Long-term Drought Impacts on Ecosystems

California Water Commission Meeting
November 16, 2022

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Groundwater is our drought strategy

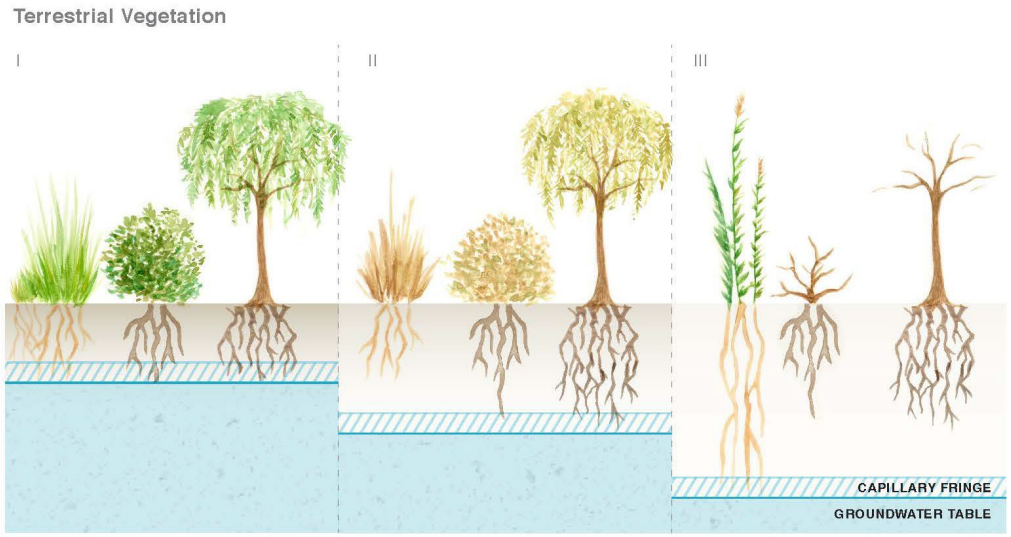
Ecological Responses to Groundwater Depletion

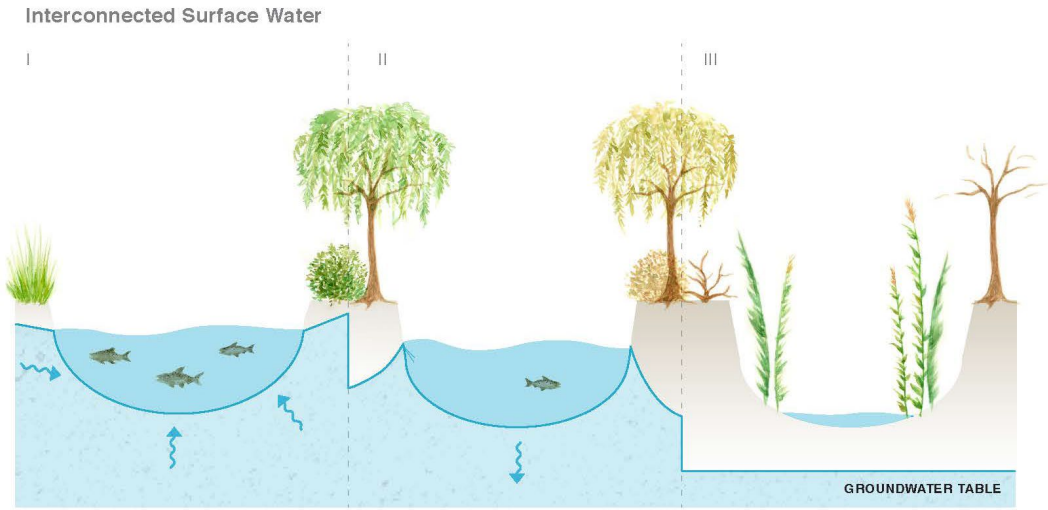
DECREASING GROUNDWATER AVAILABILITY

- Productivity High
- Population Healthy
- Species Diversity
- Instream Conditions Ideal

- Productivity & Growth Decline
- Loss in Biodiveristy
- Reproduction & Recruitment Decrease

- Mortality Increases
- Invasive Species Appear
- Ecosystem Structure and Function Shifts





Source: MM Rohde, R Froend, J Howard. 2017. A Global Synthesis of Managing Groundwater Dependent Ecosystems Under Sustainable Groundwater Policy. *Groundwater*. doi: 10.1111/gwat.12511

Groundwater impacts to ecosystems

ACUTE

Chronic

Sources:
(1) CL Kibler, EC Schmidt, DA Roberts, JC Stella, L Kui, AM Lambert, MB Singer. 2021. A brown wave of riparian woodland mortality following groundwater declines during the 2012-2019 California drought. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/ac1377.
(2) J Williams, JC Stella, SL Voelker, AM Lambert, LM Pelletier, JE Drake, JM Friedman, DA Roberts, MB Singer. 2022. Local groundwater decline exacerbates response of dryland riparian woodlands to climatic drought. *Global Change Biology.* https://doi-org.esf.idm.oclc.org/10.1111/gcb.16376.
(3) MM Rohde, SB Sweet, C Ulrich, J Howard. 2019. A transdisciplinary approach to characterize hydrological controls on groundwater-dependent ecosystem health. *Frontiers in Environmental Science.* http://dx.doi.org/10.3389/fenvs.2019.00175.

Declining shallow groundwater puts ecosystems at risk

The Nature Conservancy

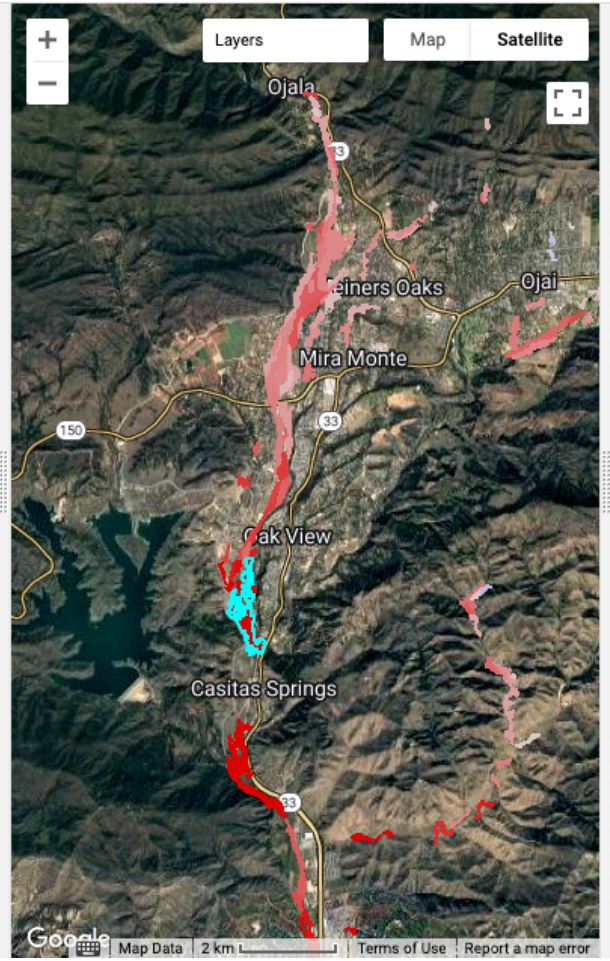
SAGE: Shallow Groundwater Estimation Tool

Groundwater dependent ecosystems (GDEs) are critical habitats throughout California that rely on shallow groundwater. Unfortunately, only a small subset of wells provide monitoring data for shallow groundwater. This tool, developed for Rohde et al. (2021), uses satellite data and machine learning tools to predict shallow groundwater levels with the goal of improving GDE-monitoring capabilities throughout California.

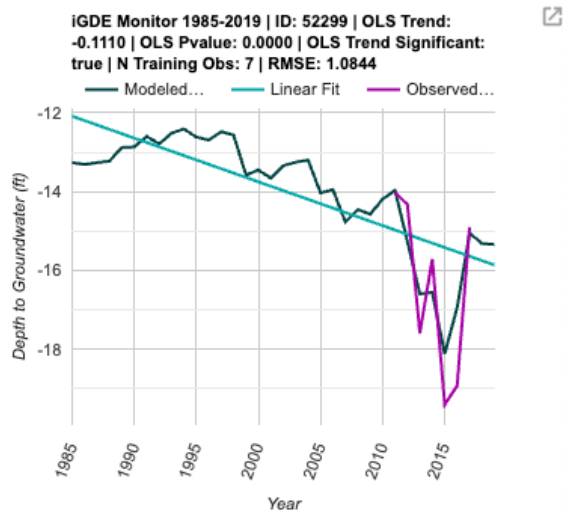
Rohde M. M., T. Biswas, I. W. Housman, L. S. Campbell, K. R. Klausmeyer, and J. K. Howard, 2021: A Machine Learning Approach to Predict Groundwater Levels in California Reveals Ecosystems at Risk. Frontiers in Earth Sciences, 9.

https://doi.org/10.3389/feart.2021.784499

Github repository for manuscript code can be found here



Click on any iGDE to plot depth to groundwater time series



Map Key

Significant Trend (P < 0.05) 1985-2019

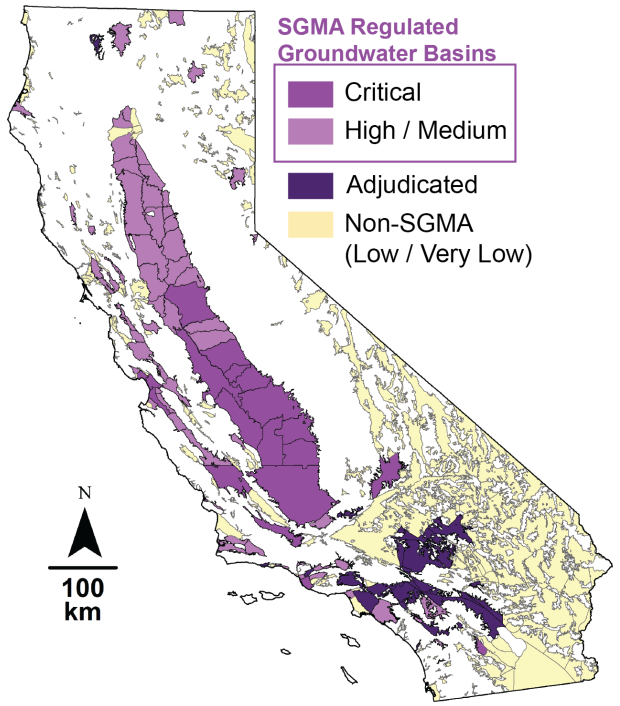
- Sig Decrease
- No Sig Trend
- Sig Increase

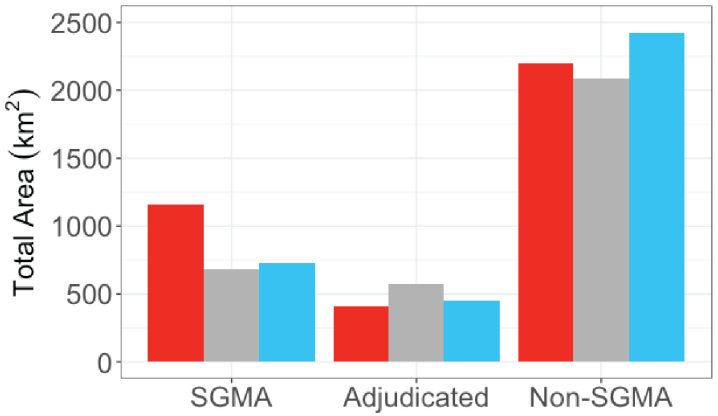
Raw Trend 1985-2019

-0.1 ft/yr | 0 ft/yr | 0.1 ft/yr

Root Mean Square Error (RMSE)

0 ft (more accurate) | 1 ft | 2 ft (less accurate)

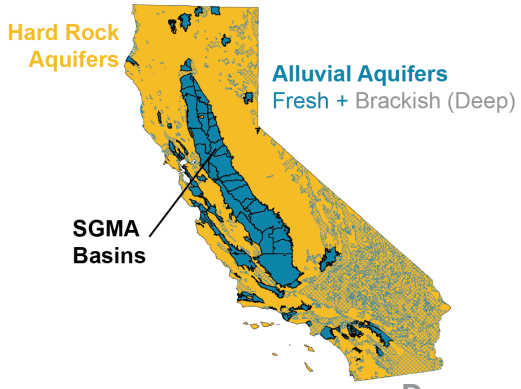


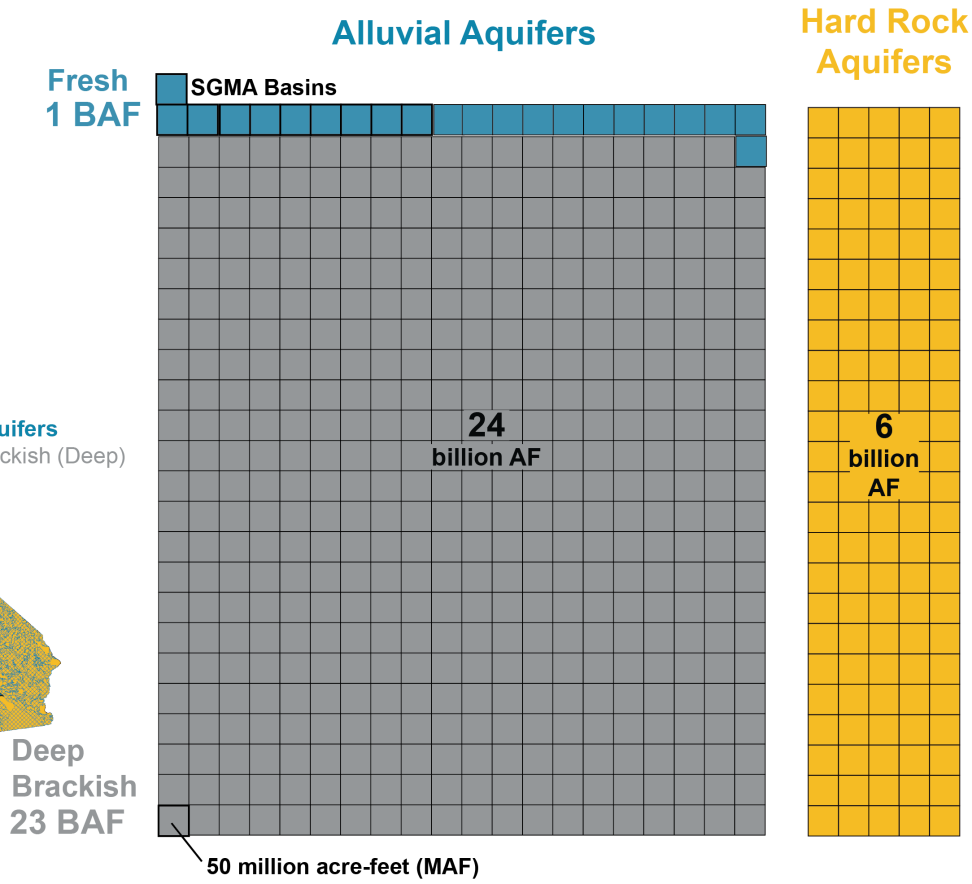


https://igde-work.earthengine.app/view/sage

Source: Rohde, MM, T Biswas, IW Housman, LS Campbell, KR Klausmeyer, JK Howard. 2021. A Machine Learning Approach to Predict Groundwater Levels in California Reveals Ecosystems at Risk. Frontiers in Earth Sciences, 9. https://doi.org/10.3389/feart.2021.784499

Comprehensive statewide groundwater management is needed





Source: BH Thompson, MM Rohde, JK Howard, S Matsumoto. 2021. Mind the Gaps: The Case for Truly Comprehensive Sustainable Groundwater Management. Water in the West. Stanford Digital Repository. Available at: https://purl.stanford.edu/ hs475mt1364.

Protection is lacking under the California's Sustainable Groundwater Management Act

Less than 10%
of groundwater-dependent ecosystems

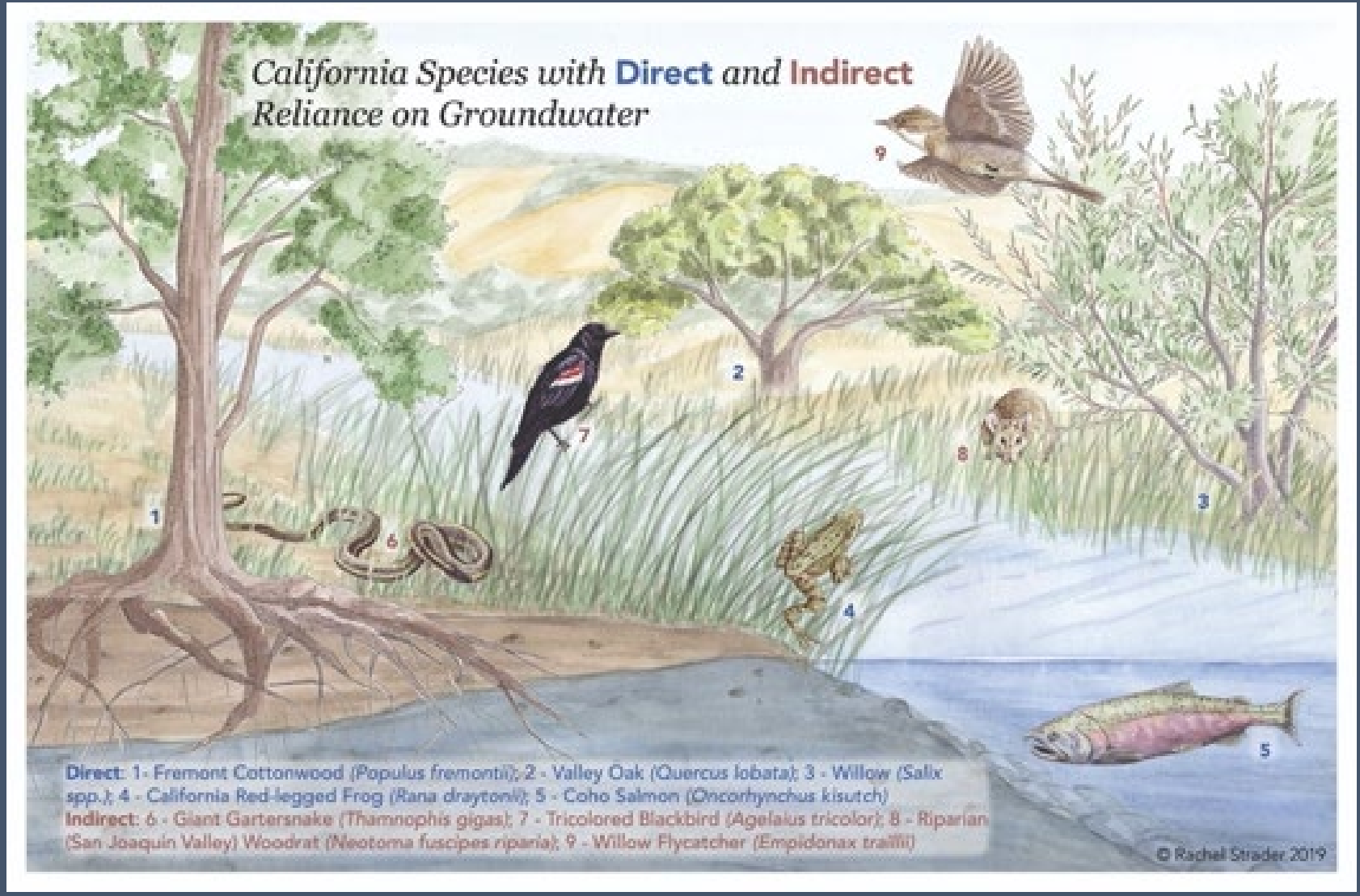
Source: D Perrone, MM Rohde, CW Hammond et al. *in preparation*

95%

Wetland and River Habitat Gone

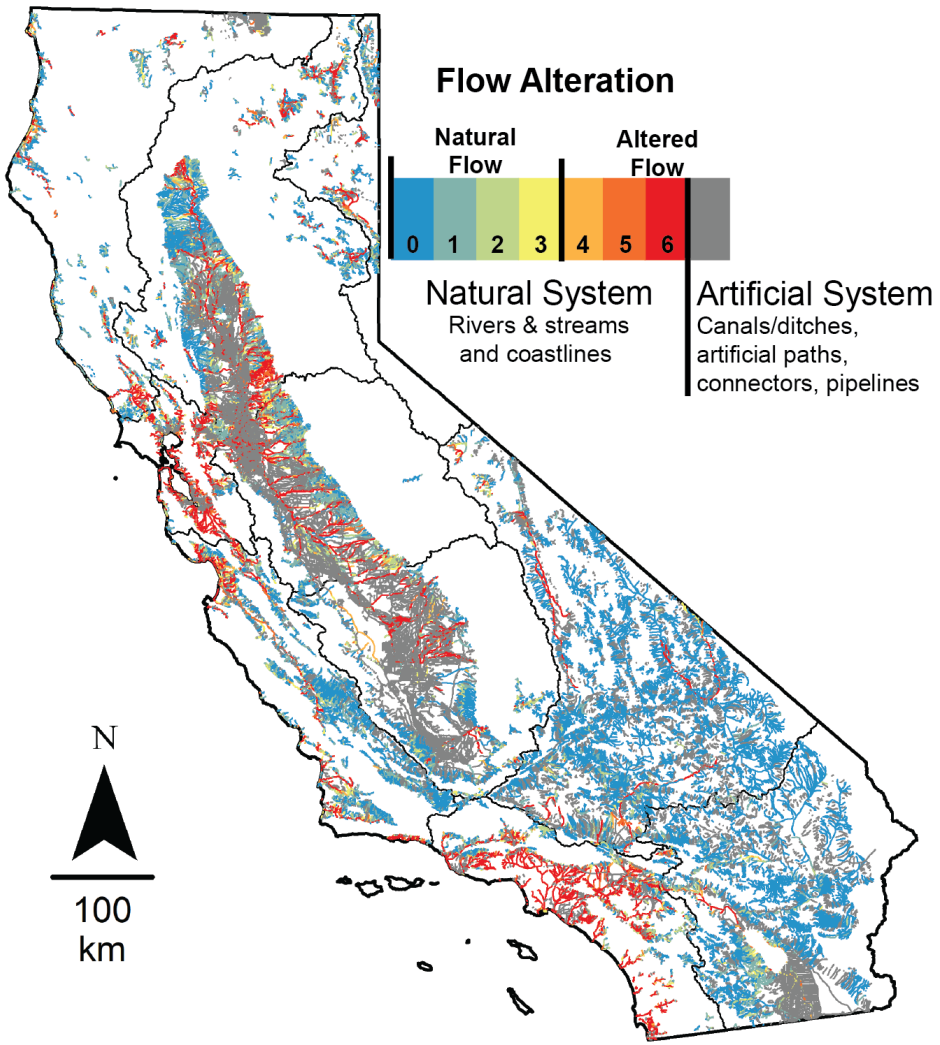
Source: The Bay Institute, 1998; SFEI-ASC, 2016

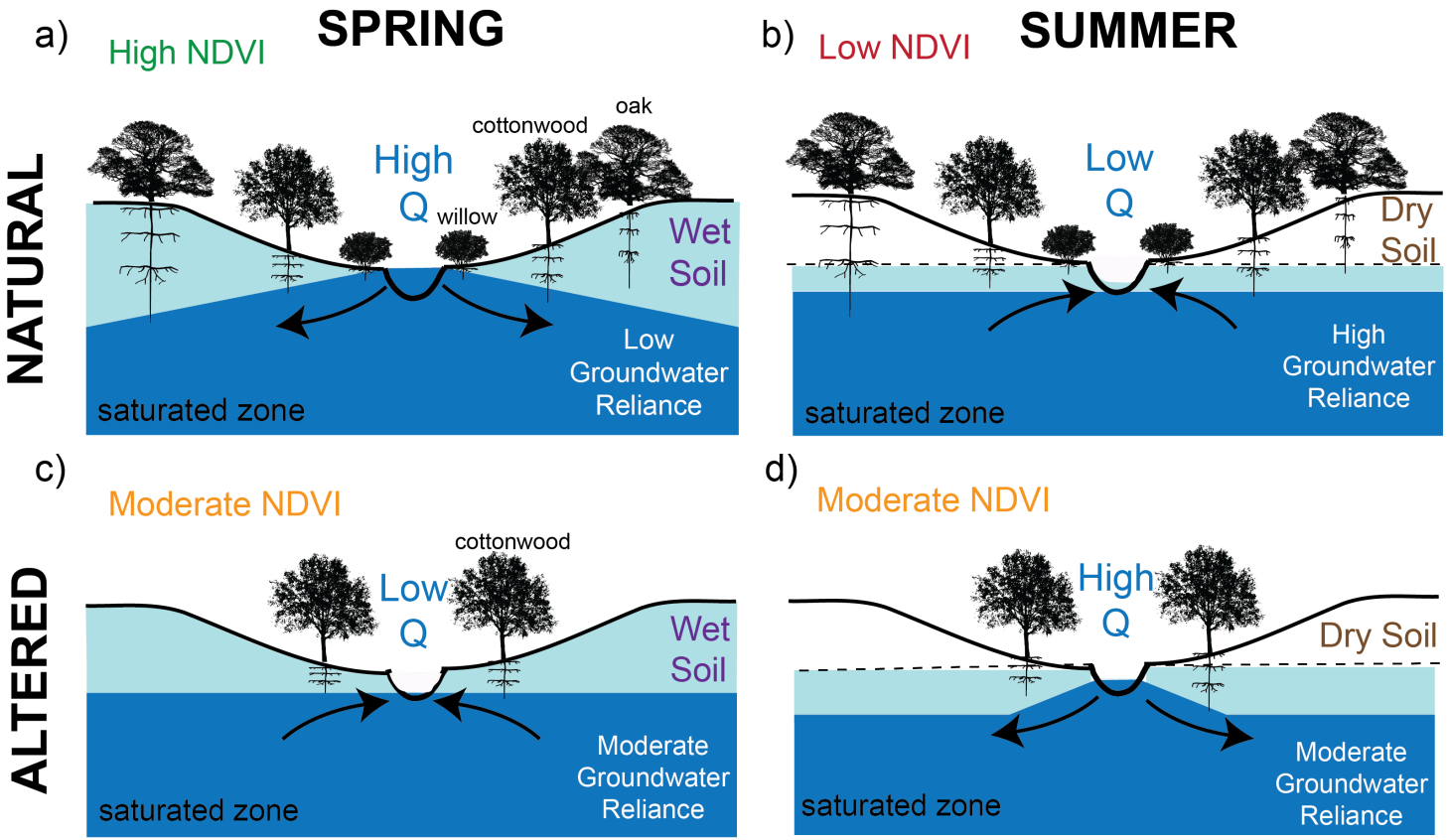
Groundwater supports drought oases



Source: MM Rohde, B Seapy, R Rogers , X Castañeda, editors. 2019. Critical Species LookBook: A compendium of California's threatened and endangered species for sustainable groundwater management. The Nature Conservancy, San Francisco, California.

Hydrologic alteration creates difficult tradeoffs and management challenges



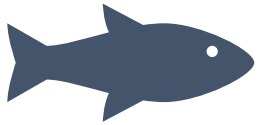


Source: MM Rohde, JC Stella, D Roberts, MB Singer. 2021. Groundwater dependence of riparian woodlands and the disrupting effect of anthropogenically altered streamflow. *Proceedings of the National Academy of Sciences.* https://doi.org/10.1073/pnas.2026453118.

Recommendations

Seize the opportunity that SGMA provides by implementing it right.

Achieve comprehensive groundwater management for all California.



Be more prepared and intentional about ecosystem water needs.

Thank you

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