Perceptions of Aridification and Impacts on Ranchers and Rangeland Managers in the Southwestern United States

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Southwest Climate Adaptation Science Center

SWCASC NWRD Fellowship

- **Interdisciplinary** cohort
- Training and practice developing actionable science


user-inspired science
remote sensing
plant ecophysiology
hydrodynamic modeling
rangeland ecology
water management
environmental sociology

How well do the public and resource managers understand the increasing aridity phenomenon in contributing to megadrought?

How well do ranchers and rangeland managers understand the increasing aridity phenomenon in contributing to megadrought?

ARIDIFICATION: long-term average water supply (precipitation) compared to long-term average water demand (evapotranspiration)

DROUGHT: short-term, discrete dry periods

ARIDIFICATION: long-term average water supply (precipitation) compared to long-term average water demand (evapotranspiration)

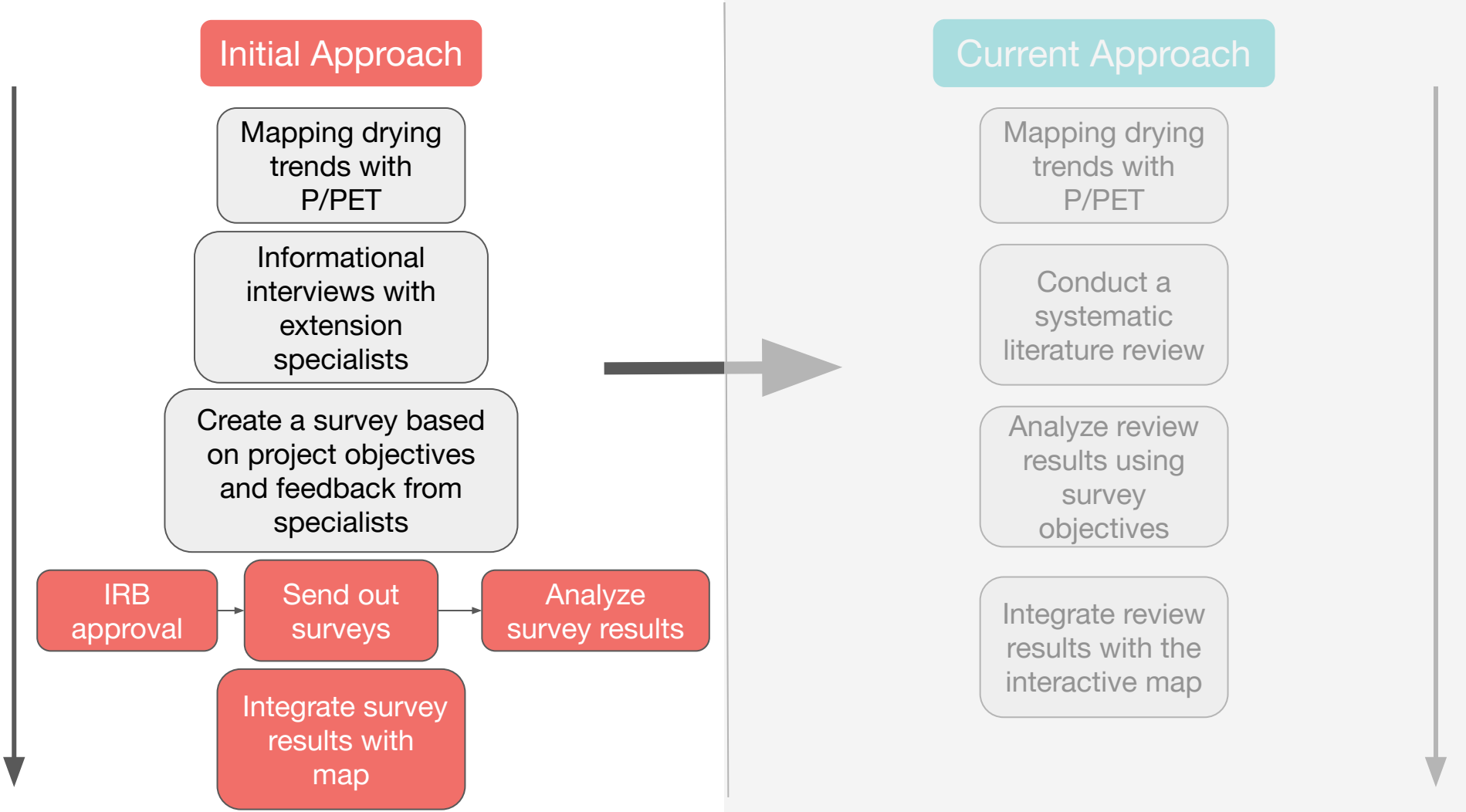
DROUGHT: short-term, discrete dry periods

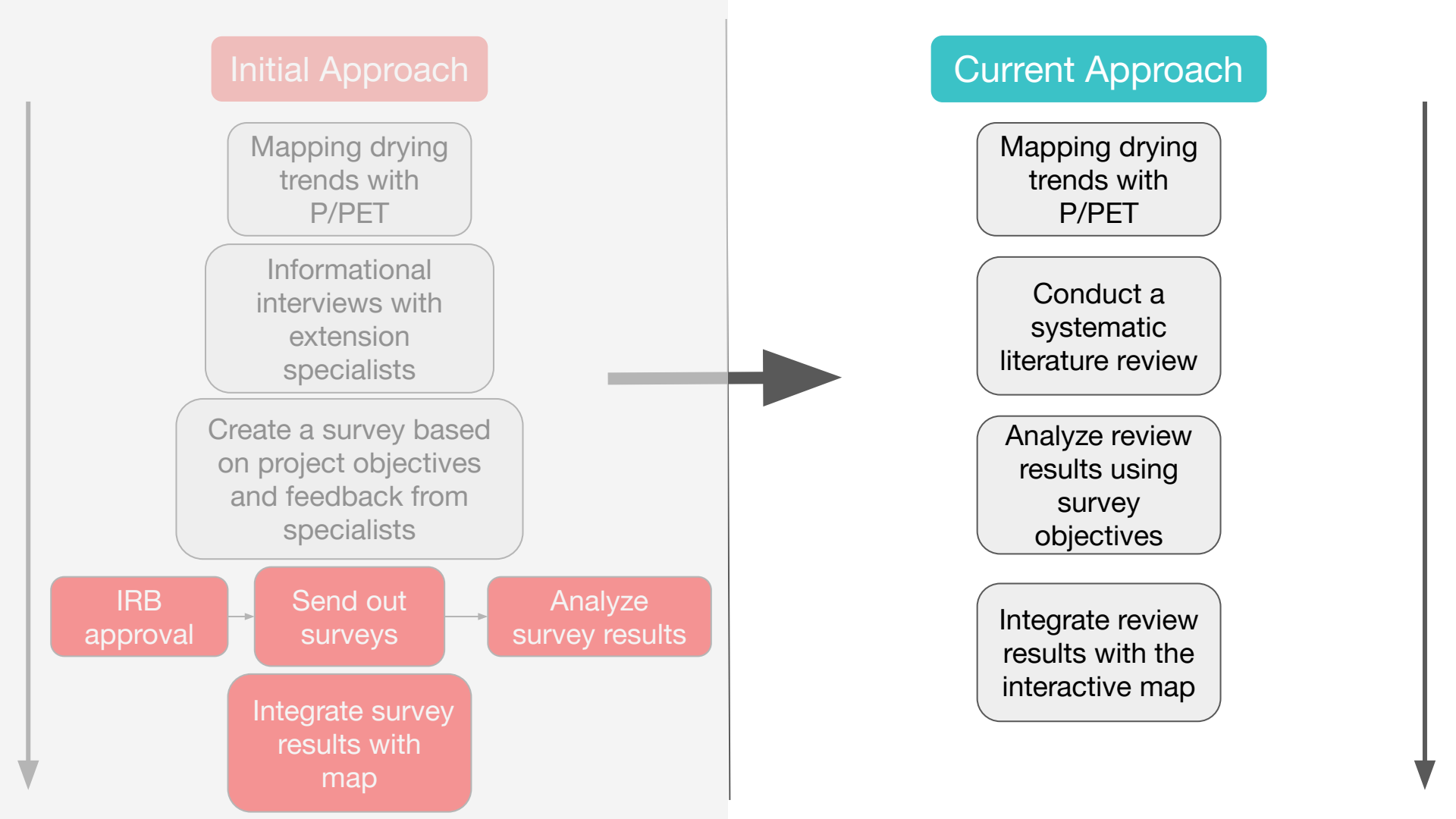
Project Objectives

Determine changes in aridity over time across watersheds in the SW U.S.

Assess ranchers and resource managers' perceptions and experiences of aridification in the SW U.S.

Design an interactive map to report our findings and analyses


Initial Approach
Mapping drying trends with P/PET
Informational interviews with extension specialists
Create a survey based on project objectives and feedback from specialists
IRB approval
Send out surveys
Analyze survey results
Integrate survey results with map
Current Approach
Mapping drying trends with P/PET
Conduct a systematic literature review
Analyze review results using survey objectives
Integrate review results with the interactive map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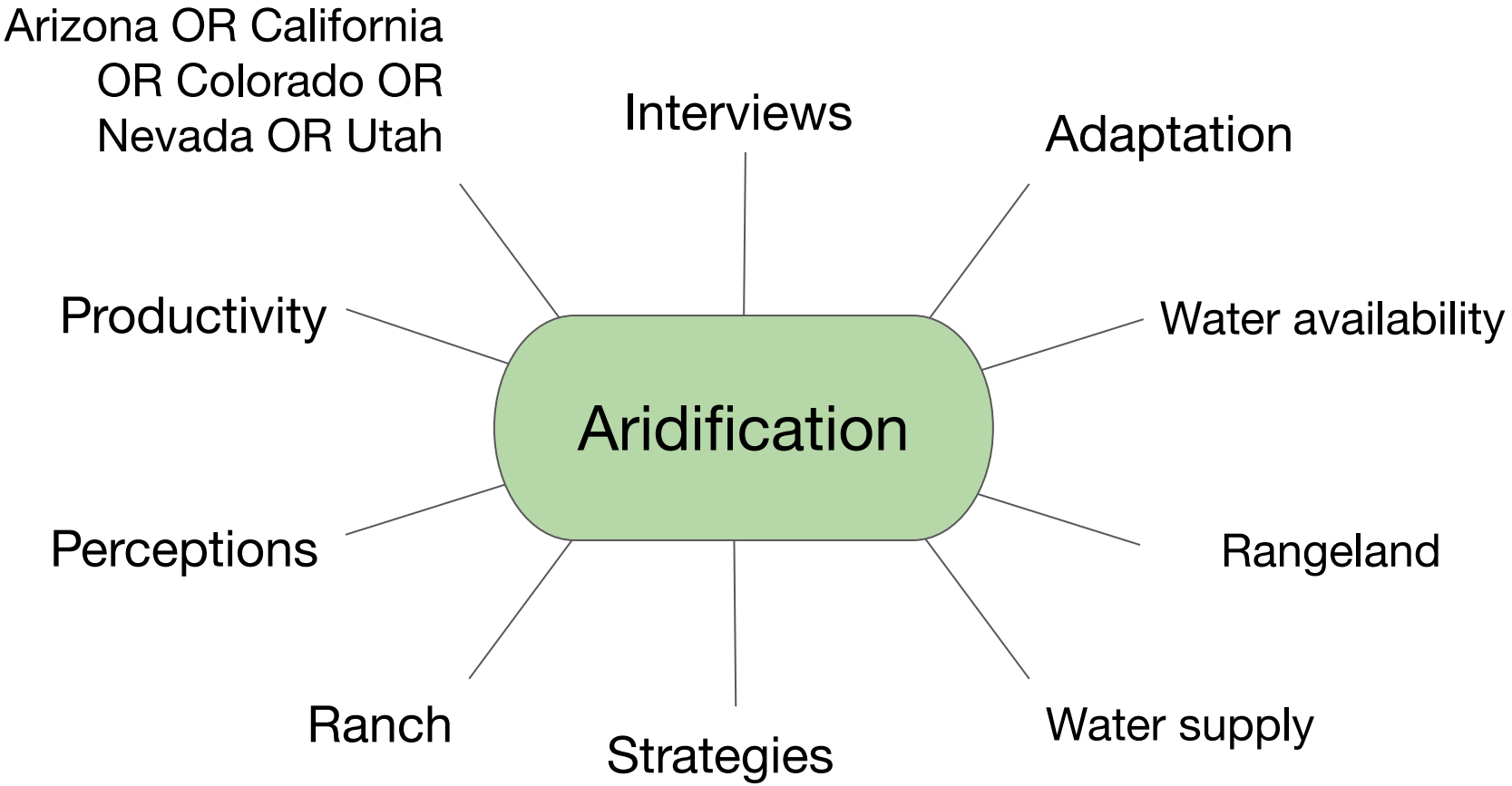
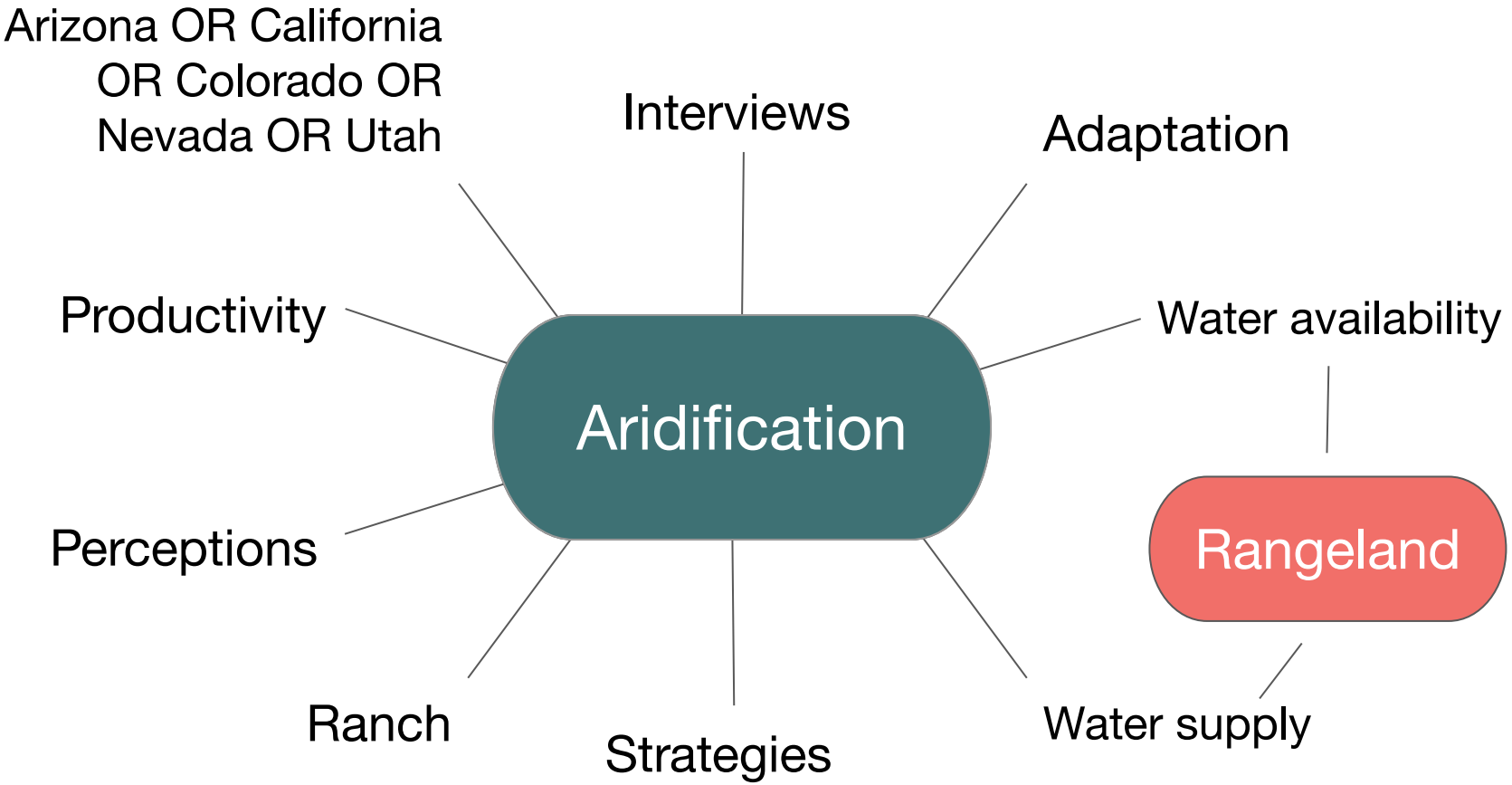
Justin Sullivan/Getty Images

Part I: **Literature Review**


Arizona OR California OR Colorado OR Nevada OR Utah
Interviews
Adaptation
Productivity
Water availability
Aridification
Perceptions
Rangeland
Ranch
Strategies
Water supply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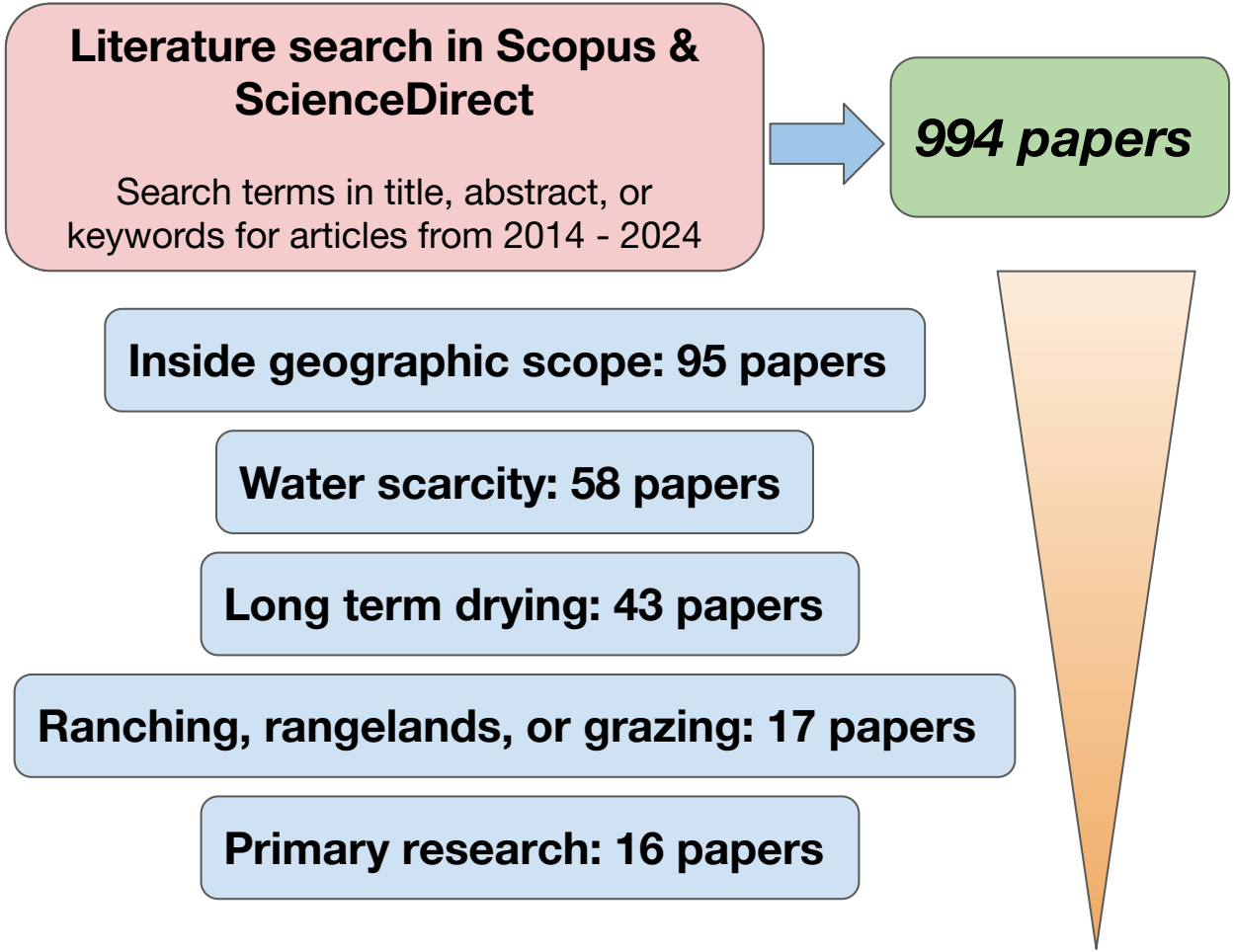
Literature search in Scopus & ScienceDirect
Search terms in title, abstract, or keywords for articles from 2014 - 2024
994 papers
Inside geographic scope: 95 papers
Water scarcity: 58 papers
Long term drying: 43 papers
Ranching, rangelands, or grazing: 17 papers
Primary research: 16 papers

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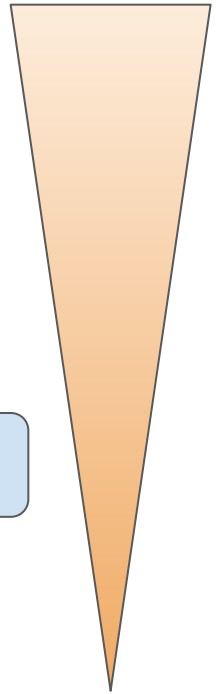
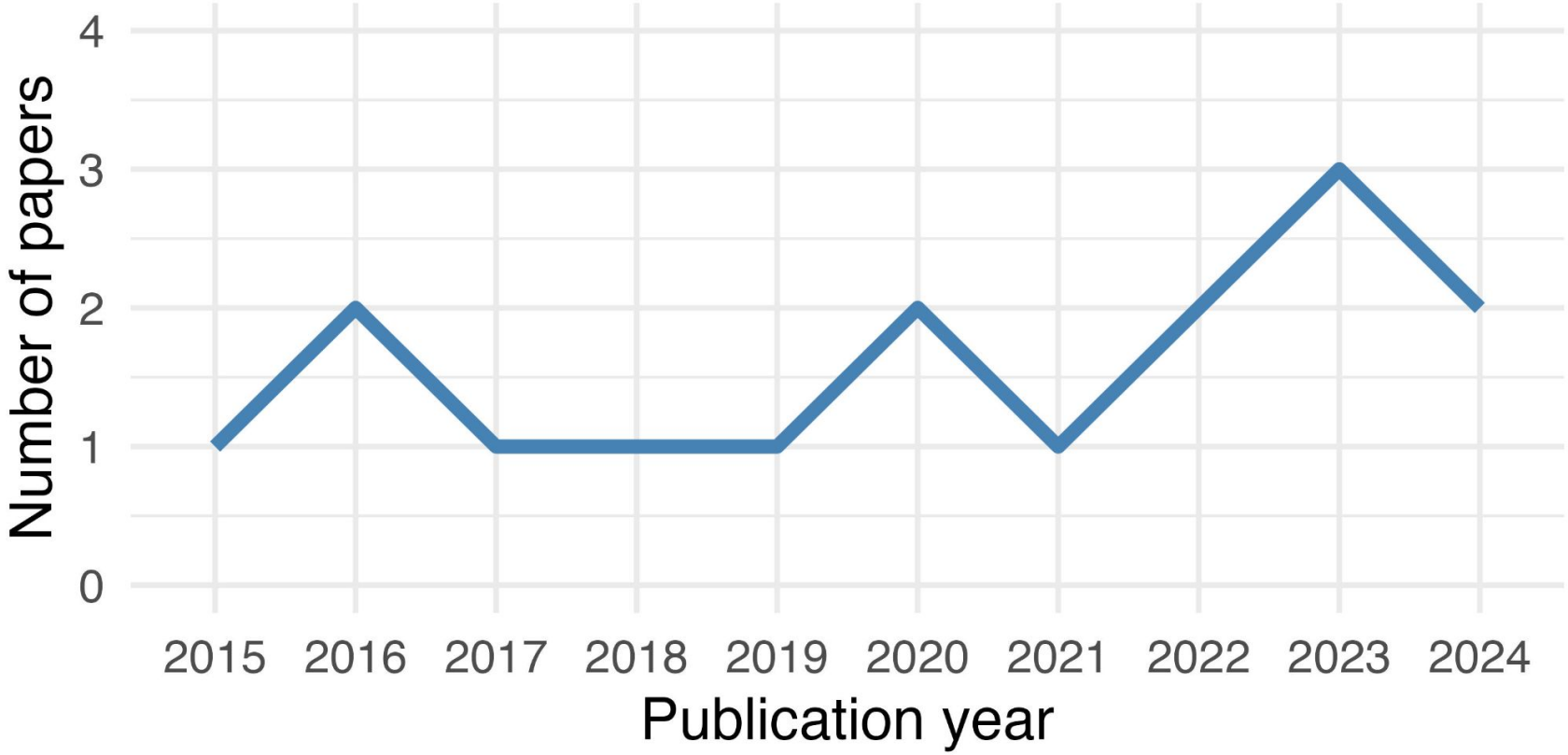


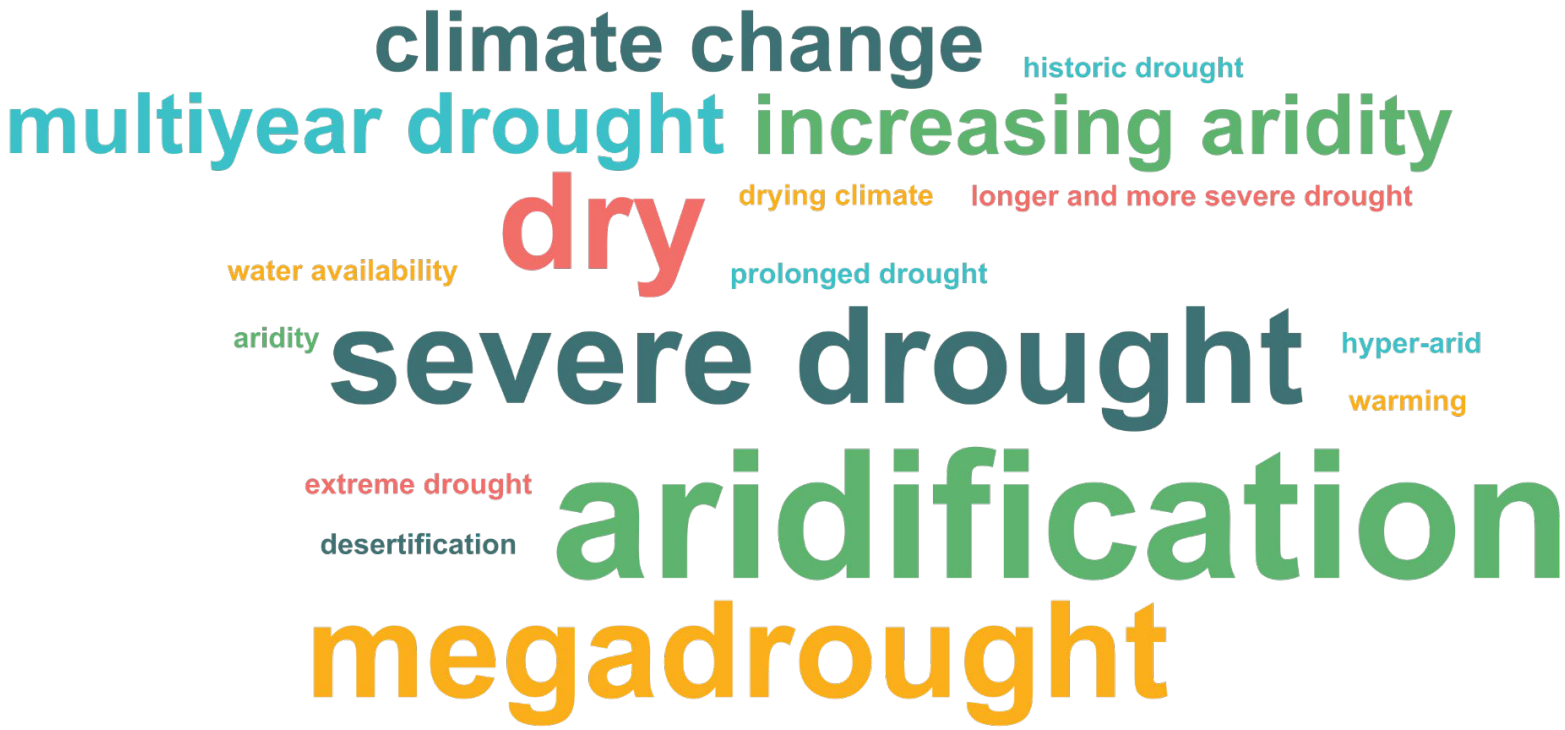
Papers included in analysis:



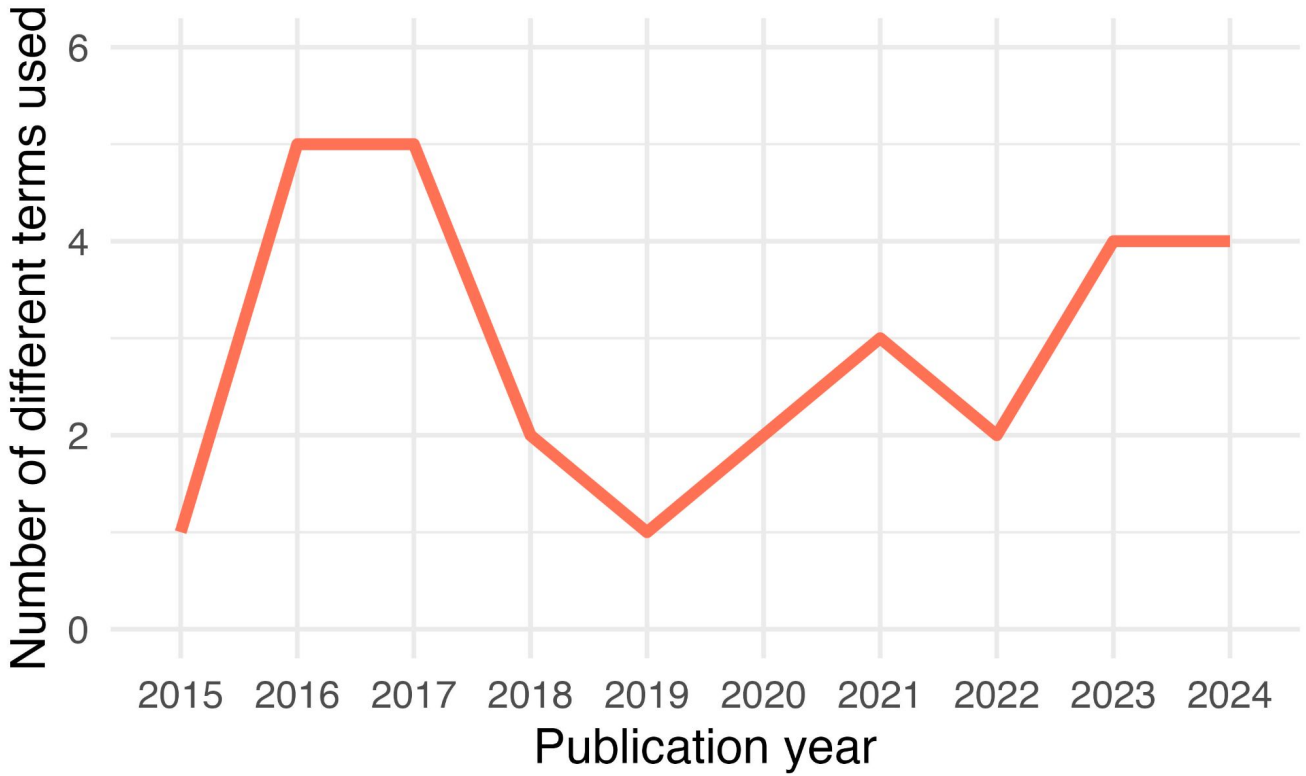
Analysis

From each paper, we extracted:

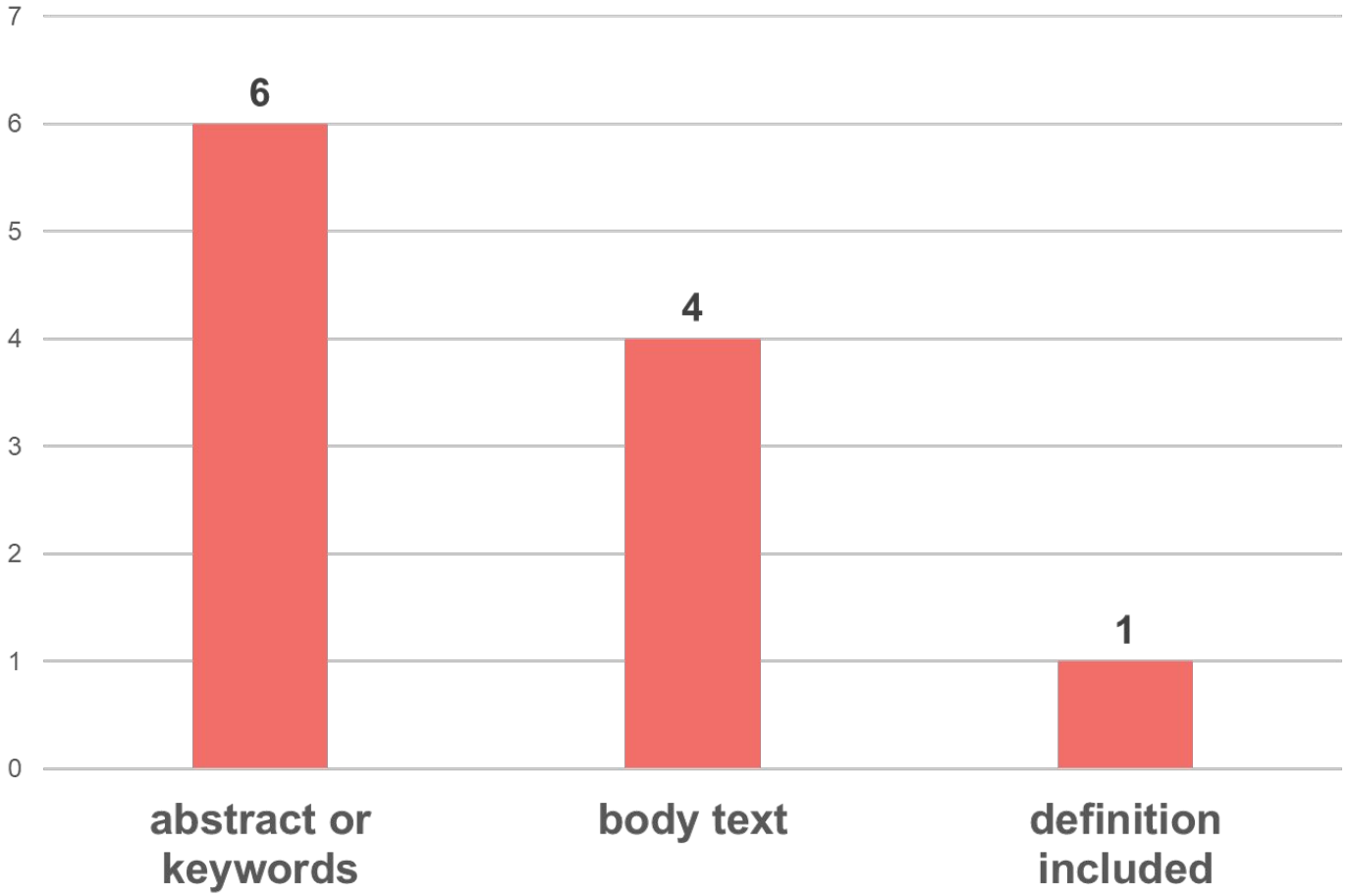
- Terms used for drying
- Provided definition of aridification
- Ecological impacts of drying
- Sociological impacts
- Adaptive management strategies
- Other results and identified research/communication gaps


climate change
historic drought
multiyear drought
increasing aridity
dry
drying climate
longer and more severe drought
water availability
prolonged drought
aridity
severe drought
hyper-arid
warming
extreme drought
aridification
desertification
megadrought

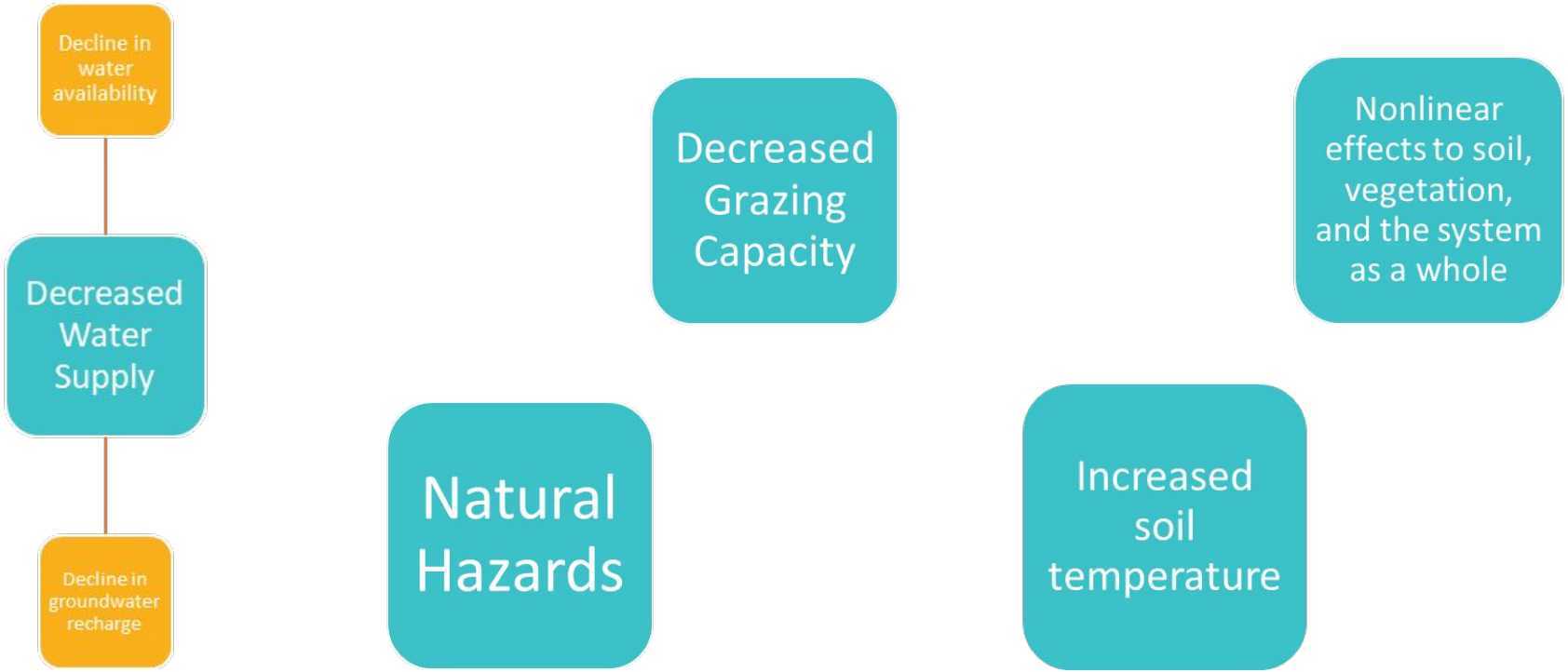
How did terminology used vary over time?



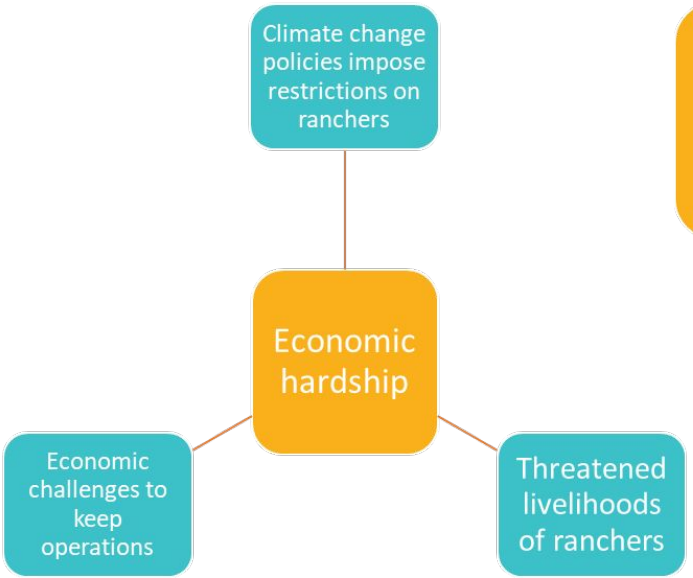
Mentions of aridification:



Ecological impacts of aridification



Societal impacts of aridification



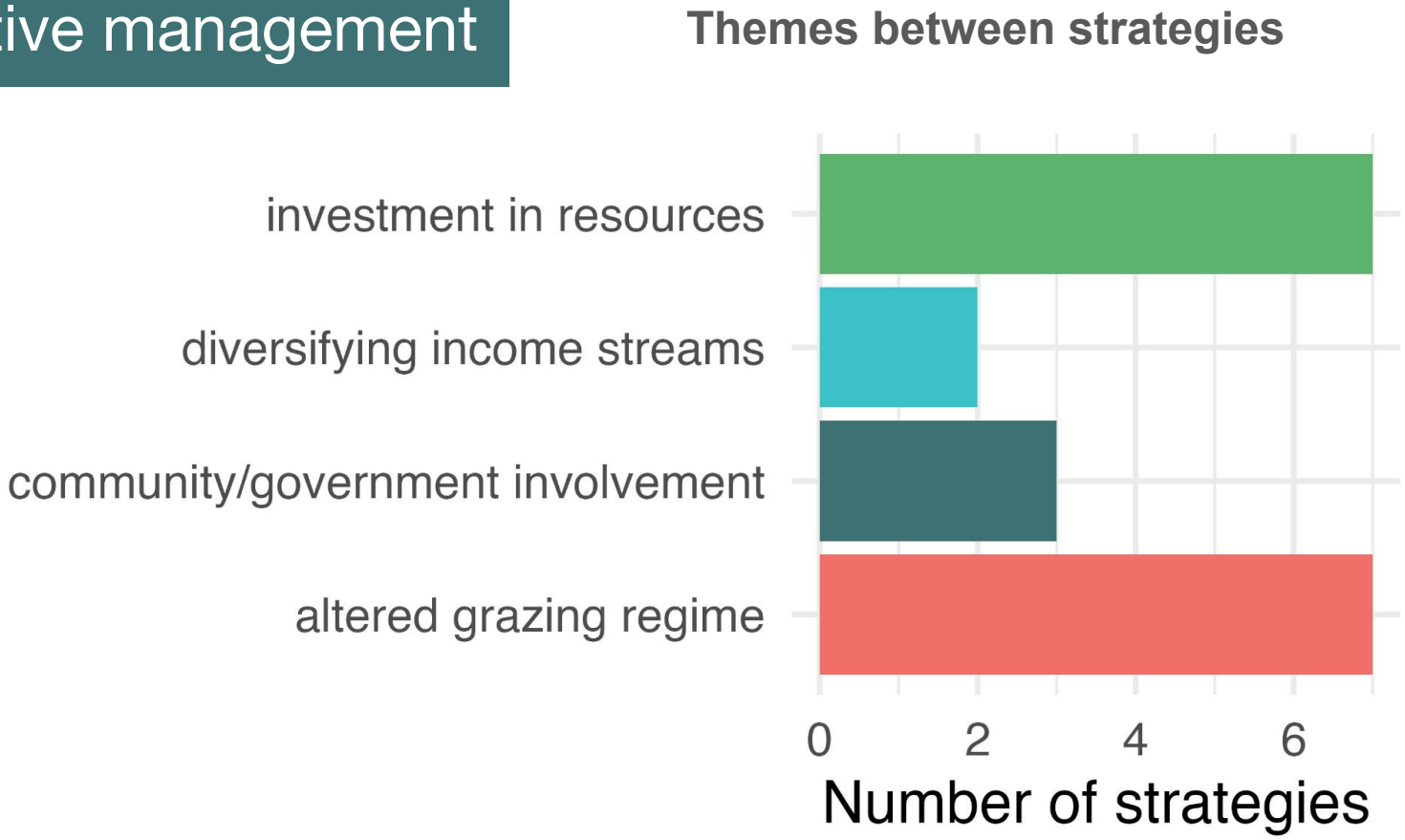
Impacts Tourism

Perceptions on climate change

Health risks

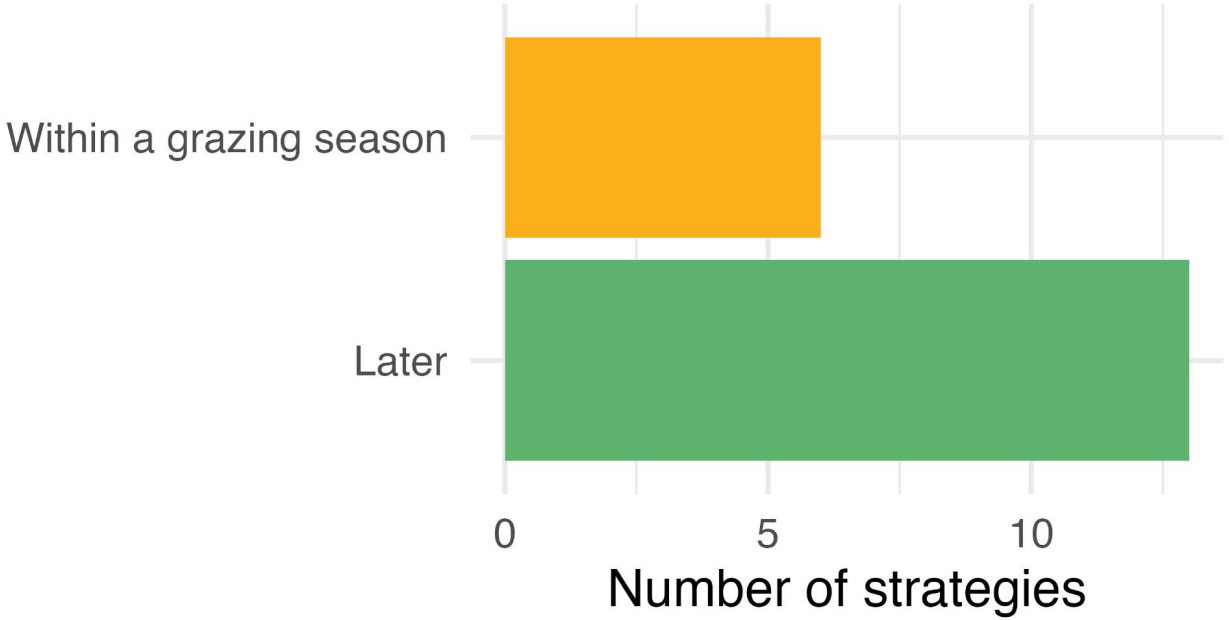
Community losses

Adaptive management



Adaptive management

When are the reported adaptive management actions likely to yield results?



Takeaways - Literature Review

- Lack of consensus on terminology
  - Clear need for relevant research to be compiled into accessible media
- Studies don’t focus on/specifically target long term impacts
  - But, managers are investing in longer-term adaptive strategies
- **Next step**: clarify the spatial distribution of these studies

Part II: **The Map**

Map Creation - Metrics of Aridification

Aridification - long term trend of decreasing water supply

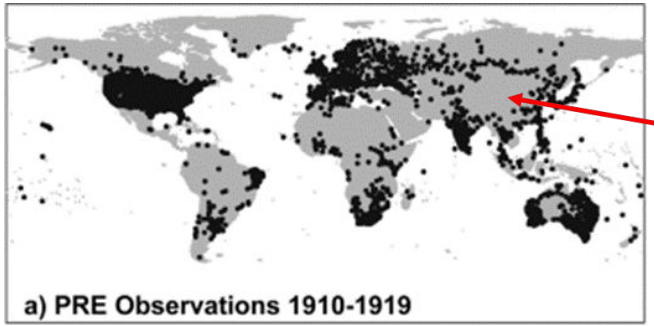
Need to look at regional shifts in Precipitation and Evaporative demand

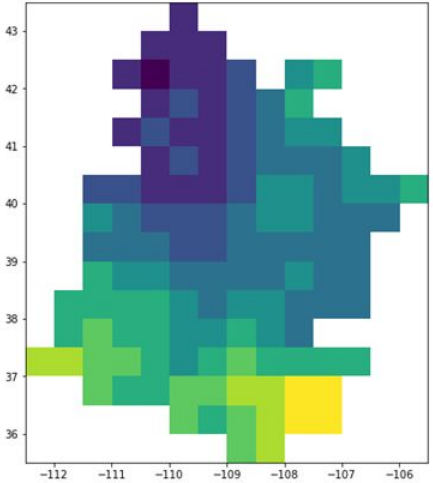
$$\phi = P/PET$$

Higher ϕ = more water
Lower ϕ = less water

Can be calculated over many time scales, including seasonally.
Intuitive system where **users decide** how to examine shifts on long time scales (100 years)

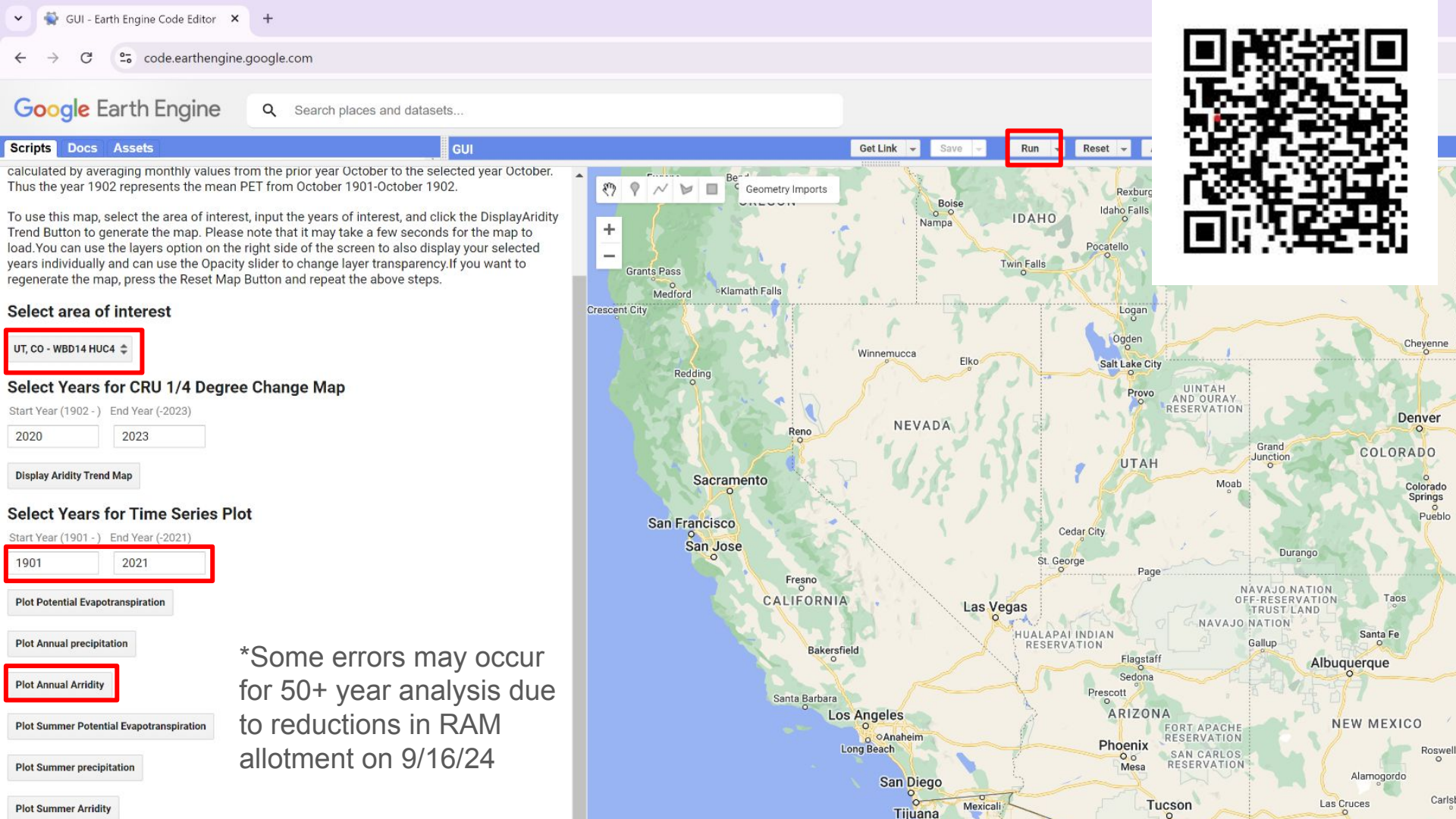
Map Creation - Underlying data



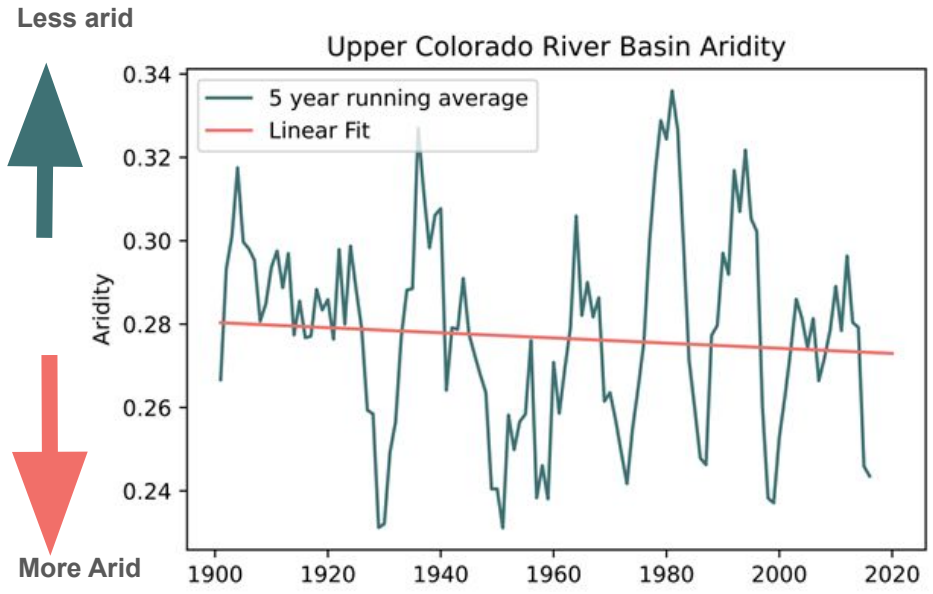


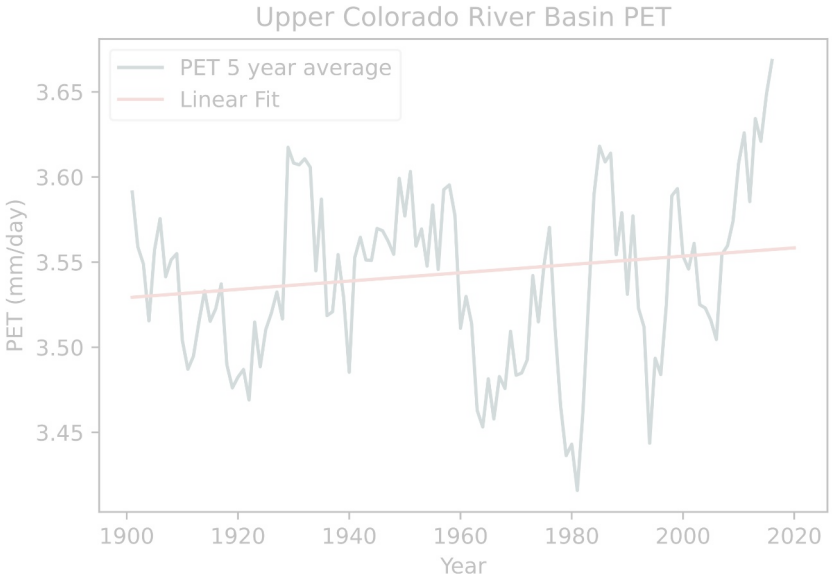
Climate Research Unit Time Series: (CRU-TS v4.05)

- Weather data from across the world interpolated to create a raster.
- Includes PET, P, & T
- Cell size of 0.5 degrees lat/long


GUI - Earth Engine Code Editor
code.earthengine.google.com
Google Earth Engine
Search places and datasets...
Scripts
Docs
Assets
GUI
Get Link
Save
Run
Reset
calculated by averaging monthly values from the prior year October to the selected year October. Thus the year 1902 represents the mean PET from October 1901-October 1902.
To use this map, select the area of interest, input the years of interest, and click the DisplayAridity Trend Button to generate the map. Please note that it may take a few seconds for the map to load.You can use the layers option on the right side of the screen to also display your selected years individually and can use the Opacity slider to change layer transparency.If you want to regenerate the map, press the Reset Map Button and repeat the above steps.
Select area of interest
UT, CO - WBD14 HUC4
Select Years for CRU 1/4 Degree Change Map
Start Year (1902 -)
End Year (-2023)
2020
2023
Display Aridity Trend Map
Select Years for Time Series Plot
Start Year (1901 -)
End Year (-2021)
1901
2021
Plot Potential Evapotranspiration
Plot Annual precipitation
Plot Annual Arridity
Plot Summer Potential Evapotranspiration
Plot Summer precipitation
Plot Summer Arridity
*Some errors may occur for 50+ year analysis due to reductions in RAM allotment on 9/16/24
Geometry Imports
IDAHO
NEVADA
UTAH
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
Boise
Nampa
Idaho Falls
Pocatello
Twin Falls
Grants Pass
Medford
Klamath Falls
Crescent City
Redding
Winnemucca
Elko
Logan
Ogden
Salt Lake City
Provo
Cheyenne
Denver
Reno
Sacramento
San Francisco
San Jose
Fresno
Bakersfield
Las Vegas
Moab
Grand Junction
Colorado Springs
Pueblo
Cedar City
St. George
Page
Durango
Taos
Santa Fe
Albuquerque
Gallup
Flagstaff
Sedona
Prescott
Santa Barbara
Los Angeles
Anaheim
Long Beach
Phoenix
Mesa
San Diego
Tijuana
Mexicali
Tucson
Alamogordo
Las Cruces
Roswell
UINTAH AND OURAY RESERVATION
NAVAJO NATION OFF-RESERVATION TRUST LAND
NAVAJO NATION
HUALAPAI INDIAN RESERVATION
FORT APACHE RESERVATION
SAN CARLOS RESERVATION

Example output: Upper Colorado River (HU14) shows signs of long term aridification





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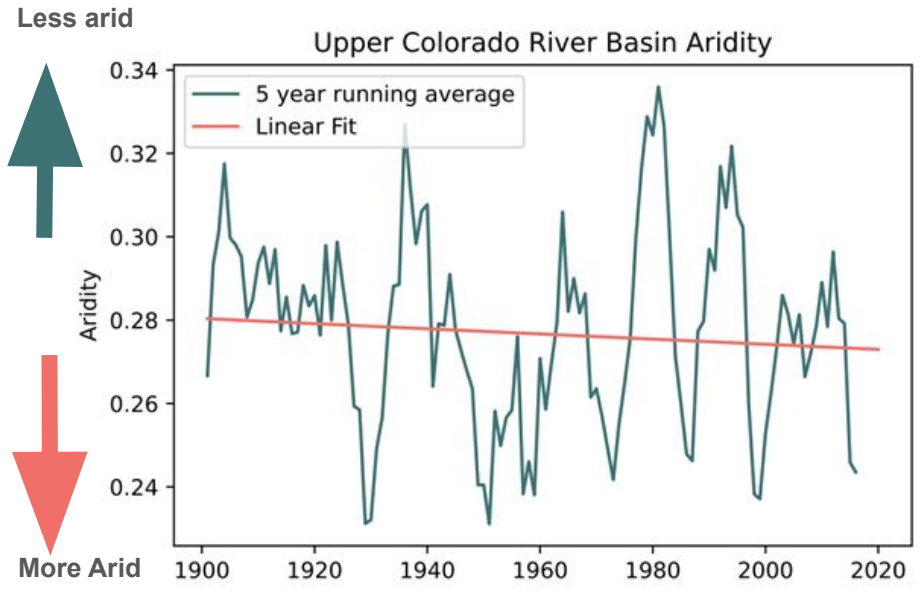
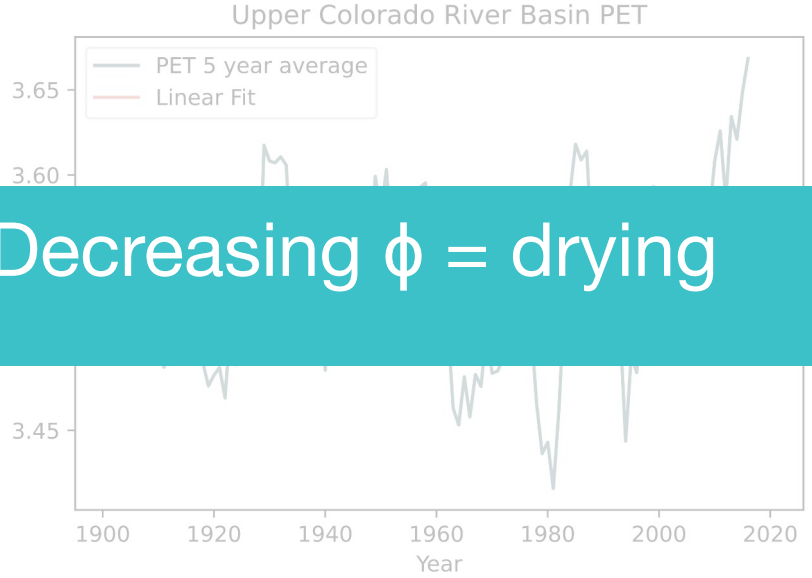
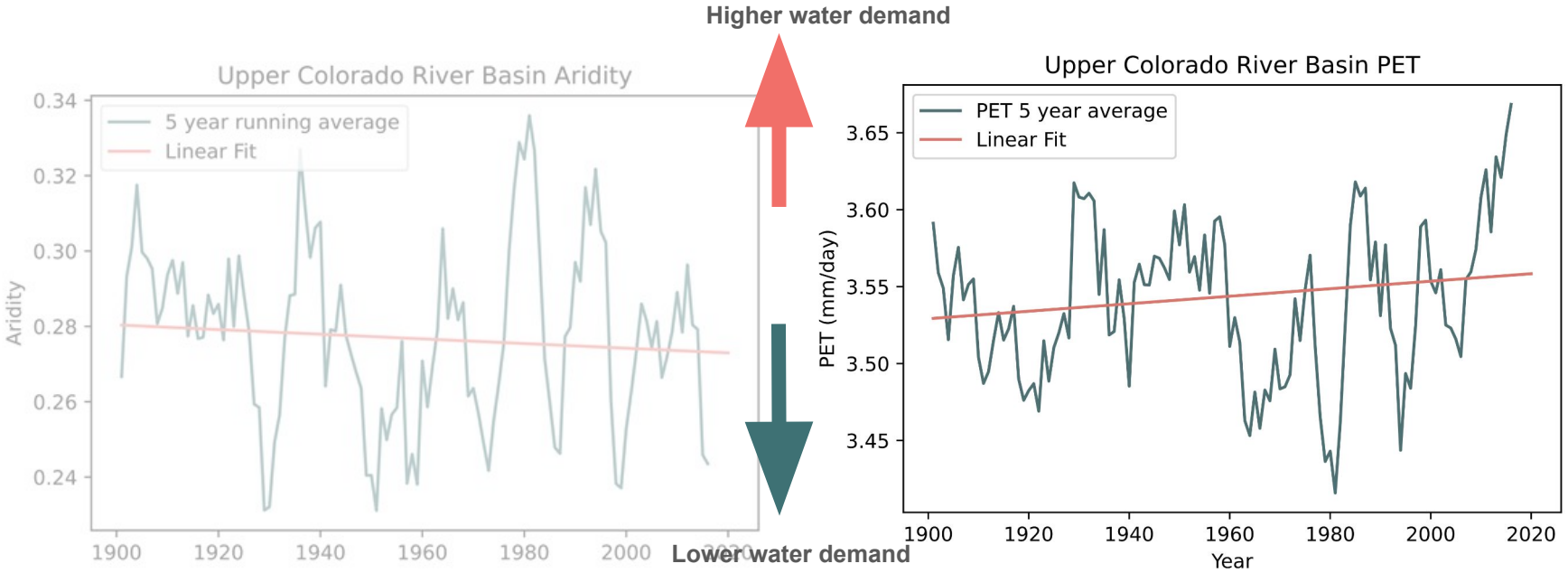




Decreasing ϕ = drying

Example output: Upper Colorado River (HU14) shows signs of long term aridification



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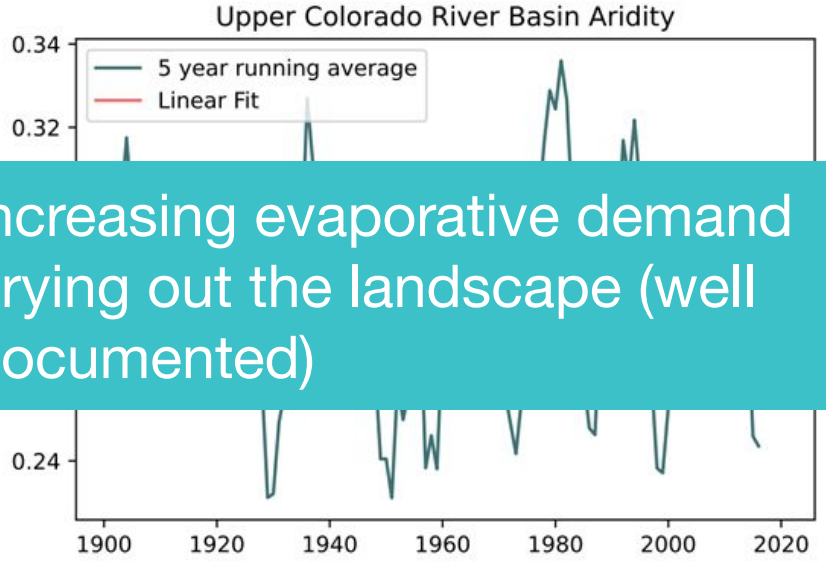
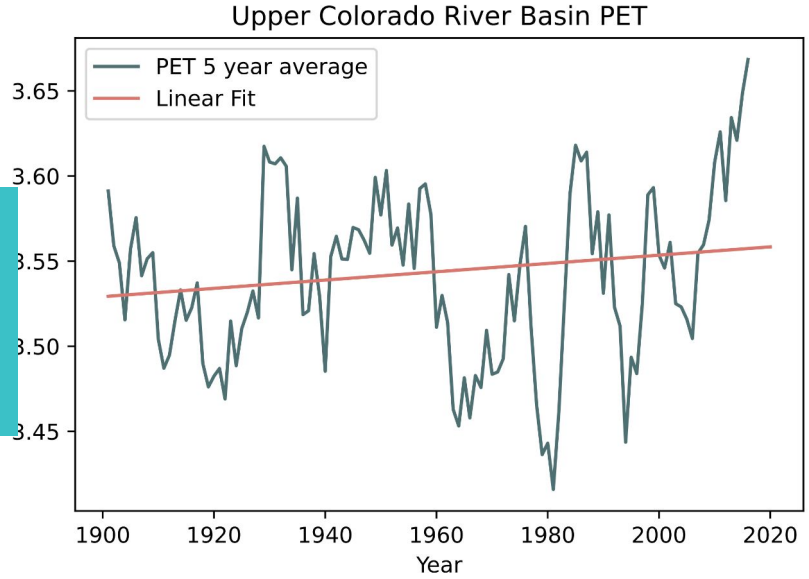
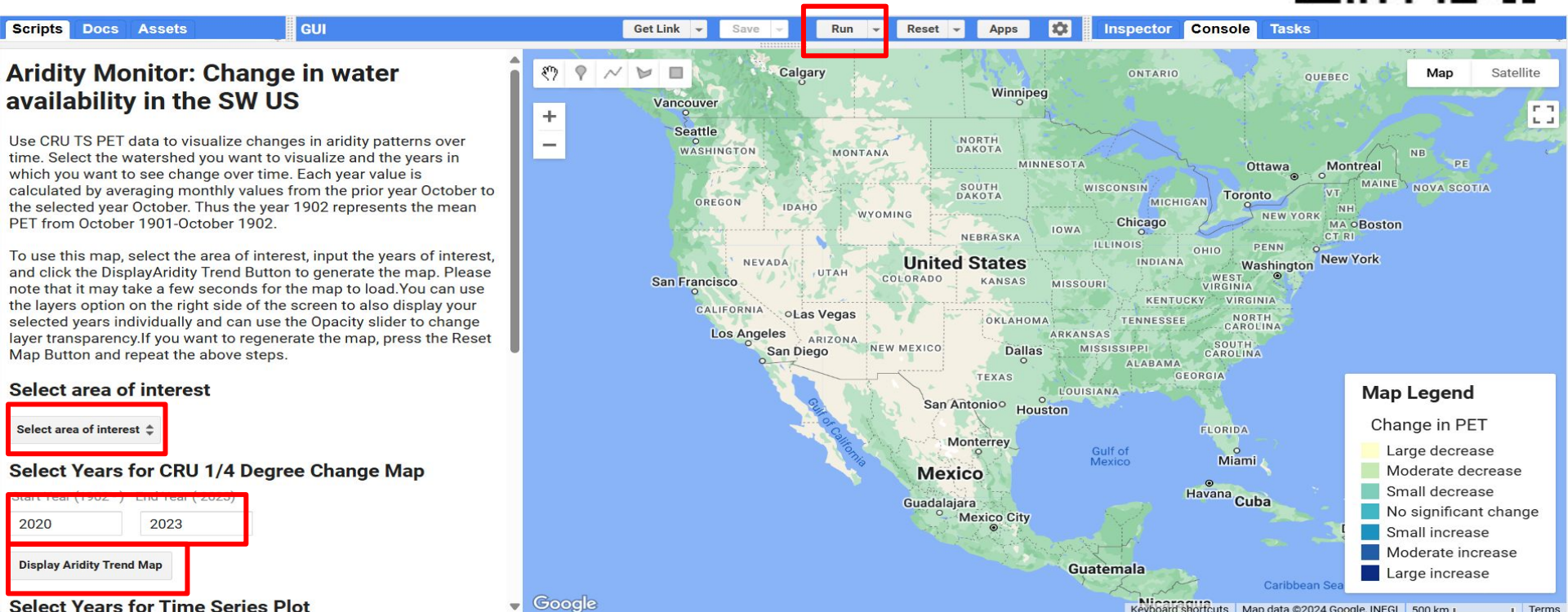


Increasing evaporative demand drying out the landscape (well documented)



Map Creation - Graphical User Interface

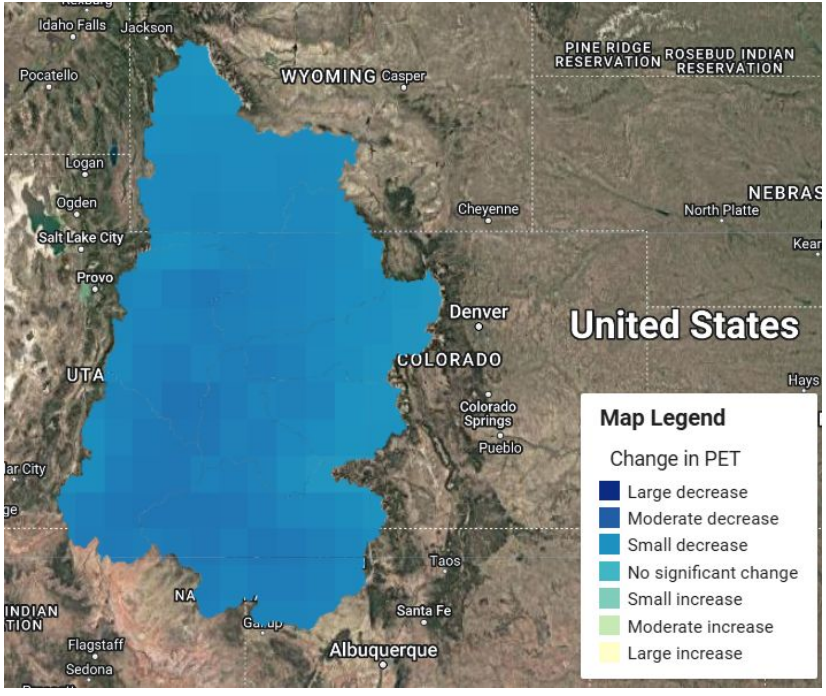
Google Earth Engine



Map Creation - Displaying Potential Evapotranspiration

Focus area = Colorado River Watershed

Focus years = 2020-2023

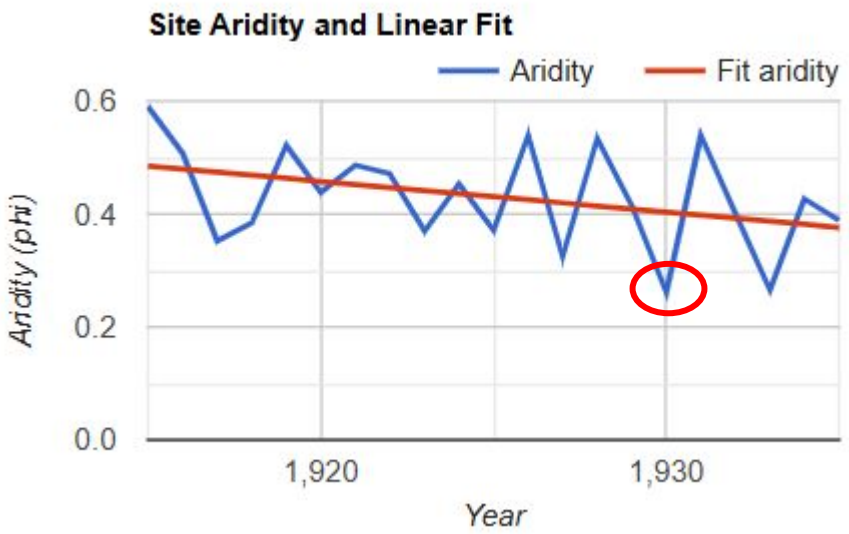


Increase in PET = more droughty

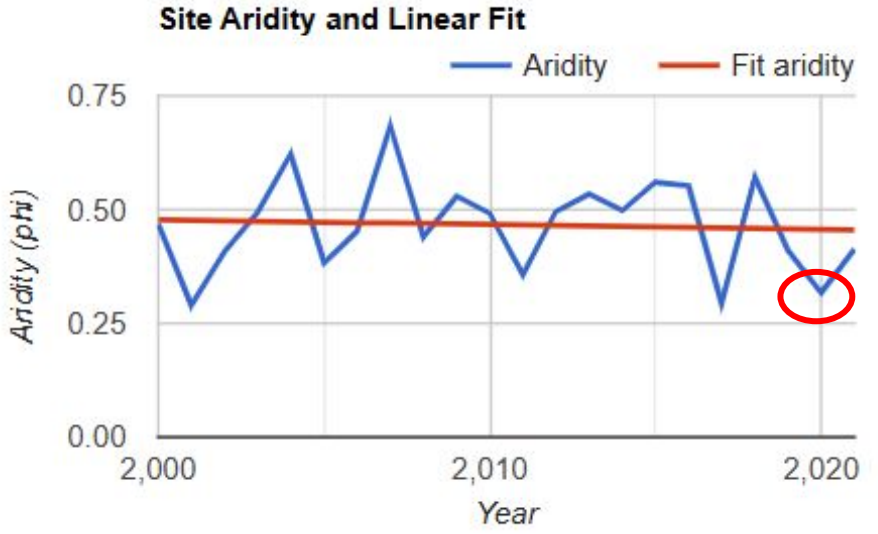
Map Creation - Low points in aridity

Compare low aridity values in WBD 14 (Colorado River Watershed)

1930 - aridity = 0.261



2020 - aridity = 0.317



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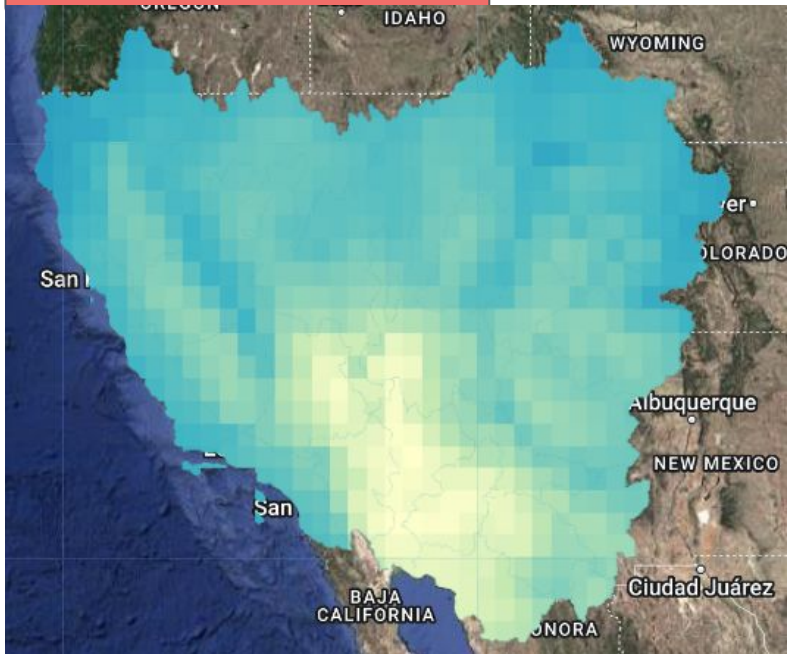
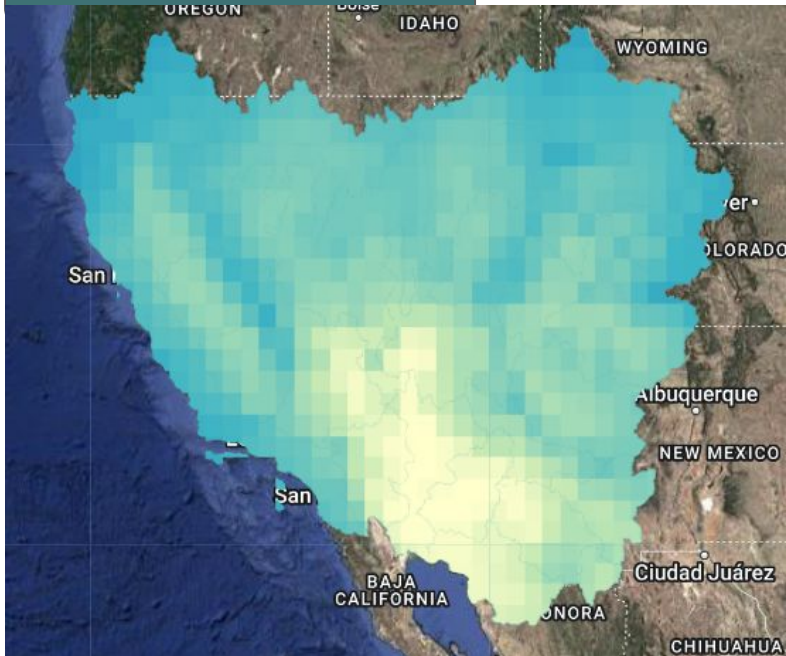


Low PET

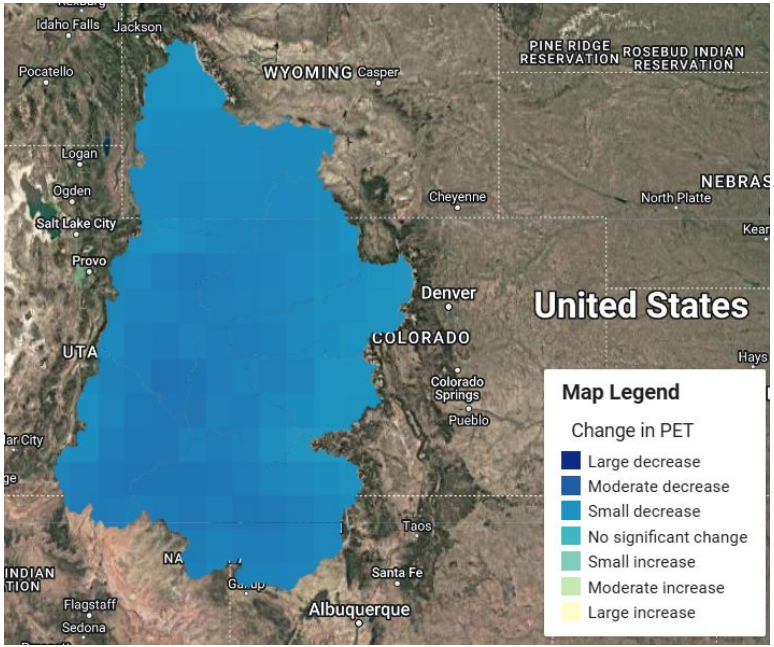
High PET

2020 - aridity = 0.317



So what?

Bringing the two together



+

climate change
historic drought
multiyear drought
increasing aridity
dry
drying climate
longer and more severe drought
water availability
prolonged drought
aridity
severe drought
hyper-arid
warming
extreme drought
aridification
desertification
megadrought

=

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Thank you!

Southwest
Climate Adaptation
Science Center

Remaining questions

How do we incorporate the results of the lit review into the GUI?

What are the improvements we can make to the GUI that will make the tool more relevant and widely utilized?