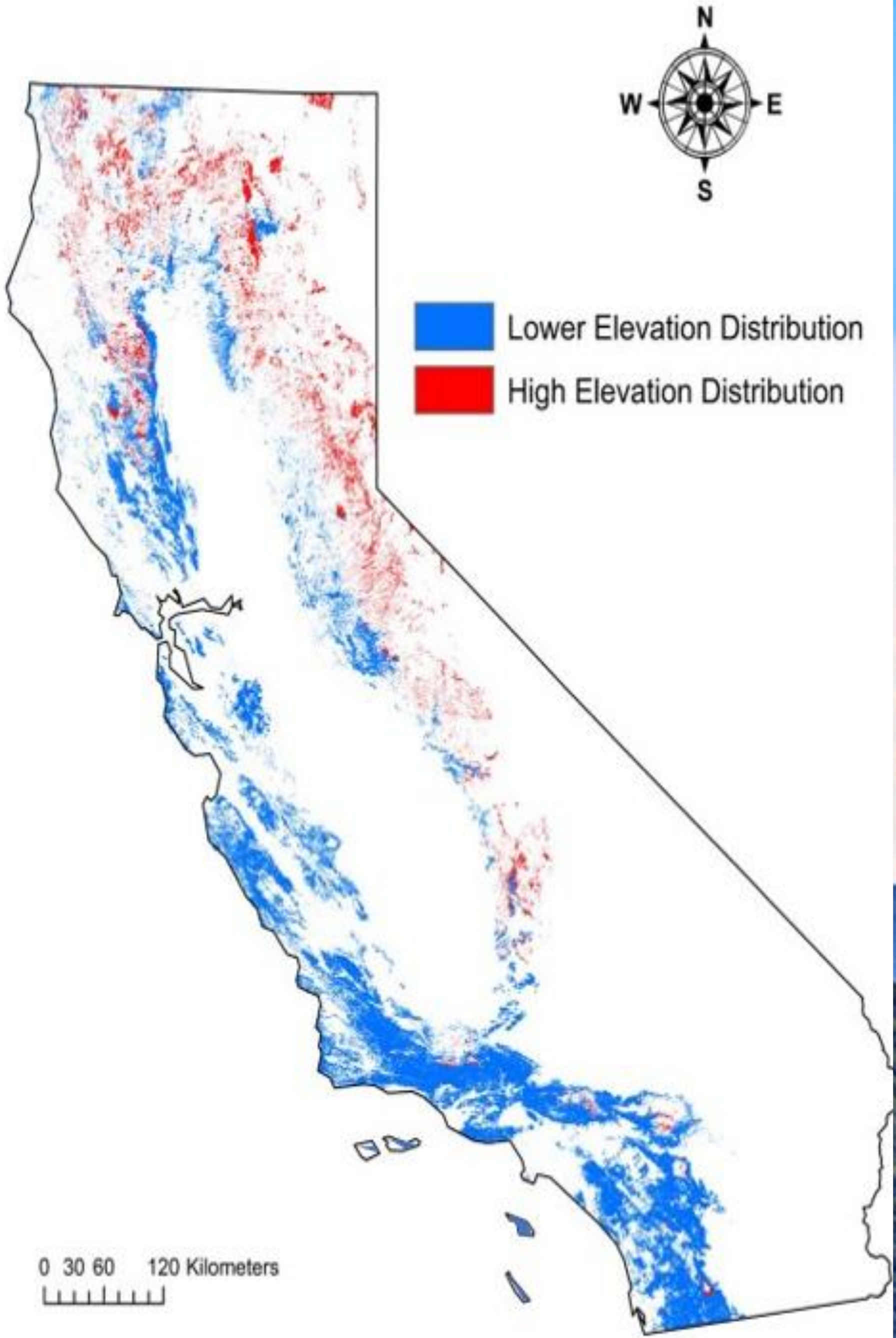


Chaparral

- A mediterranean-type climate region shrubland
- Evergreen leaves and thick hard leaves
- Fire-adapted
- Most-extensive vegetation type in California

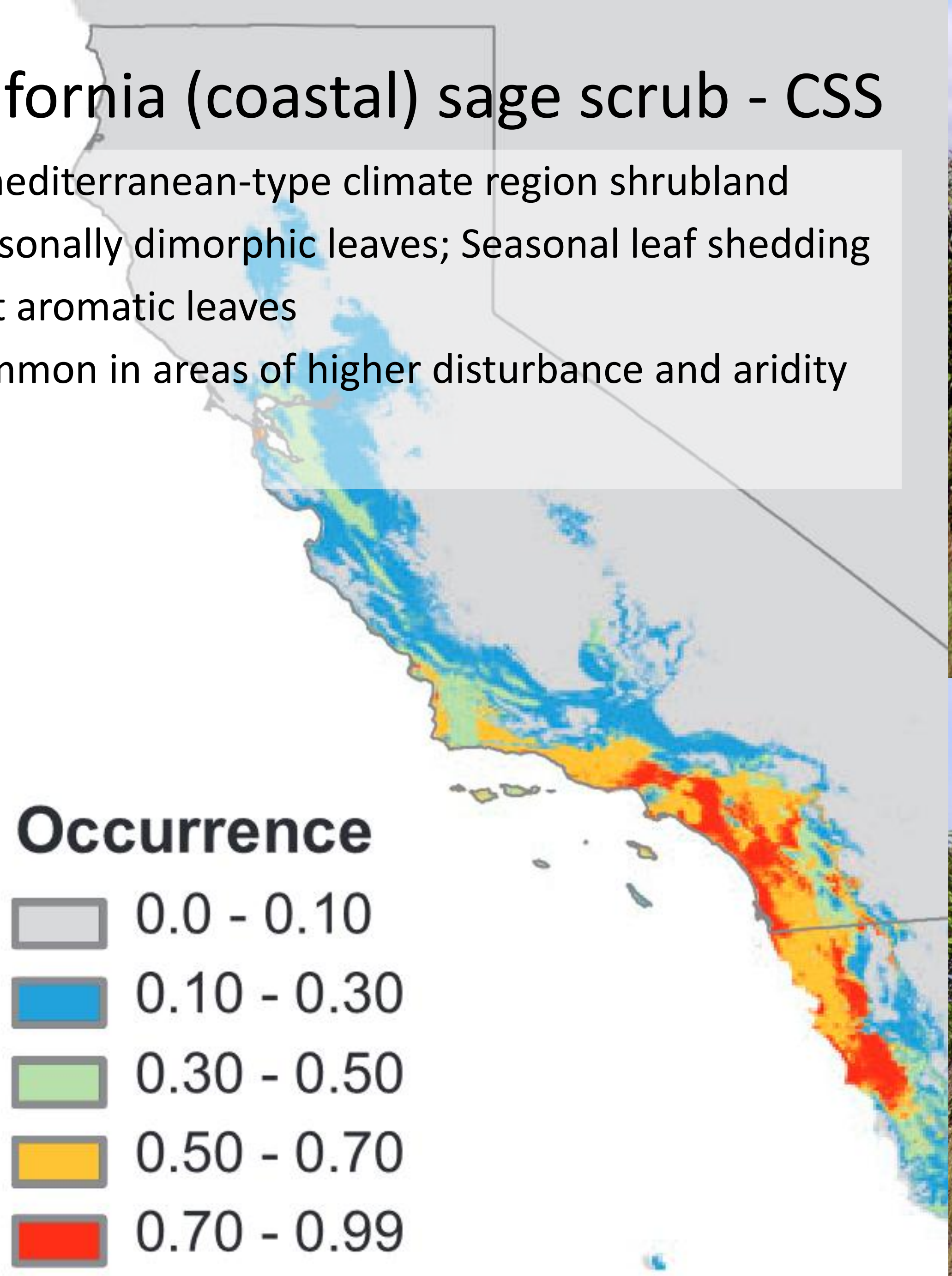
Photo Credit: Pratt



Map Credit: Parker, Pratt, and Keeley, 2016

California (coastal) sage scrub - CSS

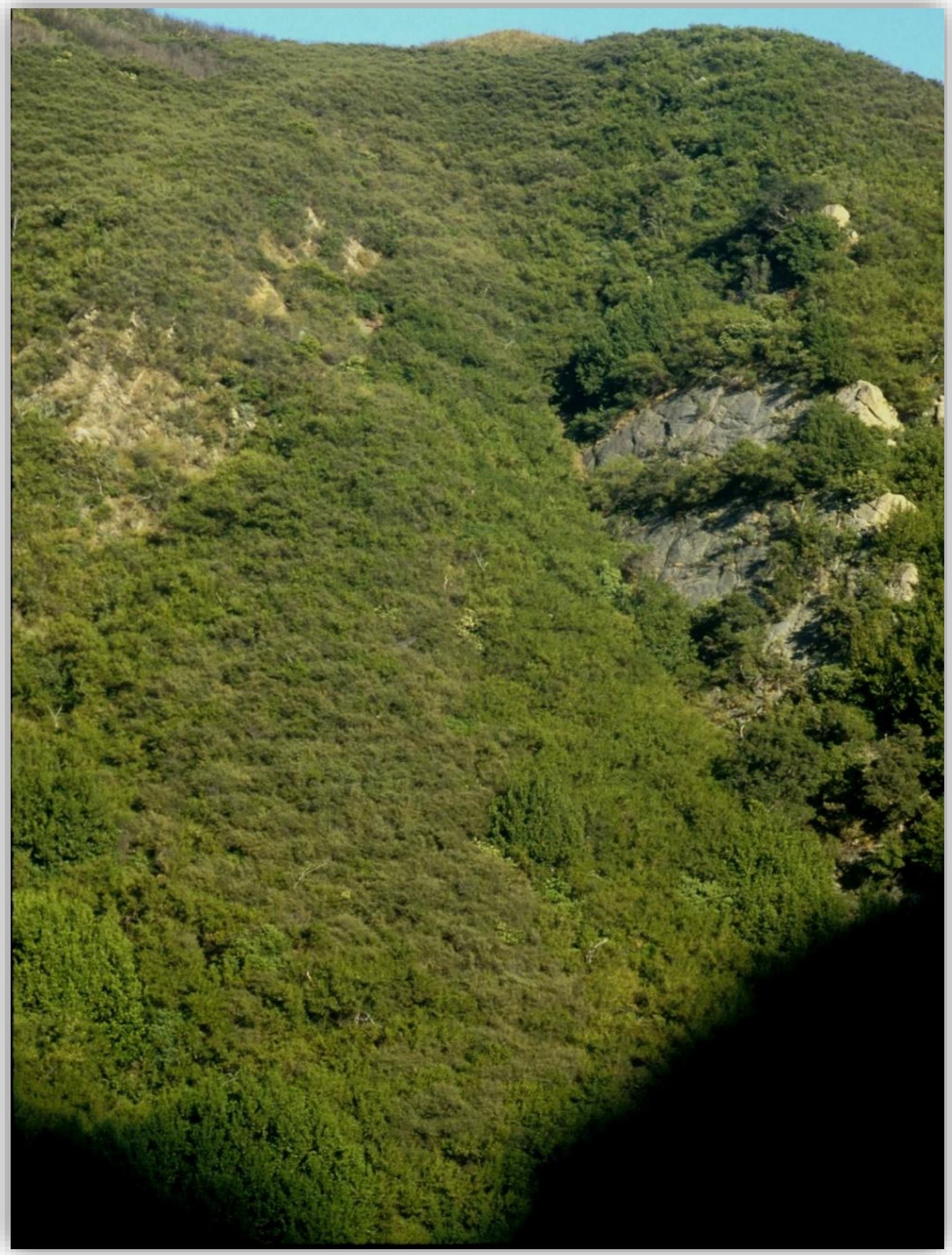
- A mediterranean-type climate region shrubland
- Seasonally dimorphic leaves; Seasonal leaf shedding
- Soft aromatic leaves
- Common in areas of higher disturbance and aridity



Riordan and Rundel 2009 Journal of Biogeography

Photo Credits: Jacobsen

Vegetation-type conversion



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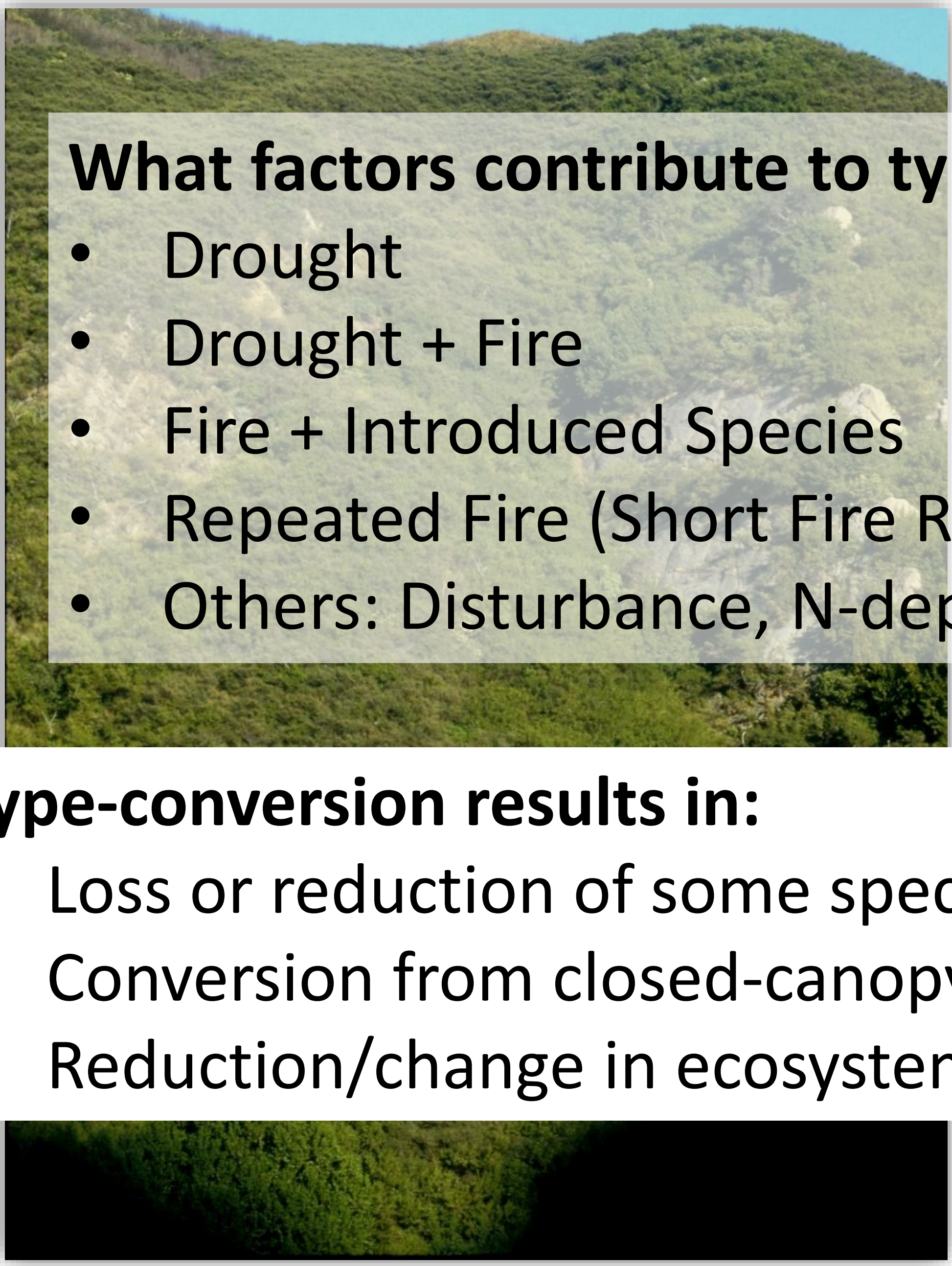
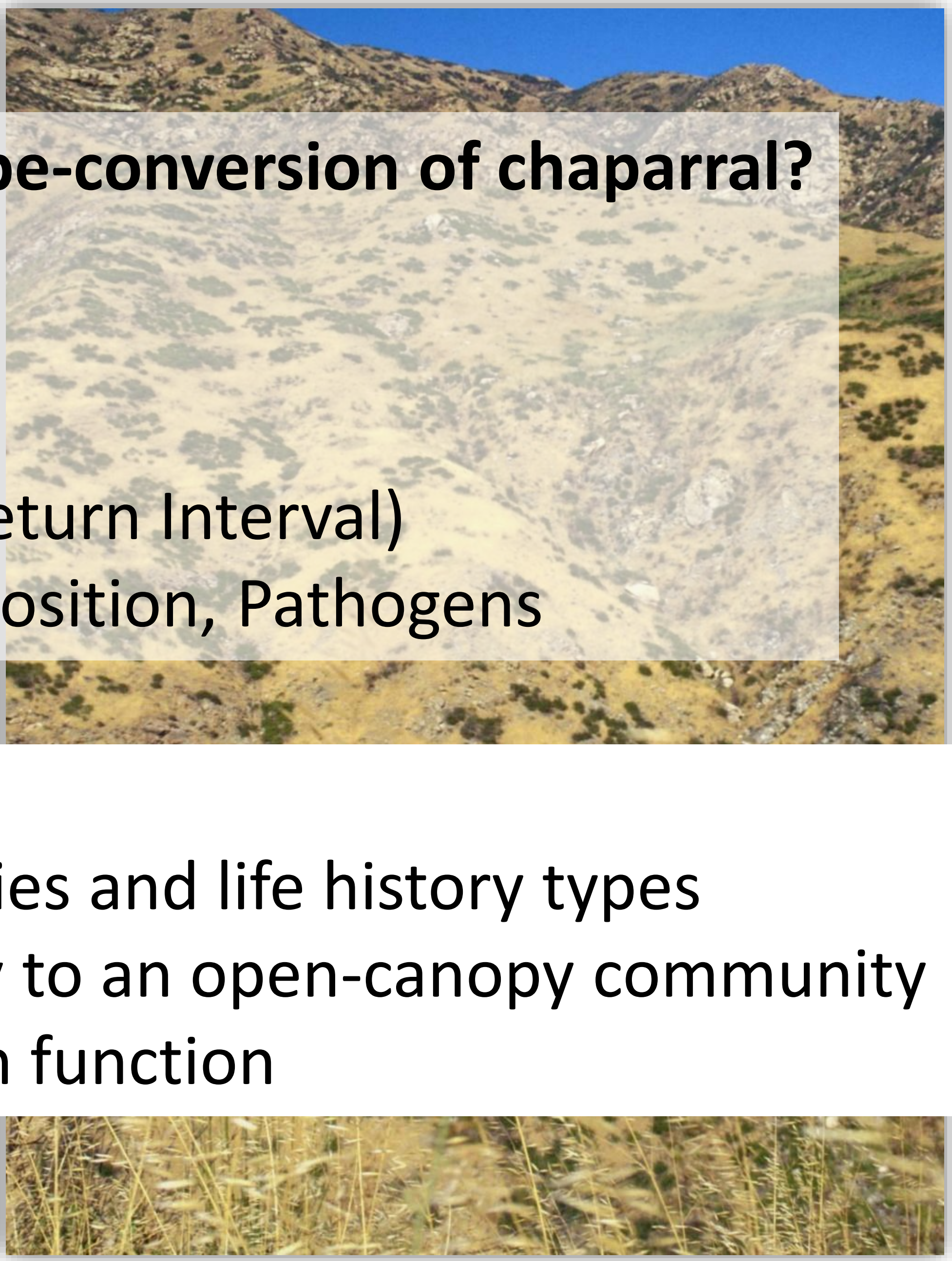




What factors contribute to type-conversion of chaparral?

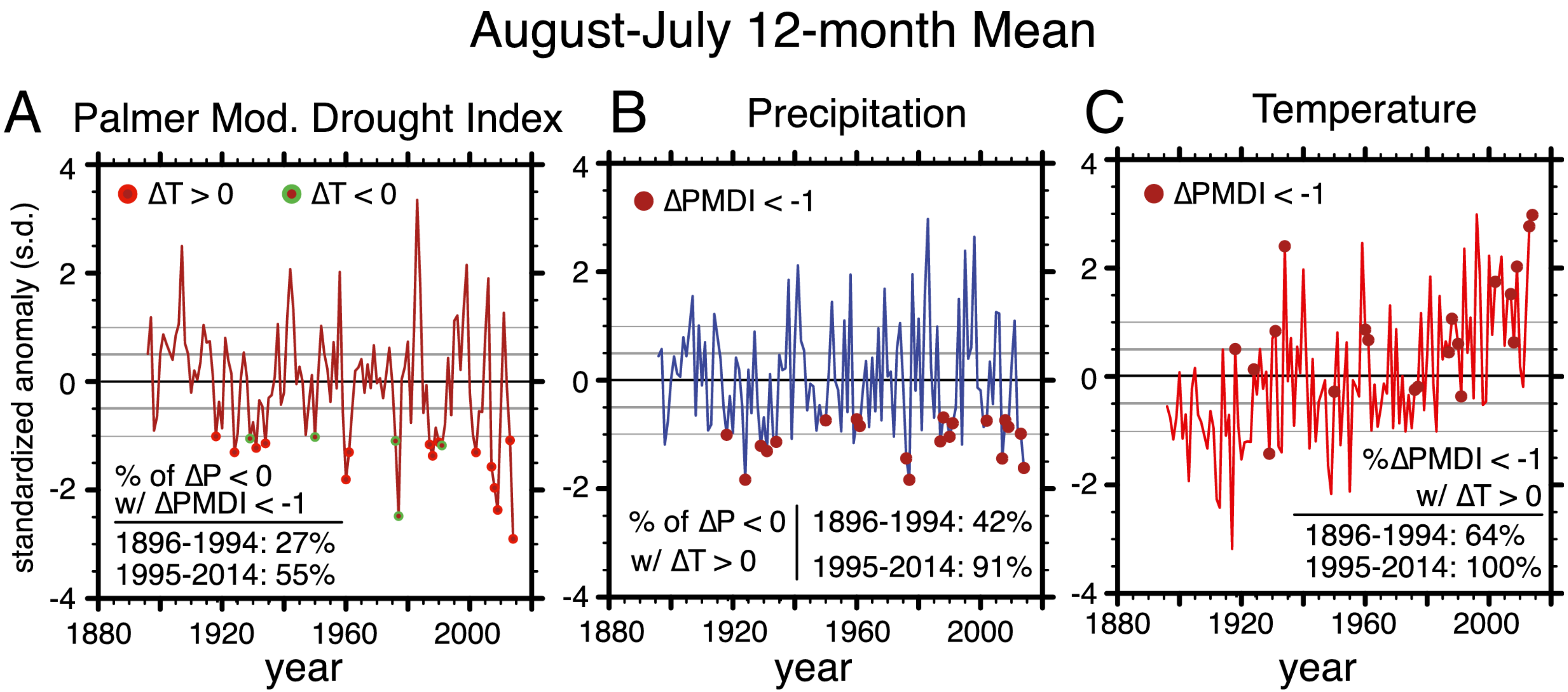
- Drought
- Drought + Fire
- Fire + Introduced Species
- Repeated Fire (Short Fire Return Interval)
- Others: Disturbance, N-deposition, Pathogens

Type-conversion results in:

- Loss or reduction of some species and life history types
- Conversion from closed-canopy to an open-canopy community
- Reduction/change in ecosystem function

Photo credits: Stephen D Davis

Climate change-type droughts: “Hot droughts”



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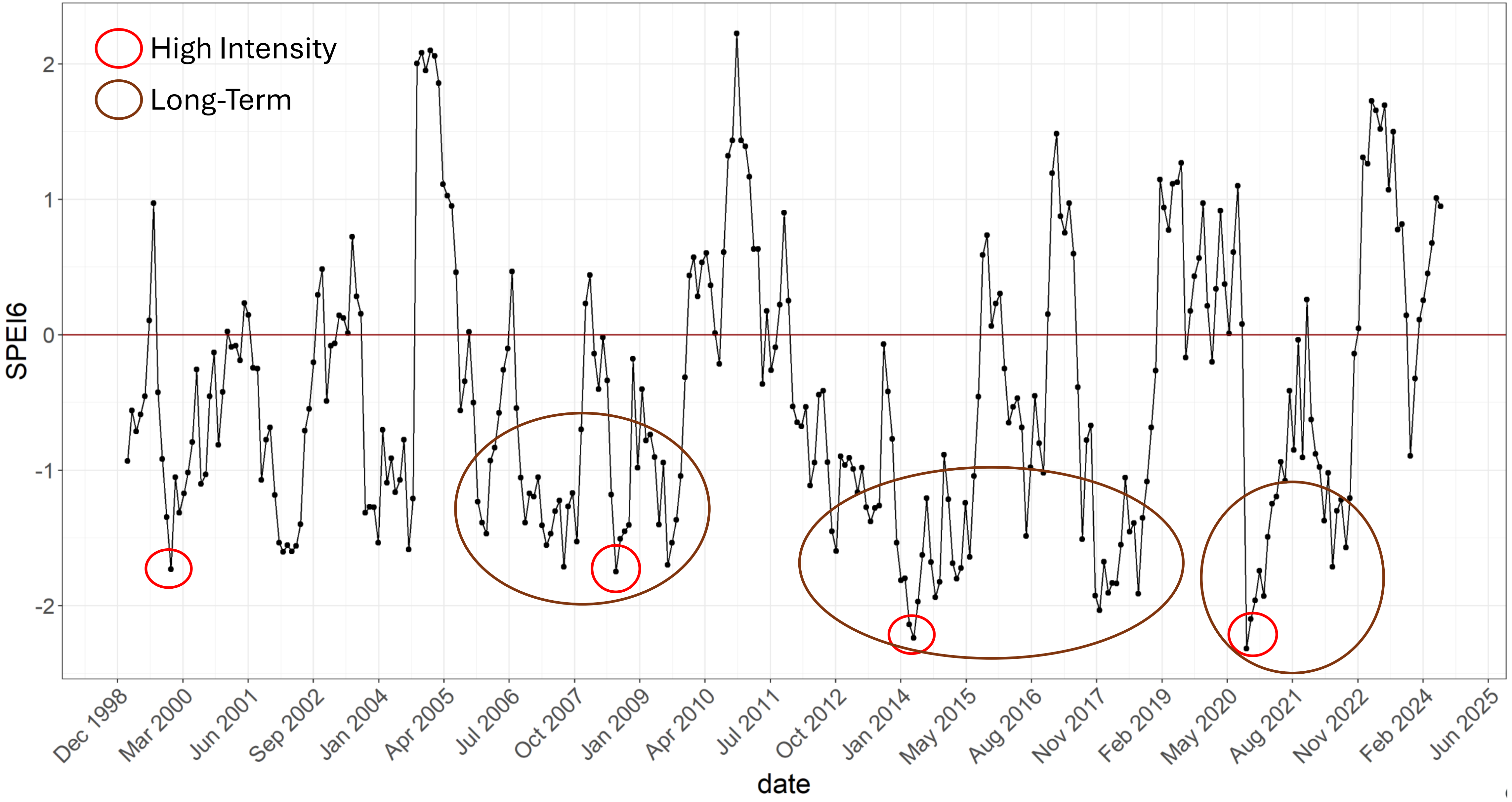
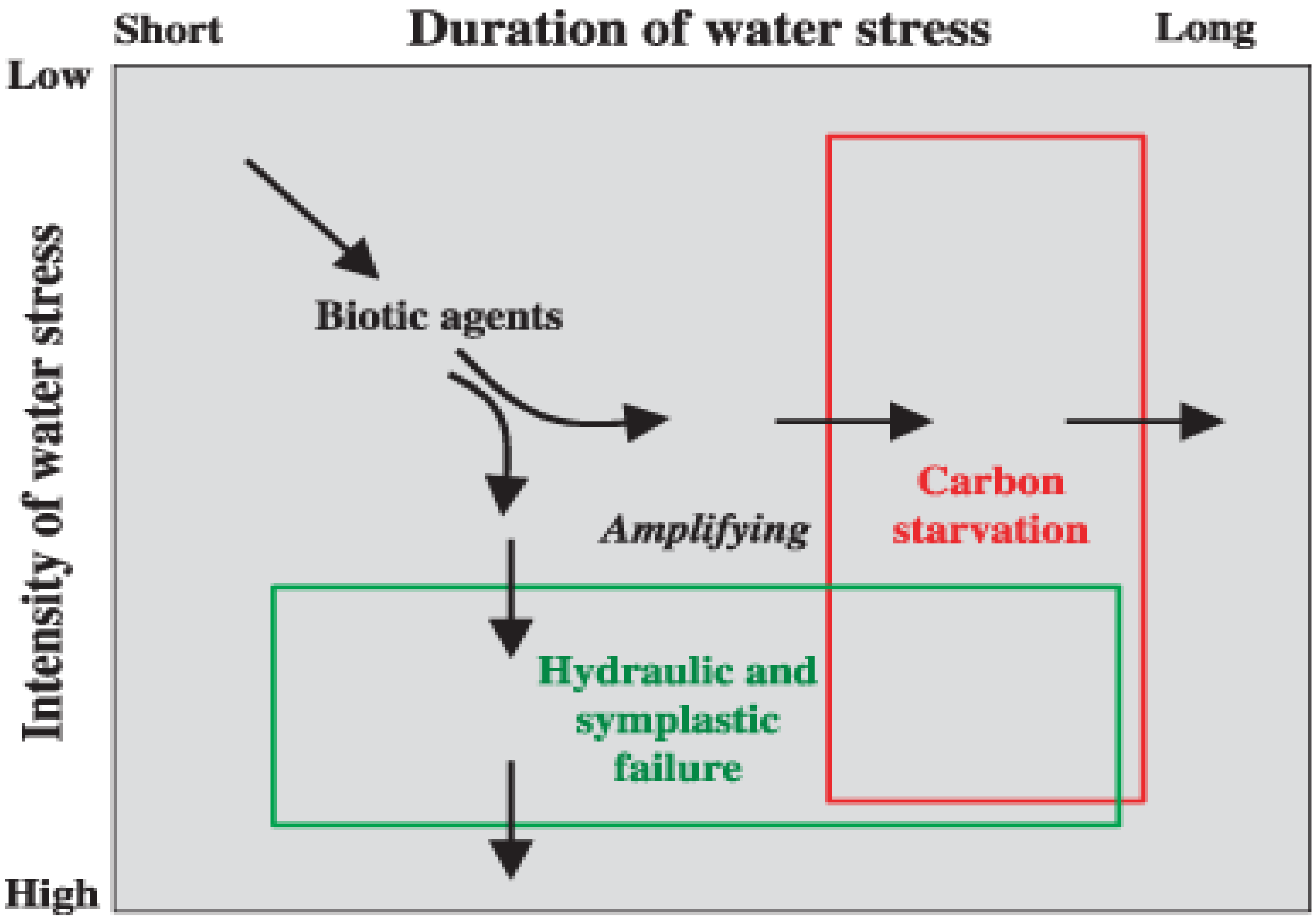
El Capitan Mountain: High Intensity and Long-Term Droughts





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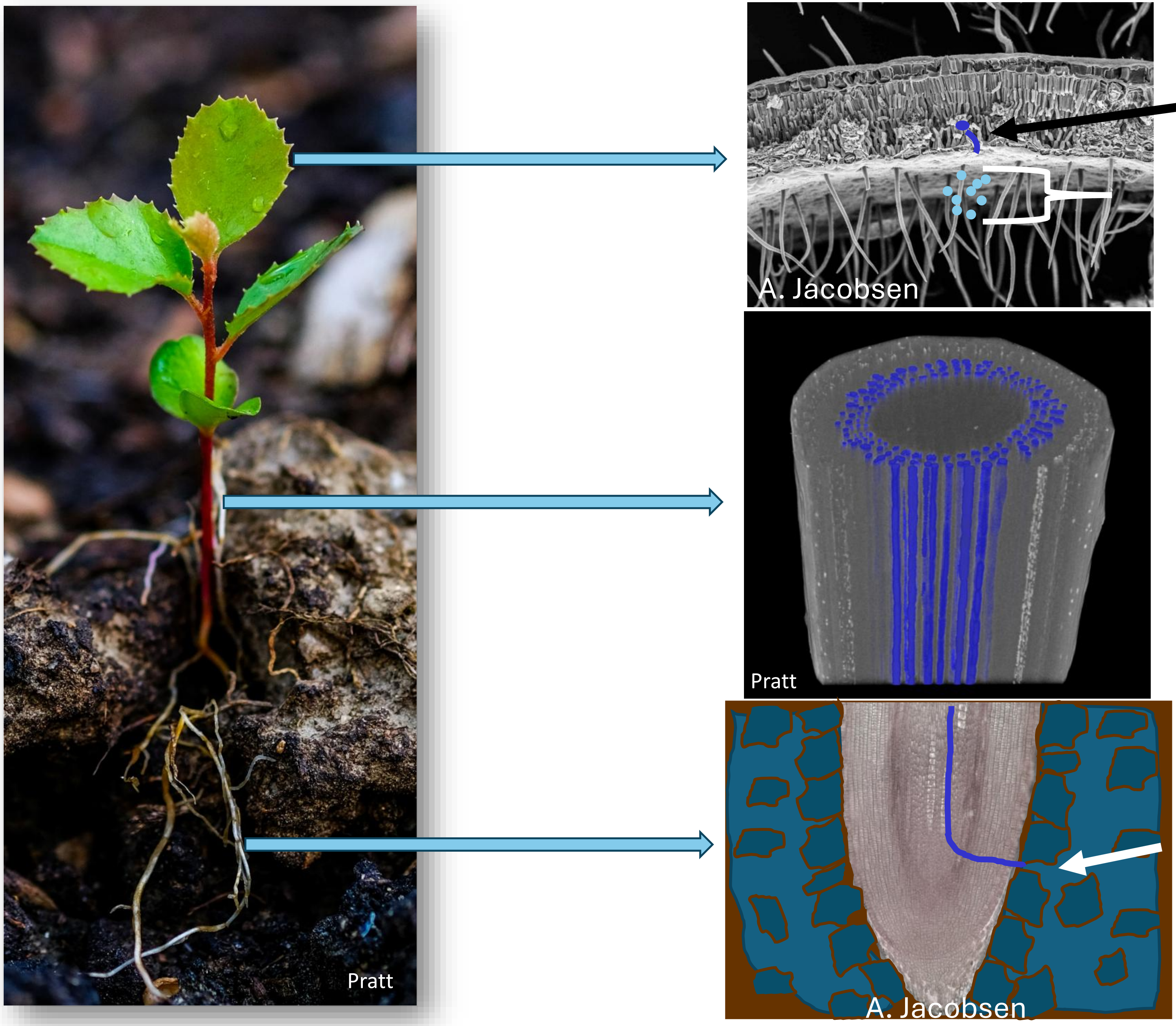


Liquid phase to vapor transition

Bulk flow of sap down a pressure gradient:

$$Q = \frac{k_h\, A\, \Delta P}{\mu\, L}$$

Water in "Supply"

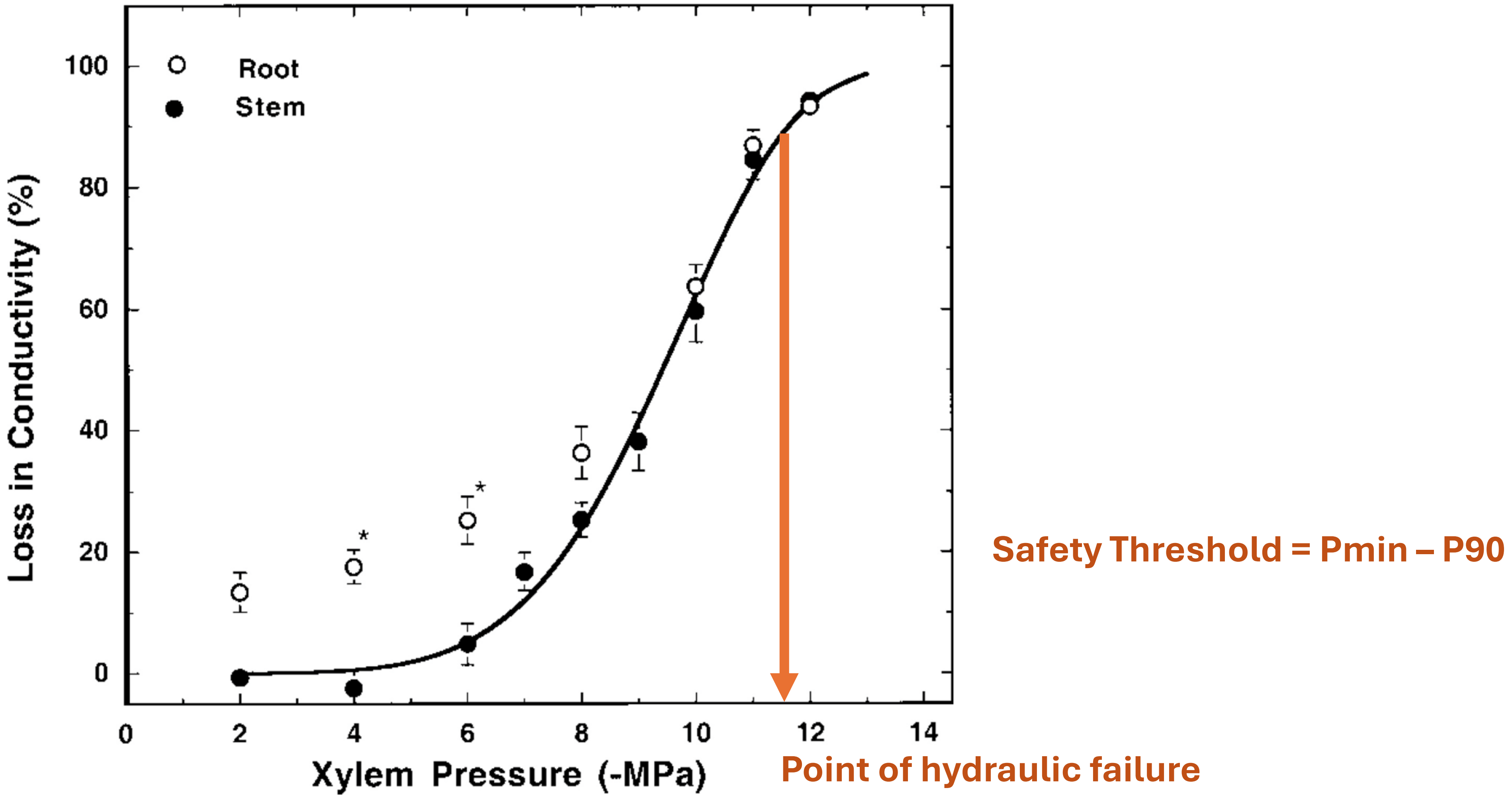
Water Under Tension Is Unstable

P_x = -0.5 MPa

Drought →

P_x = -4 MPa

Cavitation →



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Drought & Pathogens: Koch's Postulates

1. The microorganism must be found in all cases of the disease, but not in healthy individuals.

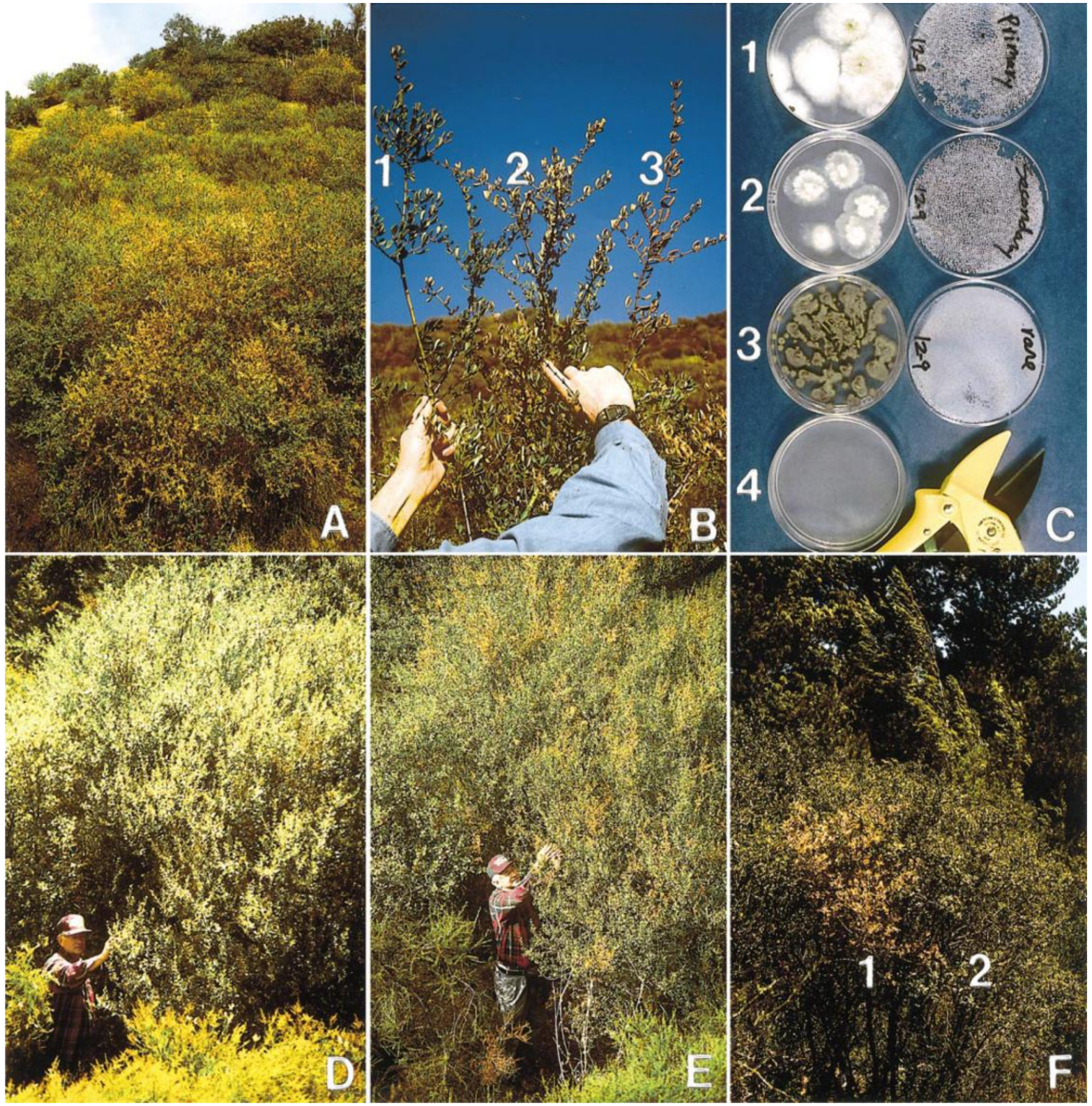
2. The microorganism must be isolated from a diseased individual and grown in pure culture.

3. The cultured microorganism should cause the same disease when introduced into a healthy, susceptible individual.

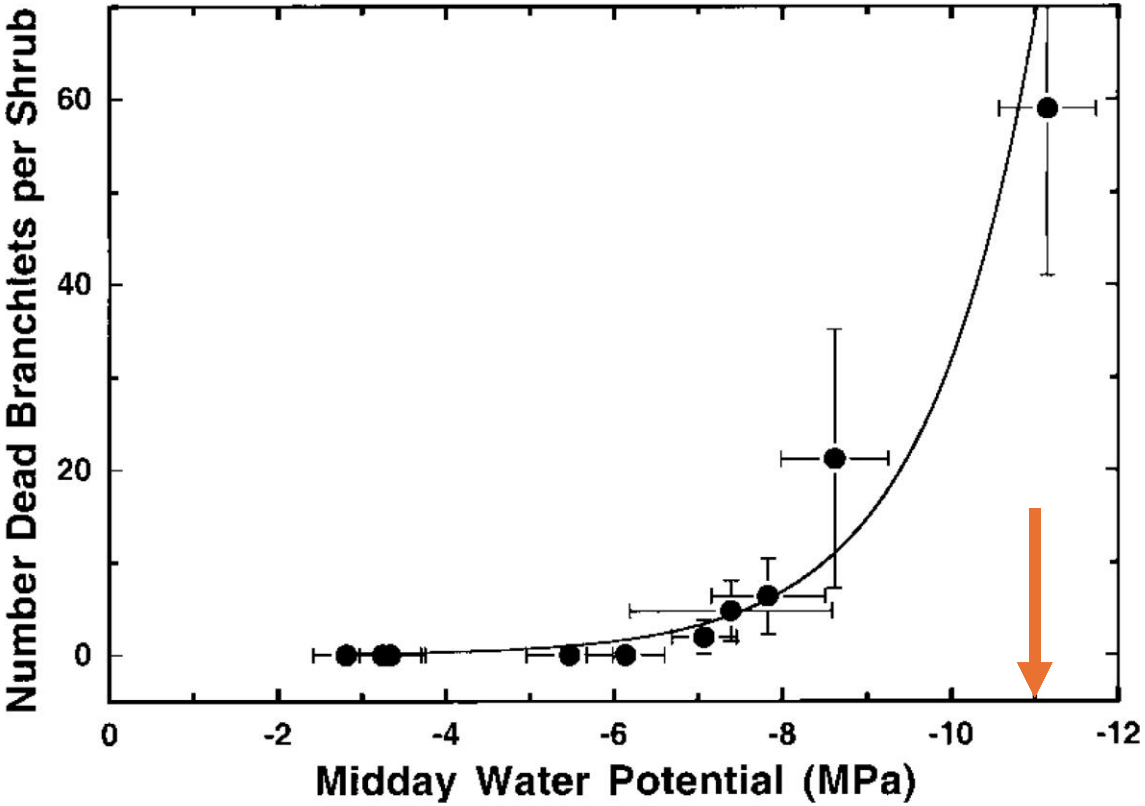
4. The microorganism must be re-isolated from the experimentally infected individual and shown to be the same as the original isolate.

Davis, S.D., Ewers, F.W., Sperry, J.S., Portwood, K.A., Crocker, M.C. and Adams, G.C., 2002. Shoot dieback during prolonged drought in *Ceanothus* (Rhamnaceae) chaparral of California: a possible case of hydraulic failure. *American Journal of Botany*, *89*(5), pp.820-828.

Hydraulic Failure Implicated In Branch Dieback



Botryosphaeria dothidea



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High Intensity Drought & Mortality Linked to Hydraulic Failure: 2014

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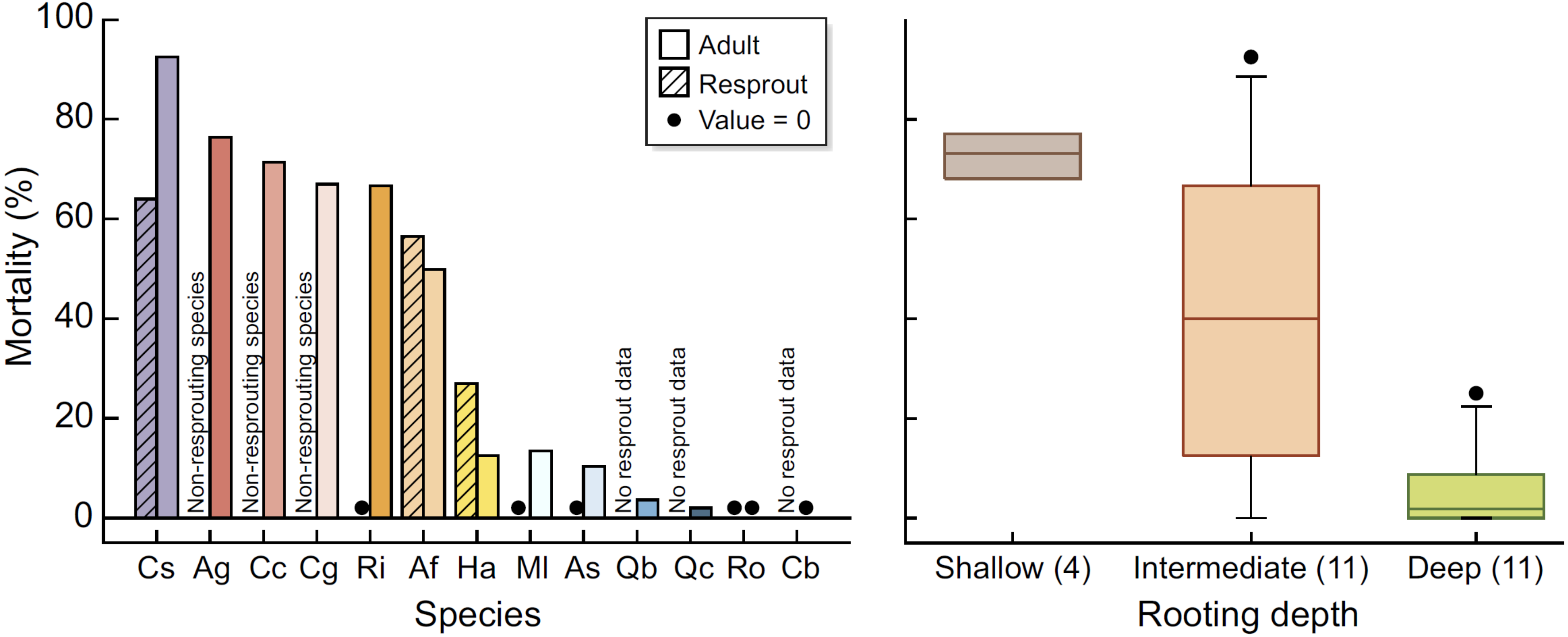
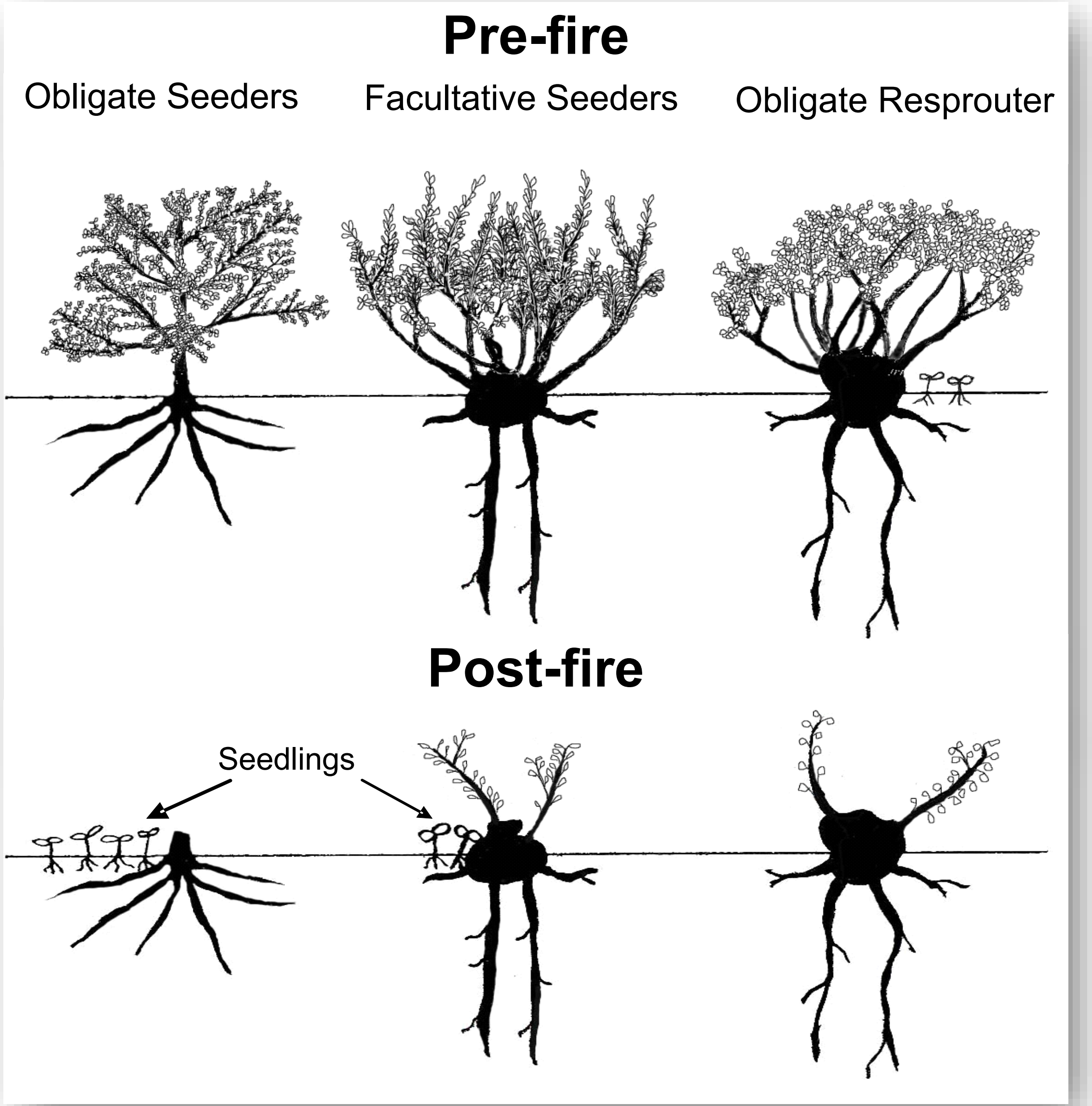
Pausas, J.G., Pratt, R.B., Keeley, J.E., Jacobsen, A.L., Ramirez, A.R., Vilagrosa, A., Paula, S., Kaneakua-Pia, I.N. and Davis, S.D., 2016. Towards understanding resprouting at the global scale. *New Phytologist*, *209*(3), pp.945-954.

Rooting Depth Is A Predictor of Mortality During Drought



Jacobsen, A.L. and Pratt, R.B., 2018. Extensive drought-associated plant mortality as an agent of type-conversion in chaparral shrublands. *New Phytologist*, *219*(2), pp.498-504.

Life History Type Is A Predictor of Mortality During Drought



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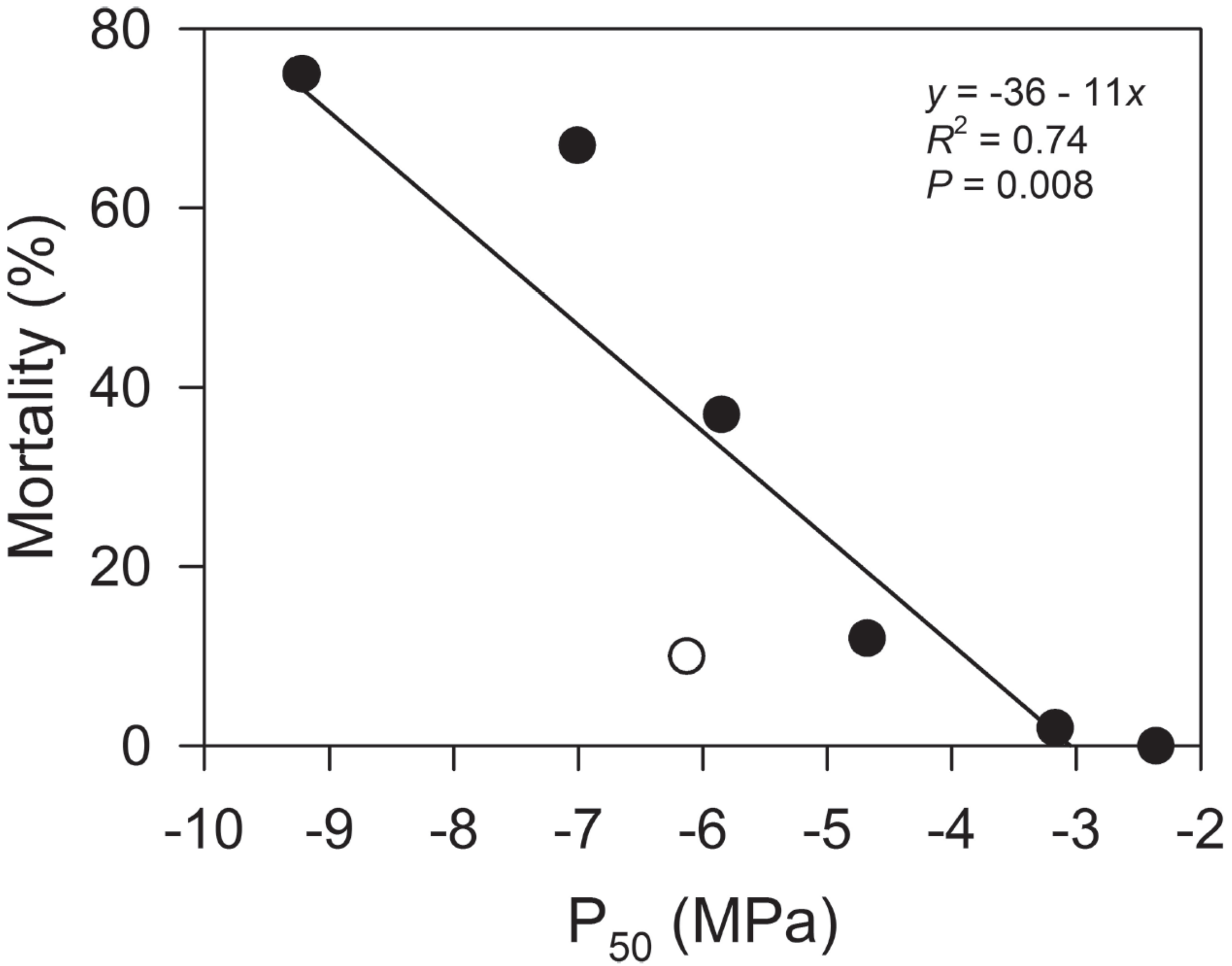
Hydraulic Failure Is Associated With Mortality During Drought: Drought Tolerant Species Most At Risk



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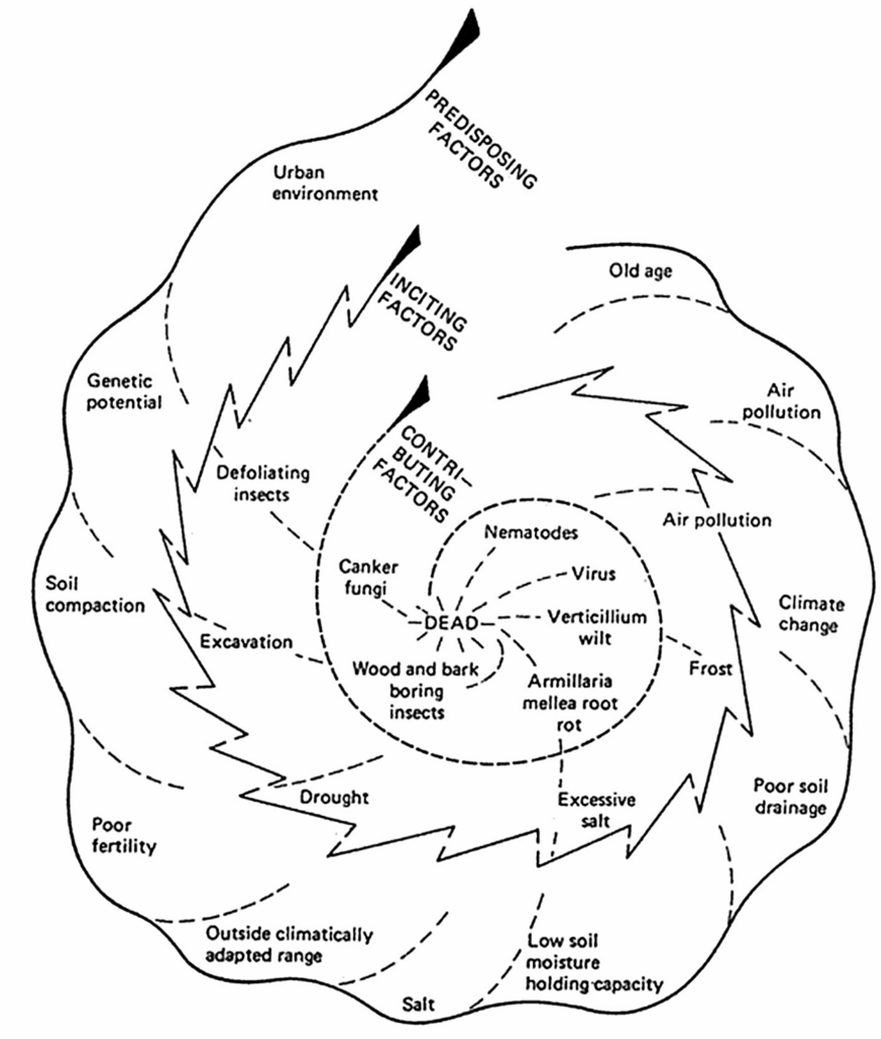
Climate Change, Pathogens, and Carbohydrate Status



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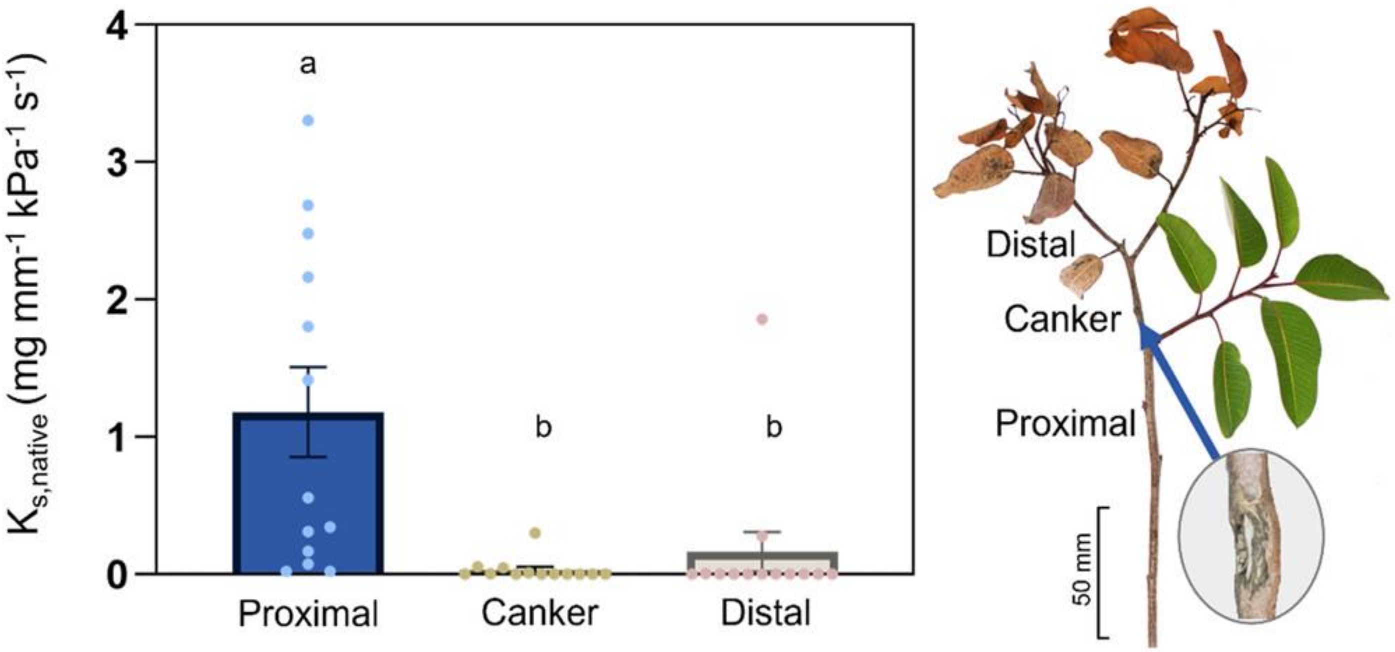
Long-Term Drought: Resprouters Vulnerable



Xylem	45%	100%	85%	% *B. dothidea* isolation
Phloem	--------	95%	--------	% *B. dothidea* isolation

Aguirre, N.M., Ochoa, M.E., Holmlund, H.I., Palmeri, G.N., Lancaster, E.R., Gilderman, G.S., Taylor, S.R., Sauer, K.E., Borges, A.J., Lamb, A.N. and Jacques, S.B., 2024. How megadrought causes extensive mortality in a deep-rooted shrub species normally resistant to drought-induced dieback: The role of a biotic mortality agent. *Plant, Cell & Environment*, *47*(4), pp.1053-1069.

Pathogens

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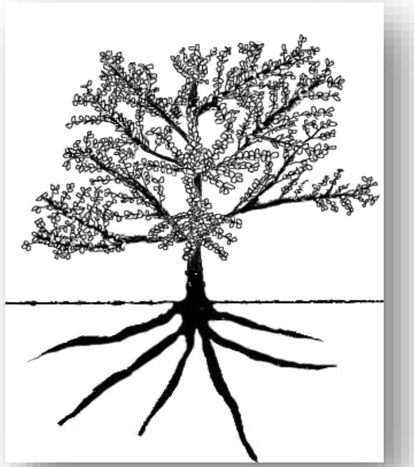
Fajardo, S.N., Bourret, T.B., Frankel, S.J. and Rizzo, D.M., 2025. Phytophthora species and their associations with Chaparral and oak woodland vegetation in Southern California. Journal of Fungi, 11(1), p.33.

Summary & Conclusions

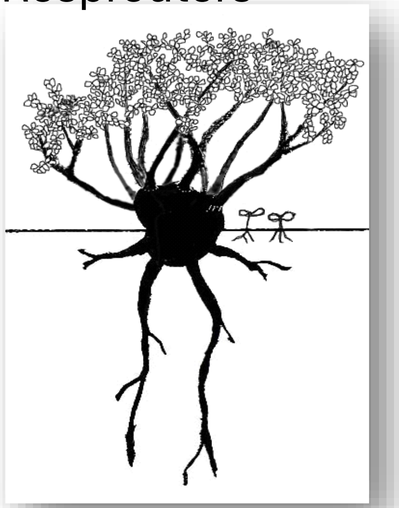
- **Short-term high intensity drought**
  - hydraulic failure supported
  - shallow rooted most vulnerable (*Ceanothus* & *Arctostaphylos* seeders)
    - experience highly negative hydrostatic pressures in xylem
    - drought tolerator
    - high embolism resistance
    - hydraulic safety margins surpassed during high intensity drought
  - role of pathogens
    - increase levels of dieback and mortality
    - reduce fitness
    - hamper recovery post-drought
- **Longer-term drought**
  - deeper rooted plants effected by pathogens (*Malosma laurina, Rhus integrifolia, Rhus ovata*)
  - carbohydrate balance is negative and defenses are compromised
  - resprouters with deep roots most affected because of carbohydrate costs

Seeders



*Biodiversity threat

Resprouters



Vulnerable Types

- Seeders in *Cerastes* are among the most drought-tolerant recorded
  - *Ceanothus* subgenus *Cerastes* (all are obligate seeders)
    - *C. megacarpus*
    - *C. crassifolius*
    - *C. cuneatus*
    - *C. pauciflorus*
- Taxa in subgenus *Ceanothus* are mostly seeders, but are not as drought-tolerant
  - *Ceanothus subgenus Ceanothus* (most are obligate seeders)
    - *C. arboreus*
    - *C. oliganthus*
    - *C. cyaneus*

???

- Highly vulnerable to hydraulic failure
  - adults die
    - survive in seedbank

Keeley, J.E., Thomas Parker, V., Zedler, P.H. and Brandon Pratt, R., 2024. Ceanothus: Taxonomic patterns in life history responses to fire. *American Journal of Botany*, *111*(11), p.e16434.

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