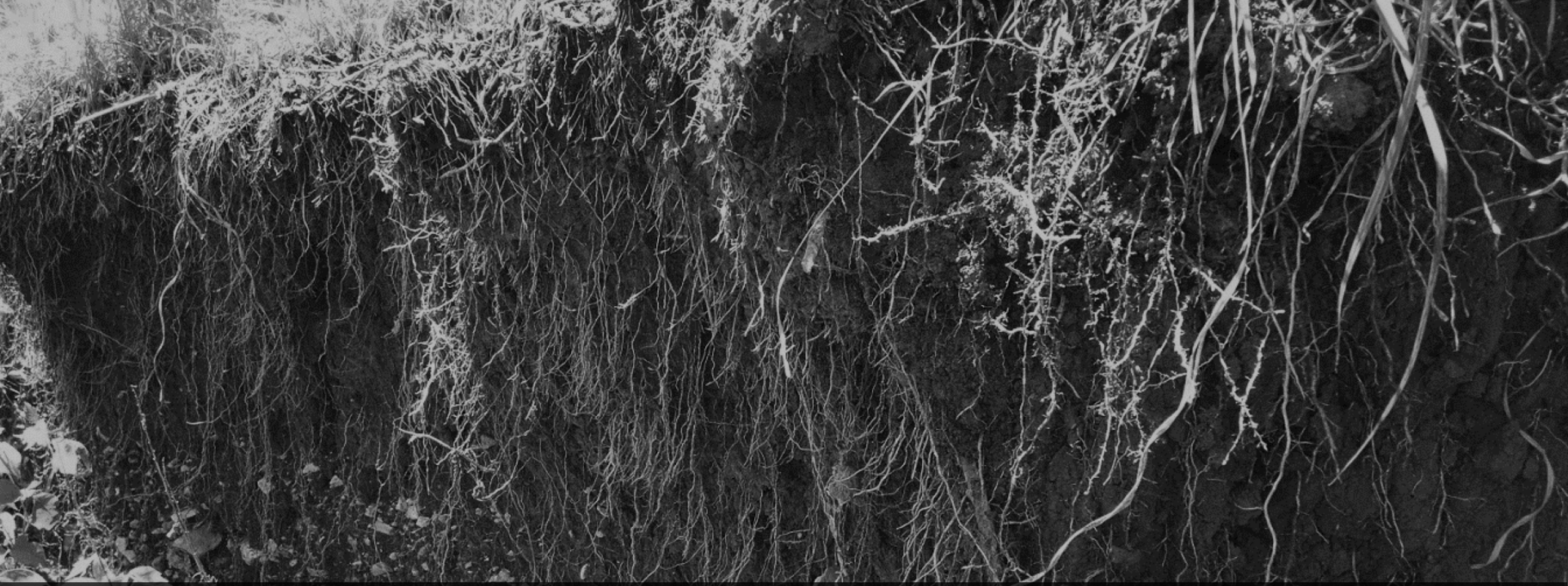
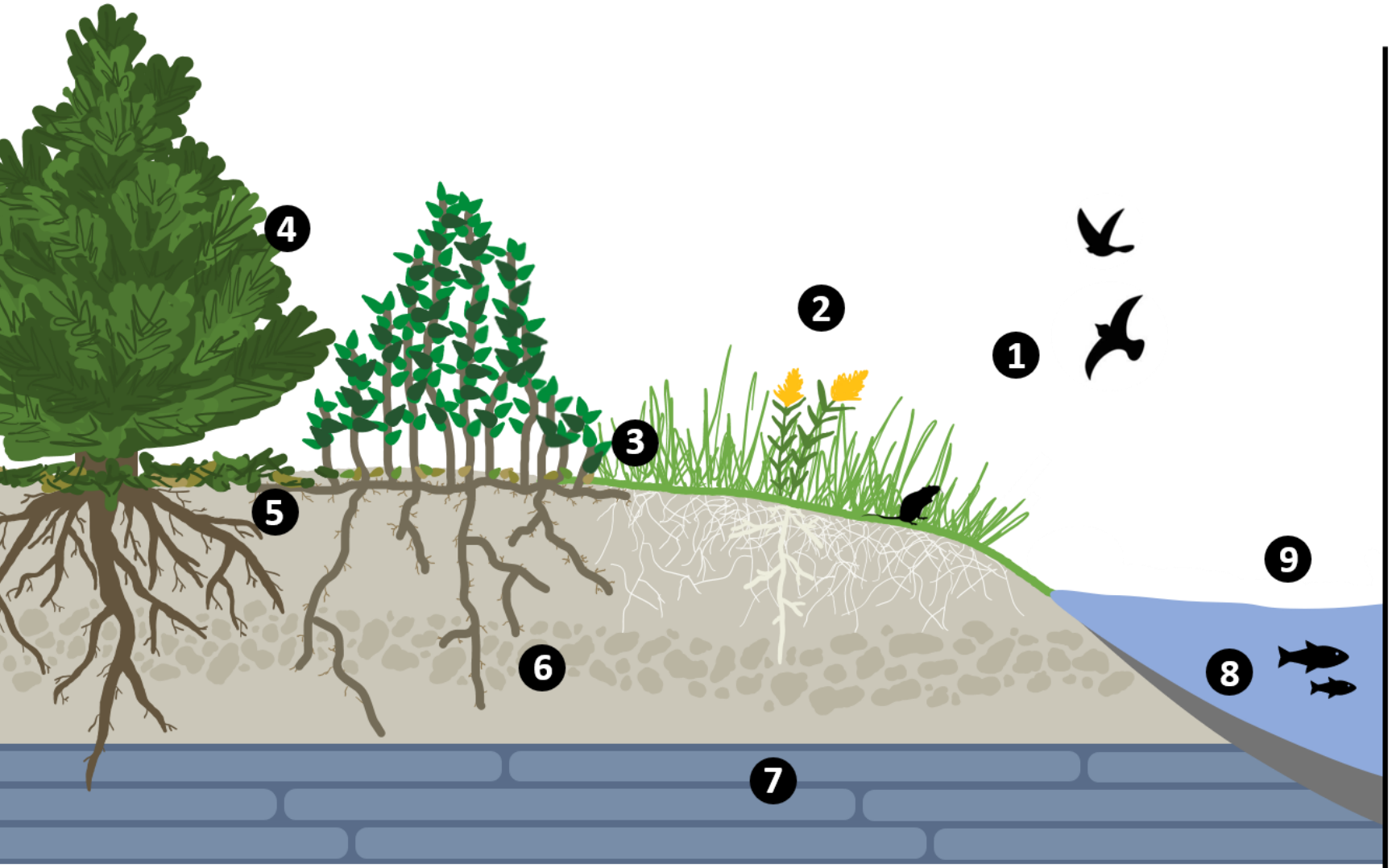


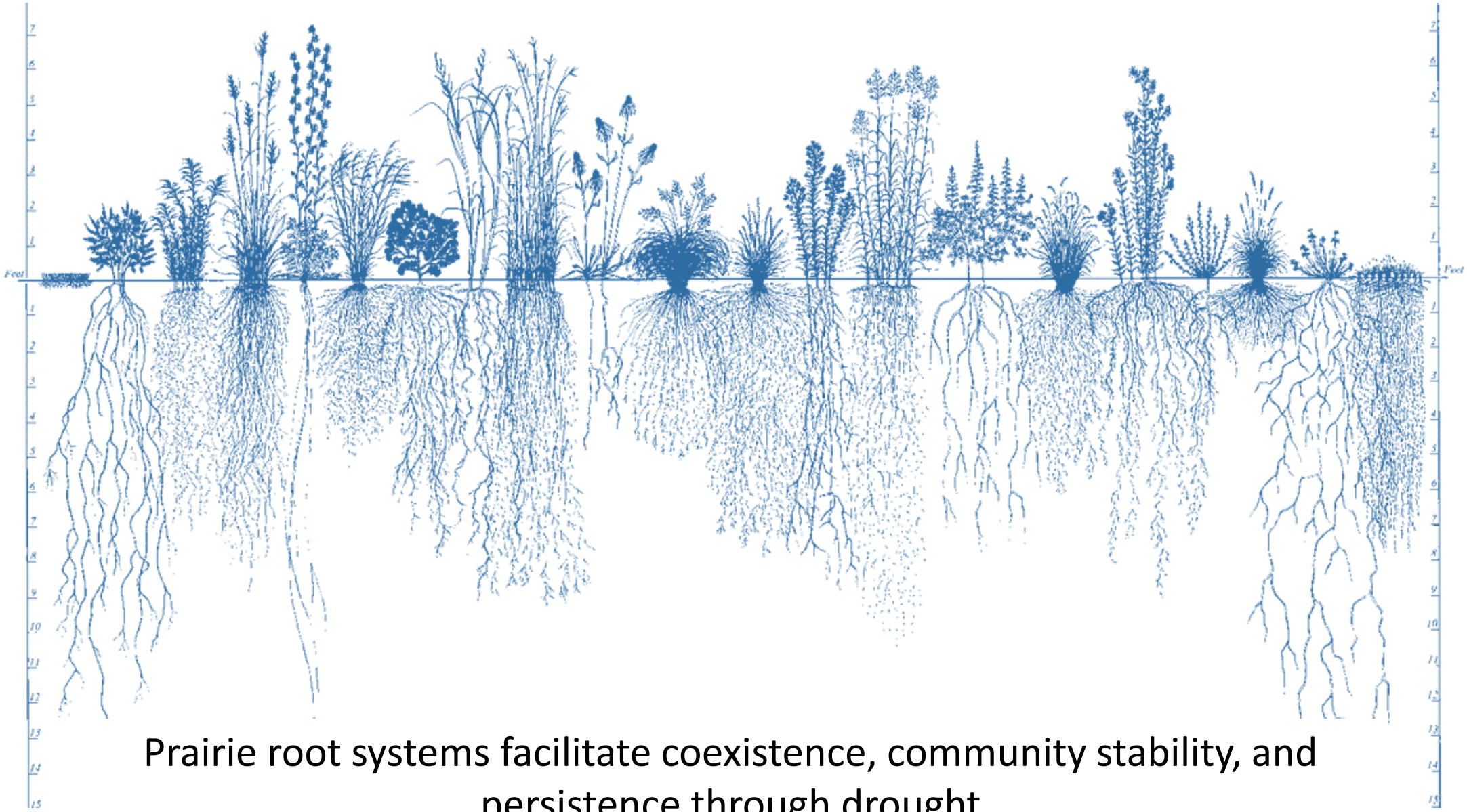
Woody plant invasion of mesic grasslands - drivers, consequences, and potential solutions

Jesse Nippert
Division of Biology, Kansas State University

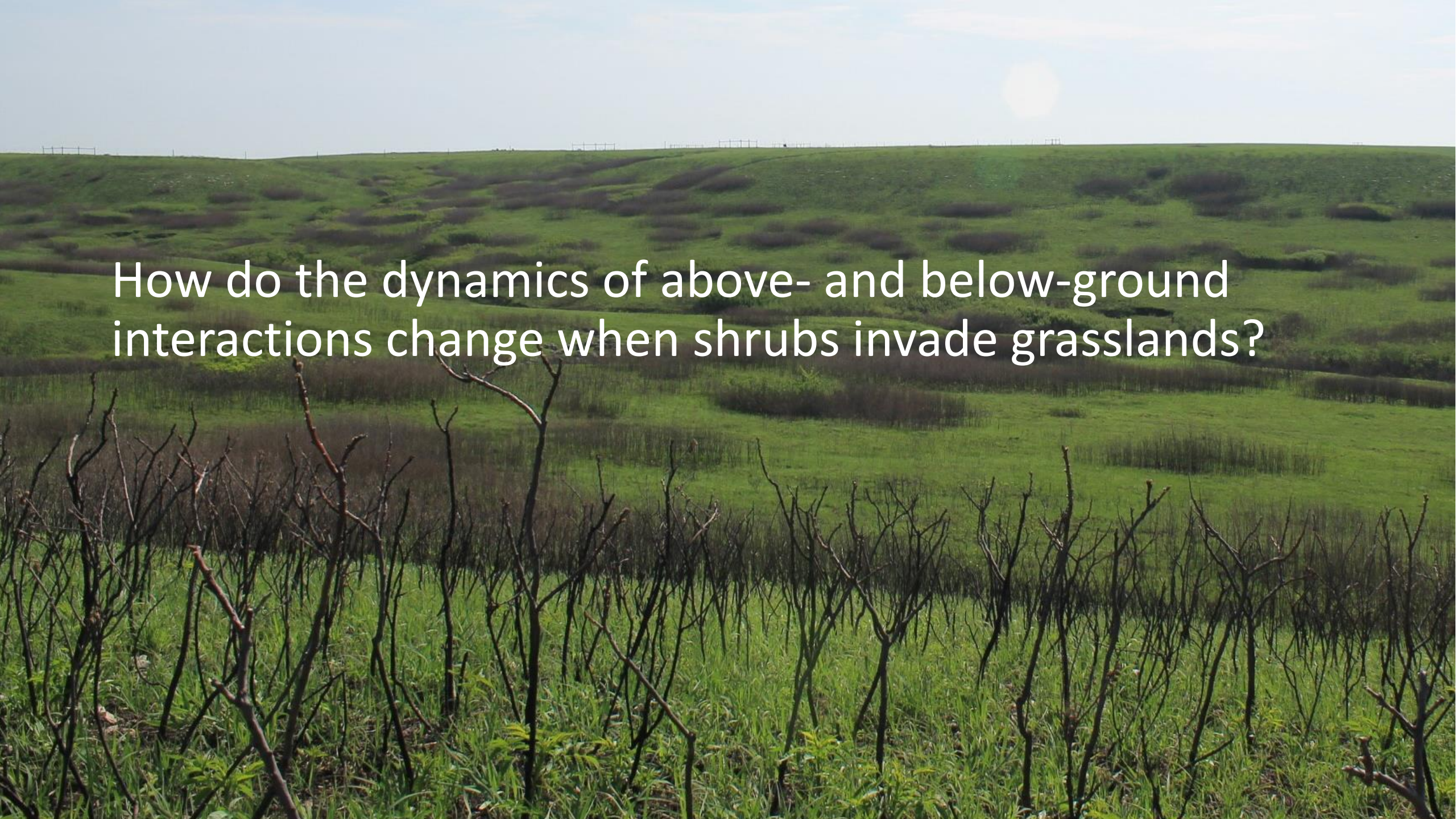
Impacts of woody encroachment



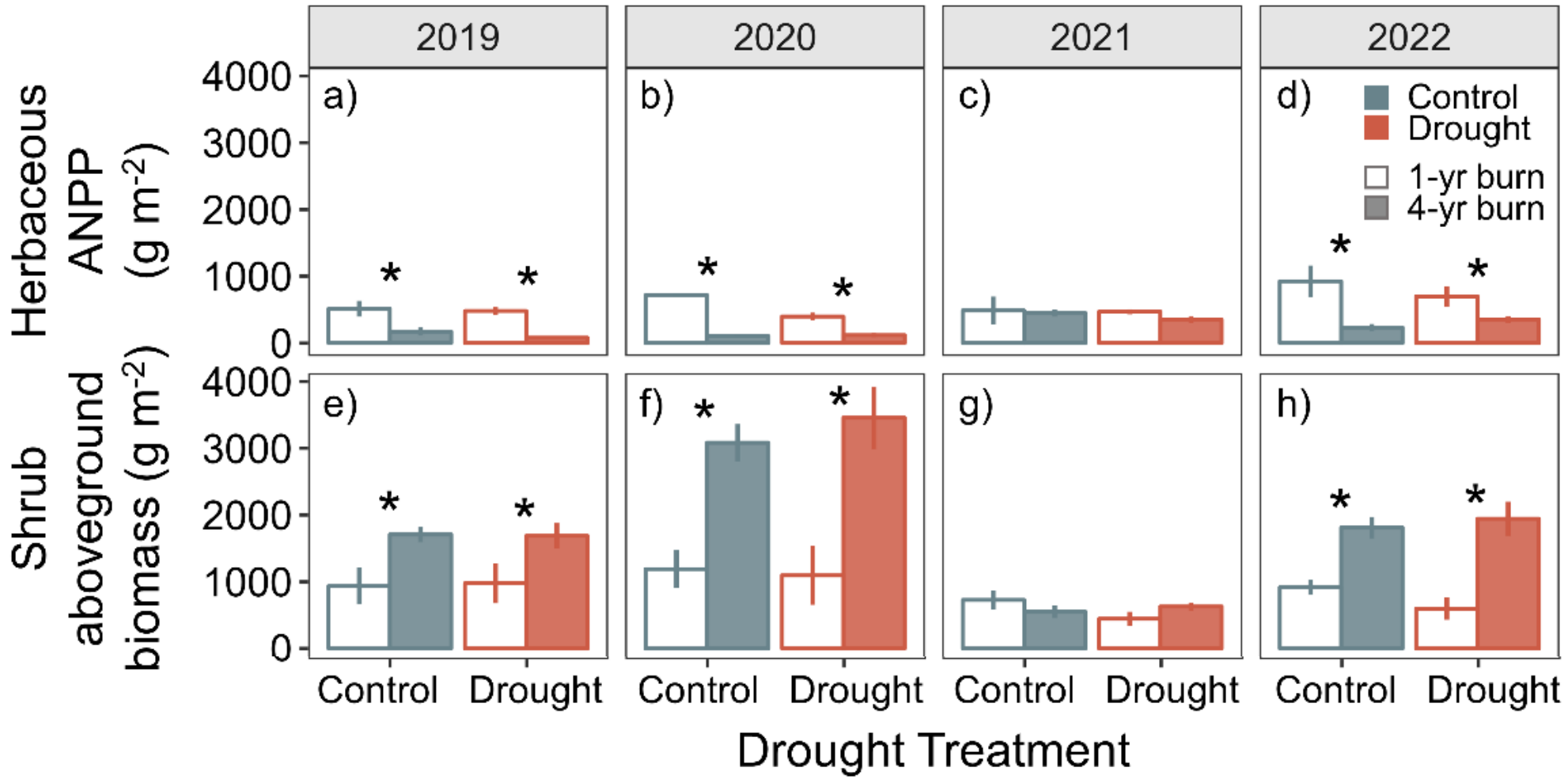
1. ↓ habitat for grassland birds and small mammals
2. ↓ herbaceous plant diversity
3. ↓ forage for grazers and altered fire dynamics
4. ↑ vector-borne diseases
5. Altered above- and belowground C cycling
6. Altered soil infiltration pathways
7. ↑ bedrock weathering rates
8. ↓ fish populations
9. ↓ stream discharge



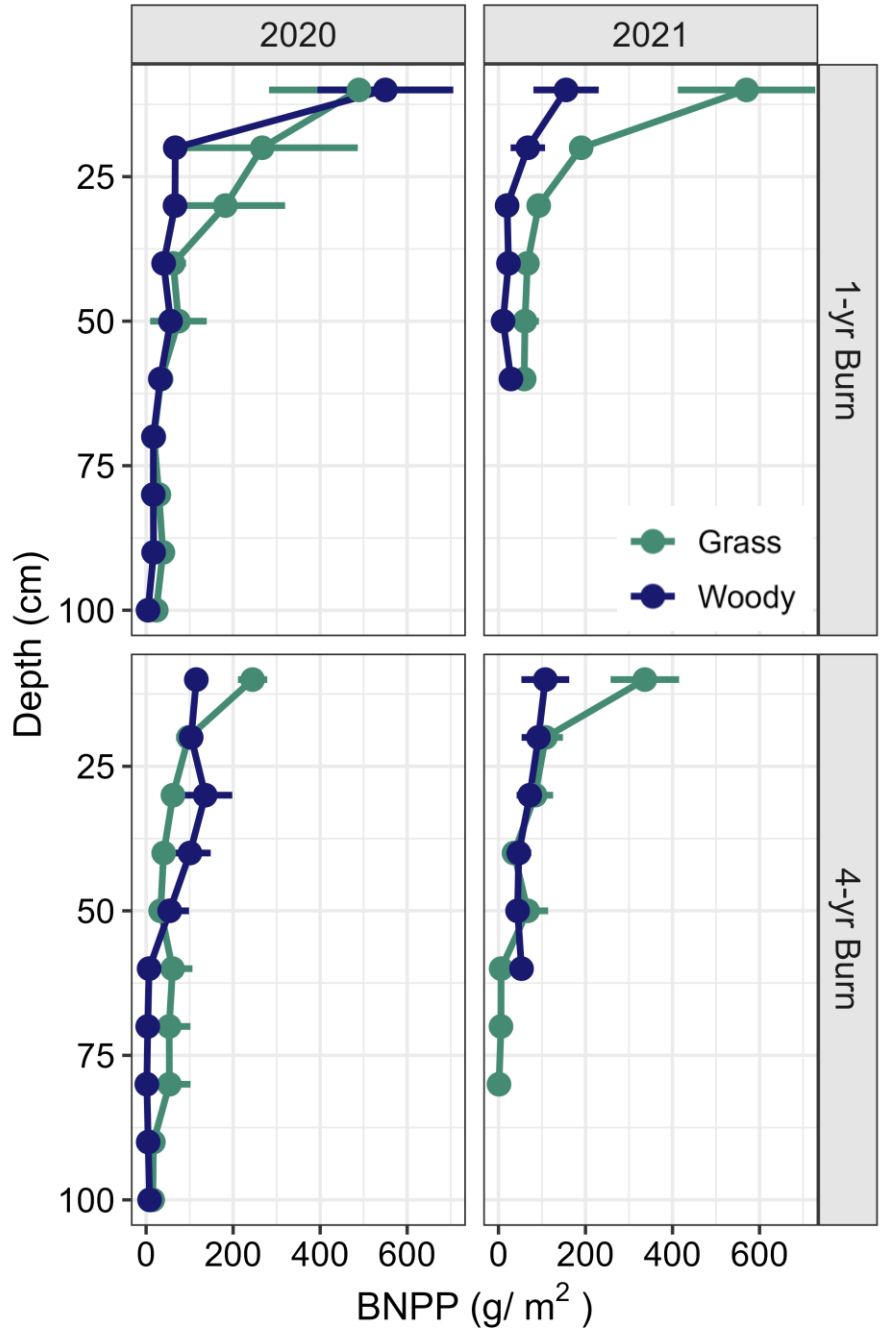
Prairie root systems facilitate coexistence, community stability, and persistence through drought


How do the dynamics of above- and below-ground interactions change when shrubs invade grasslands?

Will drought save us from our woody encroachment problem?



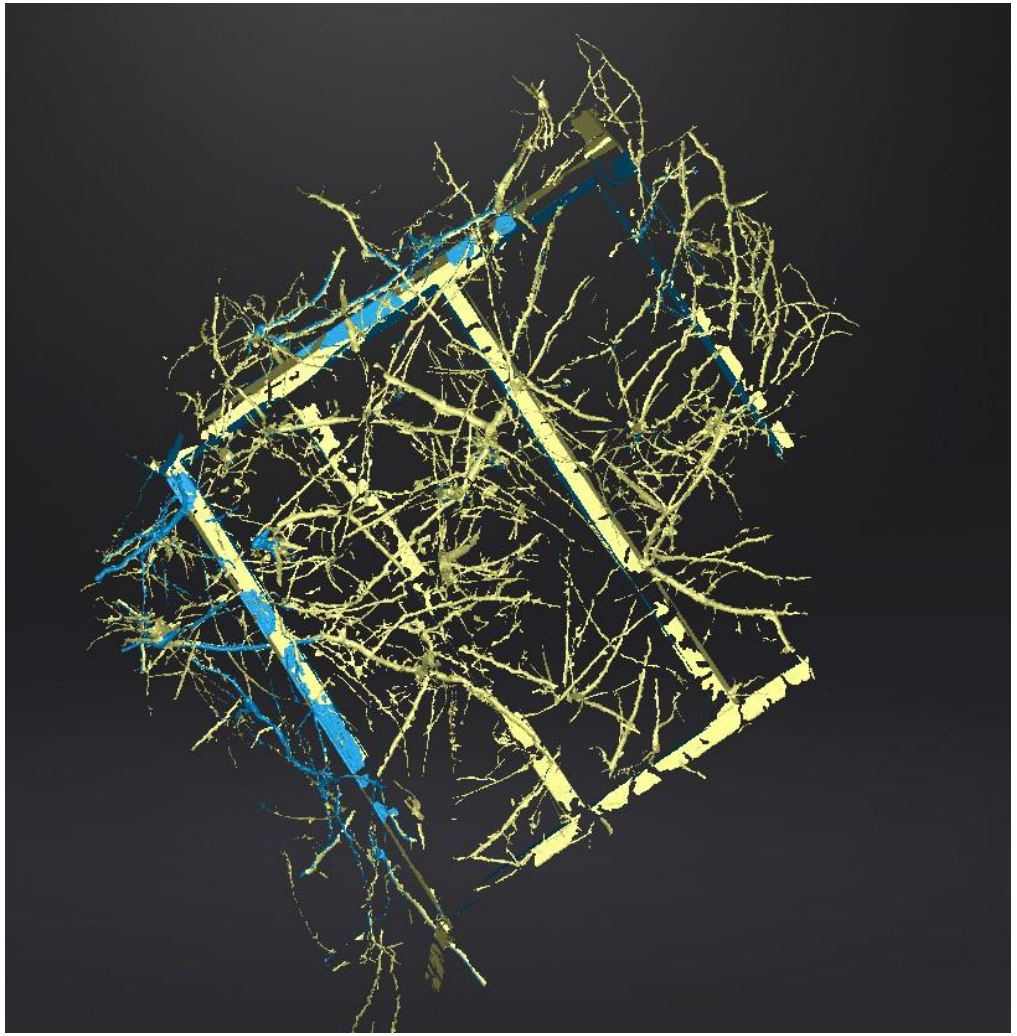
Keen et al. 2024 Oecologia



In the 1-yr burn watershed, grass biomass is significantly higher than woody fine root biomass in the top 30 cm, especially in the drier year (2021).

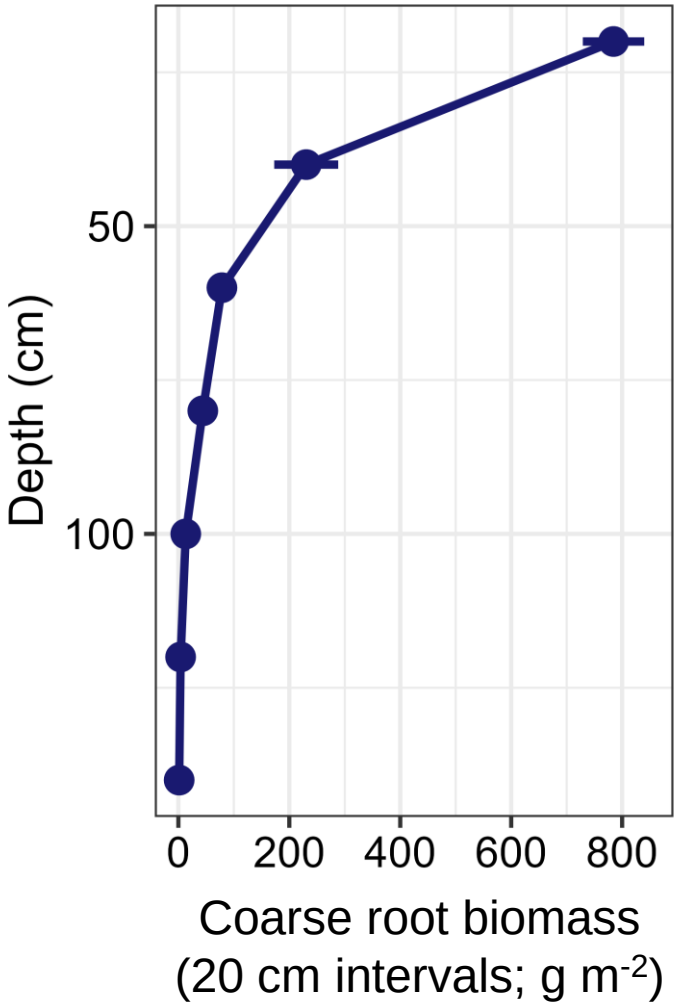
In the 4-yr burn watershed, fine-root biomass is lower in the top 30 cm, and more similar among years.

Keen et al. *in prep*



We are creating 3-D models of intact woody root systems to better understand architecture, resource use, and C-allocation within the soil profile.

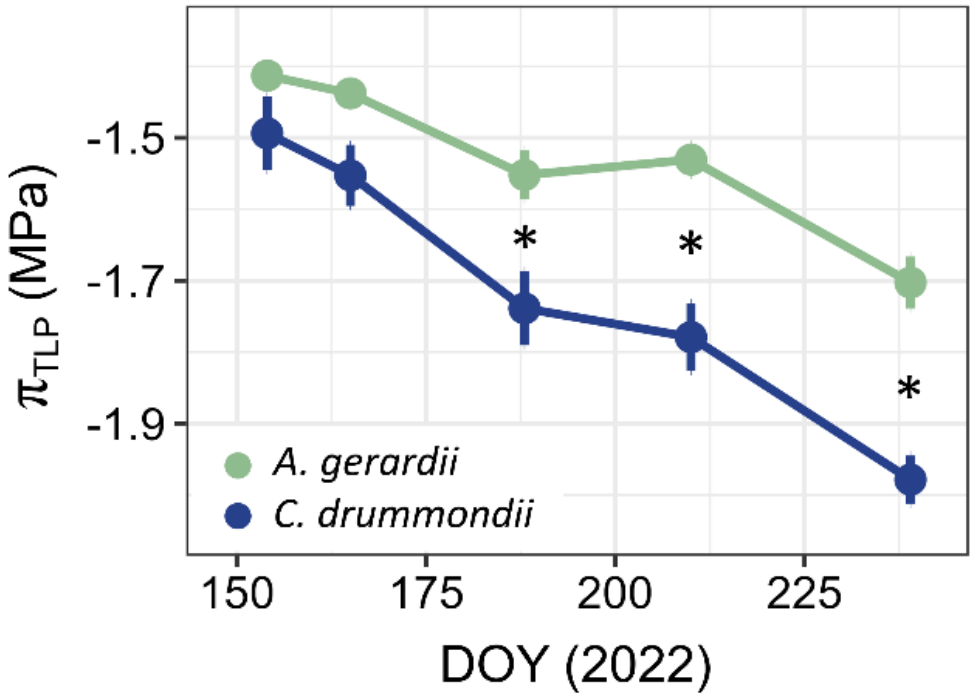
Keen et al. *in prep*



Large input of coarse roots under the shrubs, especially in the top 60 cm.

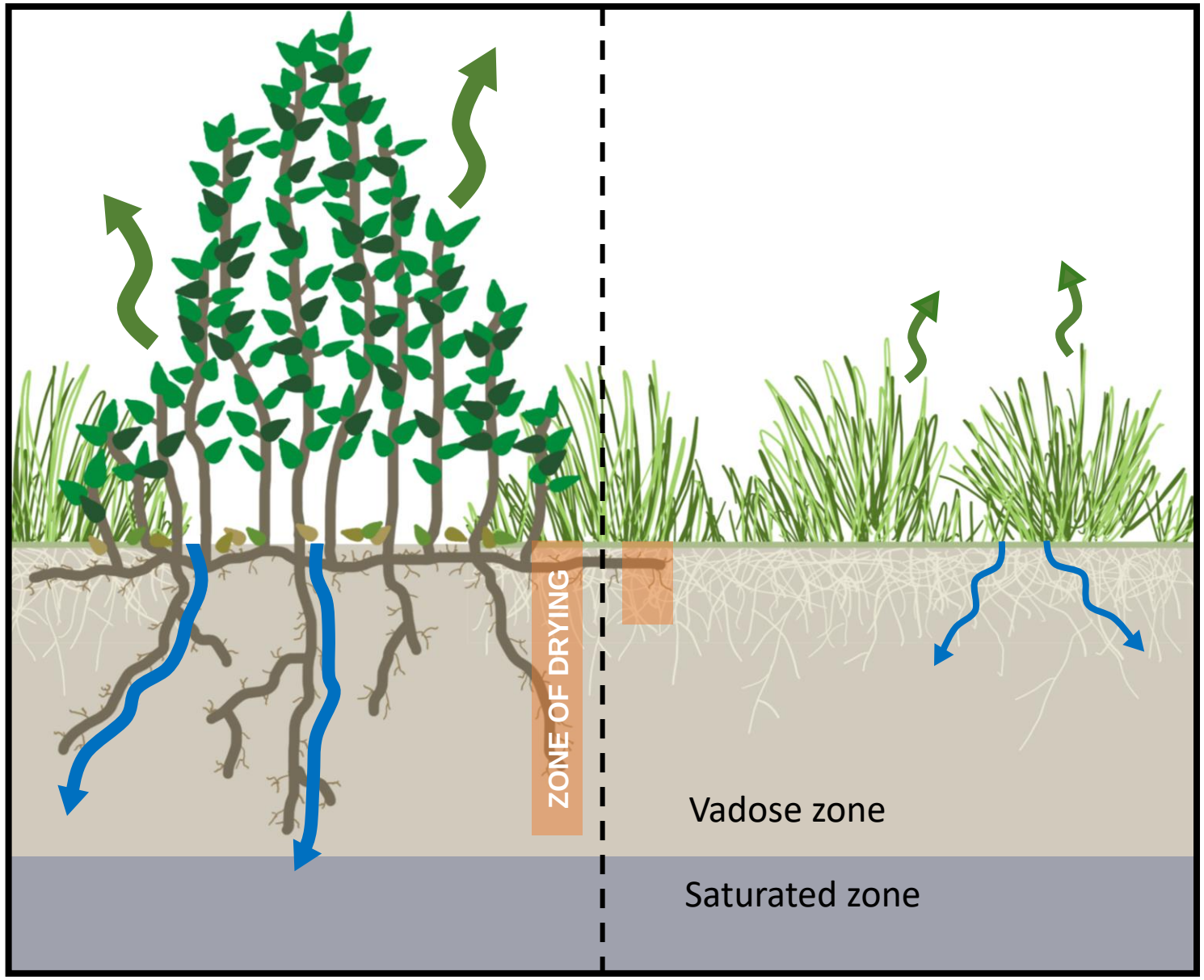
Shrubs not nearly as susceptible to drought as theorized -- *Why?*

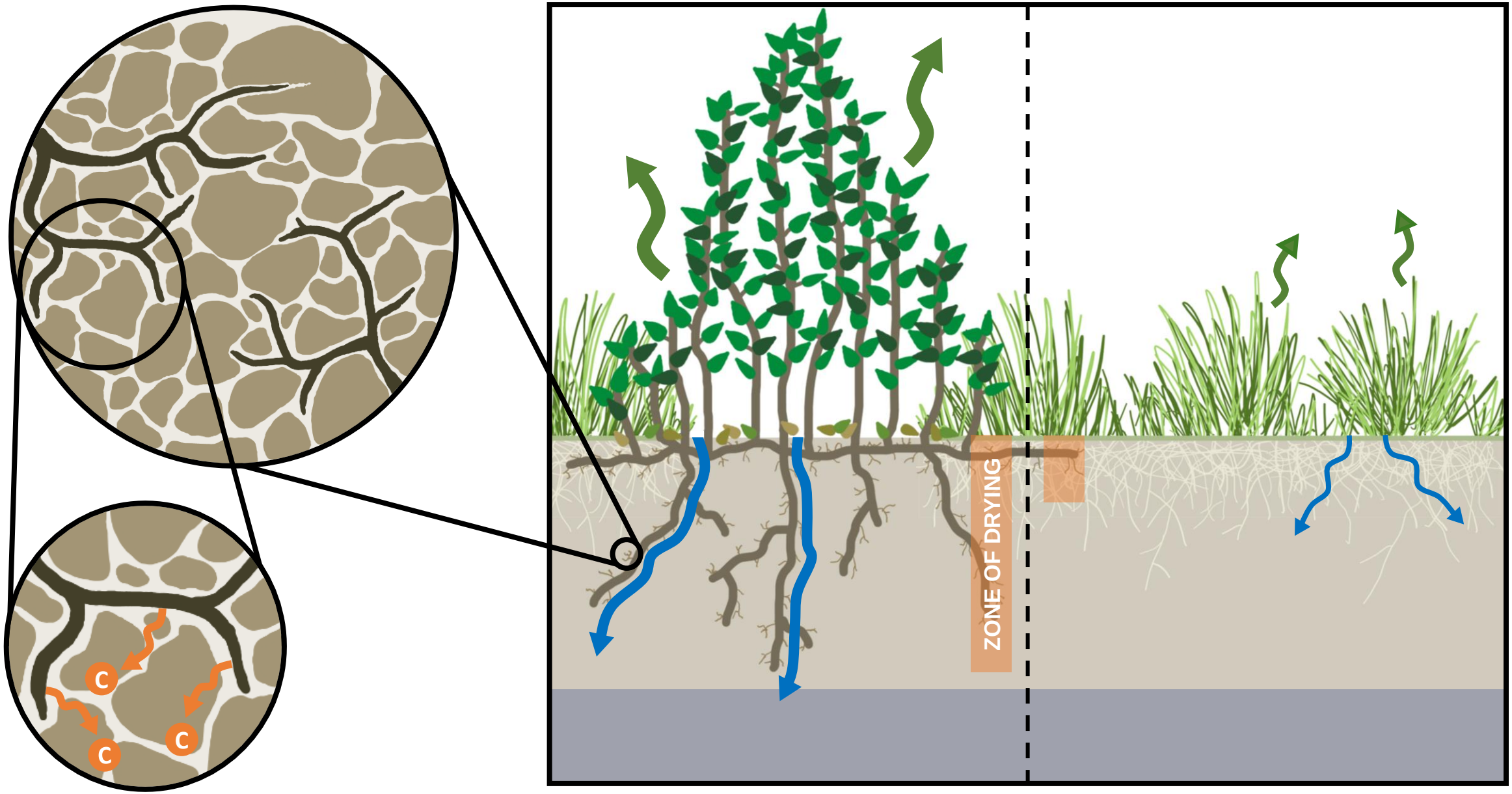
- Shrubs use more water (ET), but zones of use in the soil are plastic
- Greater allocation of coarse roots deeper in the soil, creating greater depths of soil drying
- Greater physiological ability to regulate / adjust to drought stress. For example, osmotic adjustment to manipulate leaf turgor loss point as summer dry down occurs.



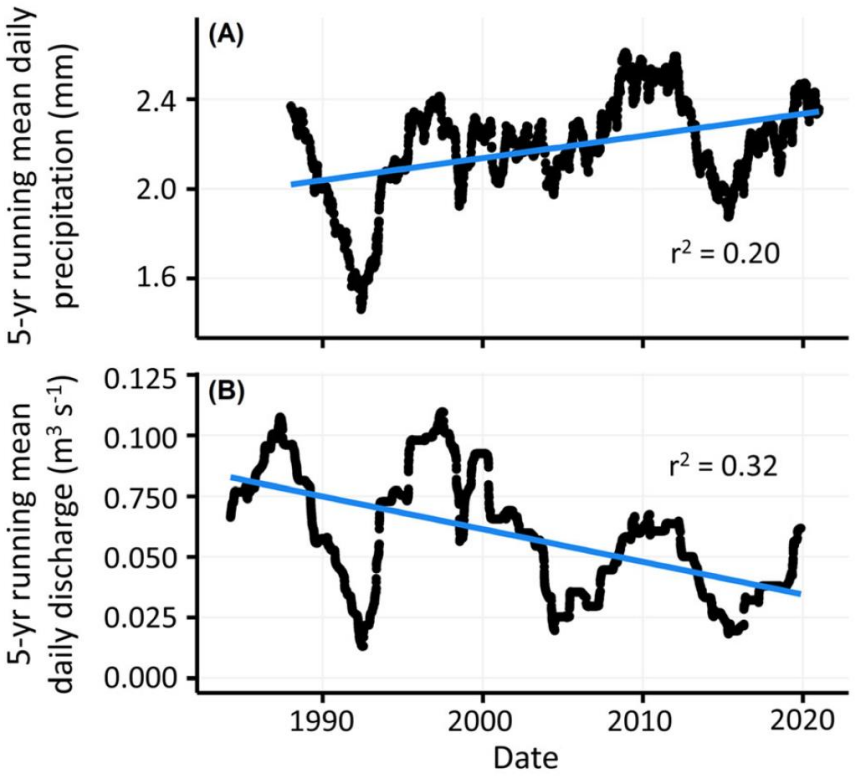
Keen et al. 2024 J. Ecology

1. Greater water use by shrubs (higher leaf-level transpiration, greater leaf area)
2. Deeper root penetration by shrubs, resulting in a change in fine vs. coarse roots in soils
3. Greater depth of soil drying, and alteration of hydrological and biogeochemical cycling

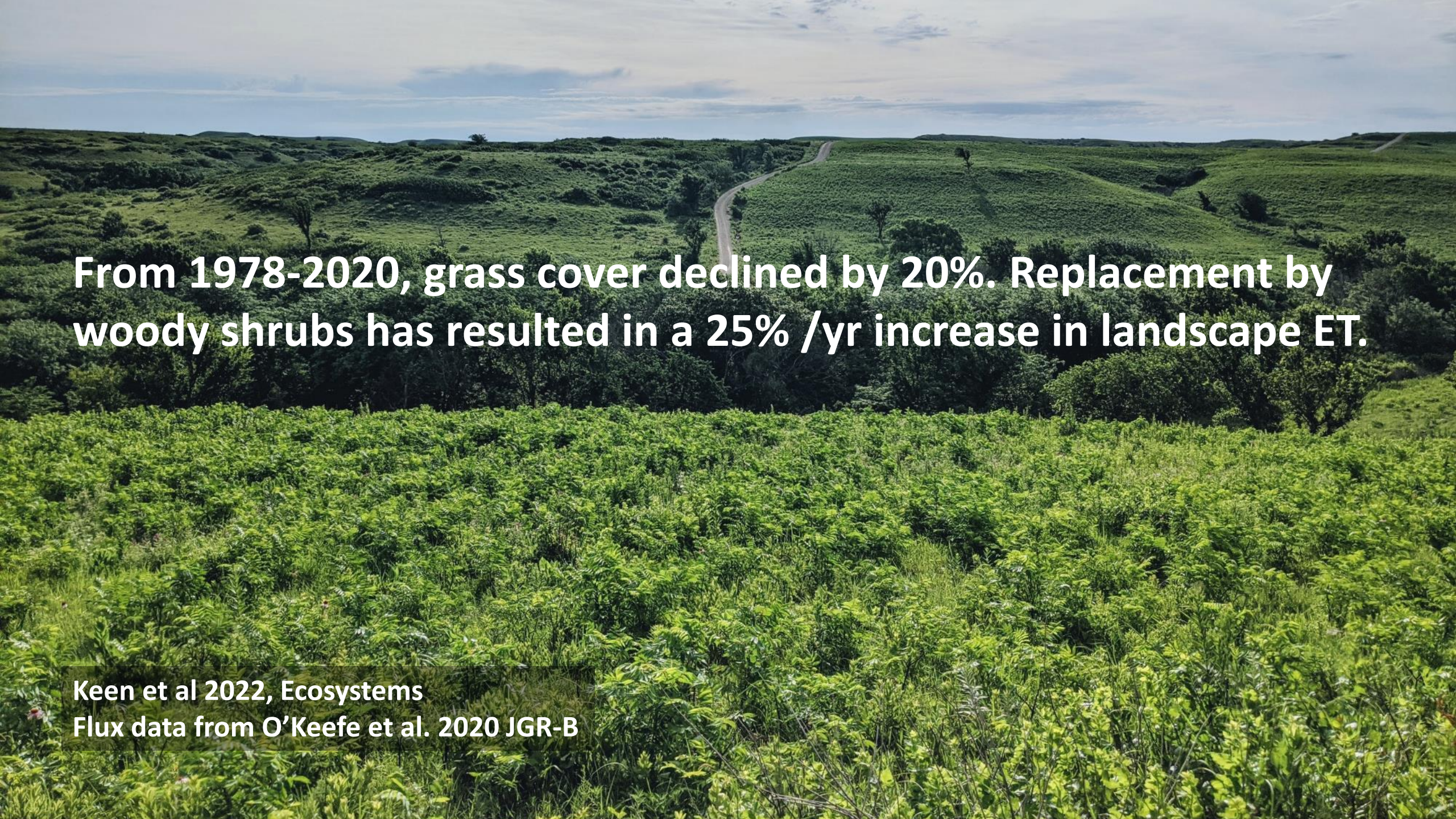



C
C
C
ZONE OF DRYING

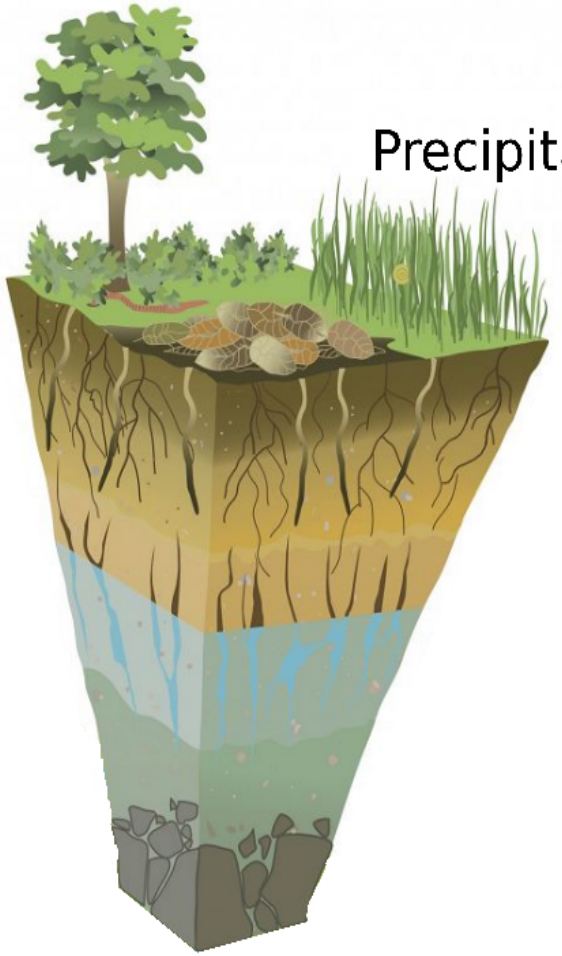
Many grassy ecosystems are drying, not explained by changes in climate alone

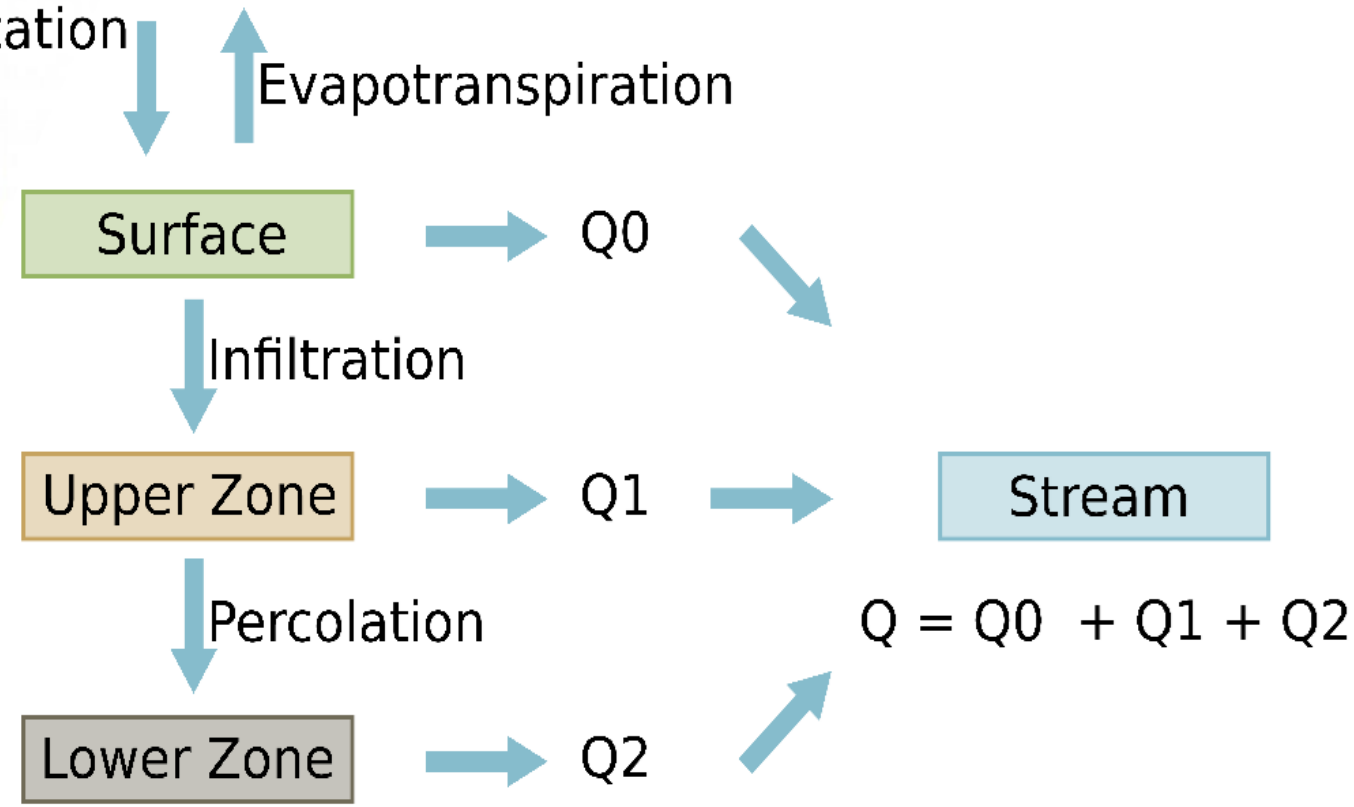


Keen et al 2022, Ecosystems

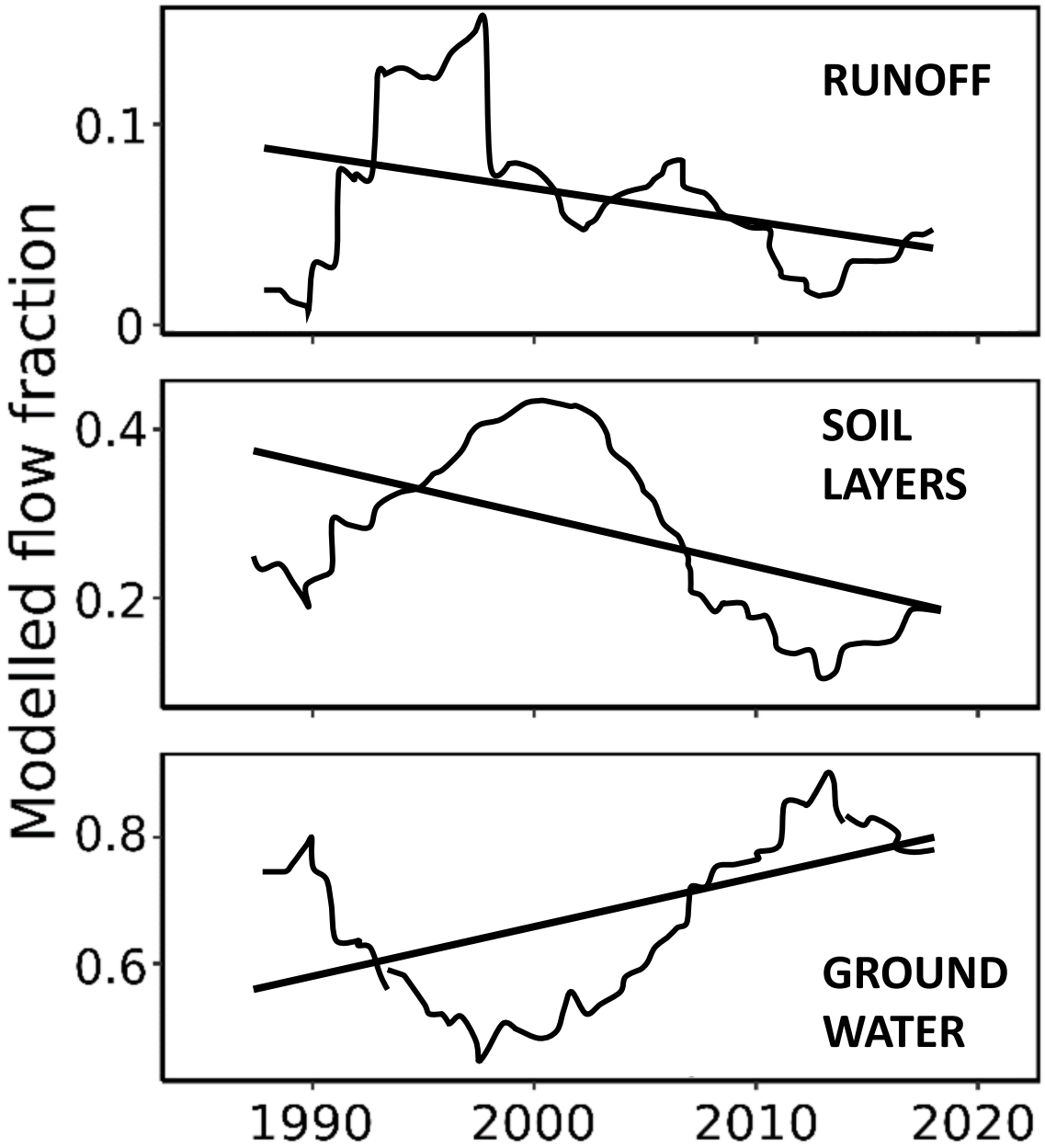

From 1978-2020, grass cover declined by 20%. Replacement by woody shrubs has resulted in a 25% /yr increase in landscape ET.
Keen et al 2022, Ecosystems
Flux data from O'Keefe et al. 2020 JGR-B

Hydrologic modeling (HBV-light) simulates impacts of woody encroachment on streamflow





Sadayappan et al. 2023 J. Hydrology



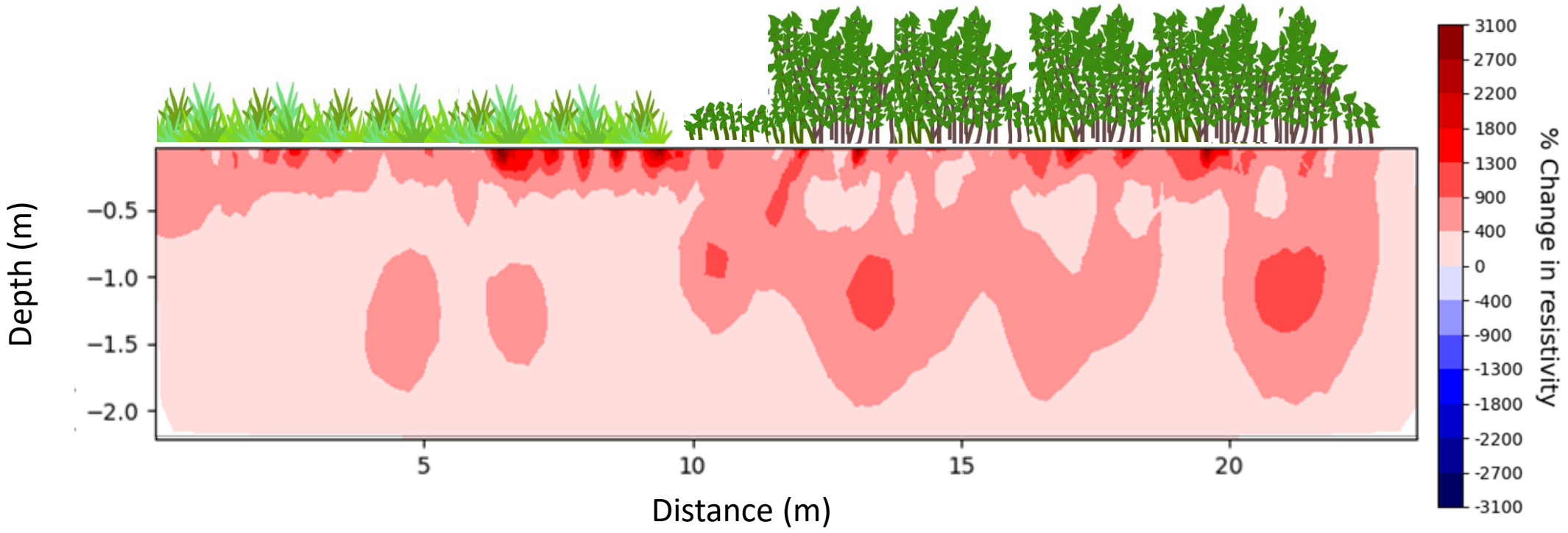
Watershed N4D

Over the last 4 decades, contributions to streamflow have declined from runoff and soil layers, yet increased from deeper groundwater.

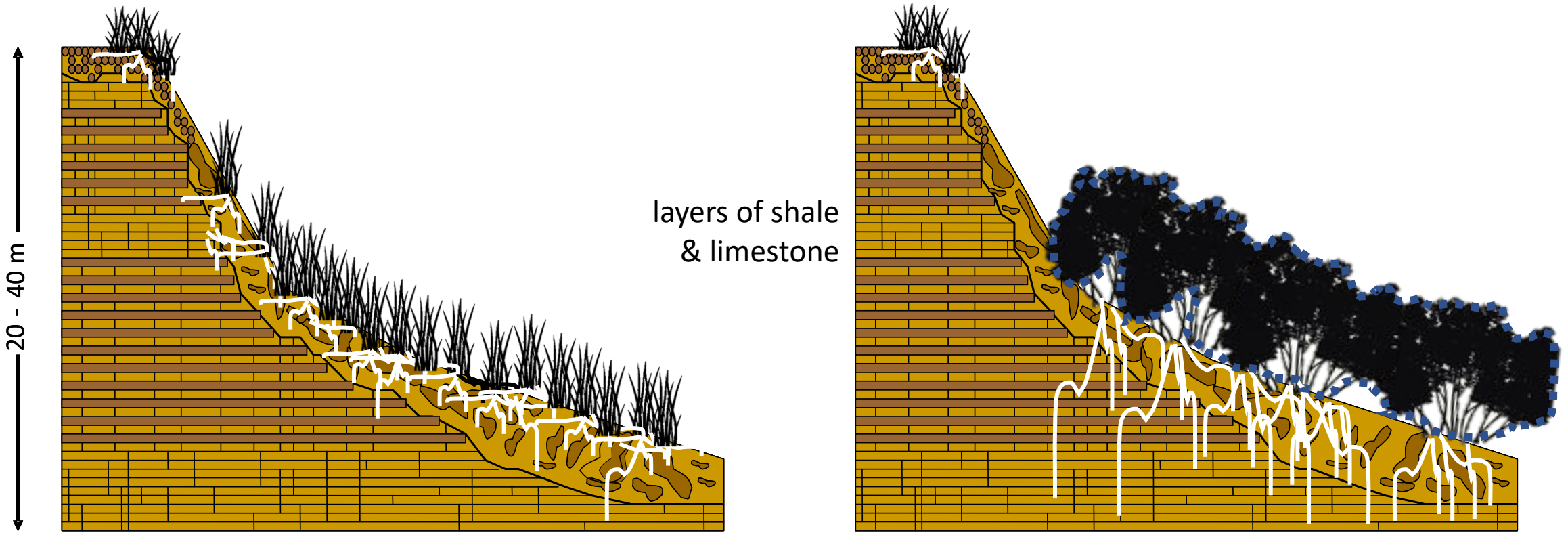
At present, streamwater is > 80% groundwater

Sadayappan et al. 2023 J. Hydrology

Soil moisture depletes faster and at deeper depths under areas with woody plants



Jarecke et al. *in prep*



Evidence suggests an indirect linkage between increased woody vegetation and accelerated water cycling whereby coarse woody roots create larger soil macropores, speed up rates of infiltration to the groundwater, reduce residence time in surface soils and the alluvial aquifer, and along with higher ET result in longer-term drying trends.

First theorized in Brookfield et al. 2017 Groundwater

Solutions

Protect grassland

Our primary focus right now should be on protecting what remains. Our best solution for woody encroachment is prevention.

Stress the shrubs

Fire, herbivory (cutting), and herbicide alone have not worked.

Interactions of multiple drivers have resulted in mortality when root NSC concentrations are reduced.

Legacies

Once established, shrub mortality and removal won’t restore functional ecosystem attributes.

Belowground legacies likely to remain for decades / centuries.

Co-Authors

Oregon State University
College of Earth, Ocean, and Atmospheric Sciences
Pam Sullivan and Karla Jarecke

St. Edward's University, Austin, Texas
Kim O'Keefe

WISCONSIN
University of Wisconsin–Madison
Department of Botany
Kate McCulloh

Kansas State University
Matt Kirk, Rachel Keen, & Greg Tooley

PennState
Institutes of Energy and the Environment
Li Li & Kayalvizhi Sadayappan

Acknowledgements

Konza Prairie LTER (NSF DEB: 2025849)
Konza Roots from Dept. of Energy: (DE-SC0019037)
Konza Hydrology (NSF Geosciences: 1911969)
More Konza Hydrology (NSF FRES: 2121652)