Drought Management, Utah

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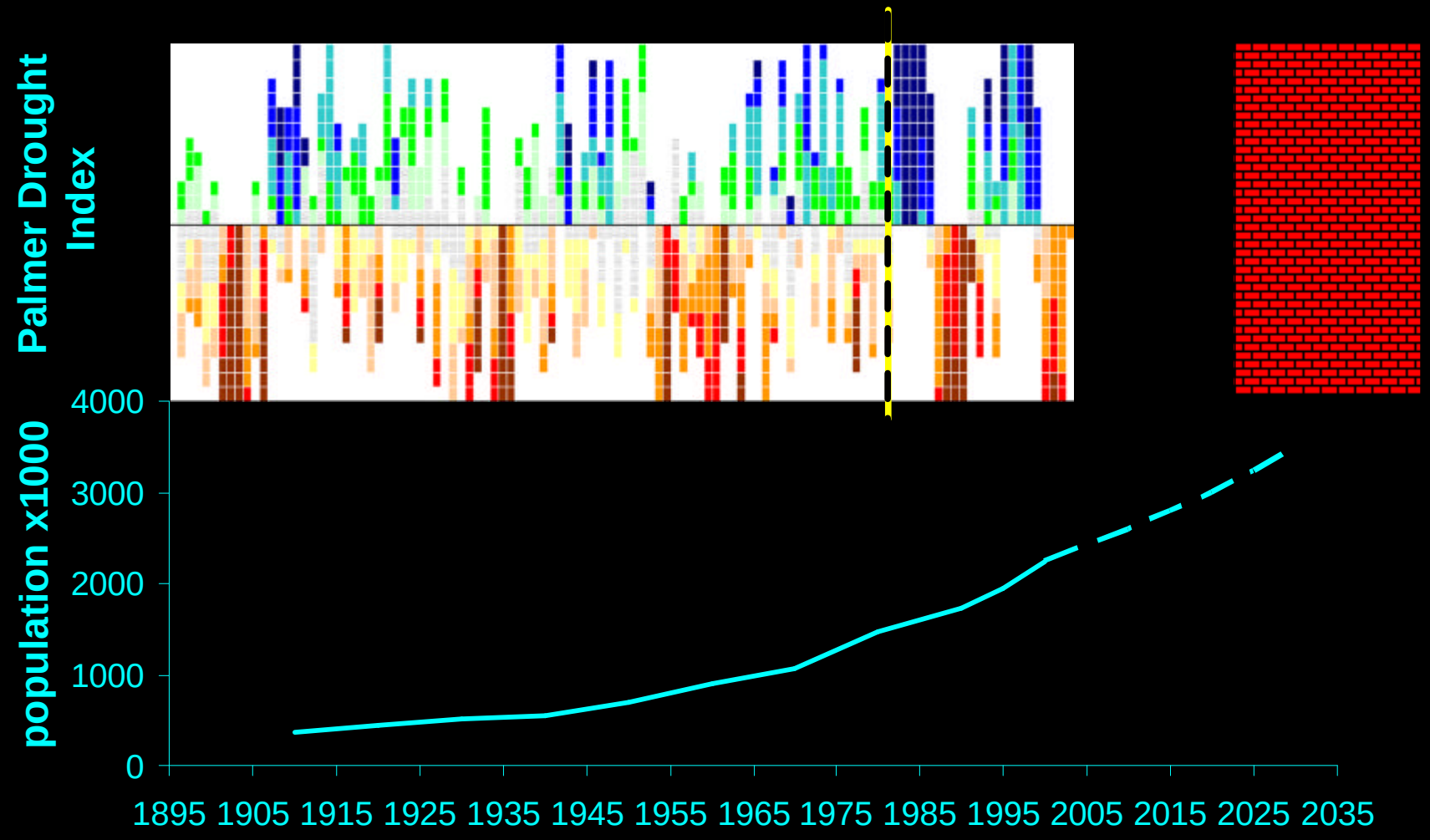
Project Motivation: Utah has a boom-bust hydrologic climate and booming population growth.

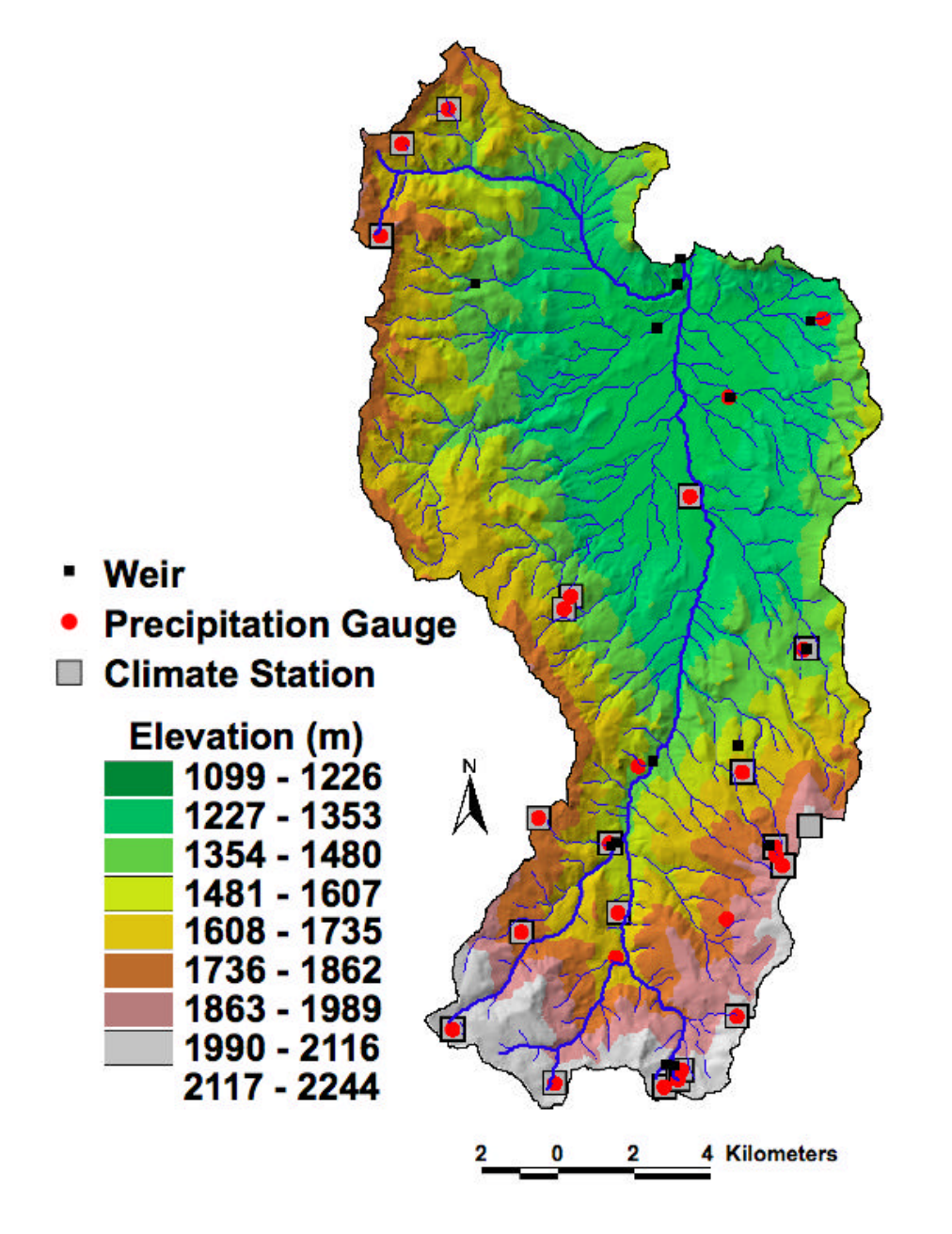


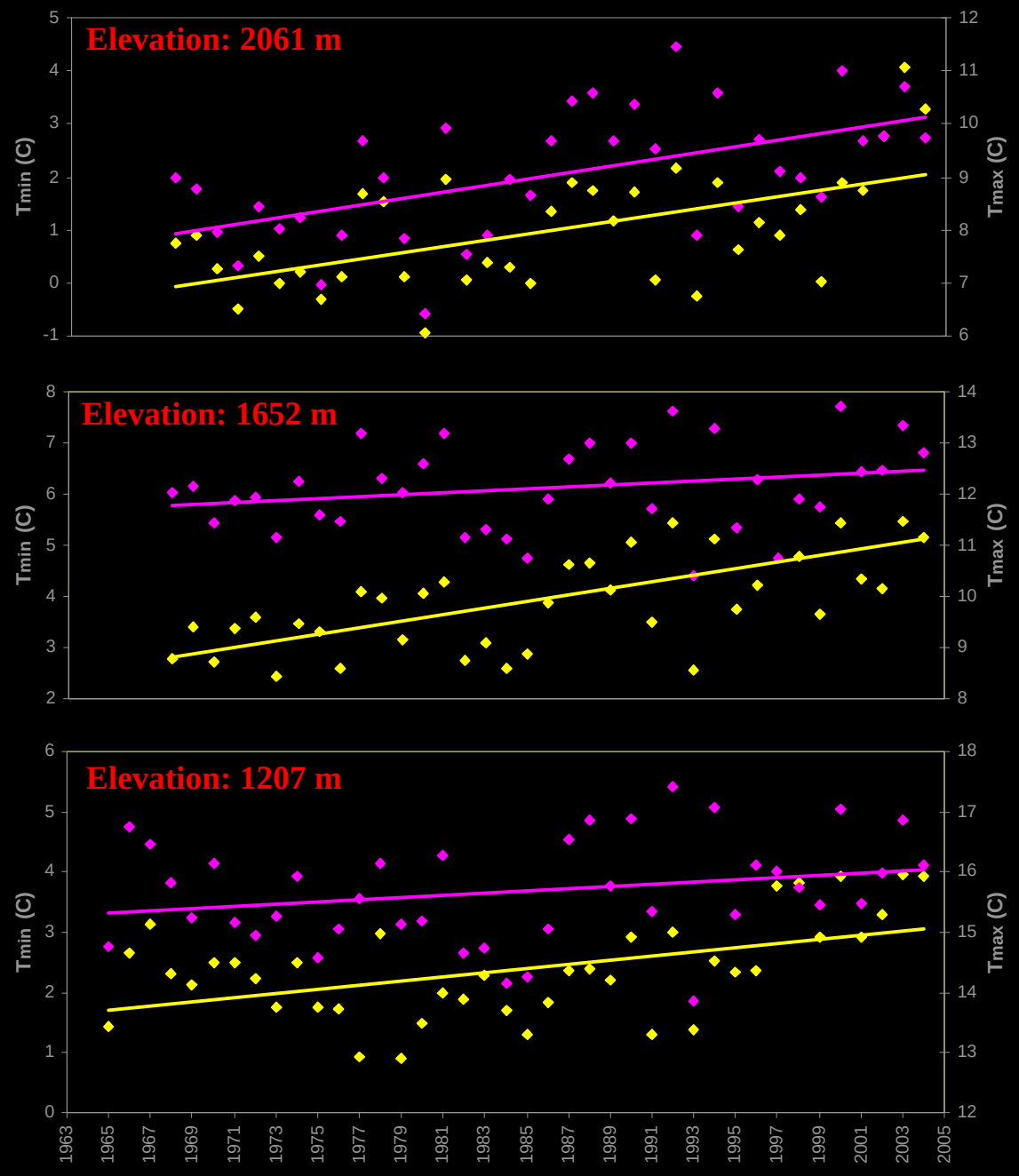
Improve understanding of the coupling between climate and water yield.

Climate Change and Mountain Hydrology

Reynolds Creek Experimental Watershed USDA-ARS

239 km2
14 Weirs
36 Precipitation Stations
27 Climate Stations
50 years of data

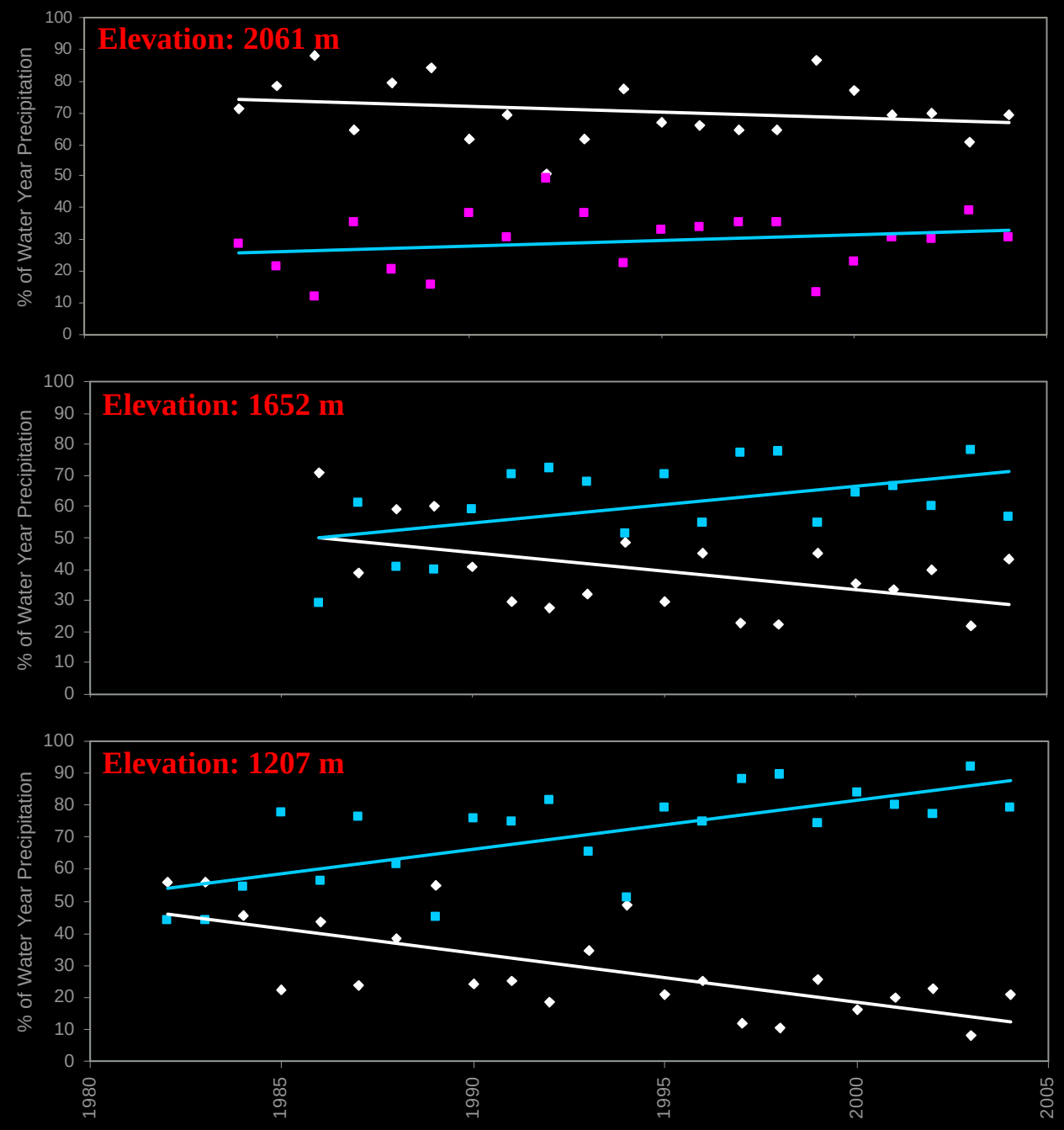




Temperature

? Tmin > ? Tmax

dT/ dt is greater at high elevations as compared to low elevations.

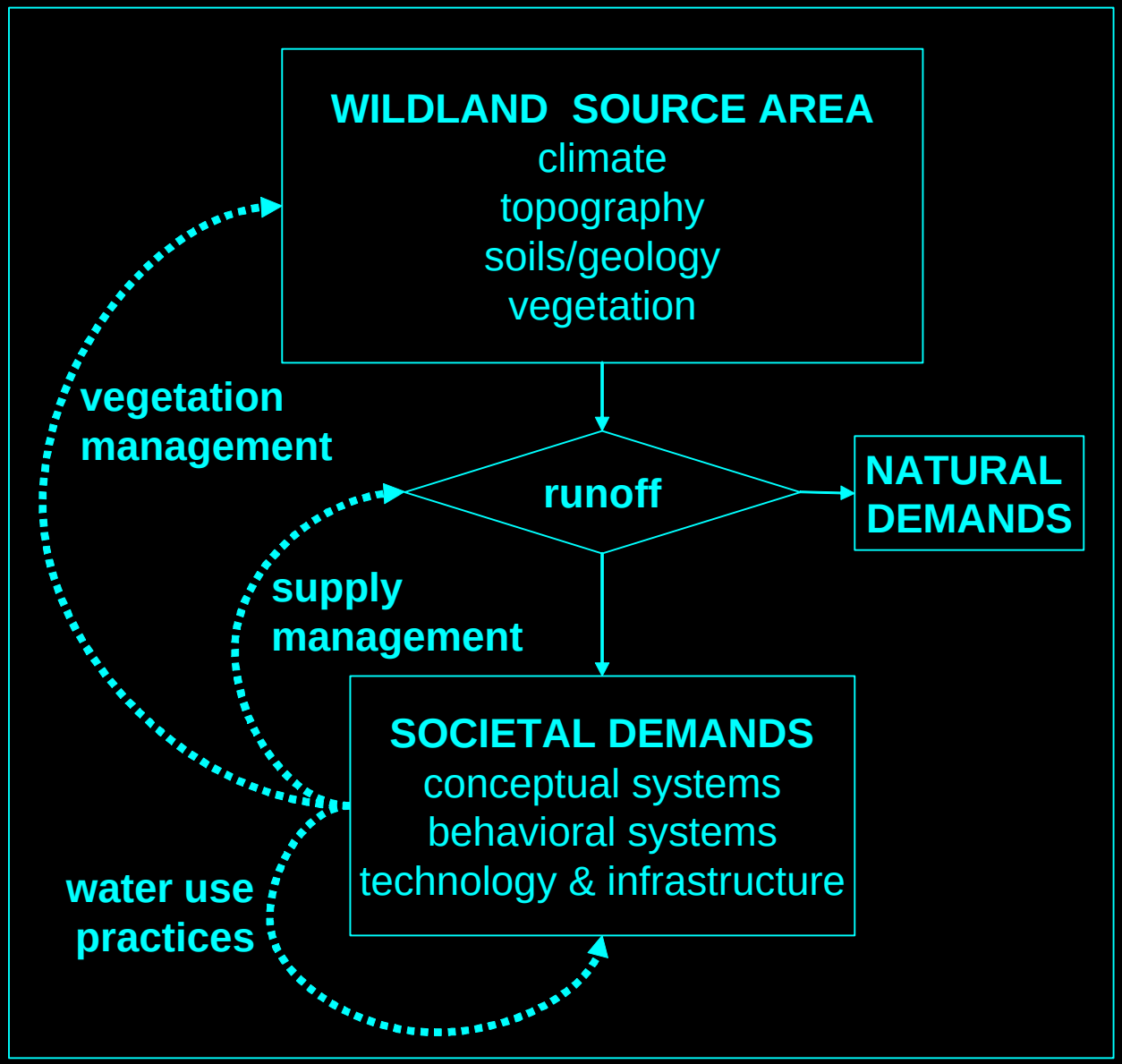


Rain Vs Snow

Decrease in Snow/Rain ratio.

Change is smallest at high elevations and greatest at low elevations.

Project Goal: Develop water management strategies for drought conditions that *integrate understanding* from social, physical and ecological sciences.



Research Approach

Supply Management

Examine water institutions and policy options for managing water under drought conditions.

Reduce the uncertainty in forecasting water yield from snowmelt:

Improve understanding of the influence of climate change on water yield.

Develop physically based hydrologic model for snowmelt runoff.

Water use practices

Examine public behaviors and perceptions regarding landscape water use.

Optimize agricultural irrigation for salinity management

Vegetation Management

Quantify minimum water use needs of conventional landscape plants.

Develop low water use landscapes using drought tolerant species.

Improve model parameterization for several vegetation types.

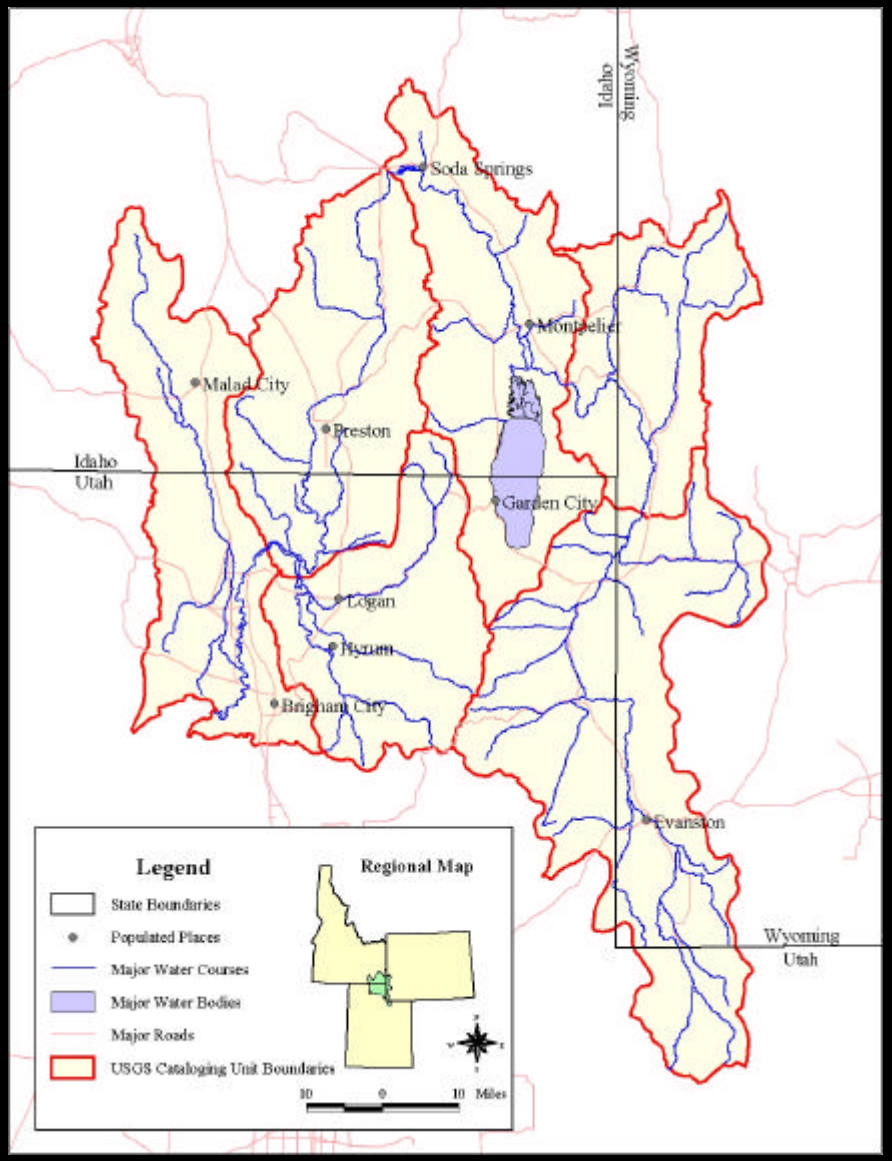
Measure the water yield benefit potential and ecological impacts of prescribed fires.

Supply management – Bear River Basin Drought Response

Examine water institutions and policy options for managing water under drought conditions to meet needs of agricultural, urban, and environmental interests in the Bear River Basin and state of Utah.

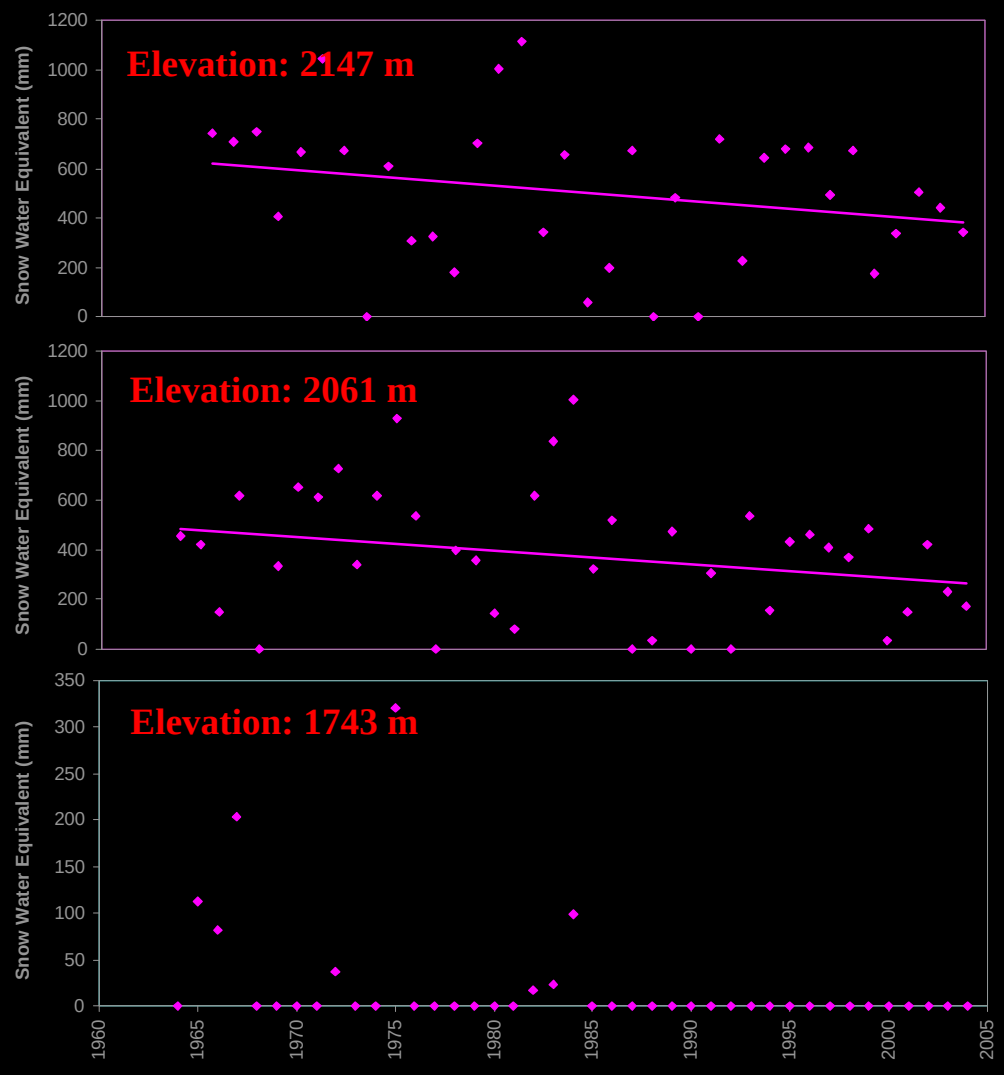
Significant Findings:

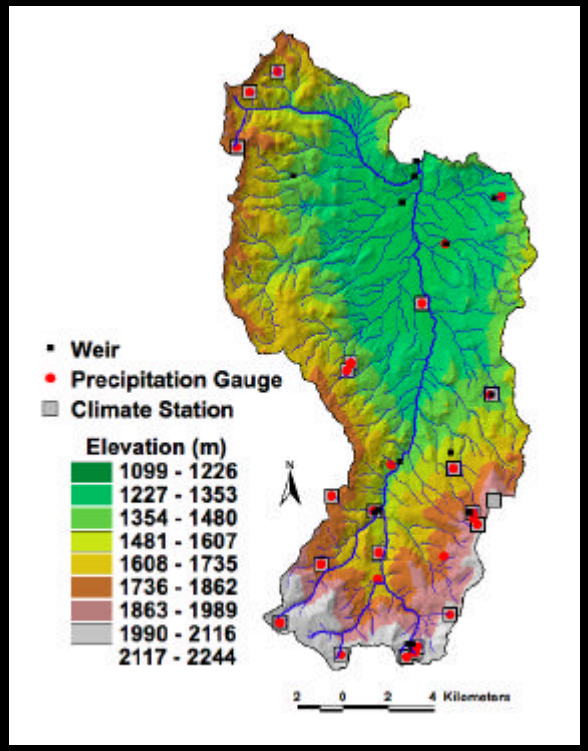
- flexibility and cooperation within fall-back positions
- hydrologic modeling to mitigate conflicts
- physical setting is important
- new players integrated into existing allocation structure



Supply management –

understanding the influence of climate change on water yield



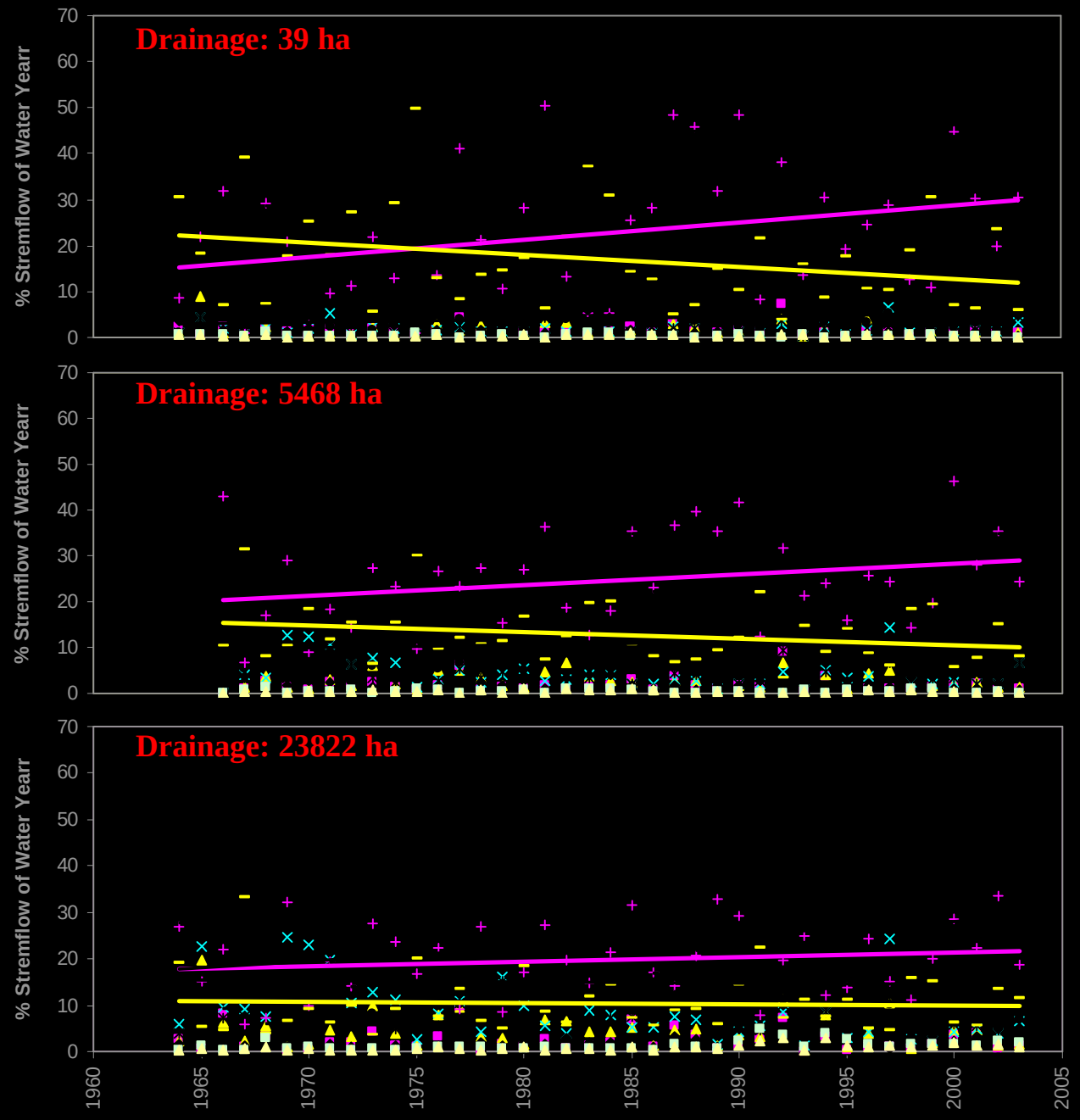


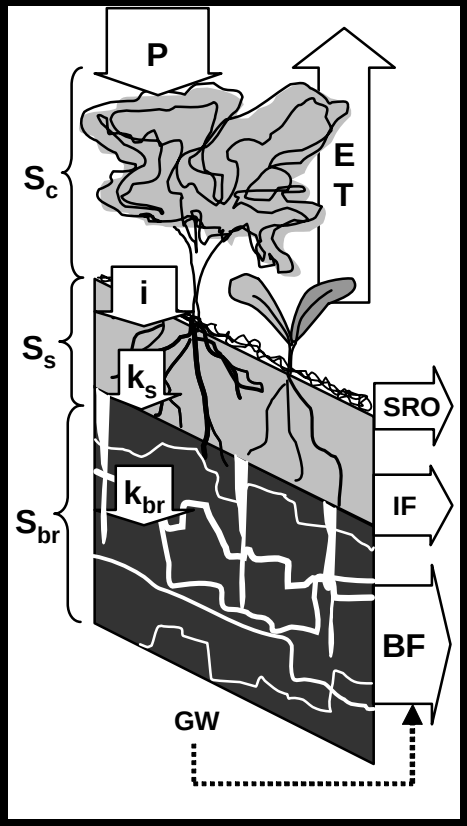
Decrease in May 1st SWE

No Snow on the Ground since 1985 at Low Elevation Site

Stream Flow

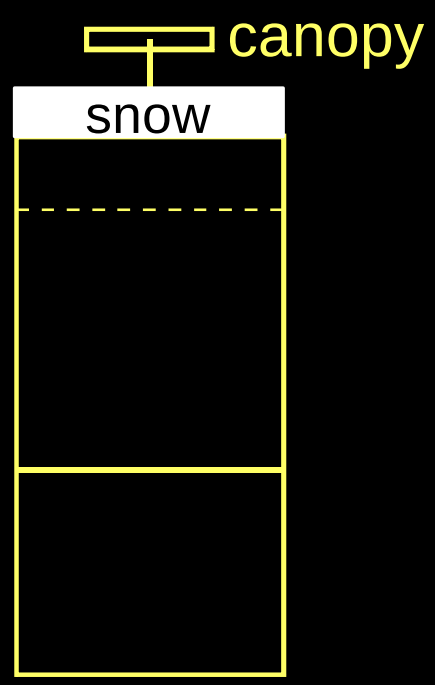
Increase in early spring (April) stream flow, decrease in late spring (June) stream flow.

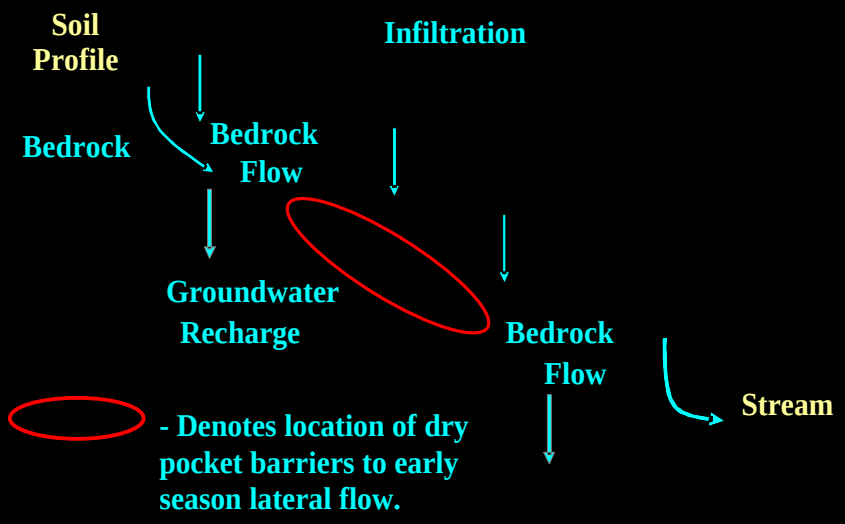


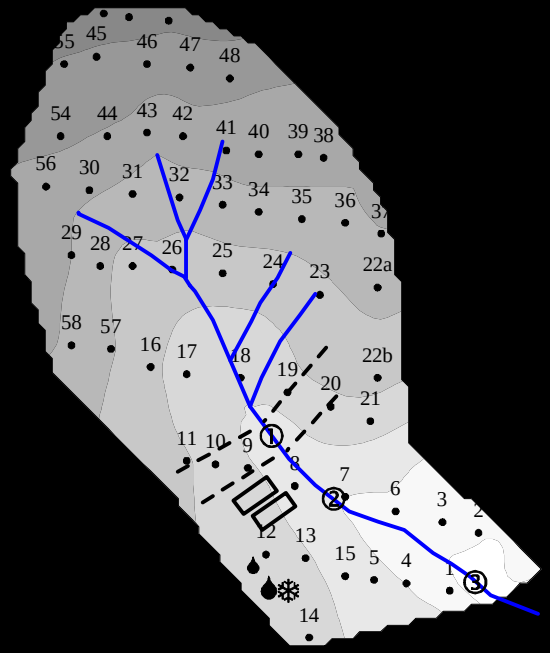


Develop distributed, process based hydrologic model for runoff

- DEM: slope, aspect, surface area, terrain shading, view factors for 10 by 10 m grid
- Direct and diffuse solar radiation are calculated using an atmospheric radiative transfer model
- Subsurface is described by 2 reservoirs (soil and bedrock)



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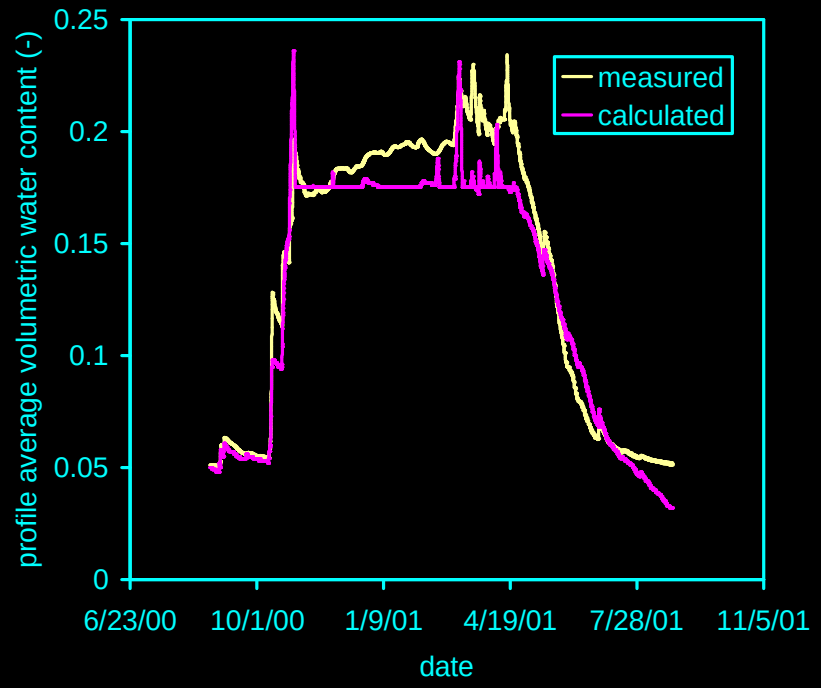
profile average volumetric water content (-)
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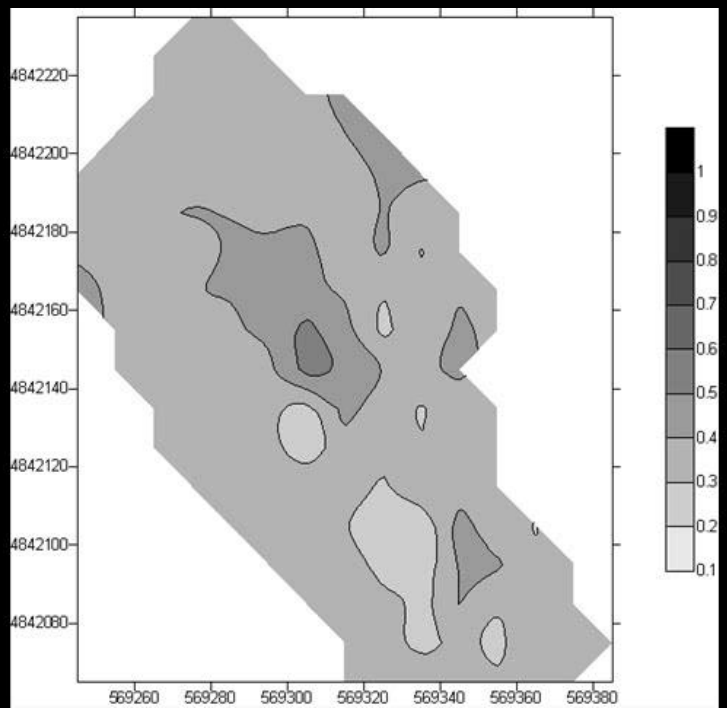
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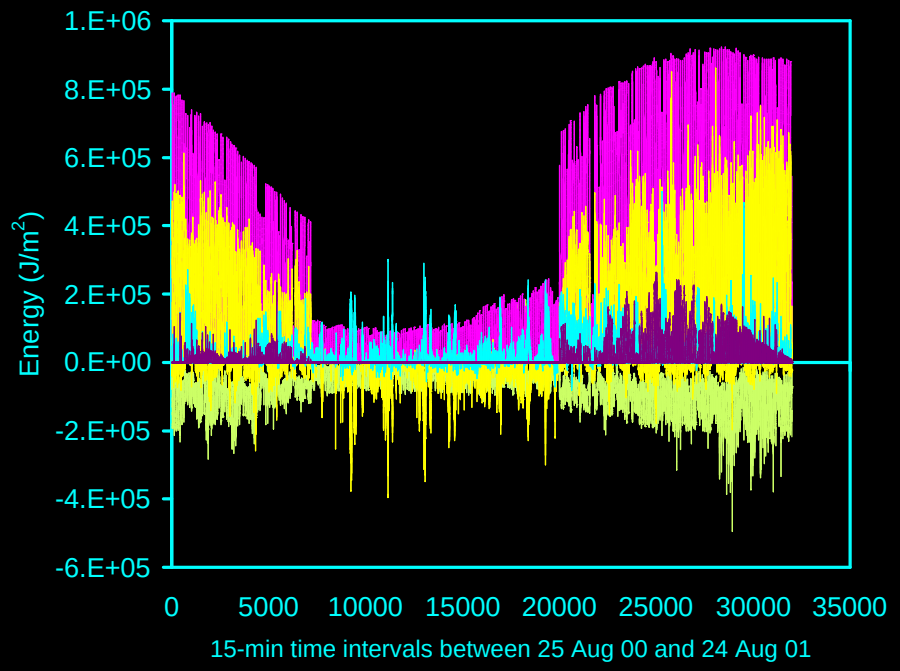
Energy (J/m2)
1.E+06
8.E+05
6.E+05
4.E+05
2.E+05
0.E+00
-2.E+05
-4.E+05
-6.E+05
0
5000
10000
15000
20000
25000
30000
35000
15-min time intervals between 25 Aug 00 and 24 Aug 01

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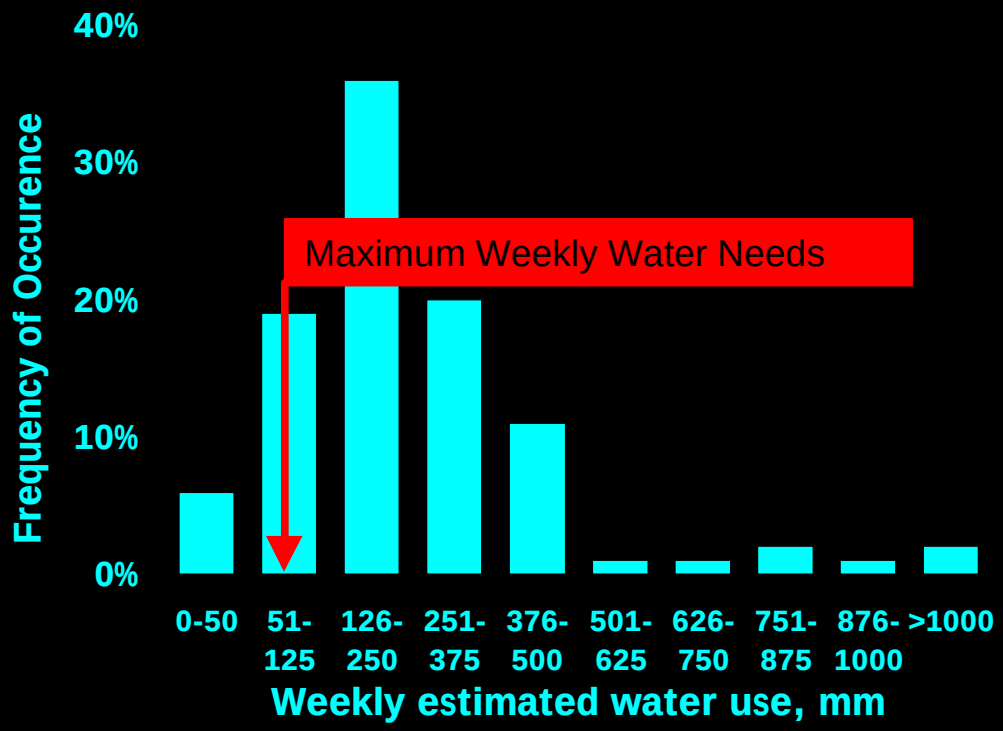
Examine public behaviors and perceptions regarding landscape water use and conservation.

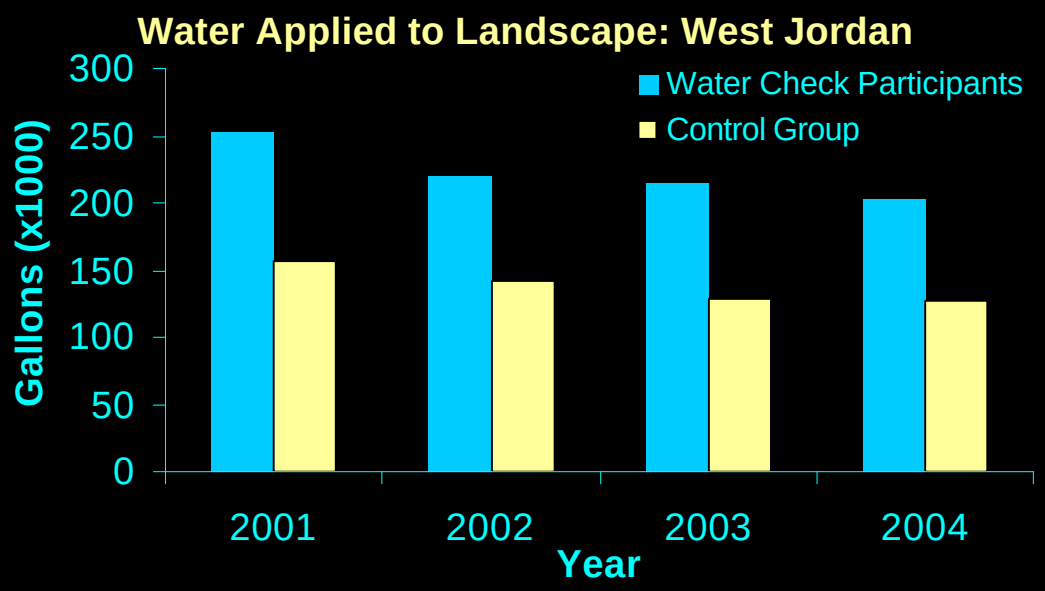
- **Why**-changing water use behavior of urban landscape owners difficult without identifying physical and social obstacles

- **How**-in 2004, performed 138 free residential landscape irrigation evaluations (out of 9,000+ solicited)

- **What**-in 2004, most solicited homeowners applying well in excess of plant water needs at midsummer, due to poor system uniformity and system flaws



Effectiveness of Water Check Programs



- "Finding out what works the best for our soil type and lawn type. We have been here six years and we haven't found something that works."
- "We have been working for years to find the right watering schedule."
- "Thank you for this program. We do need help…I will tell others about this program."
- "I am so grateful to those who have helped us with this program…..thanks to all!"

Utah Retail Nurseries' Role in Waterwise Plant Use

Focus of Inquiry:

To understand the educational and information distribution roles that different types of retail garden centers play in promoting use of waterwise plant material.

Significant Findings:

- Many garden centers are interested in waterwise plants but few can specialize in it due to lack of demand
- Customers want "lush", "colorful" and "cool"
- Many nursery owners are convinced water conservation can occur with proper watering of conventional landscapes
- Demand for waterwise plants is highly sensitive to drought cycles

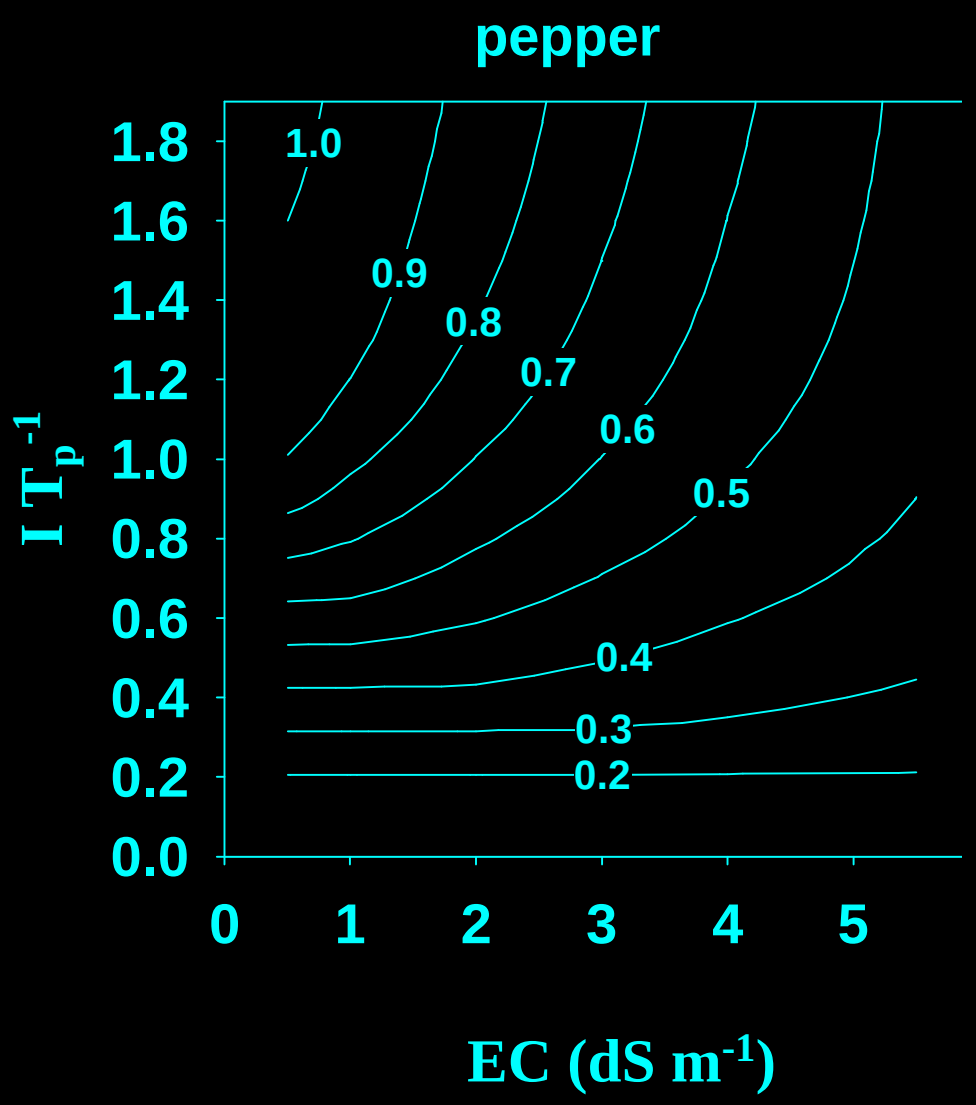
Public perceptions of landscaping water stress response

Plant Response to the Soil Environment:
An Analytical Model Integrating Yield, Water, Soil Type and Salinity

$$T = \frac{\min\left\{T_p, \left[\left(y_{root} - \frac{y_w}{\left(\frac{(I-T)}{K_s}\right)^{\frac{1}{h}}}\right)(I-T)b\right]\right\}}{1 + \left(\frac{EC_I \cdot I \cdot (q_s - q_r)\left(q_r + \left(\frac{(I-T)}{K_s}\right)^{\frac{1}{d}}\right)}{EC_{e_{50}}(I-T)q_S}\right)^r}$$

$$Y_r = \frac{T}{T_P}$$

$$D = I - T$$



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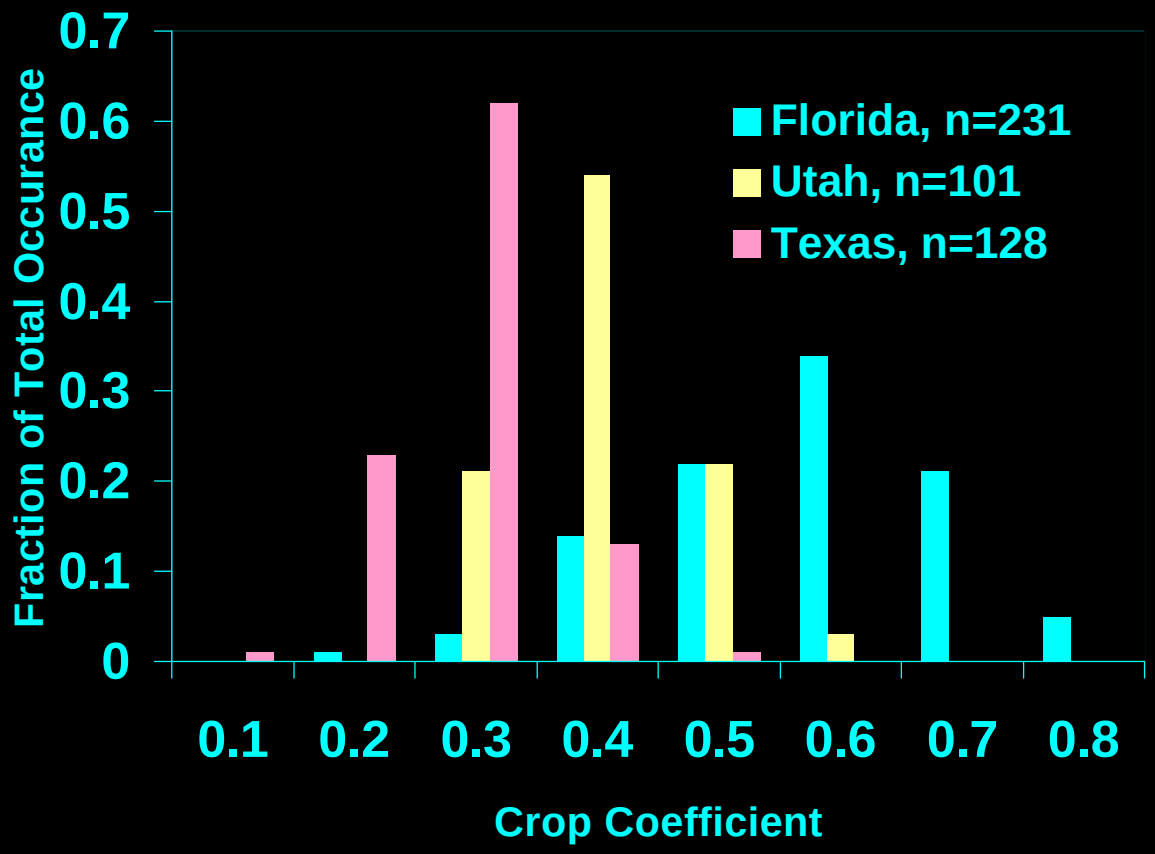
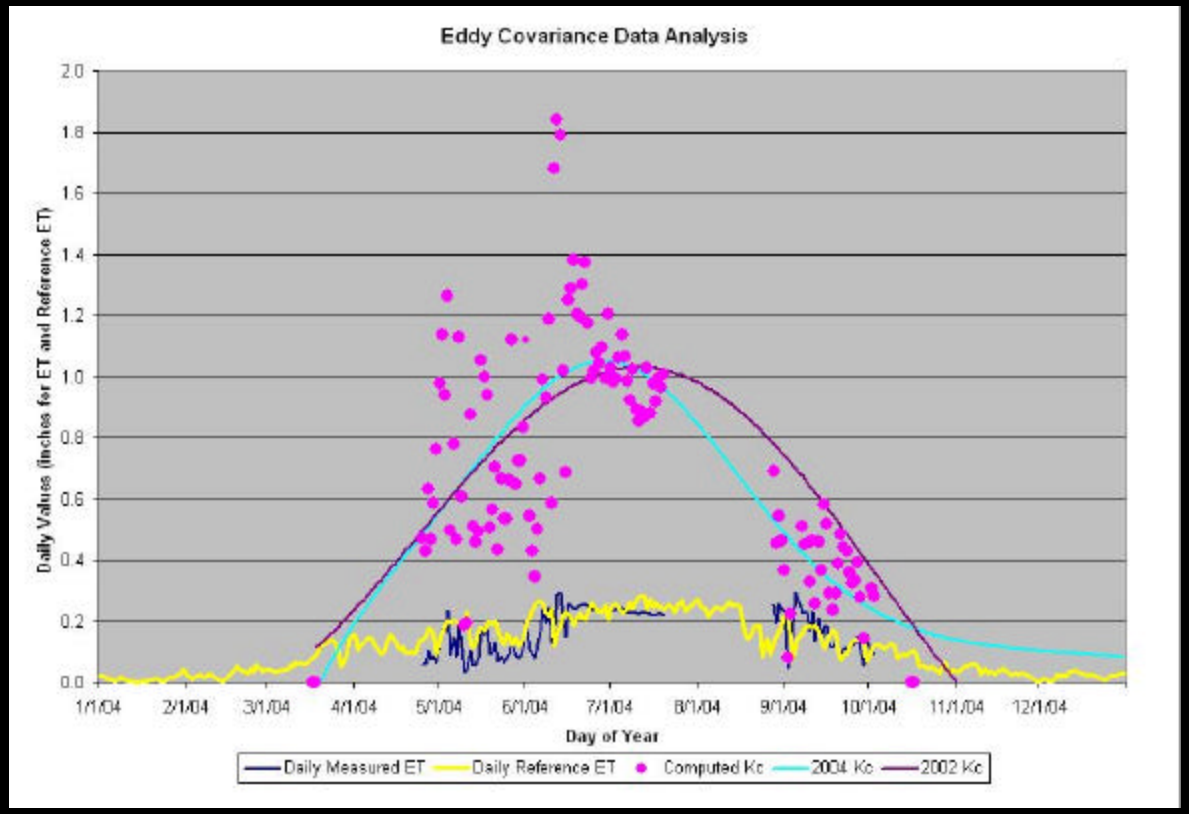
Sweetgum (Liquidambar styraciflua)
water use in three contrasting climates

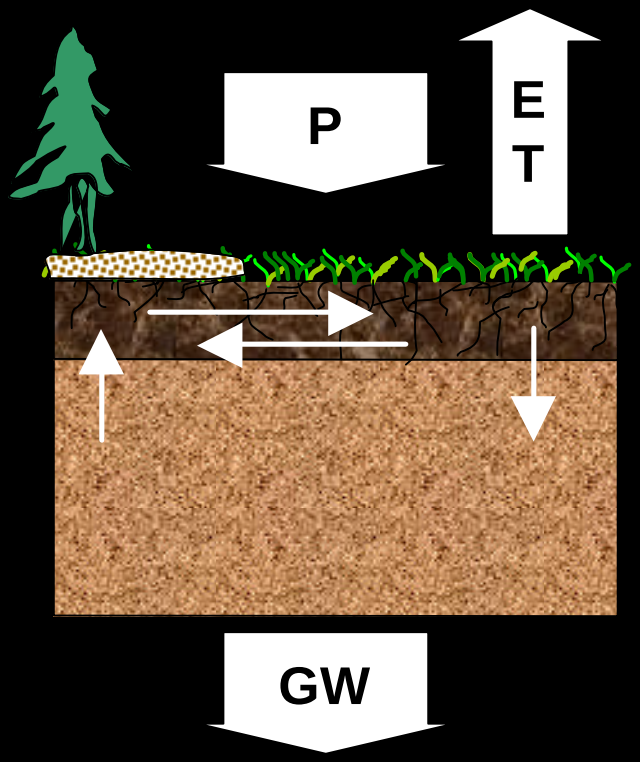


Quantify minimum water use needs of conventional landscape plants.

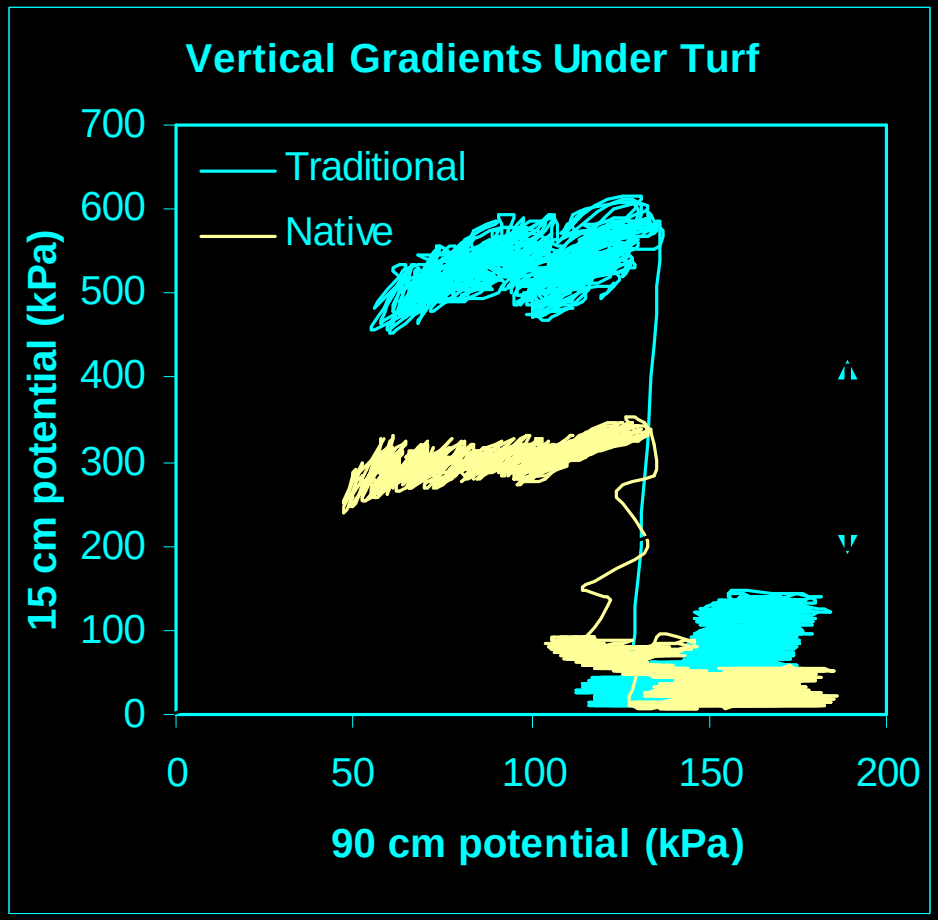
- Quantify seasonal variability of water use by Kentucky bluegrass in a high desert climate.

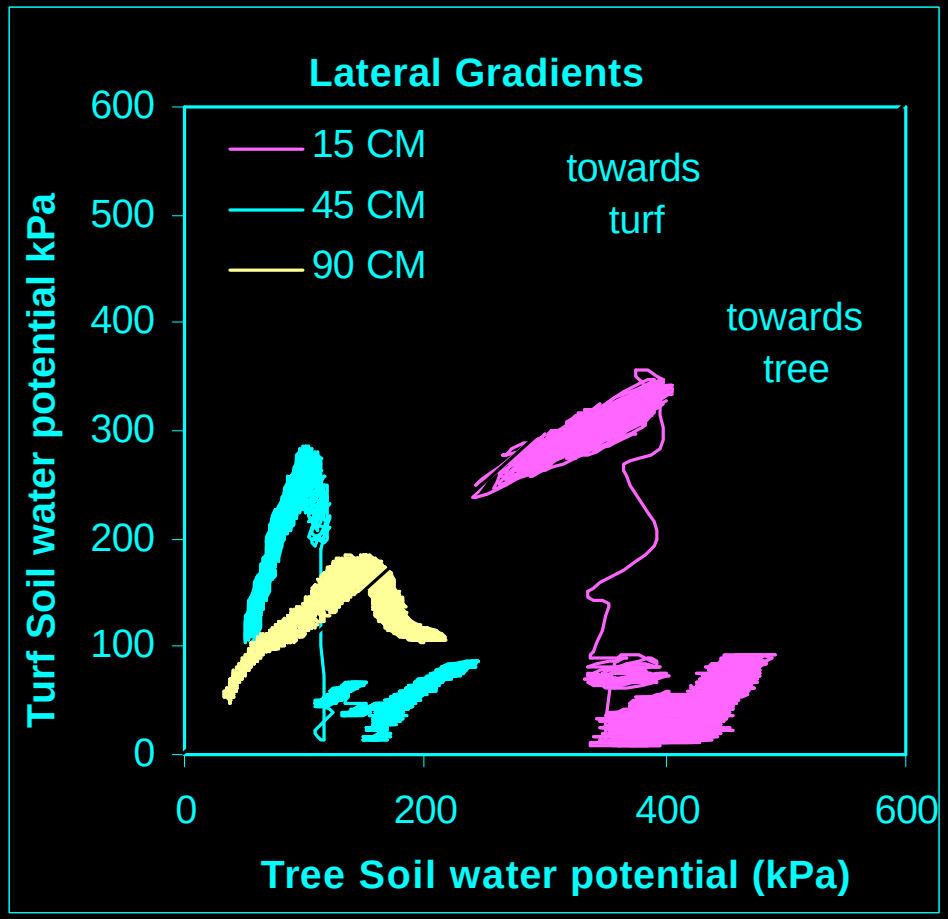


Treating landscapes as complex systems



Drought stress experiment - the quantitative approach





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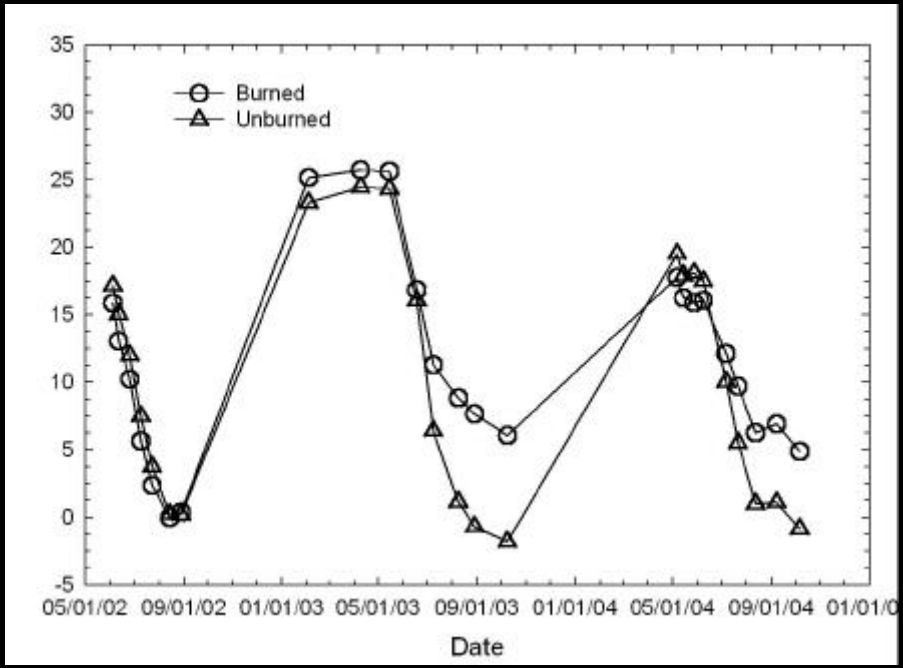

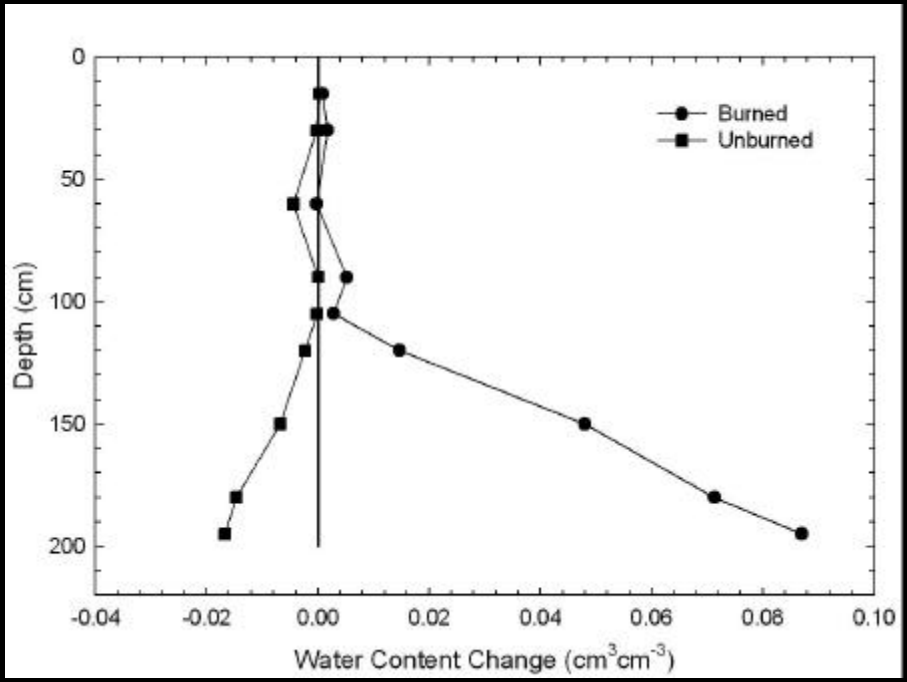

Develop water management strategies for drought conditions that *integrate understanding*
from social, physical and ecological sciences.

Can the existing legal framework for water allocation withstand protracted drought?

Will existing hydrological models be sufficient to resolve dispute?

Can future water shortages be addressed by vegetation management? What are the options and consequences?