SOUTHERN ROCKIES
Landscape Conservation Cooperative

CLIMATE CHANGE & RIPARIAN FOREST COMMUNITIES
Implications for Small Streams in the Upper Colorado River Basin

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Climate change in the western US

- Increasing CO_2
- Increasing temperatures
- Equivocal change in precipitation
- Increasing evaporative demand → increasing aridity and drought
- Less snow, earlier snow melt timing
- Longer, drier summers

Barnett et al., 2005; Seager et al. 2013; IPCC 2013

Climate change and riparian systems

- Changes in temp, precip and CO_2 will have direct and indirect effects on riparian systems

- **Direct:**
  - Growth, survival and reproduction, water status, phenology
  - Species distributions
  - Community composition
  - Trophic interactions

Perry et al. 2012. Global Change Biology

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- **Indirect via streamflow:**
  - Timing of high and low flows
  - Magnitude of high and low flows
  - Inundation
  - Water temperature
  - Geomorphic change

Perry et al. 2012. Global Change Biology

Climate change and riparian restoration

- Restoration can ameliorate climate change through:
  - Restoring environmental flows
  - Restoring geomorphic complexity and floodplain connectivity
  - Restoring habitat diversity
  - Increased resiliency in the face of climatic changes

Capon et al. 2013; Catford et al., 2013; Seavy et al., 2009

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- Restoration planning should consider:
  - Climate projections and scenarios
  - Streamflow projections and scenarios
  - How target species and target communities may shift under climate change
  - Uncertainty and alternatives

Capon et al. 2013; Catford et al., 2013; Seavy et al., 2009

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Climate change and riparian restoration

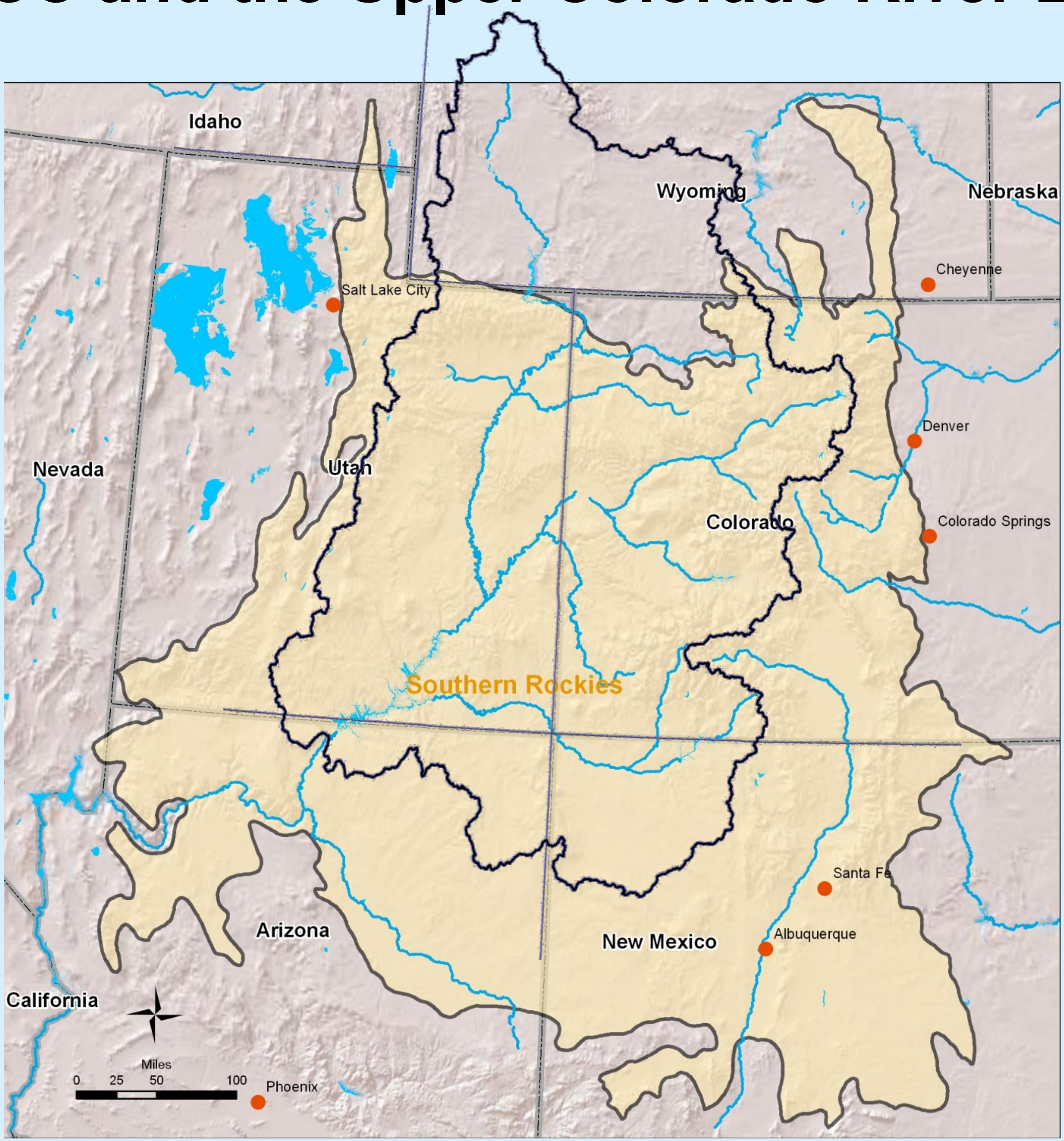
How will target species and communities shift under CC?

→Targeted restoration

Tools:

- Identify genotypes better adapted for future conditions
- Model riparian communities to identify functional groups that will perform better under future conditions
- Regional species lists that include relative tolerances and adaptations to different environmental conditions
- Local analog ecosystems for examples of appropriate plant communities under future conditions
  - Ex: Getting drier in the future? Look for drier communities nearby

SRLCC and the Upper Colorado River Basin



Background: climate and hydrology

In the Upper Colorado River Basin (UCRB):

- Observed and projected warming temperatures
  (Stewart *et al.* 2005, Milly *et al.* 2005; Mote *et al.* 2005; Christensen & Lettenmaier 2007; Cayan *et al.* 2008)

- More frequent, longer, and more severe droughts
  (Andreadis & Lettenmaier 2006; Groisman & Knight 2008).

- Streamflows in late spring and summer have declined (Burn and Hag Elnur 2002, Rood et al. 2008, Leppi et al. 2011)

- Mean annual streamflow is projected to decrease by six to 25 percent over the next 100 years in the southwestern US (Christensen and Lettenmaier 2007, Barnett and Pierce 2009, Seager et al. 2013).


Working hypotheses:

> *In arid and semiarid regions of the western US where intermittent streams are common, **minimum flows will decrease and some perennial streams will shift to intermittent streamflow regimes** under climate-driven changes in precipitation, runoff, and increases in evaporation.*

> *Changes in minimum flow volume and duration will affect stream-dependent communities such as **riparian plants**, stream invertebrates and fish.*

Perennial (Dolores River, CO)

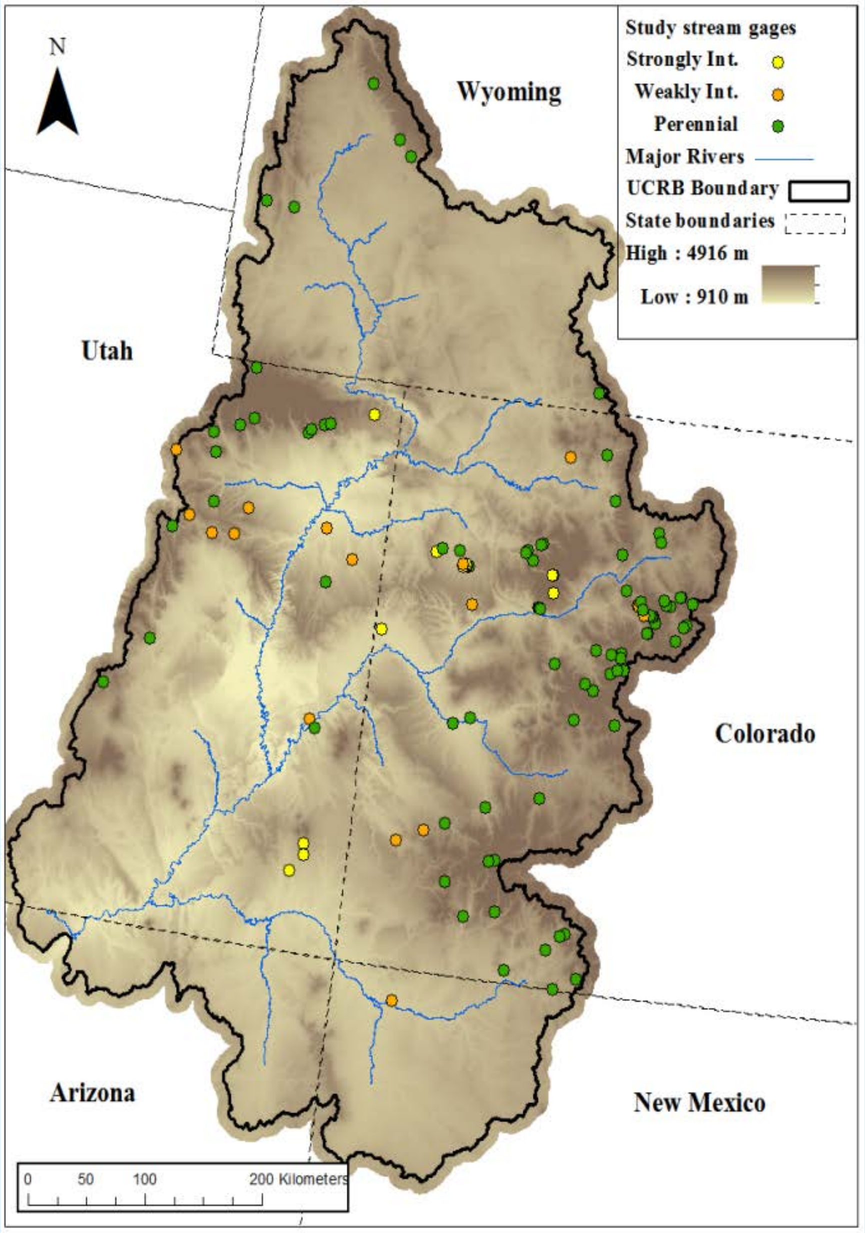
Intermittent (Montezuma Wash, UT)

Questions

I. What is the potential for streams in the Upper Colorado River basin to shift from perennial to intermittent under a warmer climate?

II. How will riparian plants in this region respond to changes in low flow?

I. Stream gage analysis of historical flow data



Study gage locations

I. Stream gage analysis of historical flow data

Methods

1. Model relationship between flow metrics and environmental variables (Falcone, 2011) using conditional inference (CI) trees and random forests (RF).

2. Use the RF model results from (1) to project stream flow metrics to ungaged reaches across the study area.

3. Model perenniality

4. Use the results from (2 and 3) to illustrate potential thresholds of stream intermittency under a drier future climate

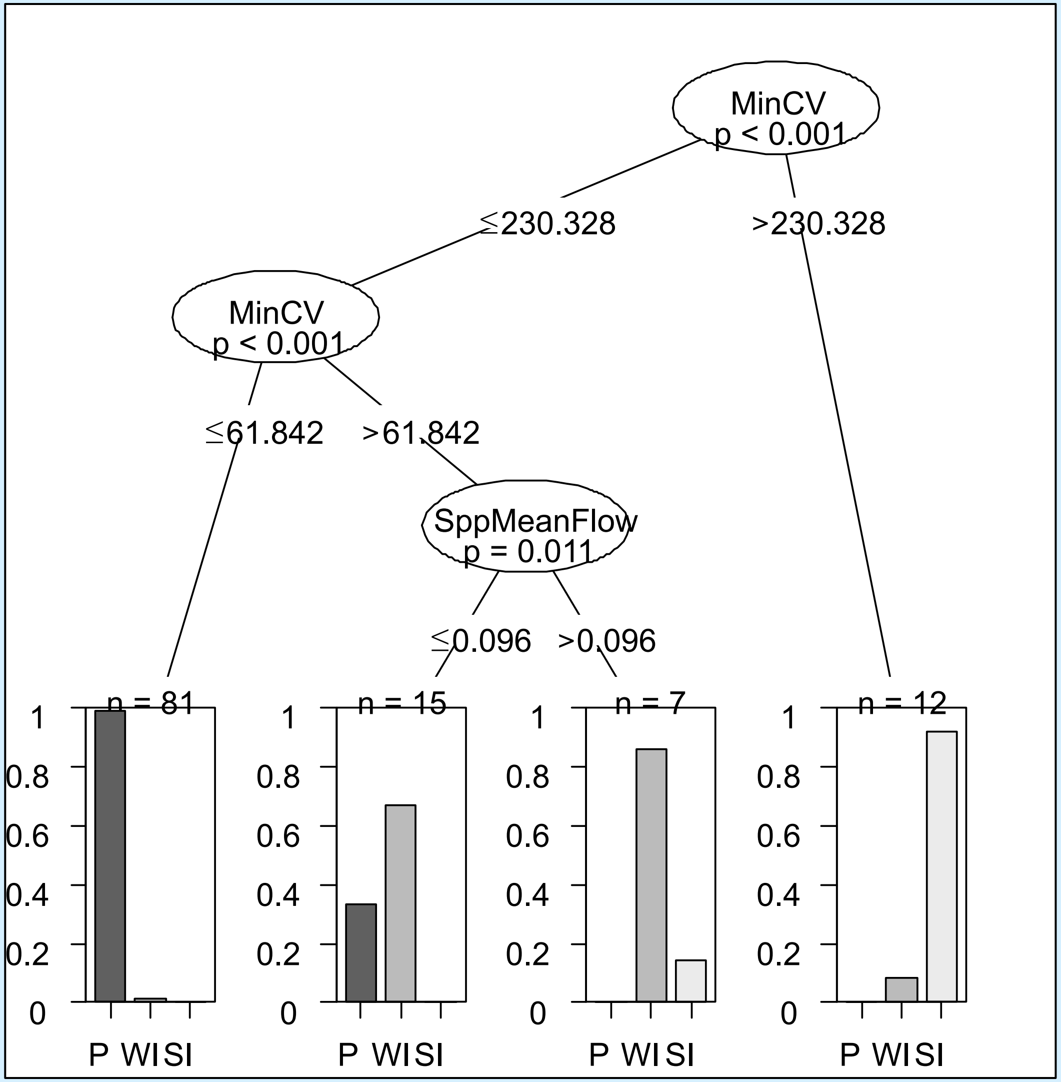
I. Stream gage analysis of historical flow data

Findings

- Landscape variables associated with aridity (precip, PET and percent snow) were most important for predicting mean and minimum flow metrics
- Under drying conditions, perennial streams with **high minimum flow CV (high variability)** and **lower mean flow per unit area** will be at risk of intermittency

I. Stream gage analysis of historical flow data

CI tree model predicting perenniality (perennial (P), strongly intermittent (SI) or weakly intermittent (WI)) using stream flow predictor variables

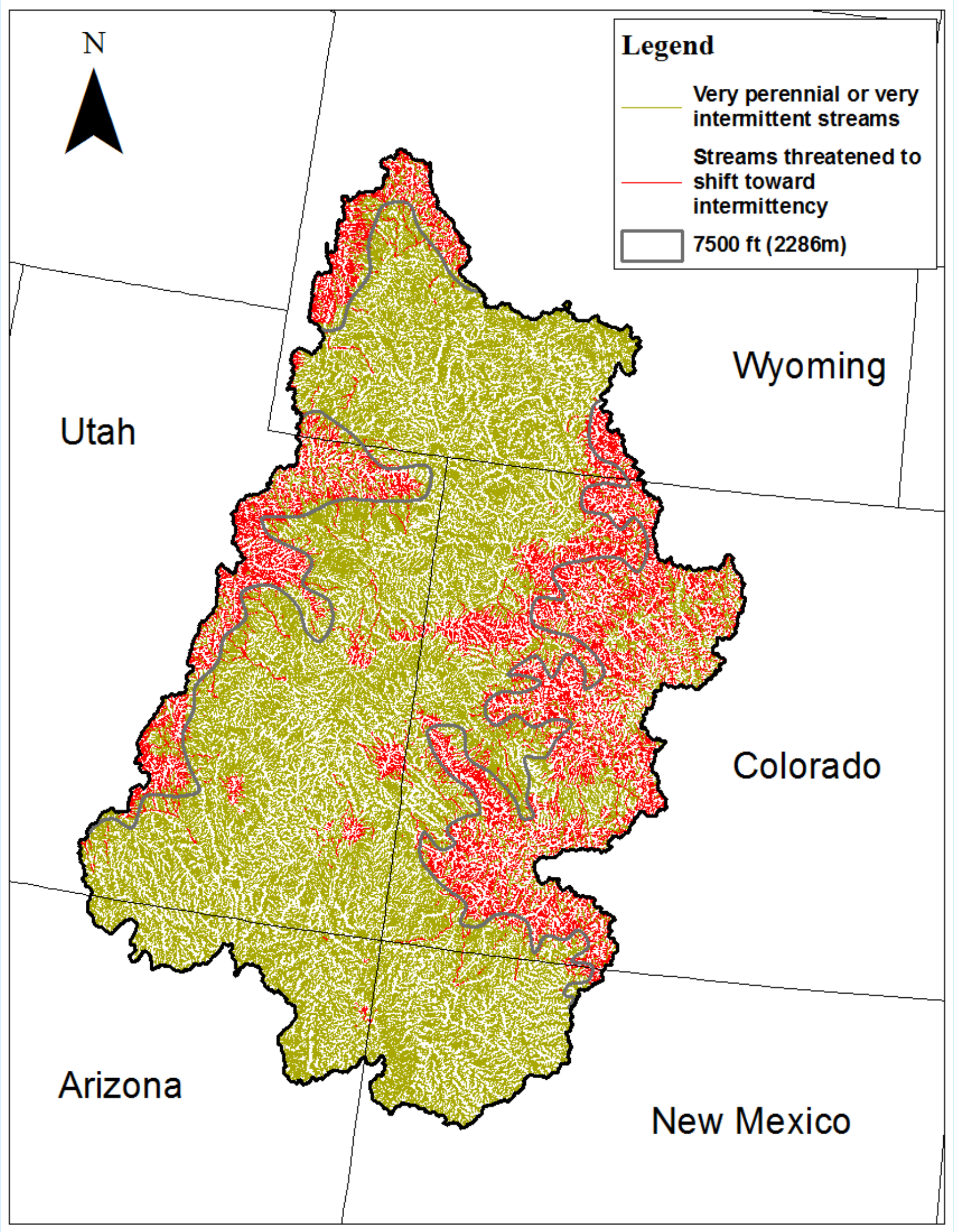


I. Stream gage analysis of historical flow data

Perenniality model

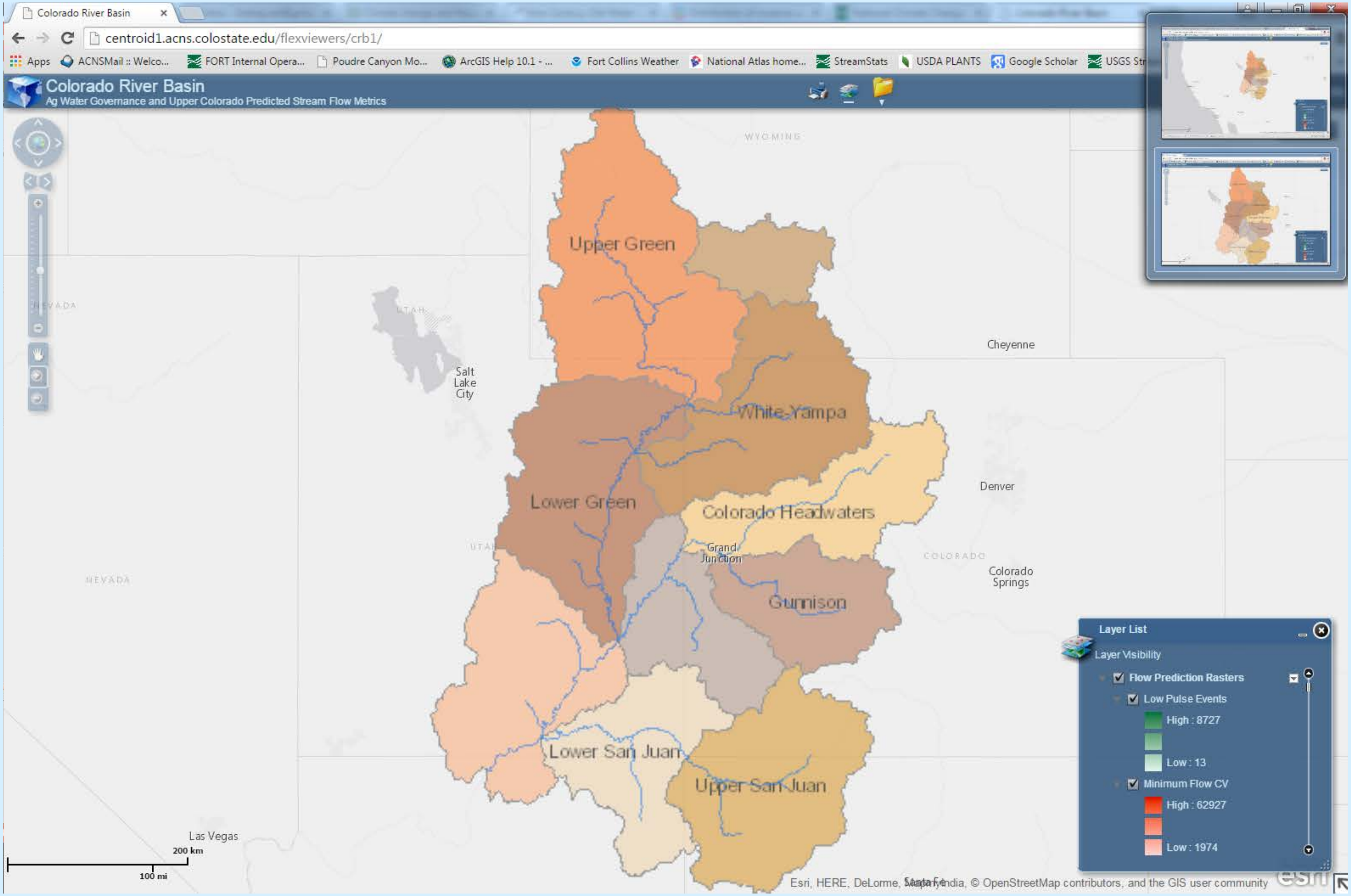
Red Streams: >61.84% min flow CV and <0.096 specific mean daily flow = threatened to shift toward intermittency under drier climate conditions.

Green streams: fall outside this threshold, are generally strongly intermittent or strongly perennial streams.



Colorado River Basin data portal via CSU's Geospatial Centriod

http://centroid1.acns.colostate.edu/flexviewers/crb1/



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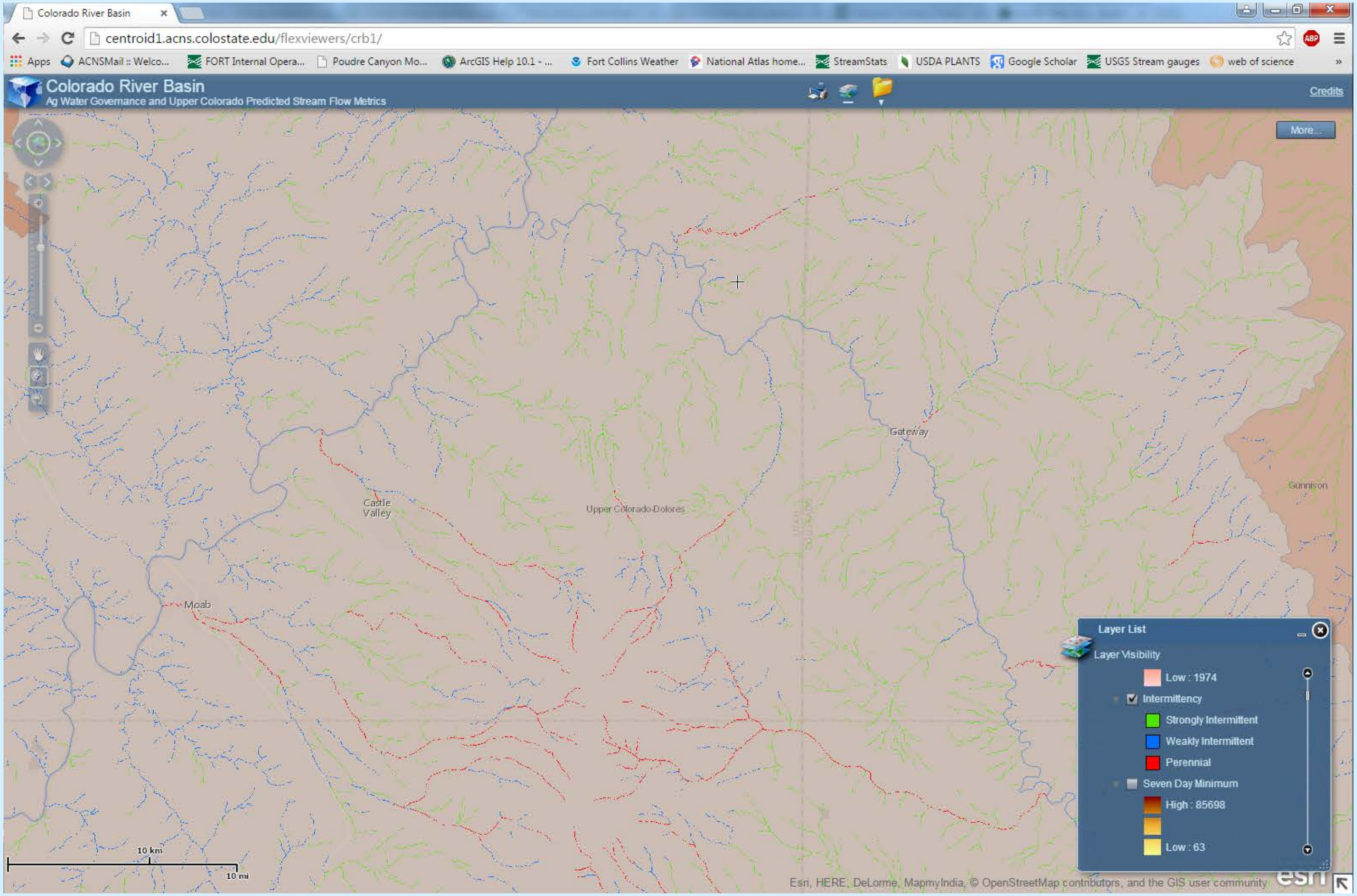
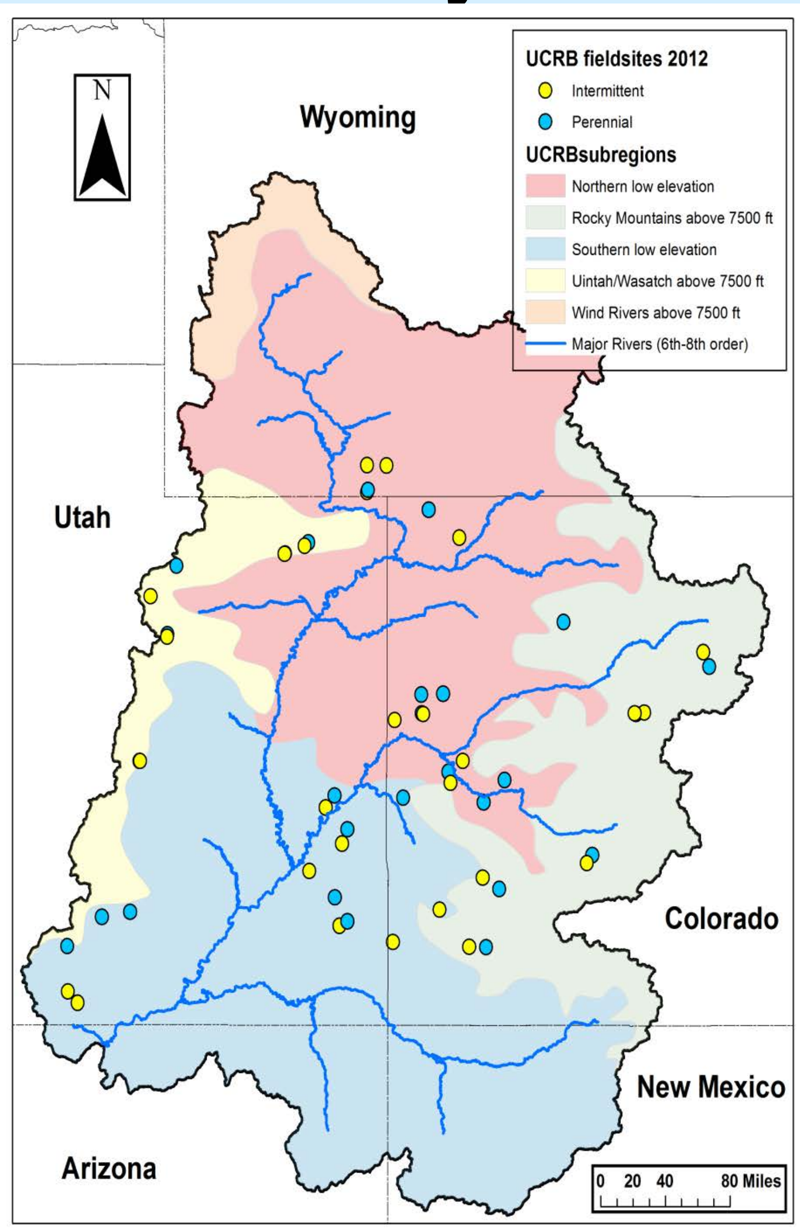


I. Stream gage analysis of historical flow data

Reynolds, L.V., P.B. Shafroth, and N.L. Poff. Modeled intermittency risk for small streams in a North American river basin under climate change. 2015. *Journal of Hydrology* 523: pp 768-780.

II. Plant communities from wet → dry streams



Study sites:

- Stream reaches along a gradient from perennial to intermittent

- Stratified by hydro-elevation group:
  - Intermittent low
  - Perennial low
  - Intermittent high
  - Perennial high

Dry

↓

Wet

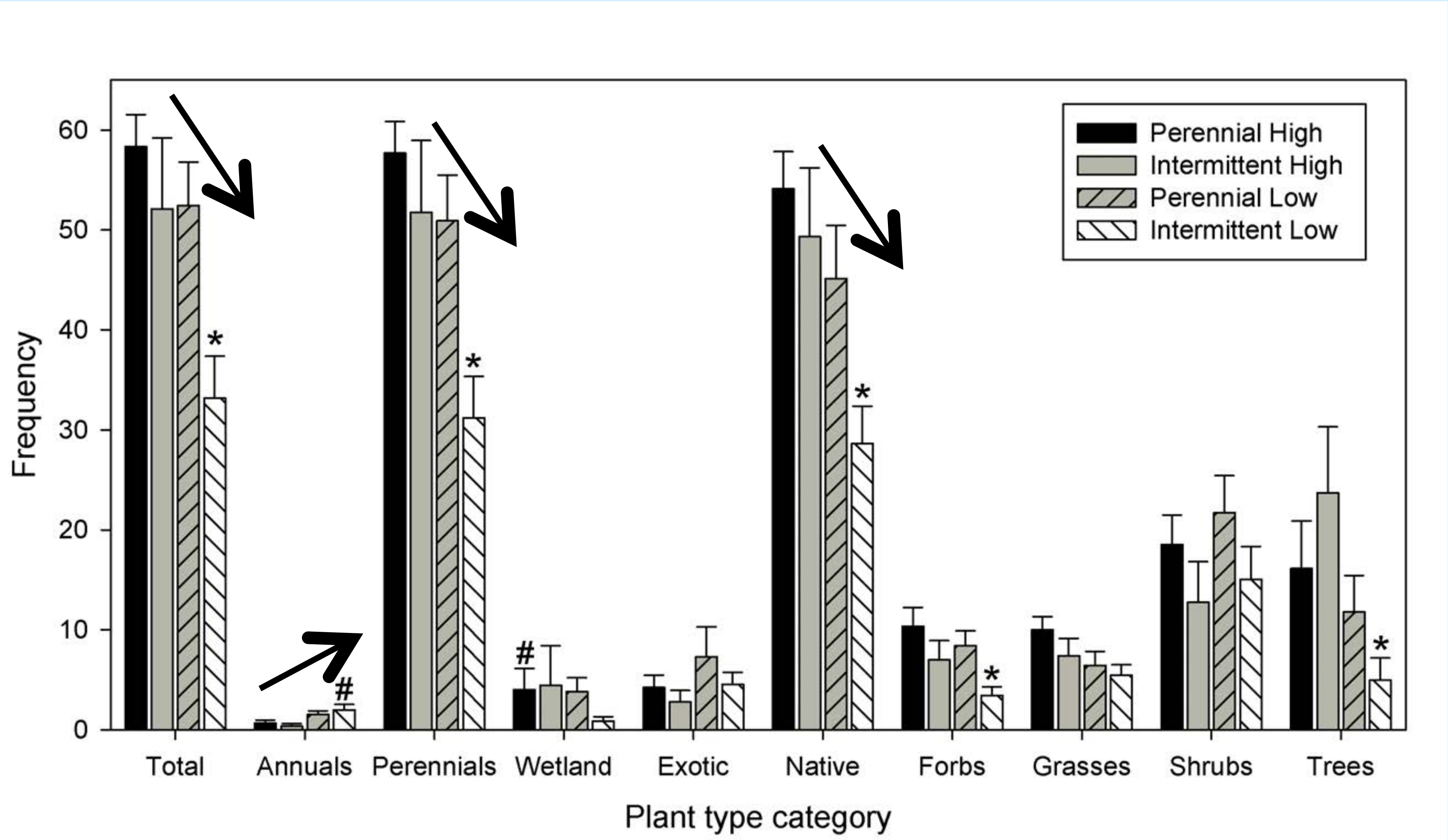
II. Plant communities from wet → dry streams

Methods:

- Riparian plant communities
  - Point-intercept sampling along transects
- Floodplain geomorphology.
  - Topographic survey of bottomland cross-section

II. Plant communities from wet → dry streams

Univariate analyses results: Plant type categories



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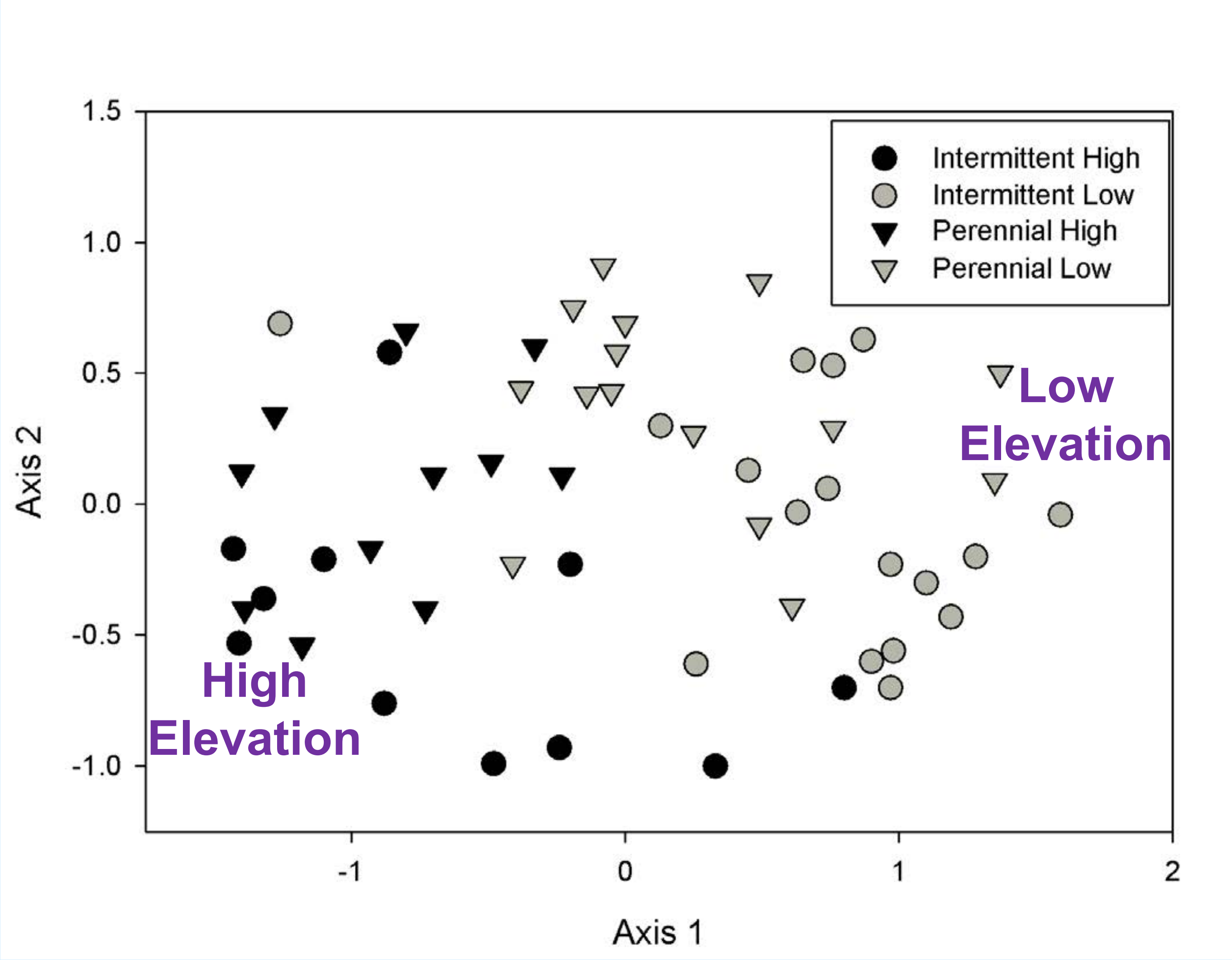
Multivariate NMDS results: plant community composition



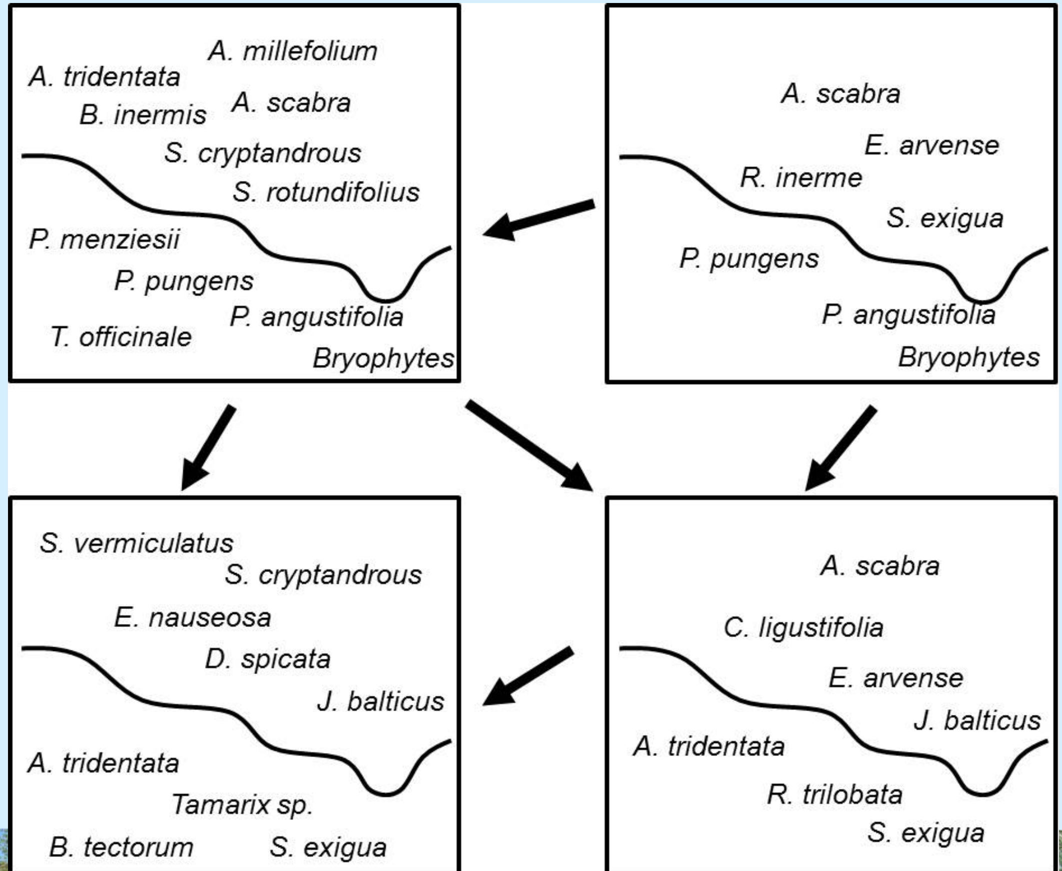
II. Plant communities from wet → dry streams

High elevation

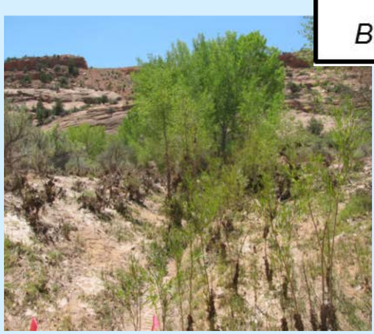
Wet

Dry

Low elevation



Characteristic species for hydro-elevation groups



Intermittent streamflow

Perennial streamflow

Dry ← Wet

Summary: plant communities from wet → dry streams

- Under drying conditions, our data suggest that:
  - •Total abundance and cover will ↓
  - •Annual plants will ↑ and perennials will ↓
  - •Native plants will ↓

- Differences between communities among elevation groups were more distinct than differences between perennial and intermittent streams

↘

- Direct effects of climate that dominate across elevation gradients will determine the most dramatic changes in plant community composition while changes in stream hydrology may drive more subtle changes.

- Implications for restoration

Future directions

- Put our models to work with future climate projections to forecast future stream flow metrics
- With stream flow projections, identify thresholds for *future streams*
- Sample more sites throughout the basin, broaden the scope of the vegetation work
- Re-sample sites in additional years, potential for wet-dry year variations.
- Other ideas?? What would be most useful for land managers, practitioners, policy makers, folks on the ground?

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