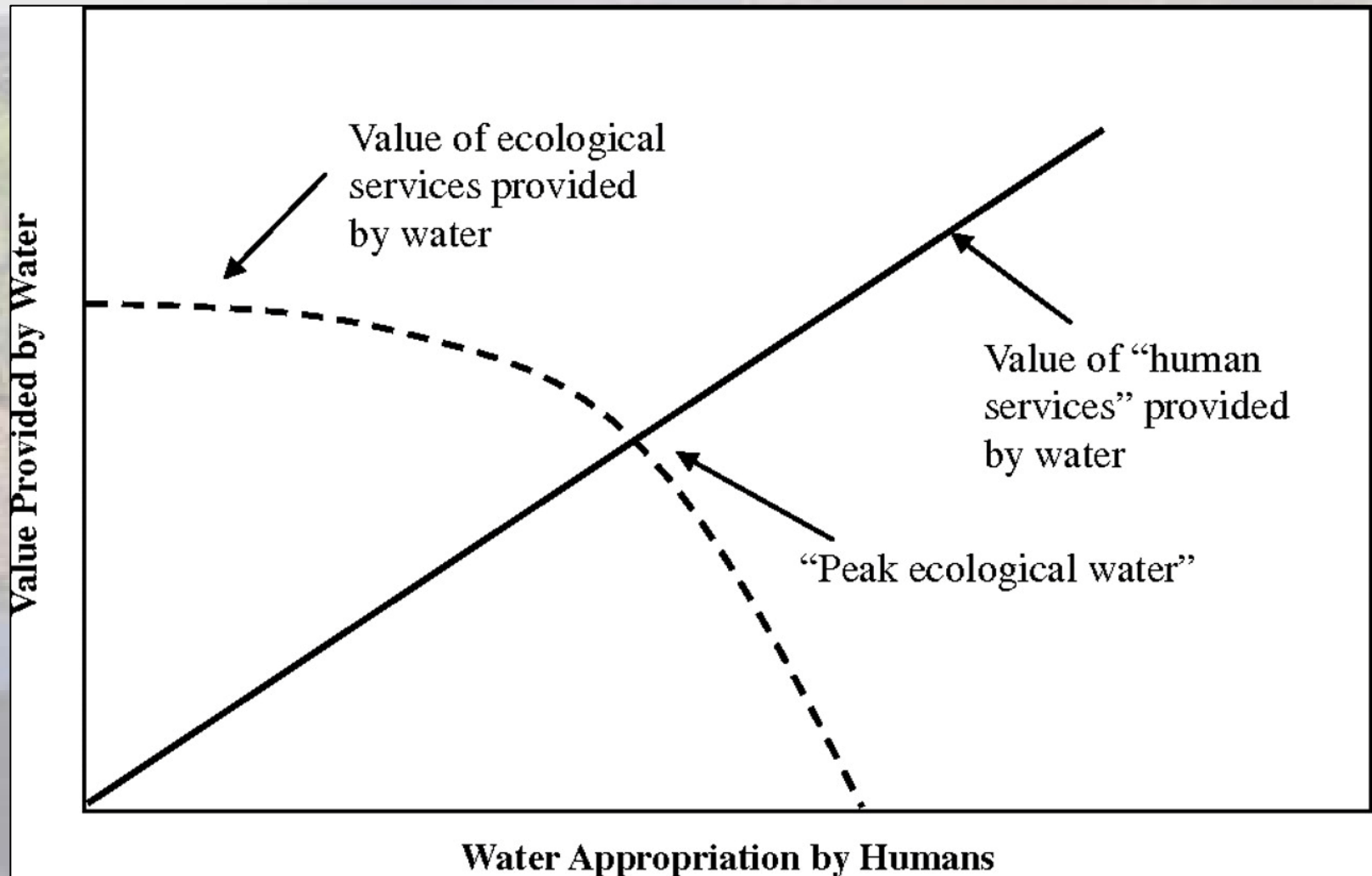


Collaborative Research: WSC-Category 3 - Climate and Population Change and Thresholds of Peak Ecological Water: Integrated Synthesis for Dryland Rivers DEB-1038938

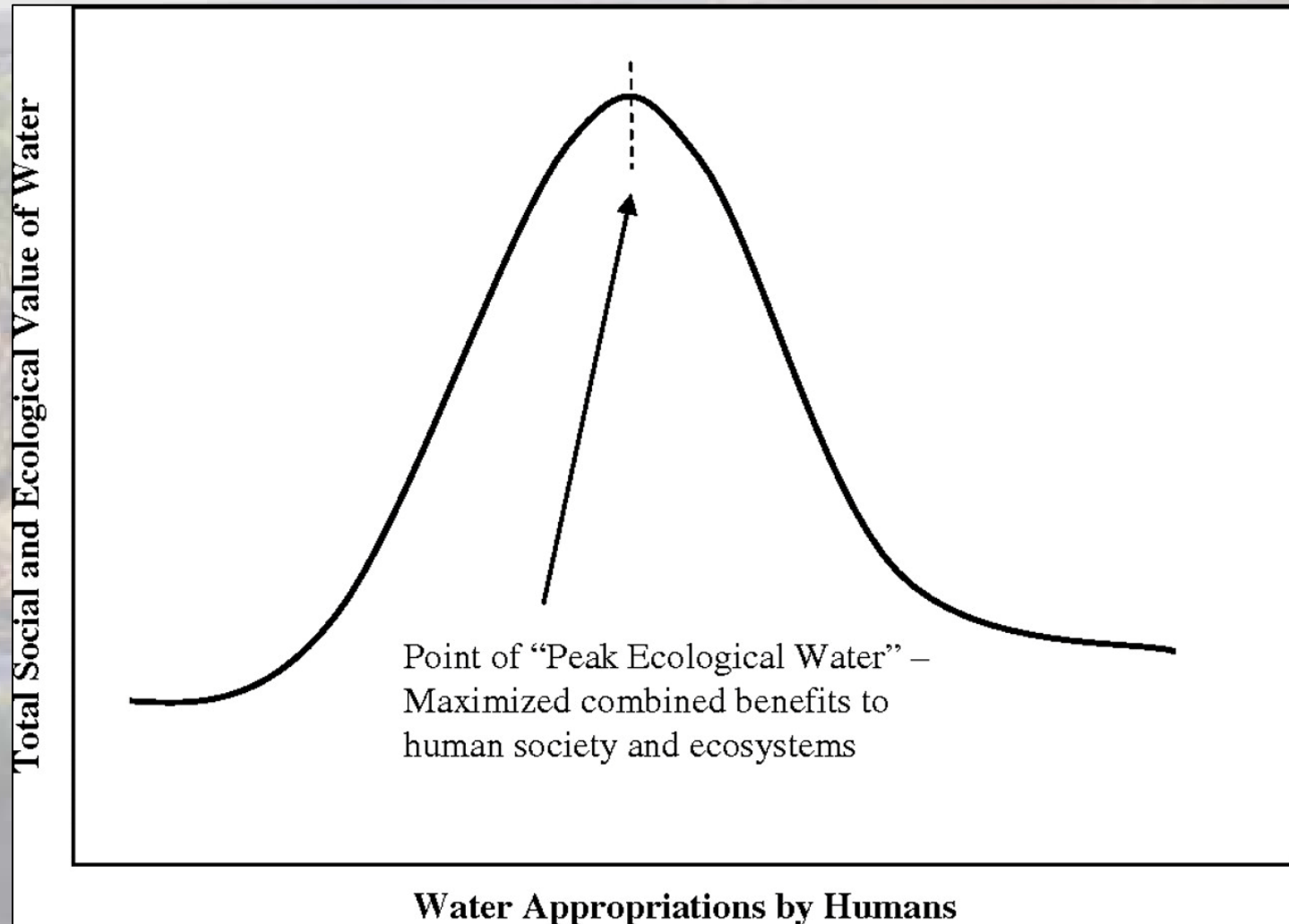
- Francina Dominguez, UA
- David Plane, UA
- Enrique Vivoni ASU
- Jennifer Duan, UA
- Thomas Meixner, UA
- Julie Stromberg, ASU
- David Brookshire, UNM
- Don Coursey – U-Chicago
- Craig Broadbent – IWU

This graph charts the value of water provided by increasing supply from various sources in a watershed against the loss in value of ecological services provided by that water.



Gleick P H , Palaniappan M PNAS 2010;107:11155-11162

This graph charts the overall value of water, a combination of social, economic, and ecological value, as water appropriation by humans increases.

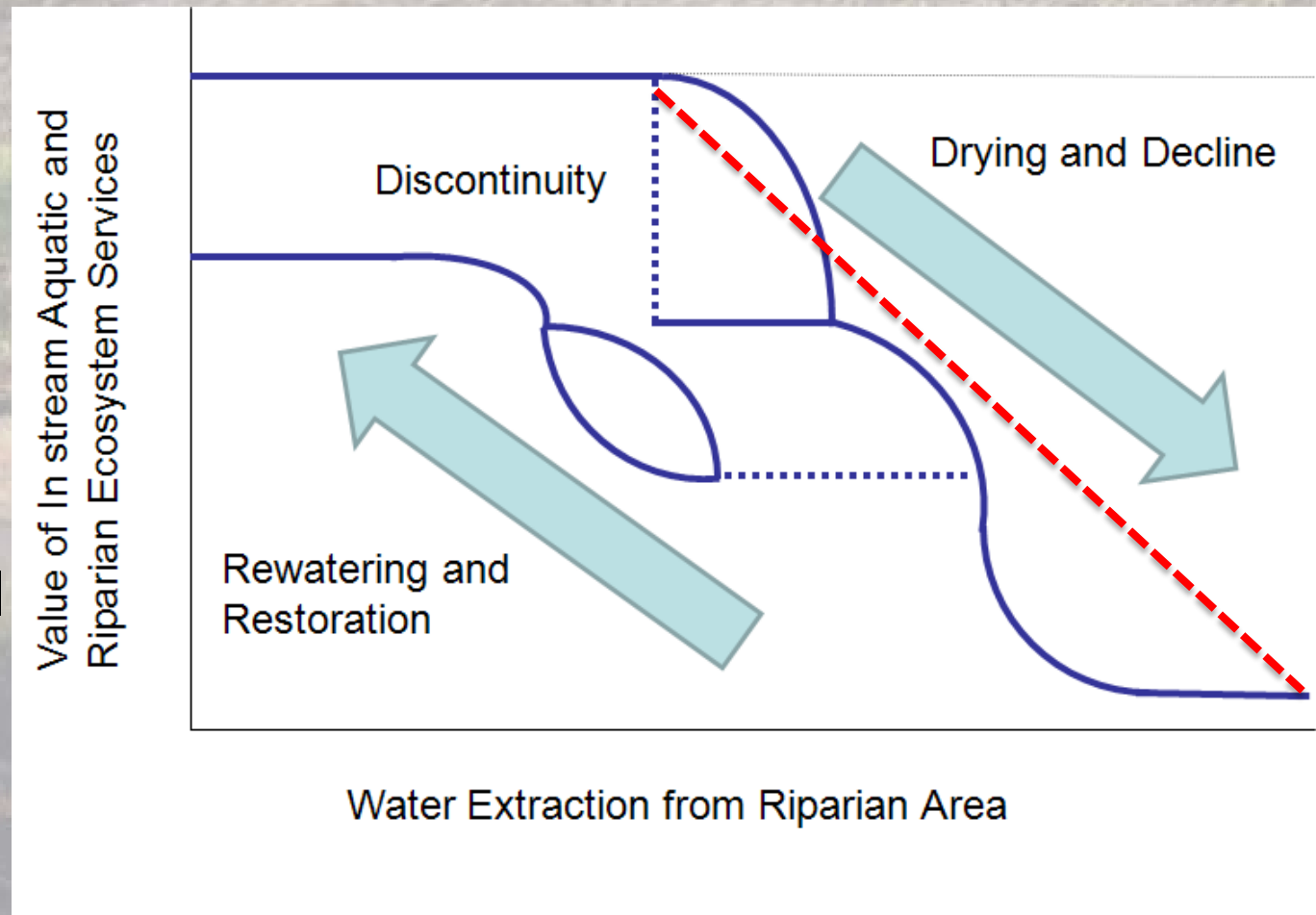


Gleick P H , Palaniappan M PNAS 2010;107:11155-11162

The Premise

- The Value of Ecosystem Services Declines in a Non-Linear Fashion
- Do Behavioral Values Decline in the Same Fashion?

Figure 1: From the Proposal



Hypotheses

- 1) The value of ecosystem services declines (increases) in non-linear and stepwise fashion as water is extracted (restored) from (to) dryland rivers
- 2) Hysteretic effects characterize stream re-watering: the *trajectories* of changes in ecosystem value are reversible, but the absolute *magnitude* of ecosystem service recovery varies depending on the degree of historic dewatering.
- 3) Climate change and population growth act together in a synergistic way to decrease the water withdrawal levels at which ecosystem services cross thresholds.

Downscaled Climate

Population Change

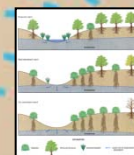
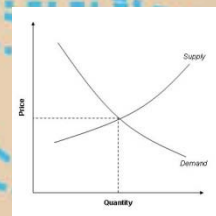
Land Surface
Rainfall/Runoff Modeling

Value of Ecosystems Services

Scour Modeling

Biotic Modeling

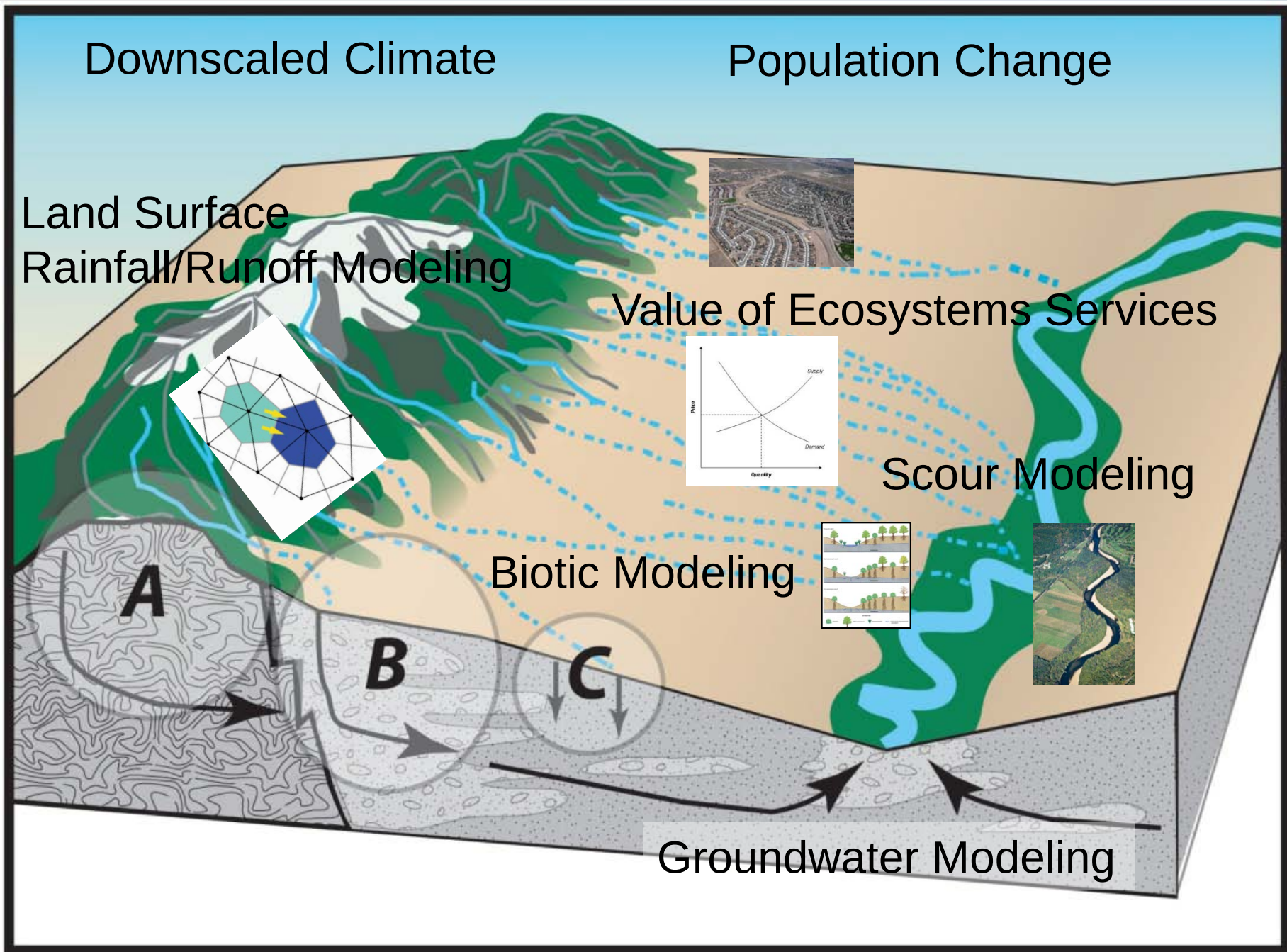
Groundwater Modeling



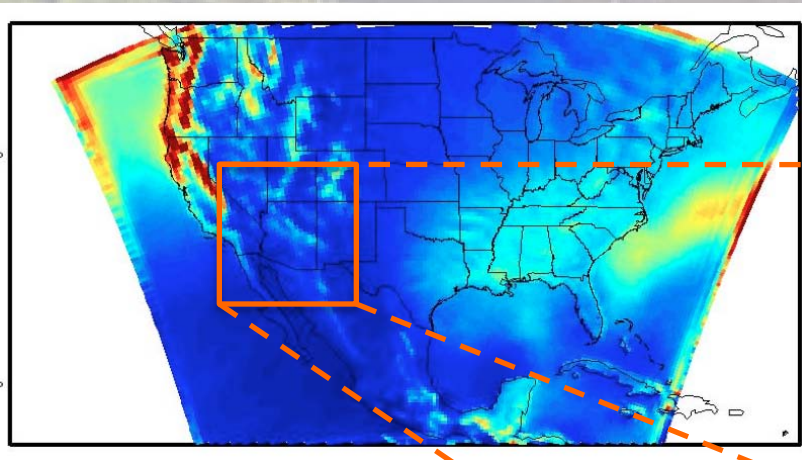
A

B

C



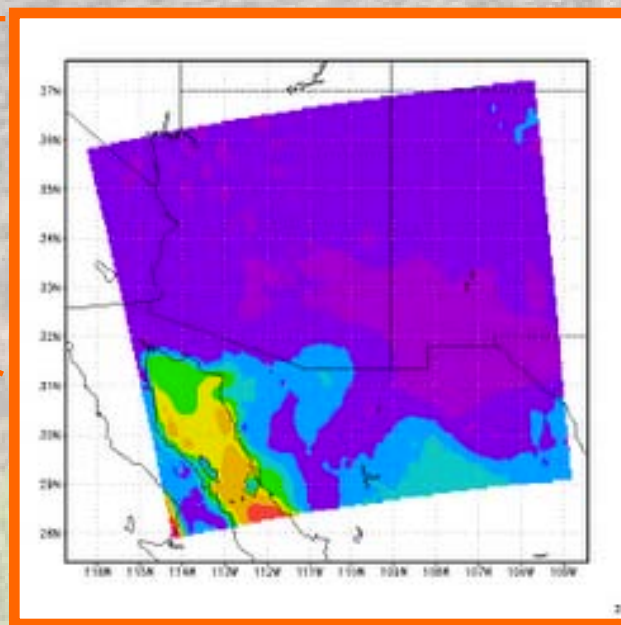
However, the hydrologic model tRIBS requires data at a **very high** spatial and temporal resolution – we use a two-step process.



We use a 112-year continuous simulation using WRF forced at it's lateral boundaries with **HadCM3 A2** data.

35km spatial resolution

6 hourly temporal resolution



Using data from the first downscaling, we further downscale to the region of interest for 3 10-year periods (1991-2000),(2031-2040) and (2071-2080).

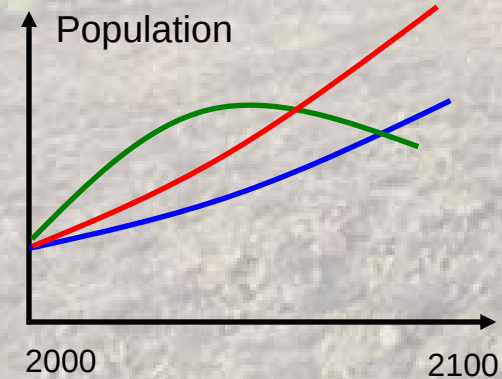
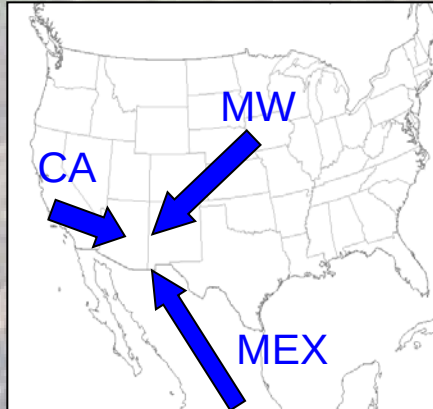
10km spatial resolution

1 hourly temporal resolution

Population Scenarios

Future growth in Arizona and the study basins will reflect broad-scale trends and cyclical variations in:

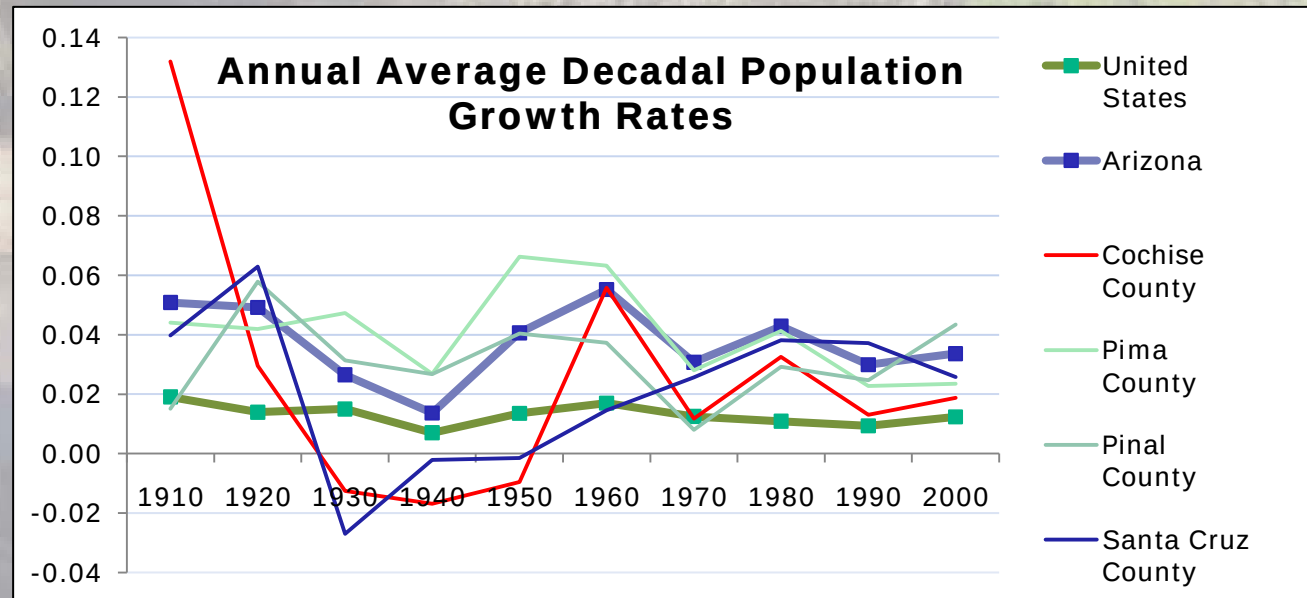
- Immigration across the Mexican border (MEX)
- Snowbird retirement streams from the Midwest (MW)



- “Rebound” migration from California (CA)

Each of these reflect strong differentials:

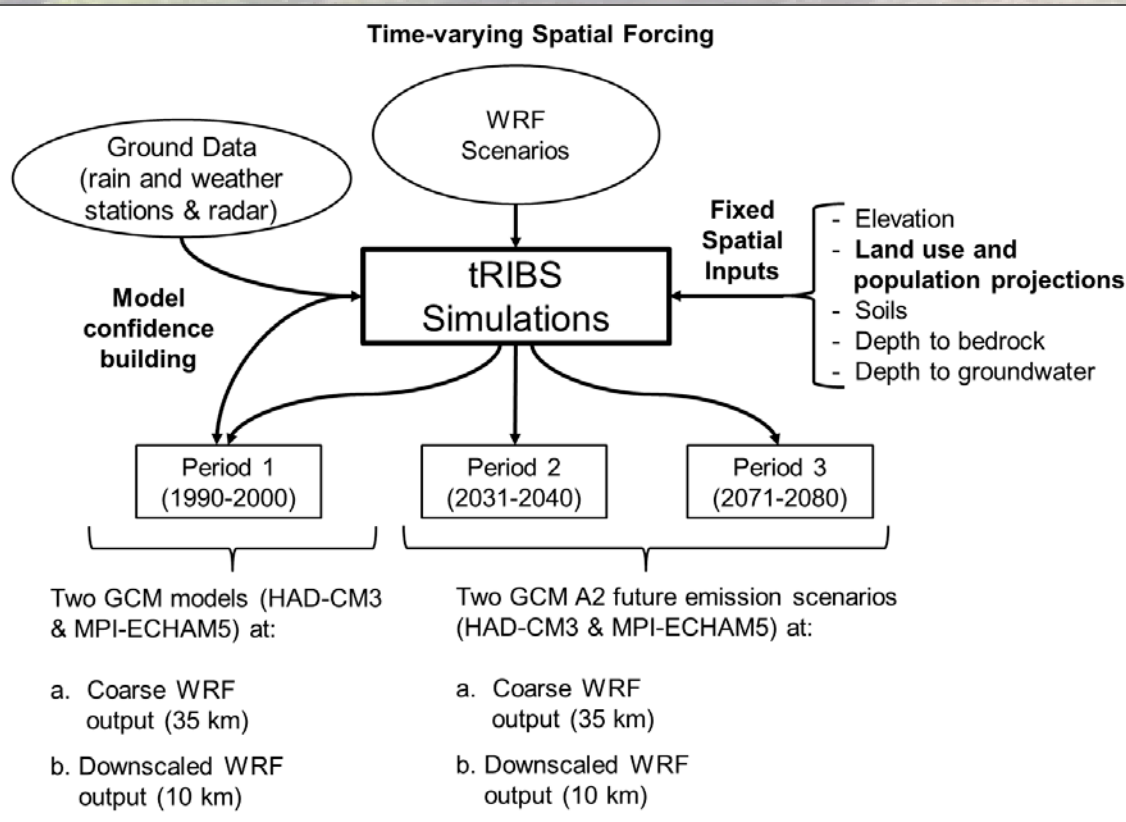
- Economic development disparity across int'l border
- Climate complementarity with the MW
- Housing affordability differential across CA border



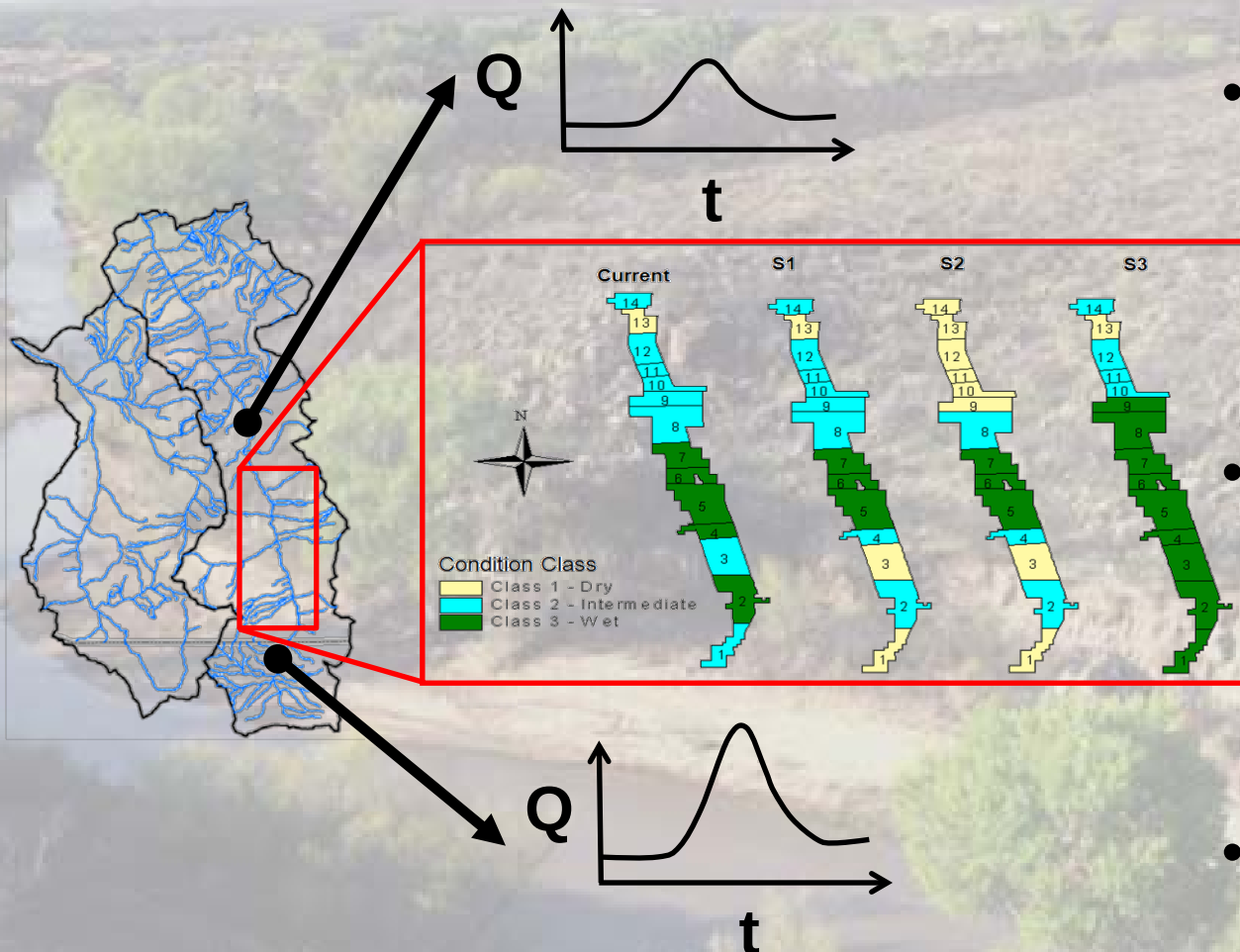
Regional climate model (WRF) forecasts will be applied as forcing in the TIN-based Real-time Integrated Basin Simulator (tRIBS).

tRIBS goals are:

- To generate spatiotemporal distributed estimates of streamflow and groundwater recharge estimates.
- Coupling tRIBS and MODFLOW dynamic outputs to be used as inputs to the Riparian Assessment models.



Model outputs from tRIBS:



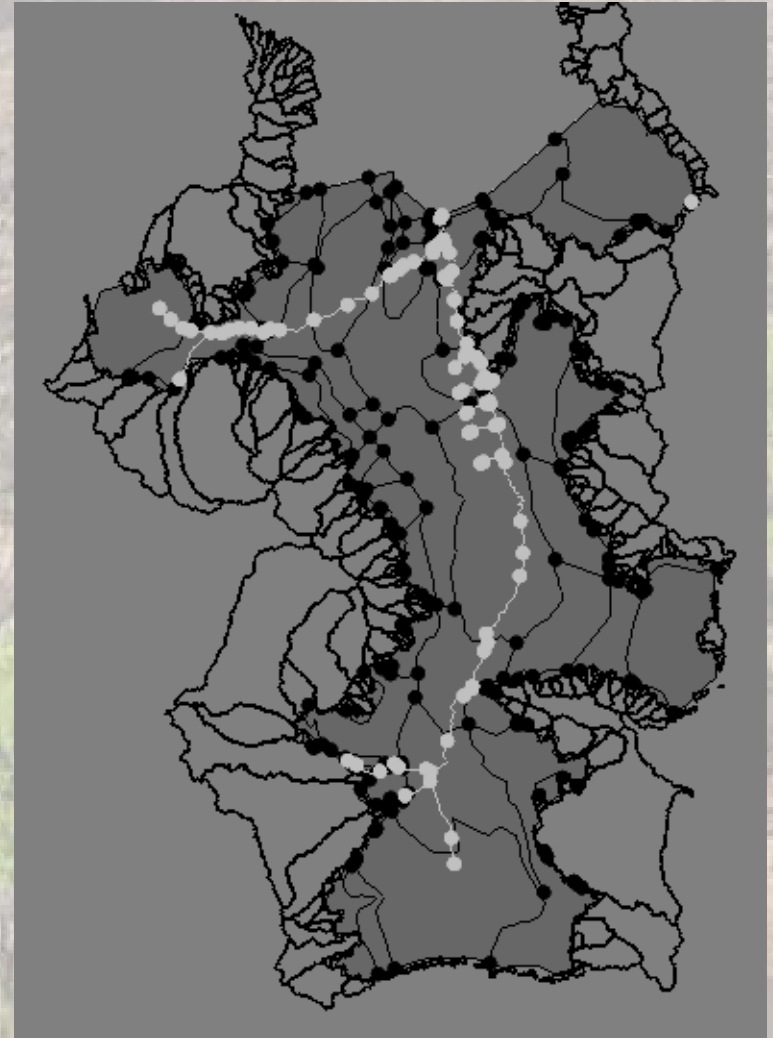
- Provide discharge and depth at river locations for the riparian model.
- Provide groundwater discharge in riparian corridor.
- Provide diffuse and direct recharge over basin locations.

San Pedro Groundwater Model

- Stream and layer data
- Boundary conditions based on mountain-front recharge basins
 - Anderson equation:

$$\log Q_{\text{rech}} = -1.40 + 0.98 \log P$$

(where $P > 8$ and P is in inches)



Vegetation vs Channel Evolution

- As sediment deposits at riparian areas and meandering channel evolves, vegetation on the outer bank will be eroded, and the new vegetation will grow on the newly deposited riparian areas.
- Meandering channel migration rate relates to the climate changes and the growth of vegetation in riparian areas.
- The vegetation strip corresponds to different stages of meandering migrations and also indicates the evolution of vegetations in riparian areas.



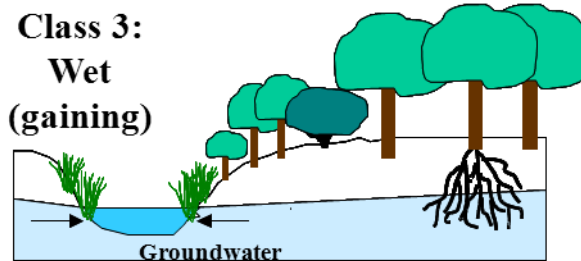
Coupling Vegetation with Hydrologic Output

Riparian Assessment Model

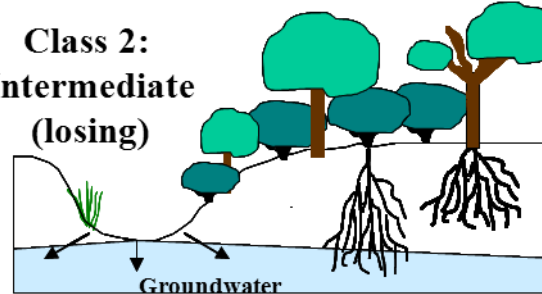
(Stromberg et al. 2006)



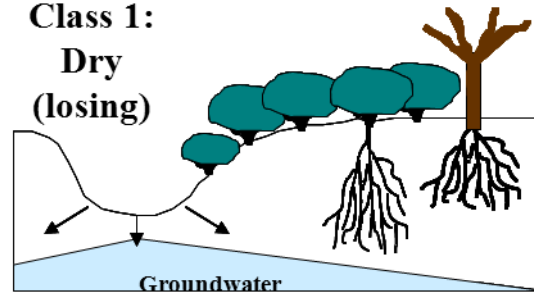
**Class 3:
Wet
(gaining)**



**Class 2:
Intermediate
(losing)**



**Class 1:
Dry
(losing)**



Tamarix

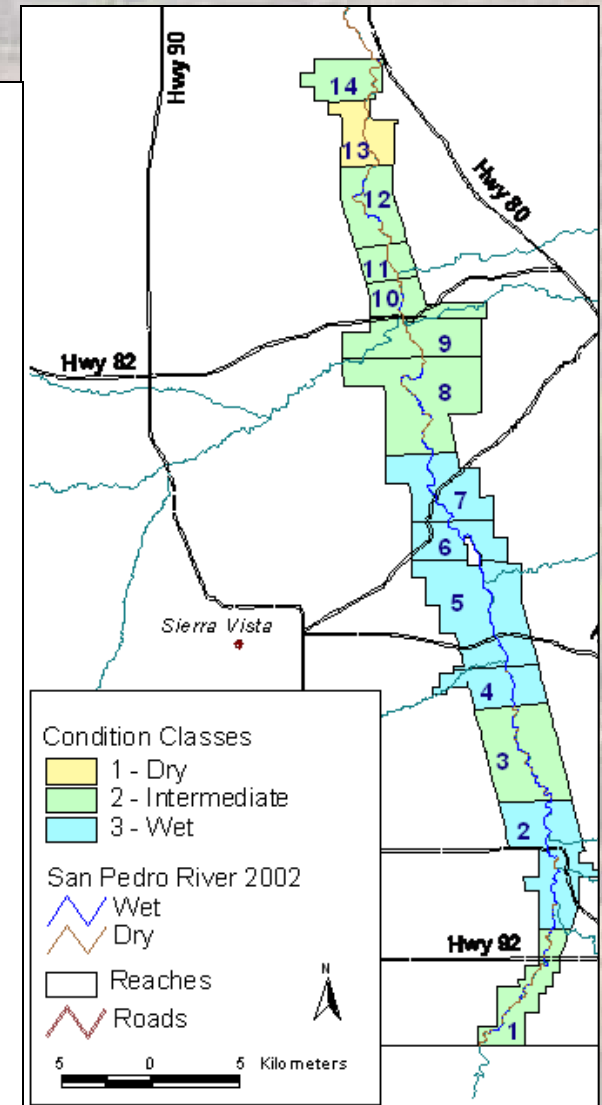


*Populus
Salix*

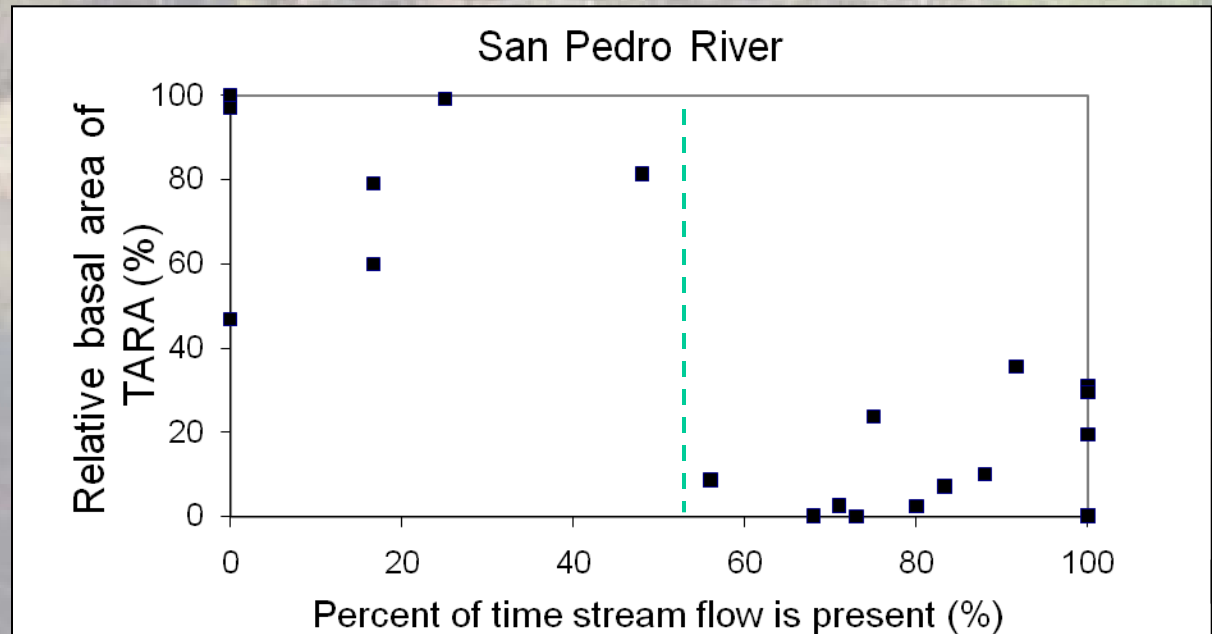
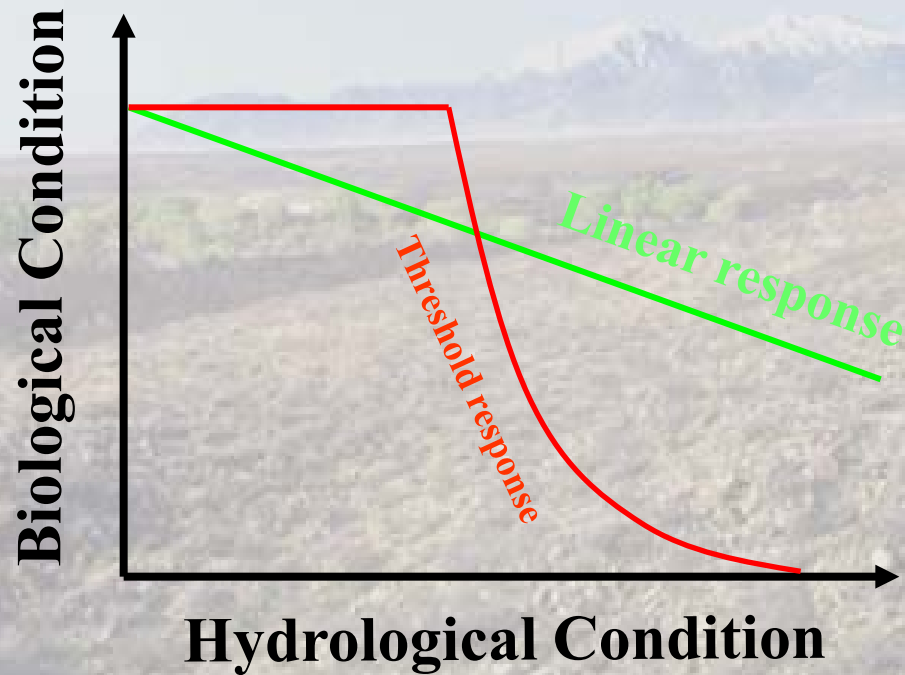


Riverine
marsh

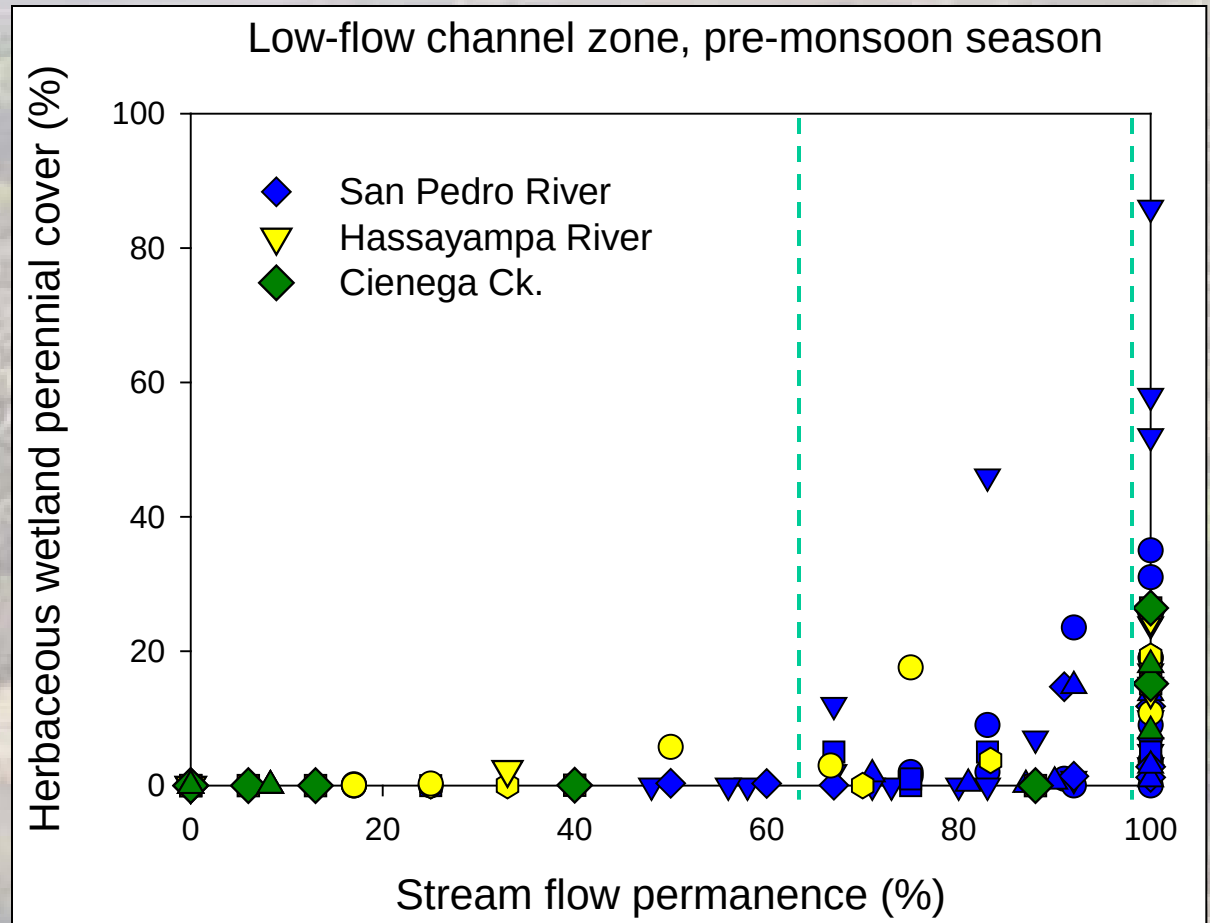
Groundwater Decline



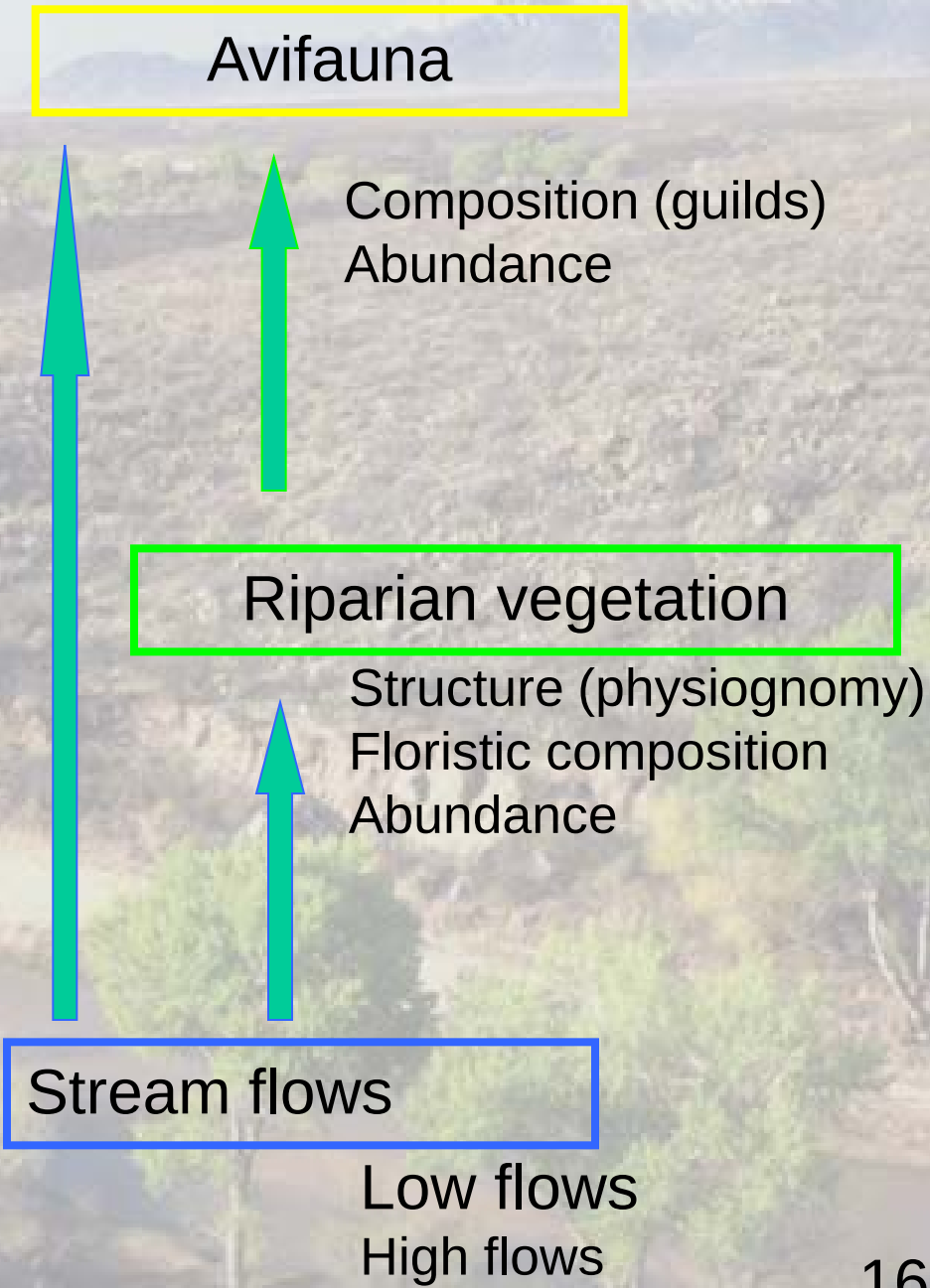
We will use empirically-derived threshold values to model abundance changes within the pioneer forests in response to changes in stream intermittence.



We will use empirically-derived threshold values to model changes in abundance of riverine marshlands



We will use empirical values
to relate avian communities
to linked changes in stream
flows and riparian vegetation

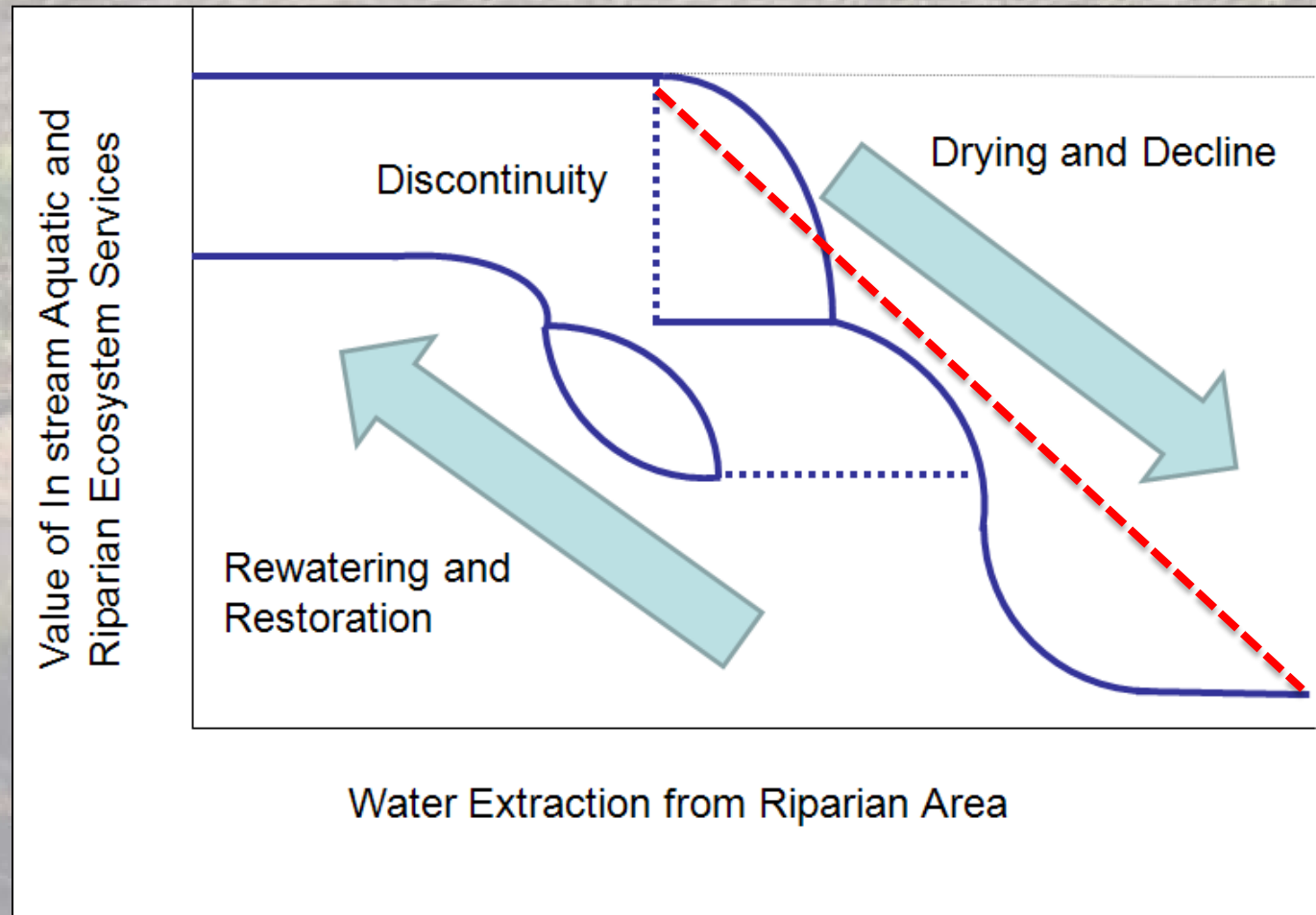


Relating Biophysical Models to Preference Models

Figure 1: From the Proposal

H1: The **value** of ecosystem services declines (increases) in non-linear and stepwise fashion as water is extracted (restored) from (to) dryland rivers

Question: Do Behavioral Values Decline/Increase in the Same Fashion?



Science and Economics

- Walk through the forest - what do you know about it?
 - The forest is pretty etc, but doubtful one knows the mix of vegetation, birds, groundwater levels etc
 - And what might change the mix; what might it then look like
 - Over what time period would the change occur
 - How would the change happen spatially
- What is needed is science driven ecosystem attribute endpoint “bundles” describing ecosystem services
 - With the drivers of change clearly defined,
 - Thus defining change in the system (marginal change of attributes)
- Framing the endpoints
 - Baseline
 - Linear / discontinuous etc
 - Spatially -- Whole system versus parts (San Pedro House versus the SPRNCA)
 - Temporally issues (near term, mid-term and long term)
 - Essentially a discounting issue
 - Use versus non-use

Total Abundance (number of birds)

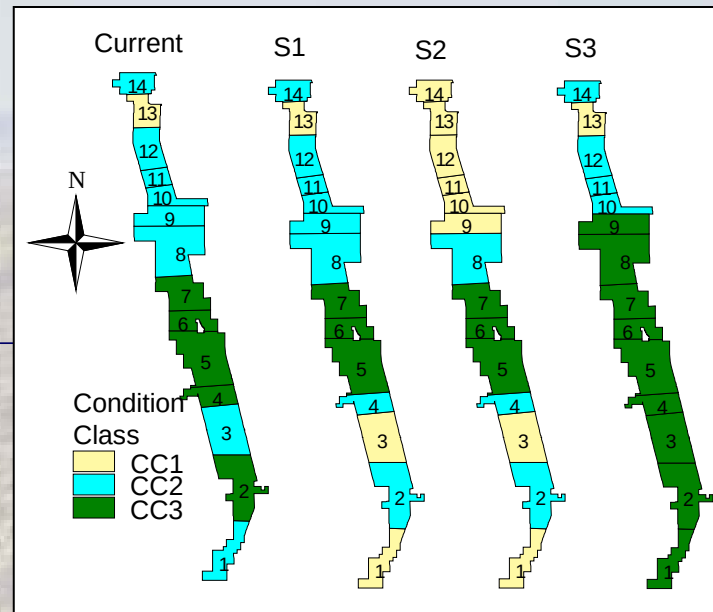
25000
23000
21000
19000
17000

S3-Wetter

Current

S1- Dryer

S2-Drying out



Next Steps

- Working on building various models
- Linking Each model in turn
- Developing database of individual responses to changes in riparian ecosystems
- Scenario development
- Pursuing structure of hypothesis testing

Questions?

- Discussion
- <http://semiarid-rivers.blogspot.com/>