ECOLOGICAL RESPONSE TO DROUGHT FOR NORTHERN GREAT PLAINS STREAMS

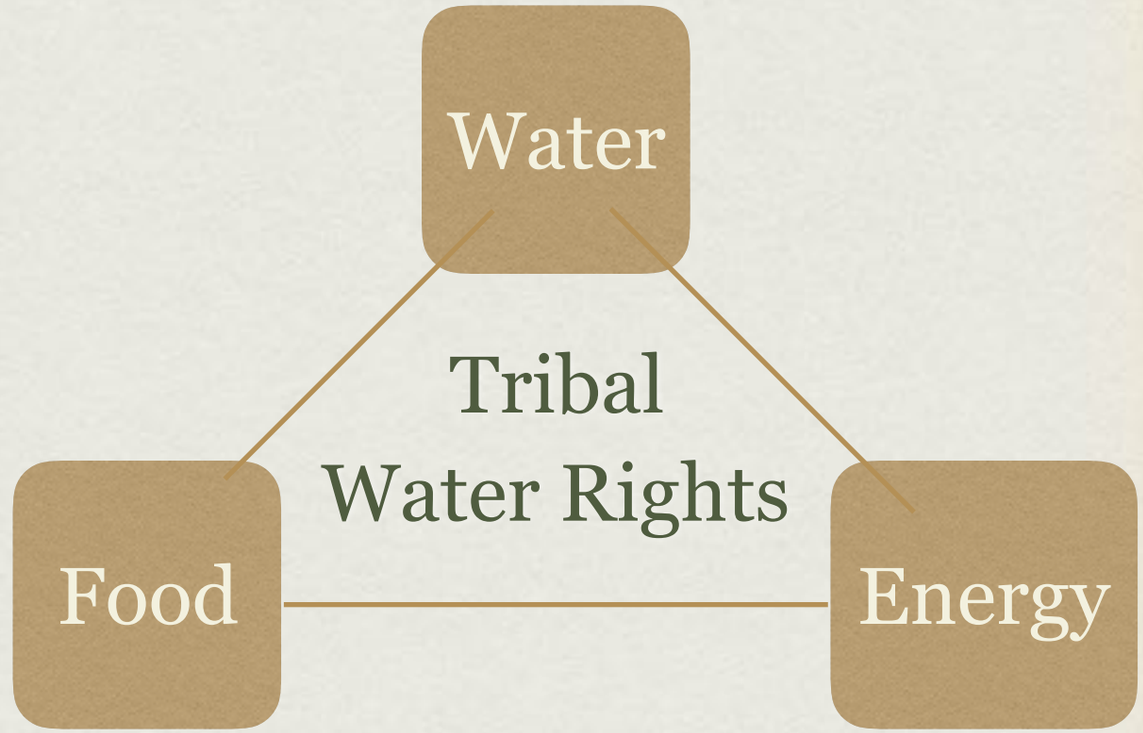
Charles Jason Tinant
Associate Professor Oglala Lakota College
PhD Candidate Civil & Environmental Engineering SDSM&T

GENERAL OBSERVATIONS

The changing climate is among the greatest threats to Indigenous Peoples

Equitable quantification of Tribal Rights to Water is a substantial near-term question for US Tribes

Indigenous peoples' identity & traditional perspectives are implicitly linked to social and ecological sustainability



VISION: TRIBAL SUSTAINABILITY

Sustainability - capacity to endure

- **Ecology** - biological diversity & productivity over time.
- **Society** - potential for long-term maintenance of well-being; depends on maintenance of the natural world

https://ouroborosponderosa.wordpress.com/2011/11/22/mitakuye-oyasin-a-lakota-sioux-prayer/
Ecology Info Center - http://environment-ecology.com

Mitákuye Oyás'iŋ

All Are Relations - Lakota concept of living in harmony with our relatives: other people, animals, birds, fish, plants, hydrosphere & lithosphere

FRESHWATER BIOTIC INTEGRITY IS A SUSTAINABILITY METRIC

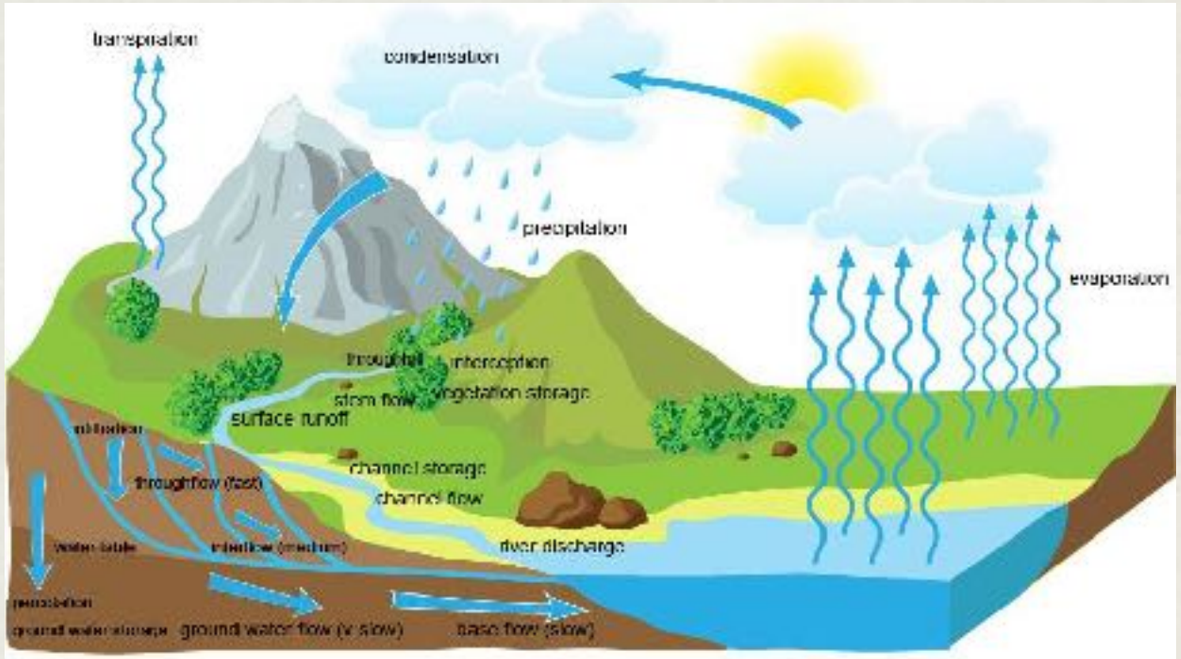
Streams are watershed "thermometers"

All land uses in a watershed are reflected in lakes & streams

- Pollutants,
- Changes in hydroperiod—urbanization, surface water abstractions,
- Unsustainable groundwater use

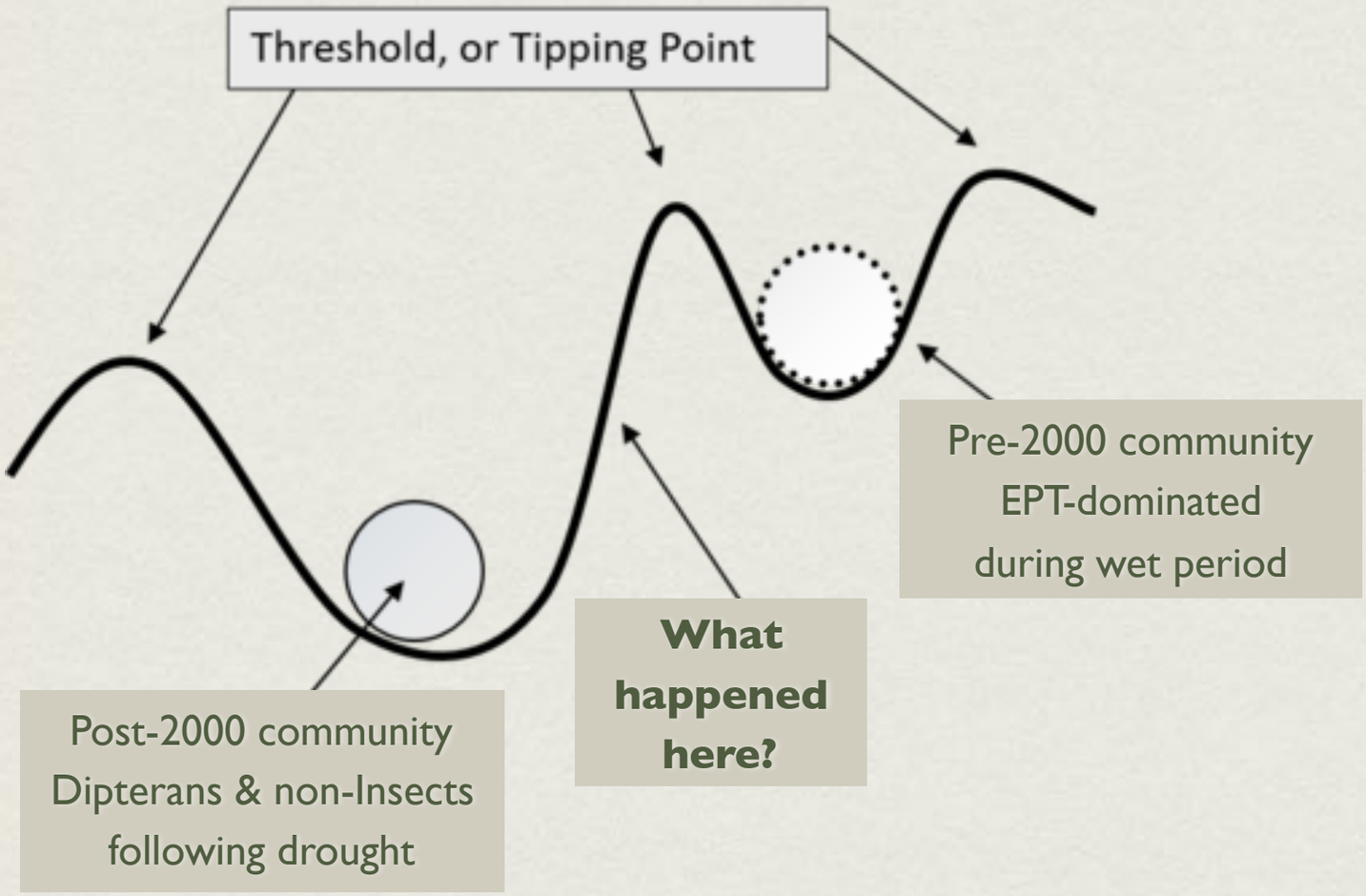
Biotic metrics—measure sustainability practices within the watershed—**but need calibration**

Generalized watershed hydrology



Source: www.alevelgeography.com

INVERTEBRATE STREAM COMMUNITY COMPOSITION BEGAN TO CHANGE AROUND 2000



Past findings: Declines in biotic metrics don't correlate with increases in bacteria or NO3 concentration, or declines in habitat quality

Present questions: Is there another explanatory variable? **Droughts?**

Are there **other biotic metrics** robust to natural disturbance & sensitive to anthropogenic disturbance?

DROUGHTS ARE POORLY UNDERSTOOD NATURAL HAZARDS —IMPACT POTENTIAL INCREASES WITH INADEQUATE PLANNING

Meteorological drought: precipitation deficit—*leads to*—

Hydrological drought: surface & ground water deficit that recovers after precipitation and soil moisture returns to normal conditions—*leads to*—

Socioeconomic drought: water demand exceeds water supply—*leads to* over-allocation, competing beneficial uses ecosystem service undervaluation & non-sustainable groundwater use—*leads to*—

Ecological drought: ecosystem stress, loss of species, declines in biotic integrity

Extreme drought South Africa. 2017-2018

https://www.timeslive.co.za/news/south-africa/2017-11-16-sa-still-plagued-by-drought/

GLOBAL & LOCAL CHALLENGES: MAJOR KNOWLEDGE GAPS

Hydrological knowledge gaps:

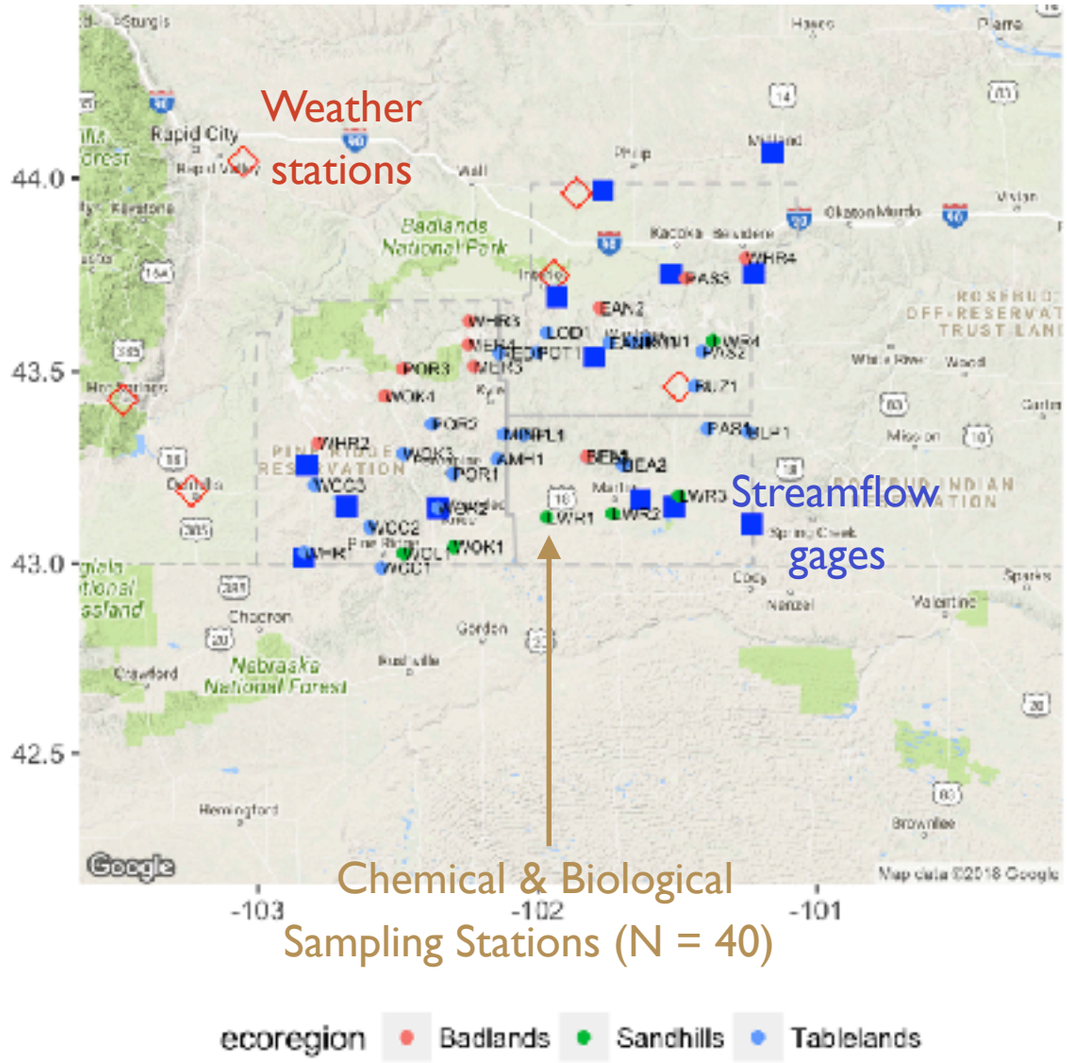
- Most **small watersheds are ungauged** with little or no available information [1]
- Watershed-scale **processes & feedbacks are poorly understood**

Ecological knowledge gaps

- "We understand how freshwater communities persist during normal and high flows better than we understand the ecological effects of droughts" [2]

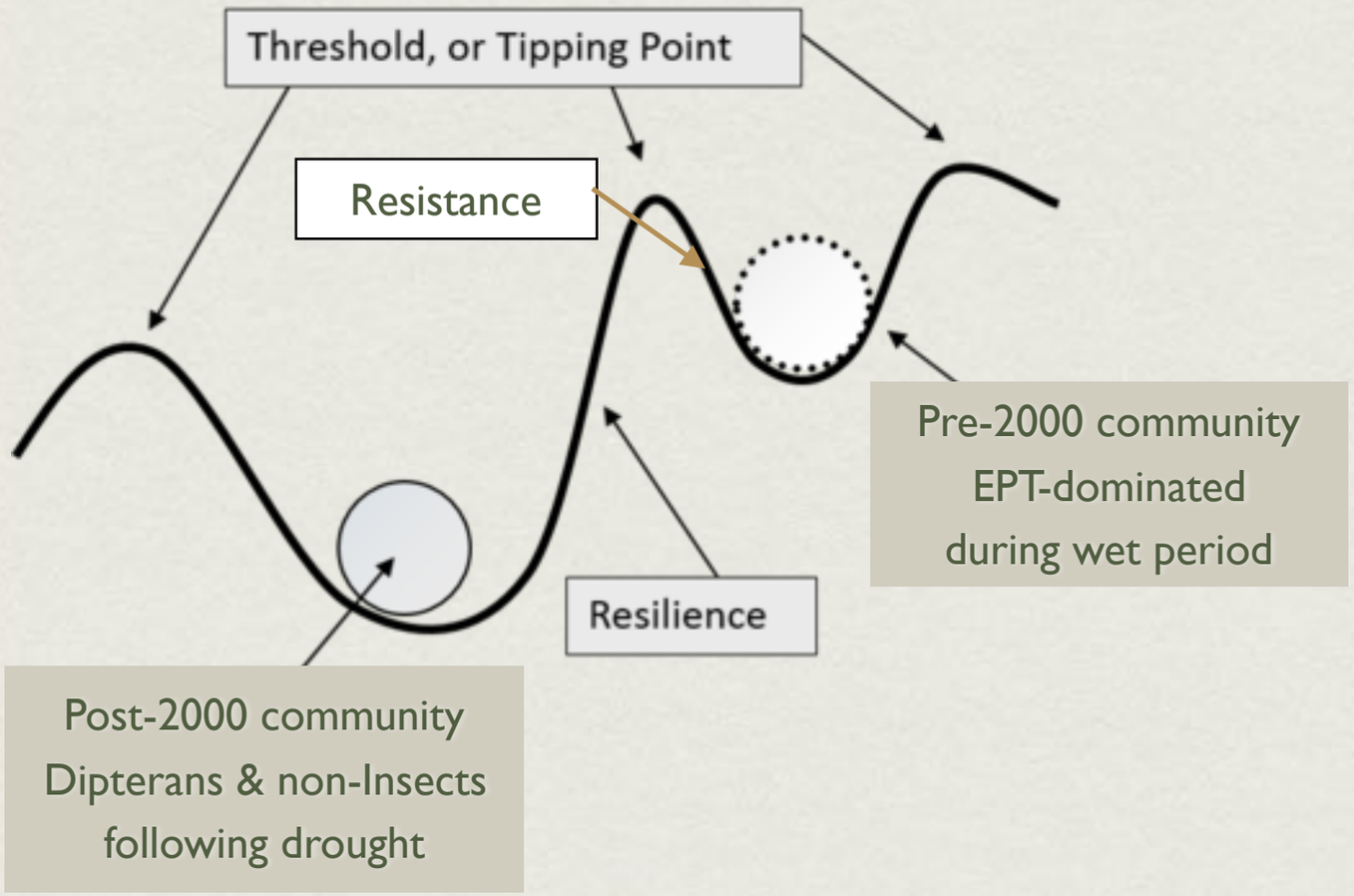
1. A decade of Predictions in Ungauged Basins (PUB)—a review (Hrachowitz et al. 2014)
2. PS Lake - Drought and Aquatic Ecosystems: Effects and Responses

Need to improve information transfer approaches (**downscaling**) from gauged to ungauged watersheds [1]



APPROACH: UNDERSTAND HOW DROUGHT PROPAGATES THROUGH THE REGION

Overall hypothesis: **Drought is a key driver of invertebrate community regime shift**

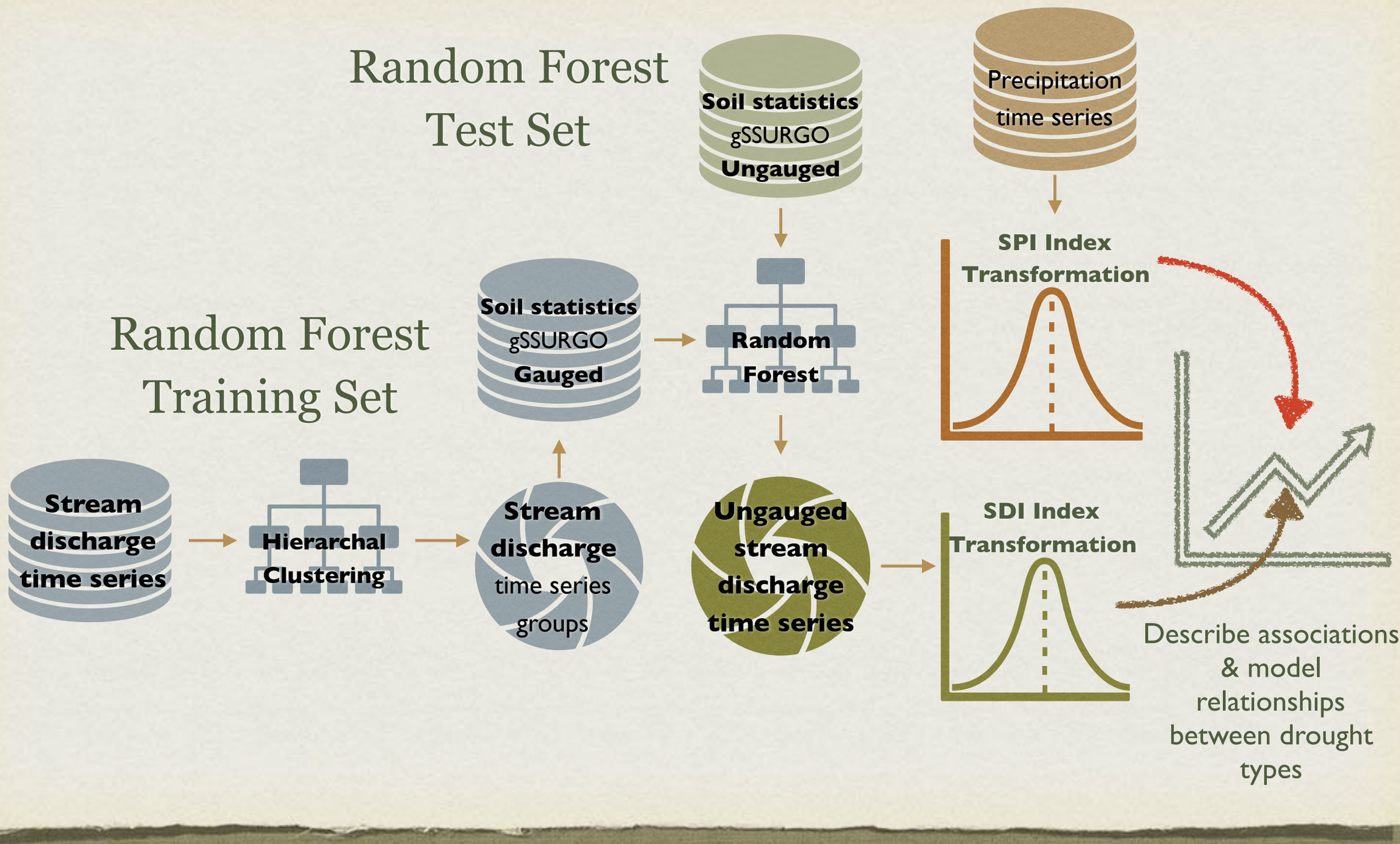


Nested Questions

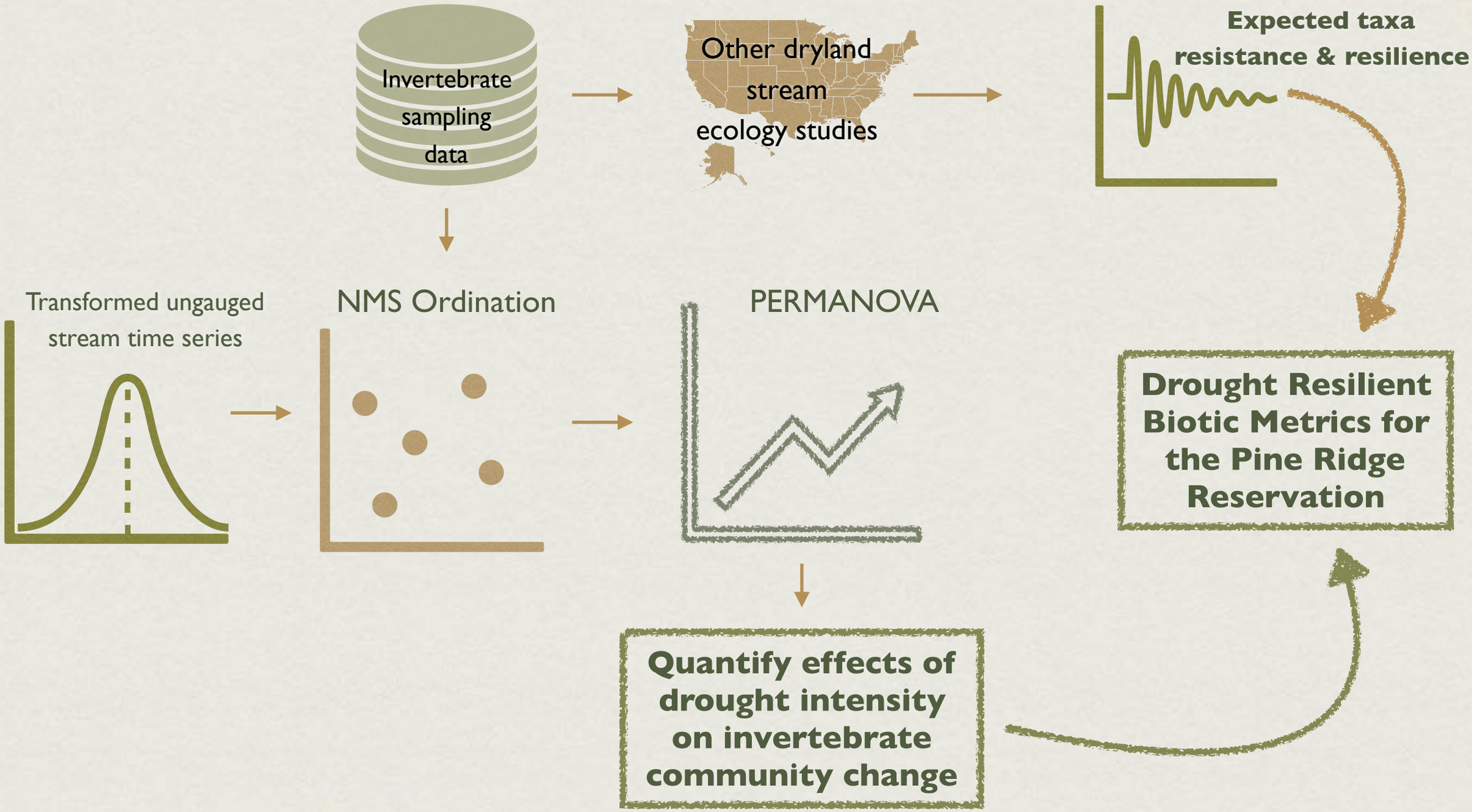
- **Q1—Hydrology:** Does greater porosity buffer hydrologic systems to meteorological drought? Does greater permeability decrease hydrological drought recovery lags? How rare were the 2000s droughts?

- **Q2—Ecology:** How similar is the observed community regime shift on the PRR to other published studies? What is the relationship between hydrologic drought and community change in PRR streams?

Q1—HYDROLOGY: DOES GREATER POROSITY BUFFER HYDROLOGIC SYSTEMS TO METEOROLOGICAL DROUGHT? DOES GREATER PERMEABILITY DECREASE HYDROLOGICAL DROUGHT RECOVERY LAGS? HOW RARE WERE THE 2000S DROUGHTS?



Q2—ECOLOGY: HOW SIMILAR IS THE OBSERVED COMMUNITY REGIME SHIFT TO OTHER PUBLISHED STUDIES? WHAT IS THE RELATIONSHIP BETWEEN HYDROLOGIC DROUGHT AND COMMUNITY CHANGE IN PRR STREAMS?



EXPECTED RESULTS

Hydrology

- Effective porosity is analogous to to carbonate alkalinity for drought propagation from atmosphere to hydrosphere
- Hydrologic systems in unconsolidated sediments should respond rapidly to a return to wet conditions—particularly high intensity convective storms
- The 2000s drought are likely to be 5% to 1% events, particularly at longer averaging periods.

Ecology

- Overall ecosystem resilience to drought is positively correlated with watershed storage
- Our work should quantify recent droughts in other regions—helping to resolve the question of the threshold of seasonal vs. supra seasonal droughts
- Expected regime shift to smaller-bodied & r-selected taxa. More gastropods following a supra seasonal drought

“Climb Mount Fuji

O snail.

But, slowly, slowly.”

Kobayashi Issa

All analysis in R & available on GitHub https://github.com/cjtinant

Follow me on twitter for data science, stream ecology, Tribal water rights @C_J_Tinant