The importance of ecosystem state factors to the hydrologic responses of woodlands to land management activities

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GRASSLAND SOCIETY OF SOUTHERN AFRICA
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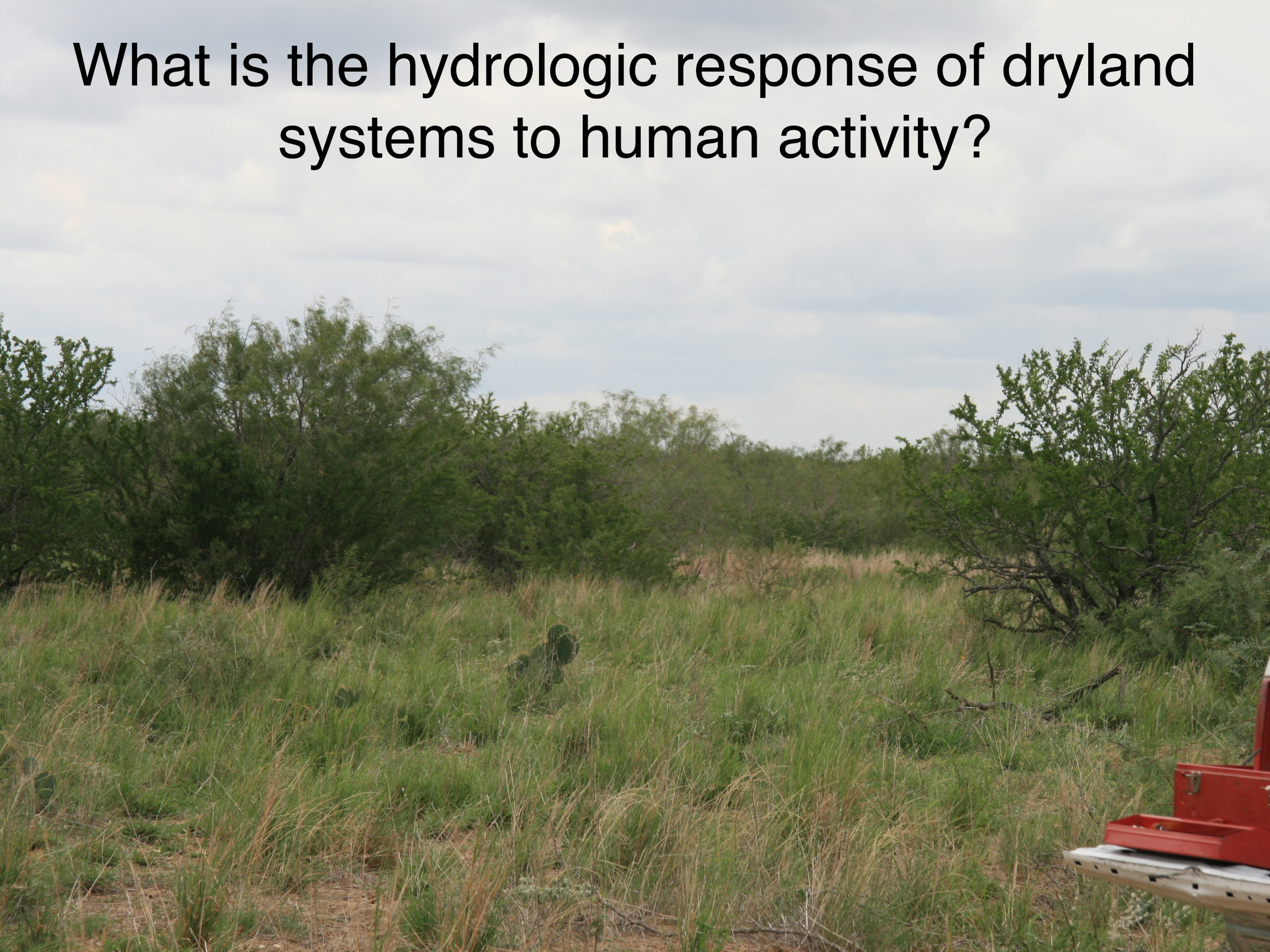
What is the hydrologic response of dryland systems to human activity?



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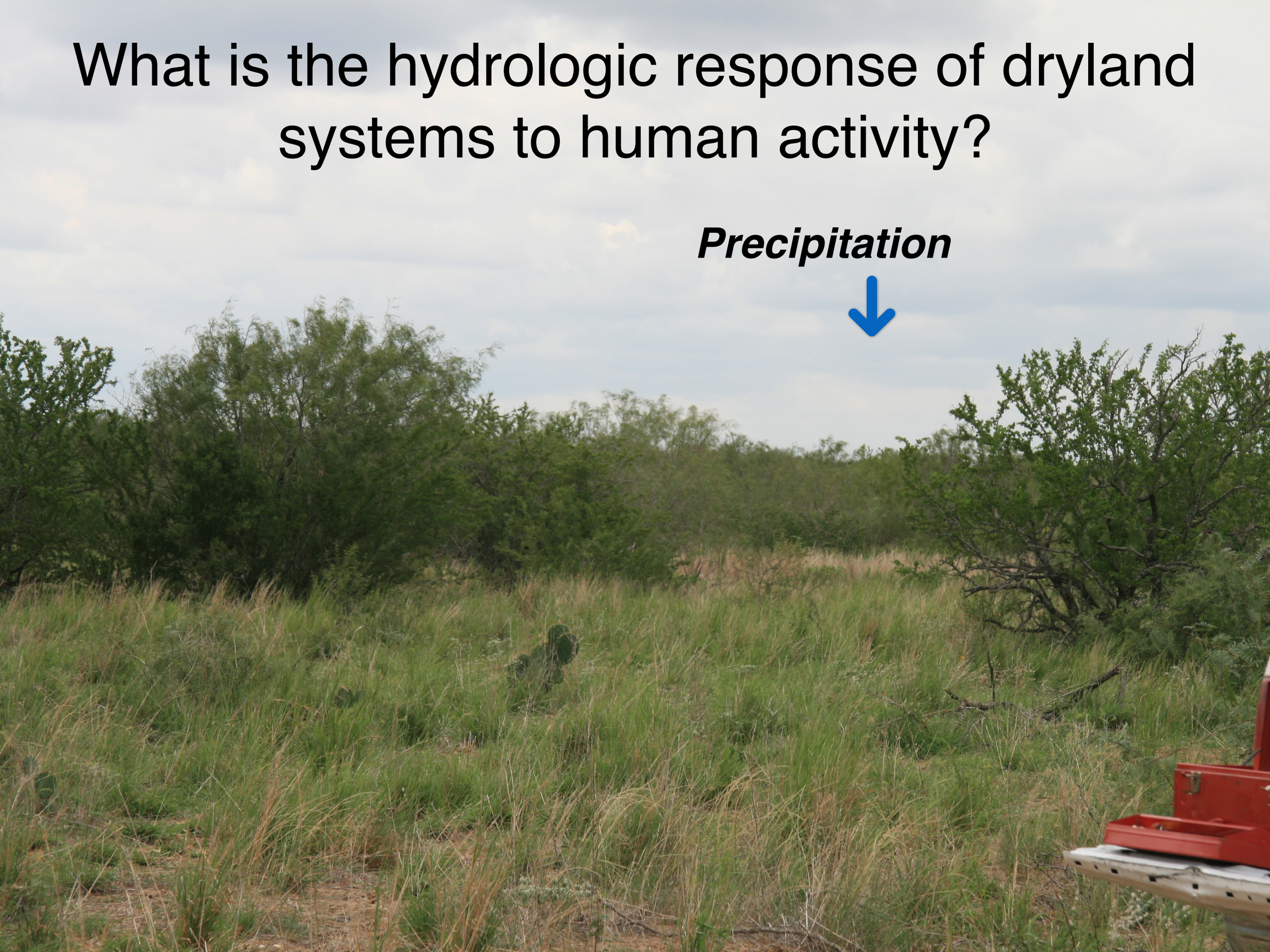

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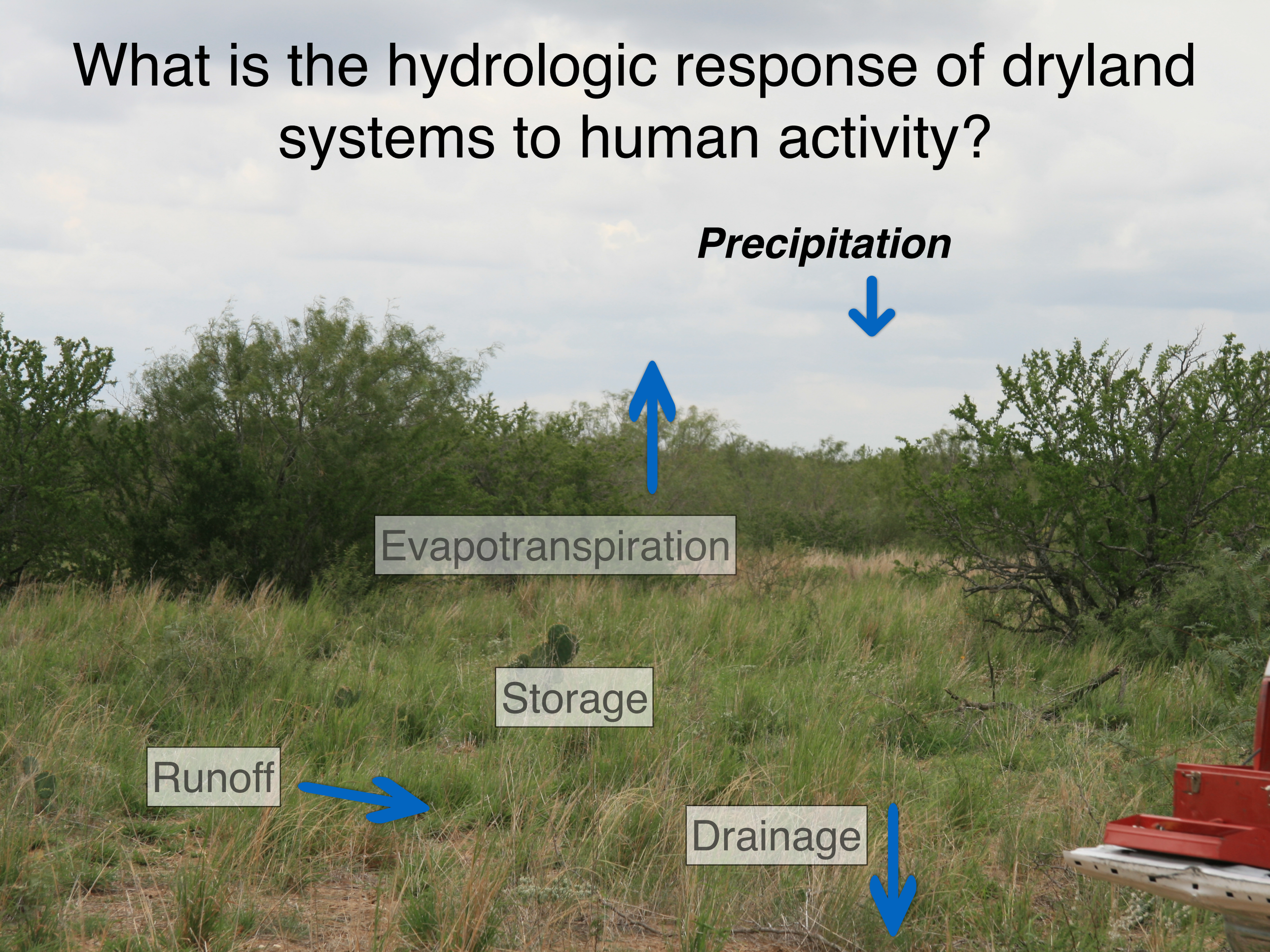

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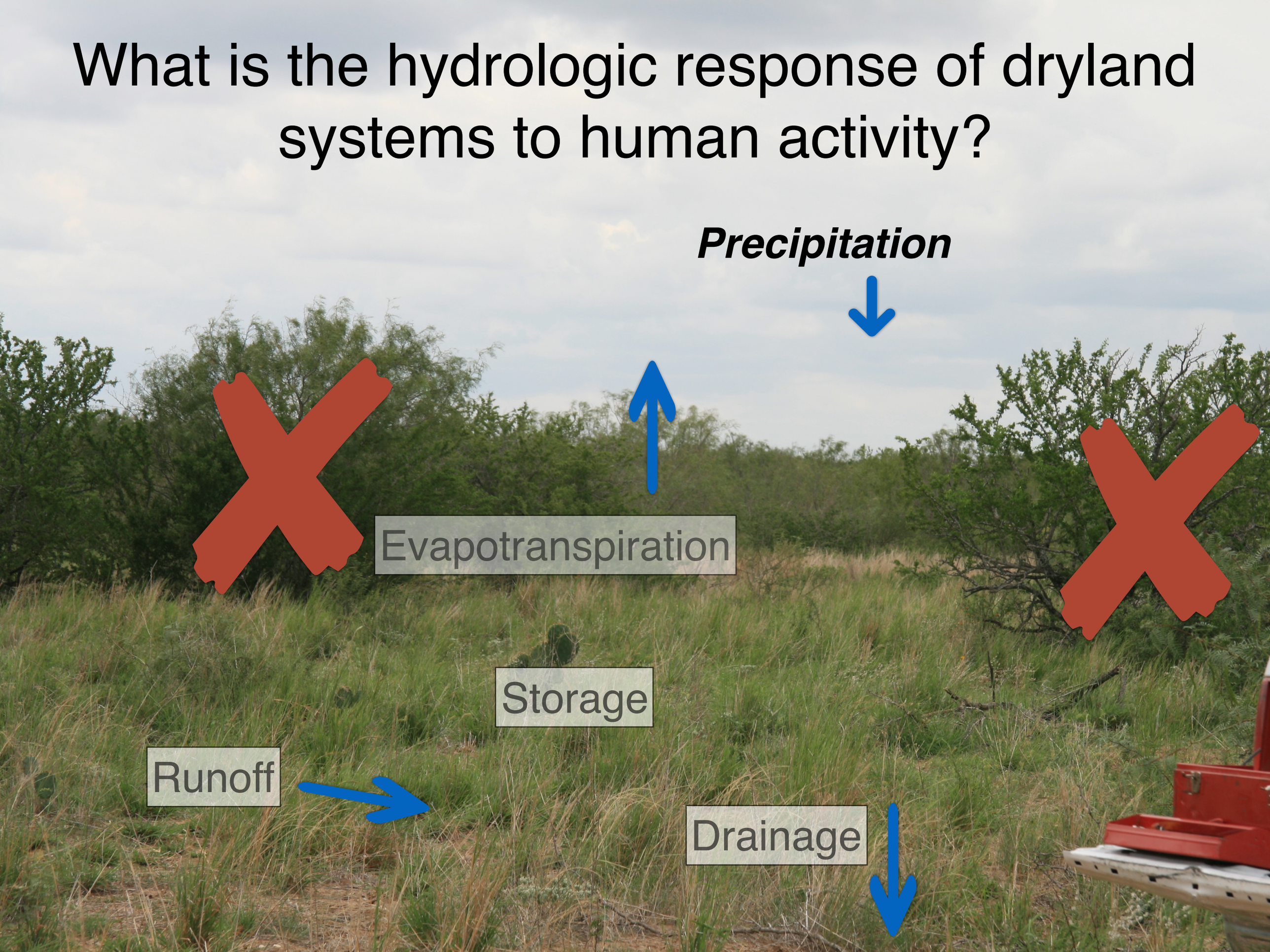


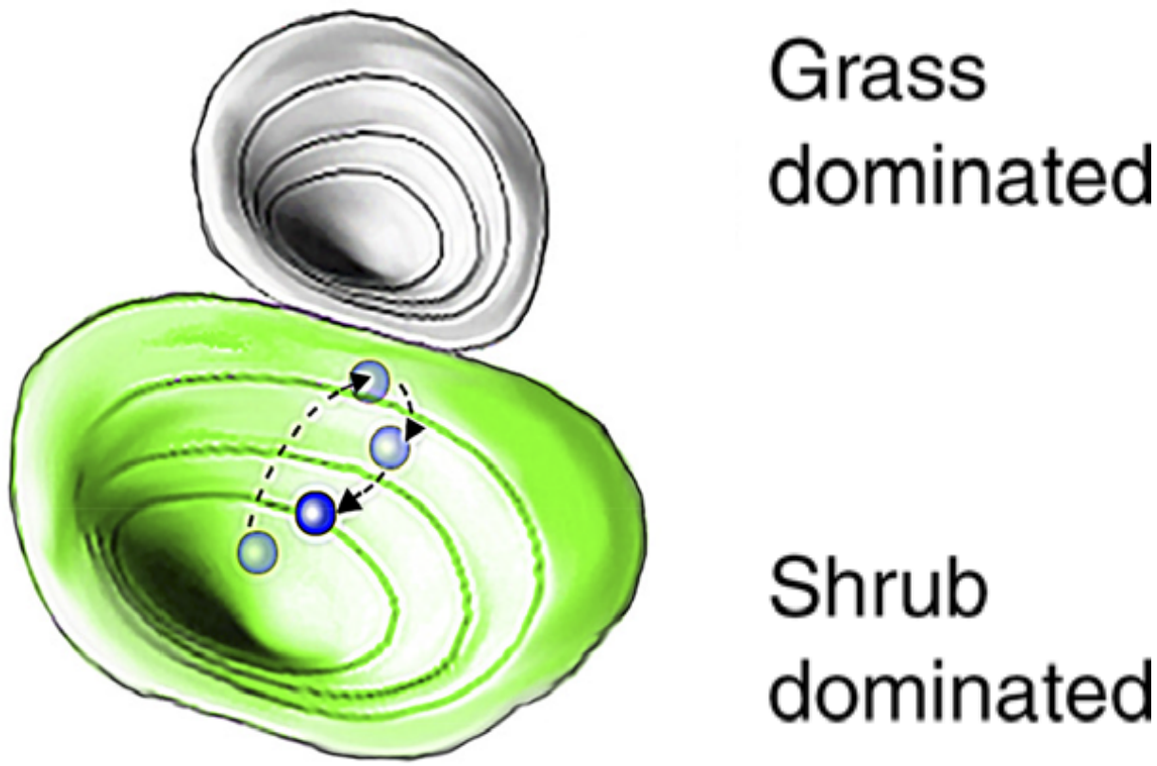
Here we pose the following questions:

1. Is ecosystem resilience dependent on state factors*, specifically soil texture?

2. If so, what are the underlying mechanisms and consequences for soil water?

*Amundson & Jenny.1981.BioScience

Resilience: the capacity to absorb disturbance and remain within the current domain of attraction*

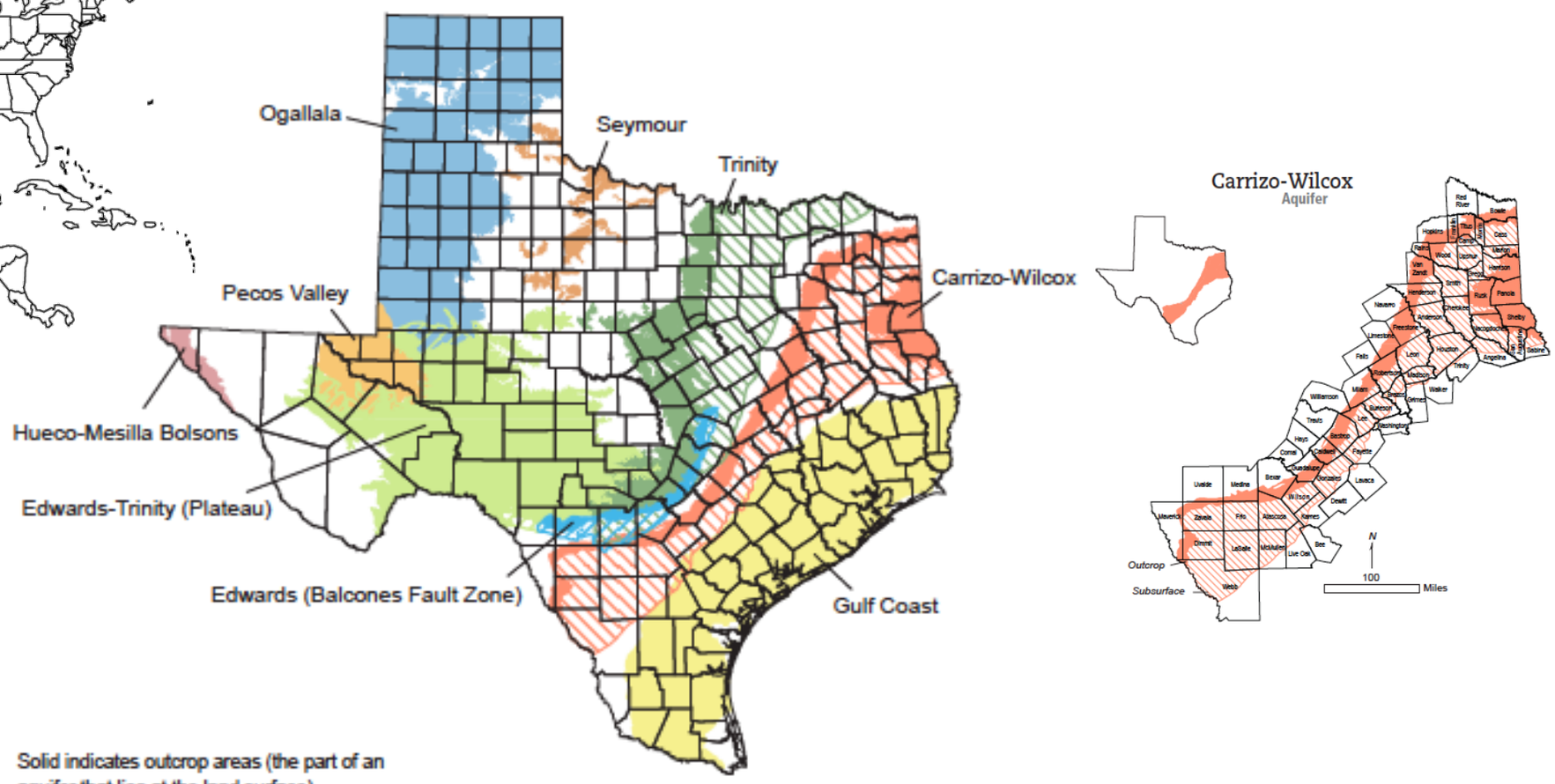


here defined with respect to vegetation structure

*Holling.1973.ARES

System: subtropical Prosopis-Acacia woodland

Location - south Texas, USA



Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).
Hatched indicates subsurface areas (the part of an aquifer that lies or dips below other formations).

Figure 2-1.
The major aquifers of Texas

Soils and climate

ABC - *"Antosa-Bobillo association*, gently undulating. This association consists of deep, sandy soils on uplands. Slopes range from 0 to 5 percent but are mostly 2 to 3 percent."

Table 1a. ABC surface soil texture (measured; 0-20 cm)

Soil	Pasture	Sand (%)	Silt (%)	Clay (%)
ABC	NBW	80.73	5.04	14.22
	MAT	74.09	9.35	16.56
	VAT	79.52	5.14	15.34

Sandy

WEB – "*Webb fine sandy loam*, gently undulating. This deep, loamy soil is on uplands. The surface is plane to convex. Slopes range from 0 to 3 percent, but they are mostly less than 2 percent."

Table 1b. WEB surface soil texture (measured; 0-20 cm)

Soil	Pasture	Sand (%)	Silt (%)	Clay (%)
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Sandy loam

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Table 1c. CKB surface soil texture (measured; 0-20 cm)

Soil	Pasture	Sand (%)	Silt (%)	Clay (%)
CKB	NBW	43.18	13.32	43.49
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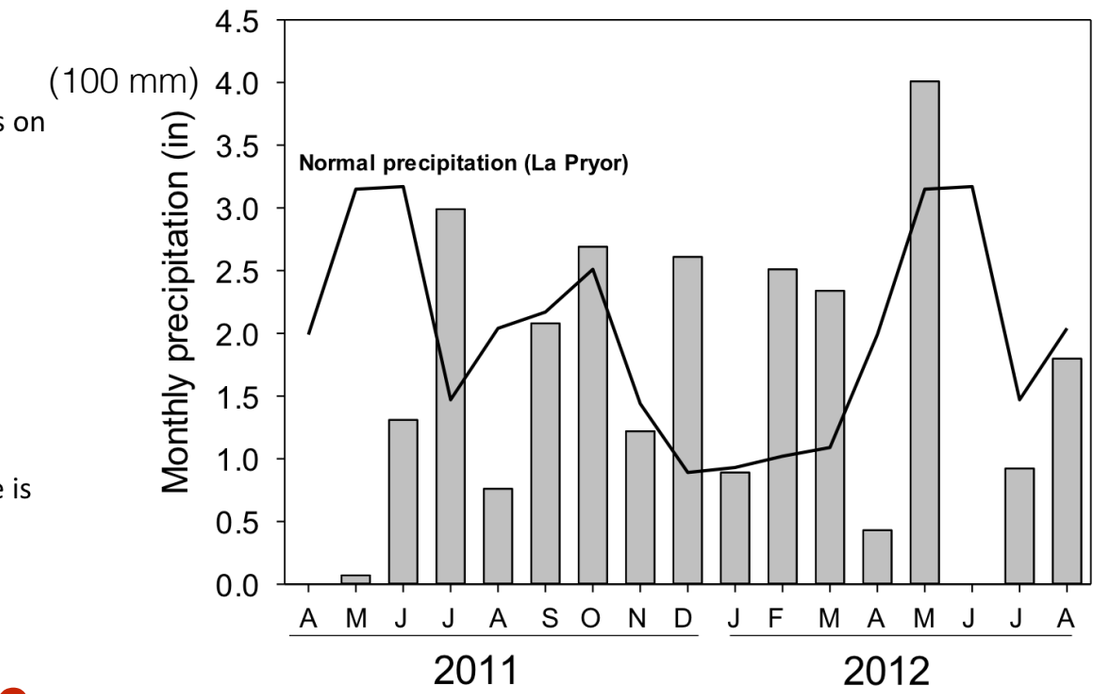
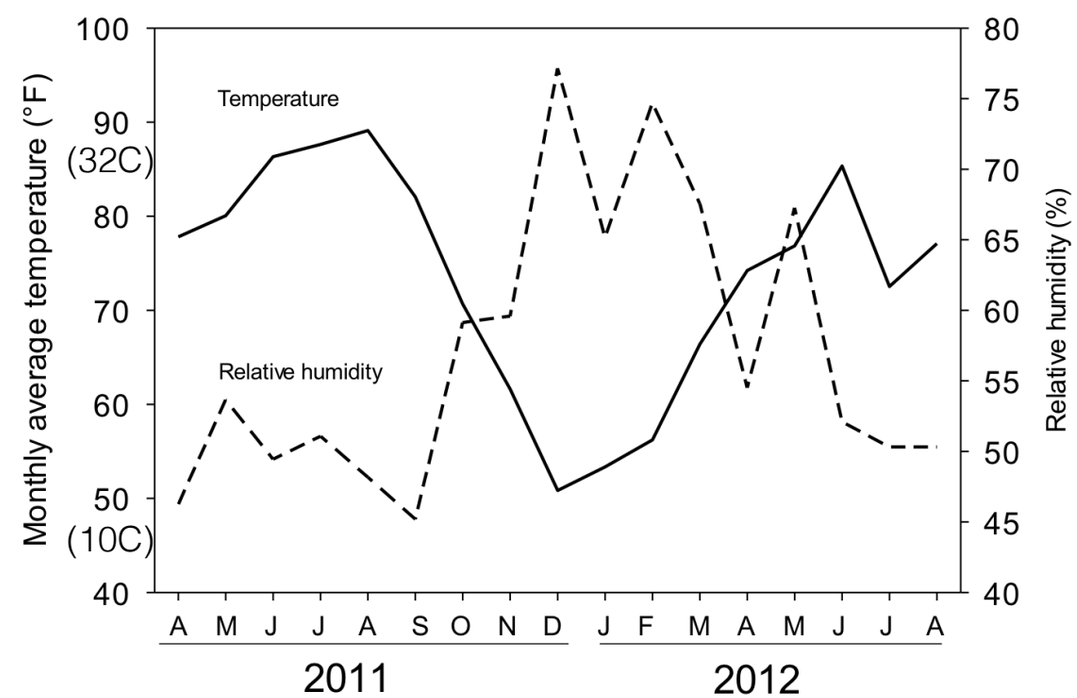
Clay loam



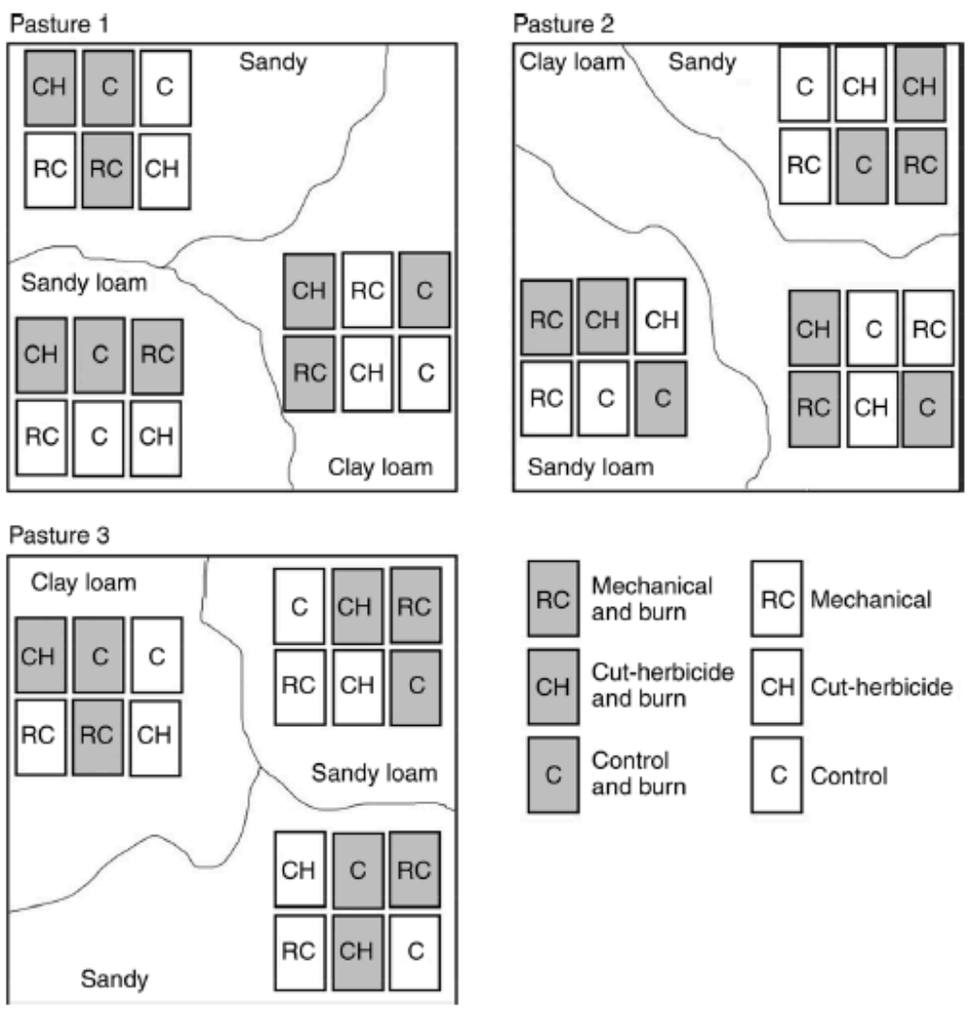


Experimental design

C,U | C-S,B
R-C,B | C,B
C-S,U | R-C,U

x 3 soil types x 3 replicates

All plots ~0.1 ha



Wonkka et al.2016.Ecoloical Applications

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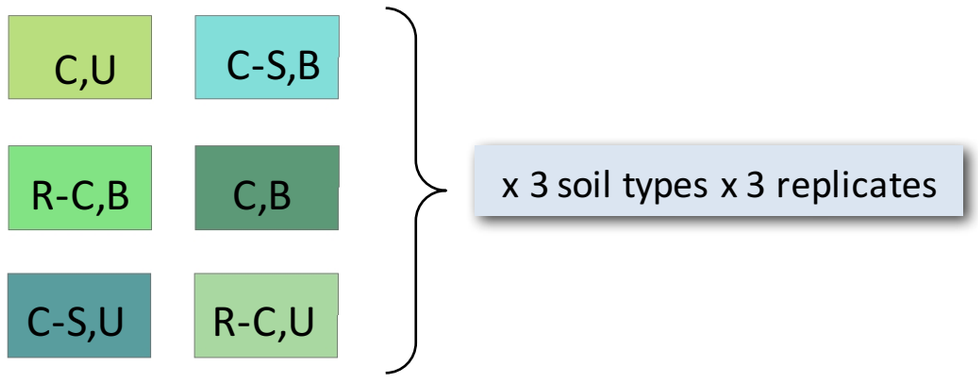

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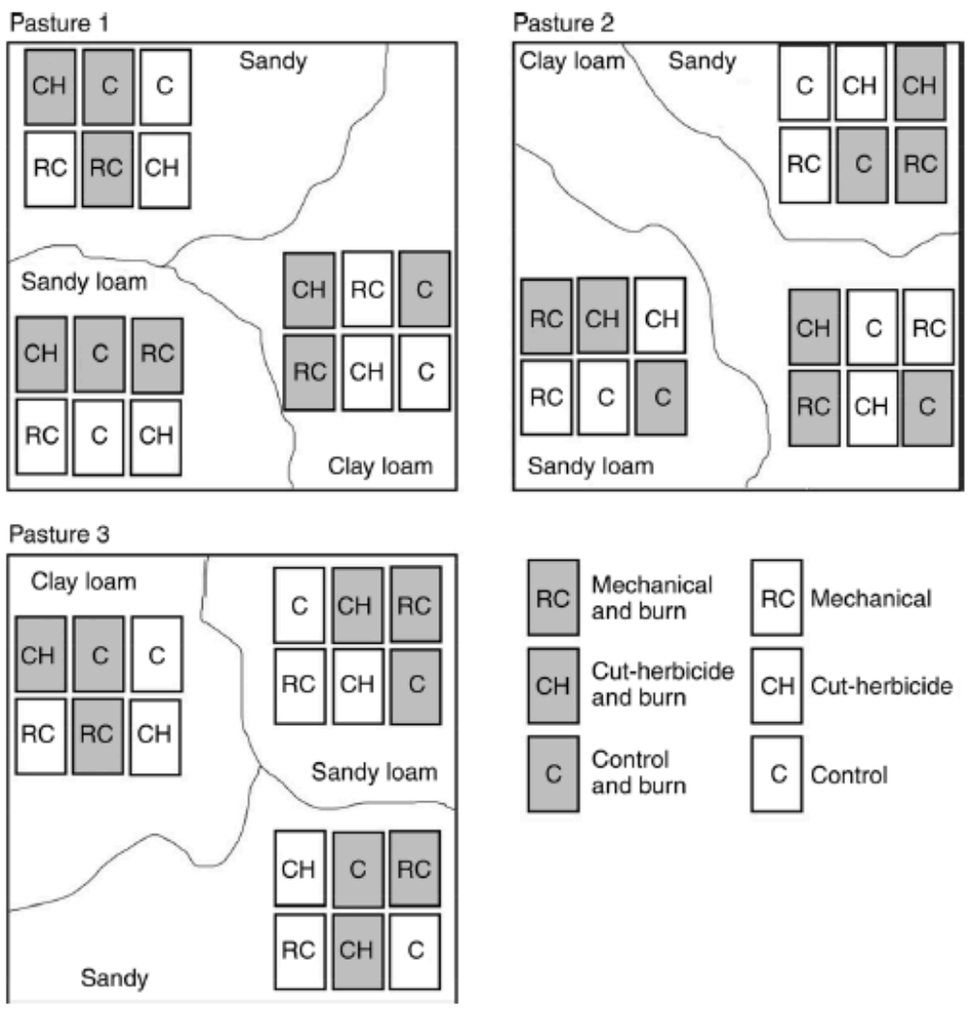


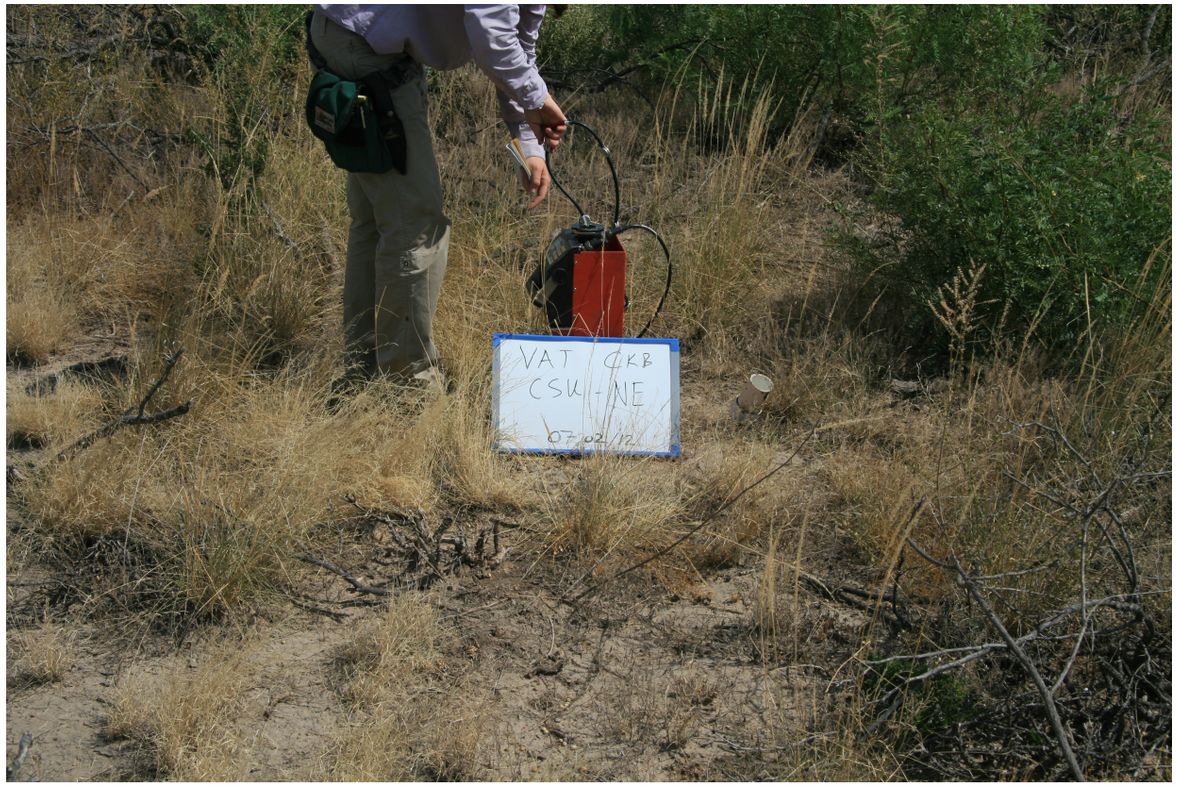
Wonkka et al.2016.Ecoloical Applications

Vegetation sampling: cover, stem counts, species composition

Soil sampling (2011 & 2012):

Neutron moisture meter
monthly, all plots, 20 cm inc., to ~180 cm

Water isotopes
once, control plots, 20 cm inc., to ~180 cm



Quick primer on stable isotopes

$$R = \frac{\text{heavy isotope}}{\text{light isotope}}$$

what do we mean by ratio

the oxygen example

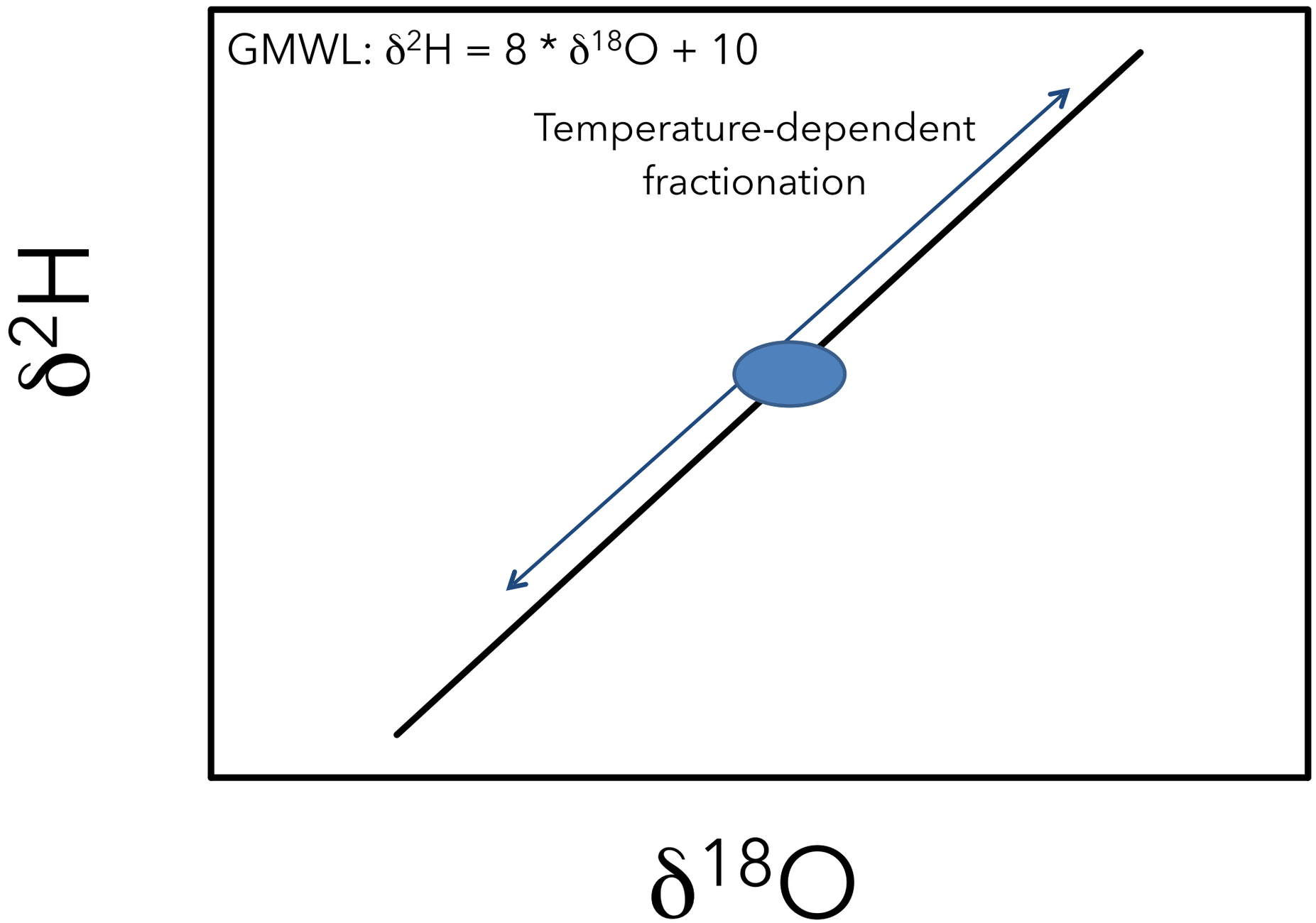
$$R = \frac{^{18}O}{^{16}O}$$

isotope ratio is presented in delta notation (δ)

$$\text{Isotope ratio} = \left(\frac{R_{sample}}{R_{standard}} - 1 \right) \bullet 1000\ ‰$$

Stem & leaf water extracted and analyzed for δ^2H and $\delta^{18}O$

Global Meteoric Water Line – isotope hydrology



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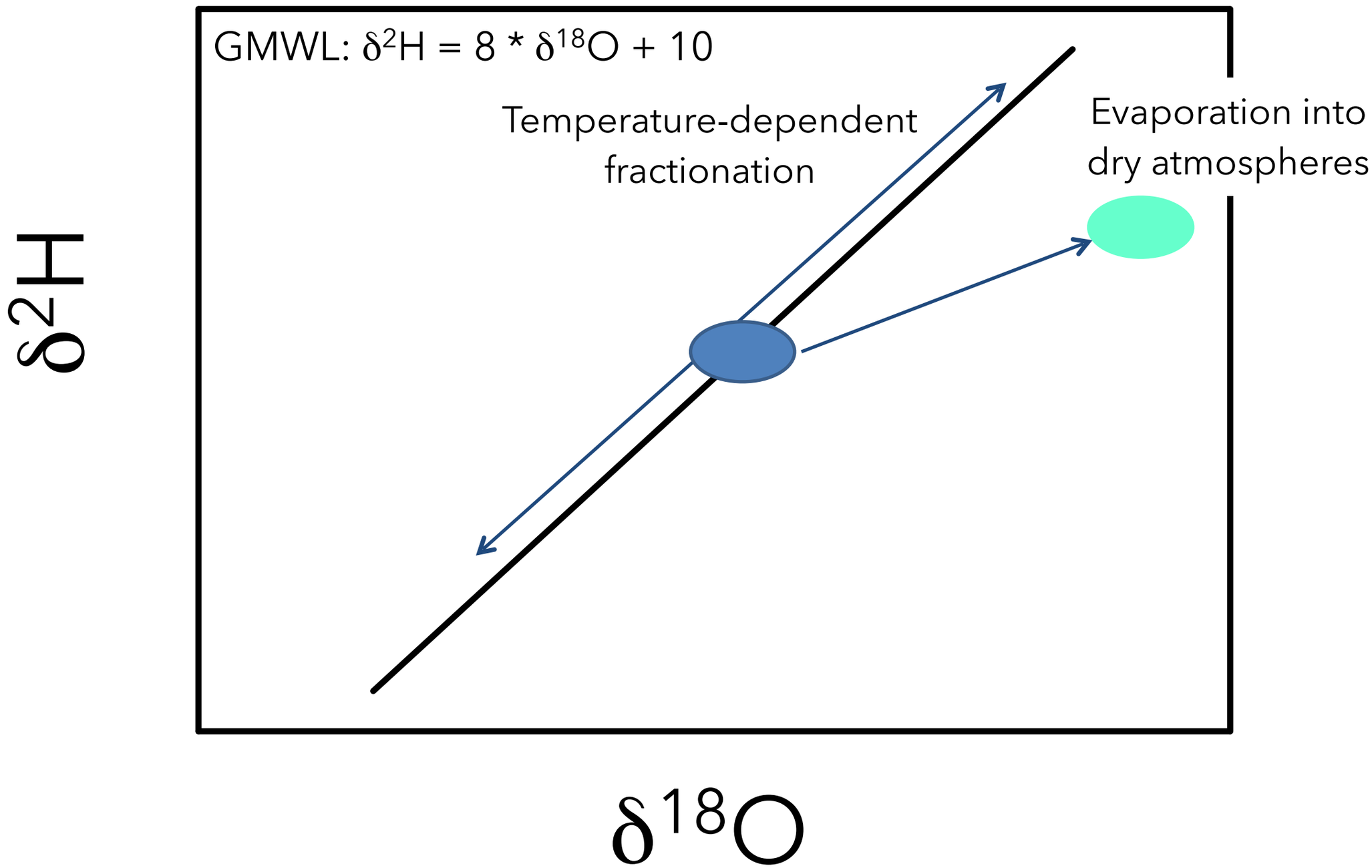

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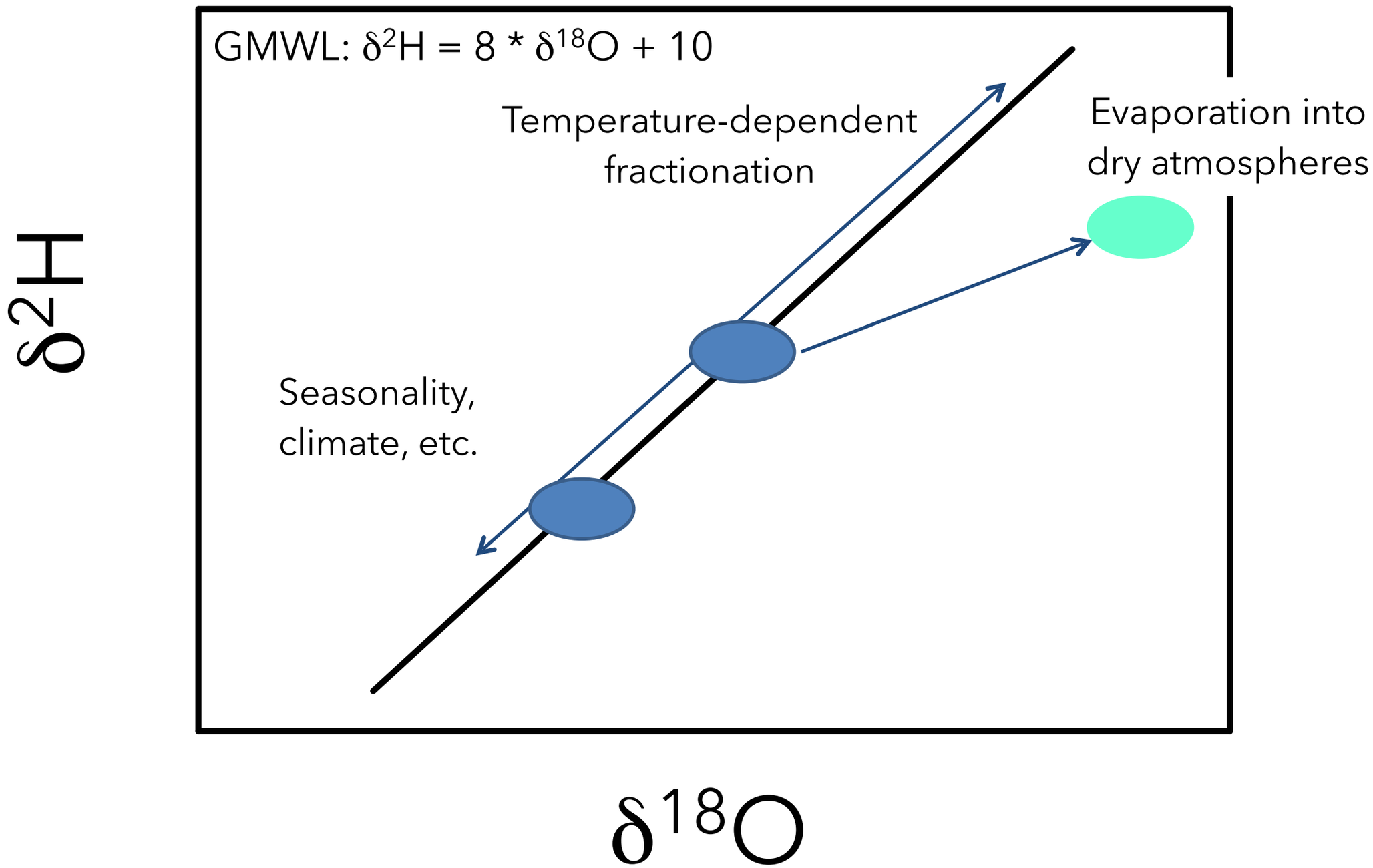

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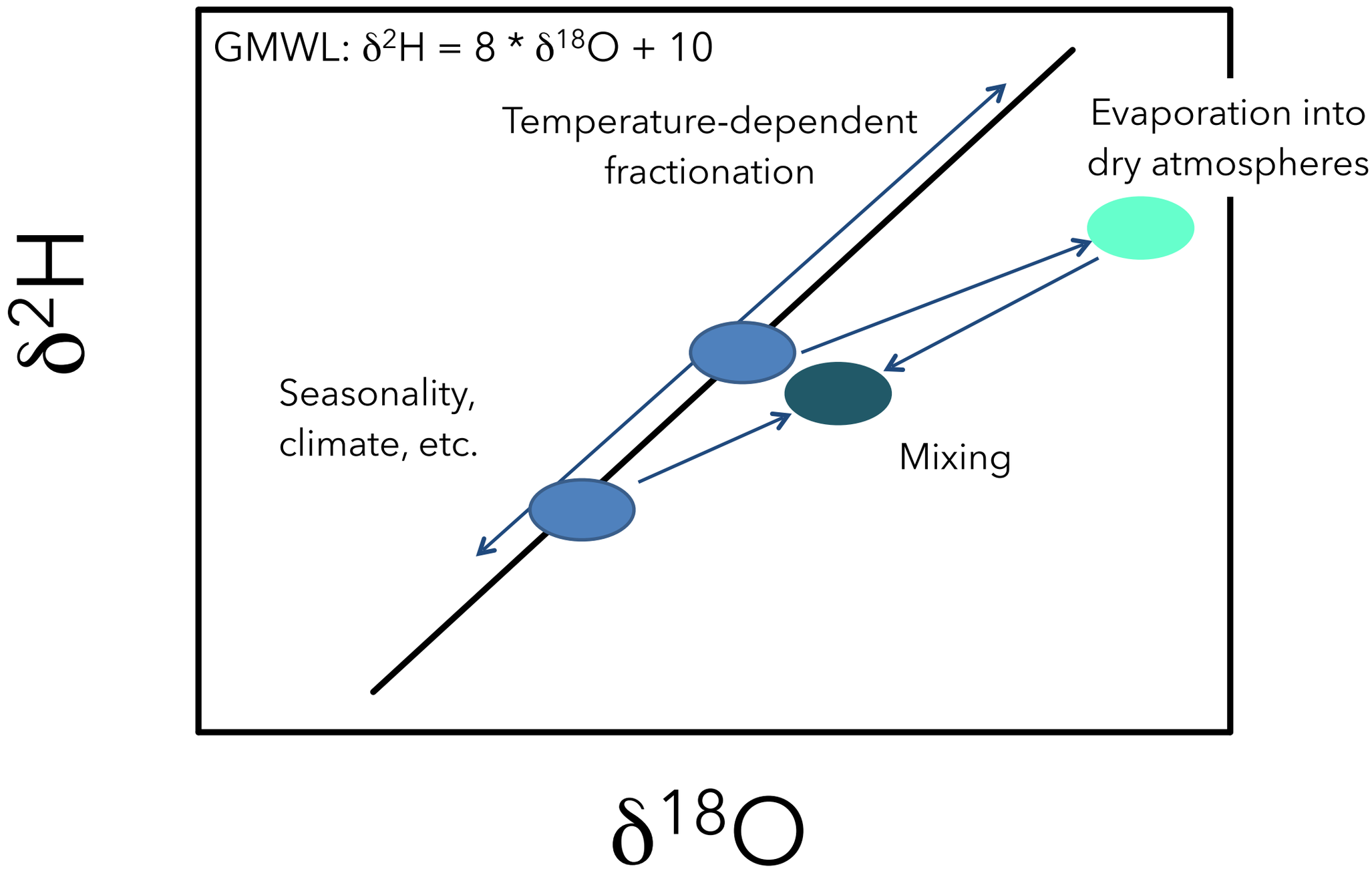
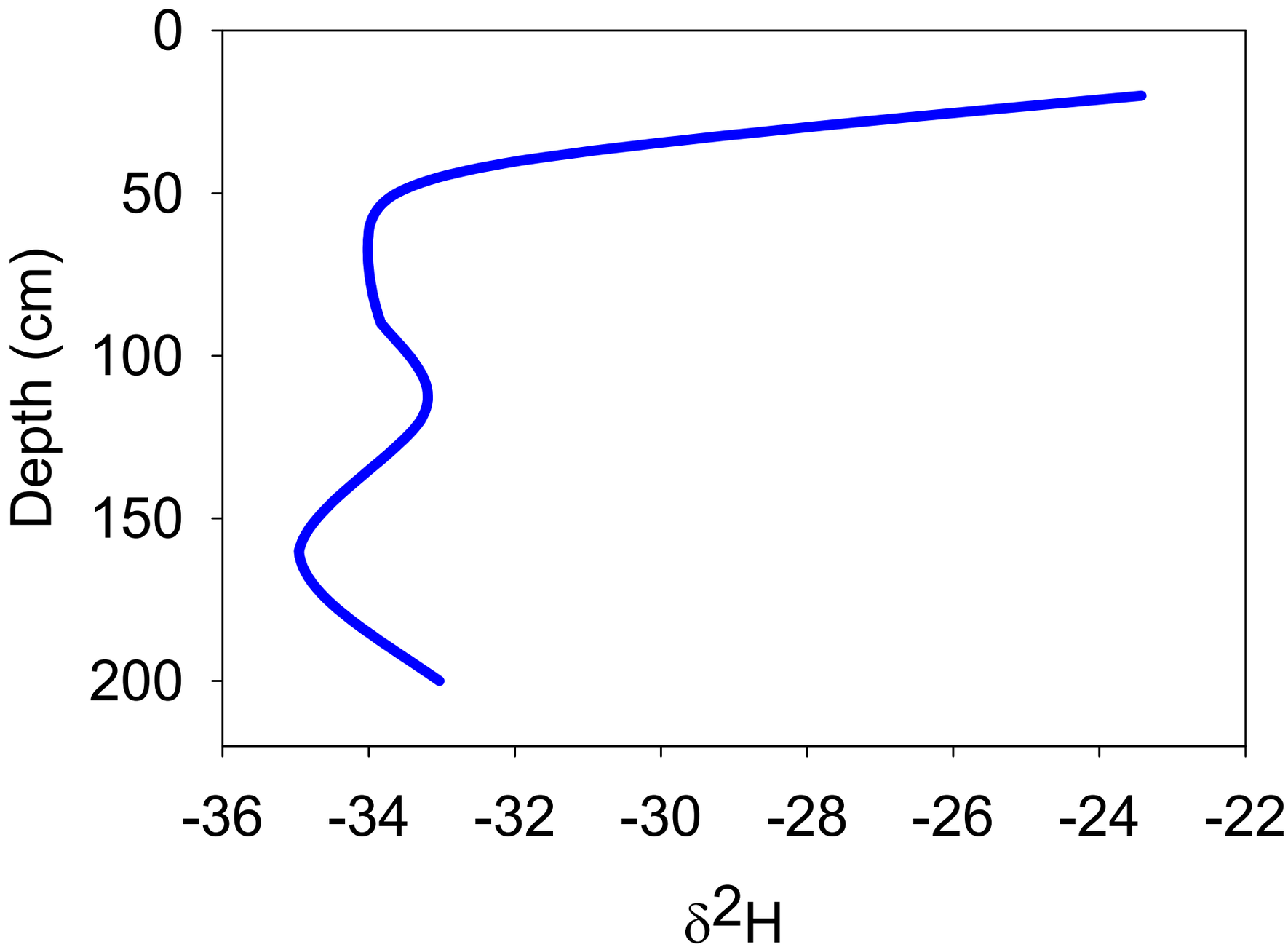


Result for isotope ratios of soil water (generalized)




OK, what did we observe in this experiment?
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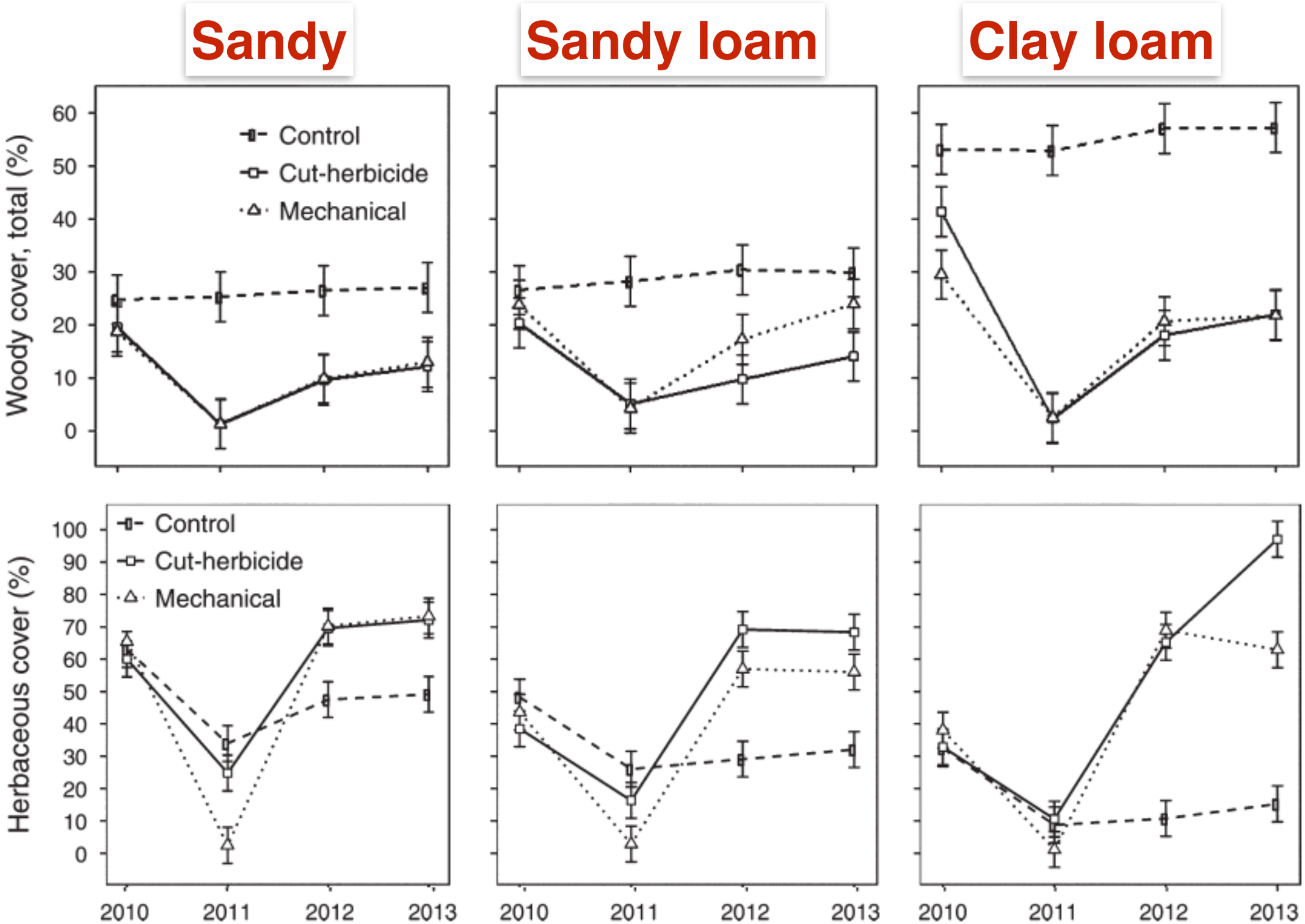
Ecosystem resilience depended on soil type



Resilience depended on soil type, ***not*** disturbance type

clays less resilient - observed stable regime shift

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Can this difference in resilience be explained by soil water?

More broadly, what are the impacts on soil moisture?

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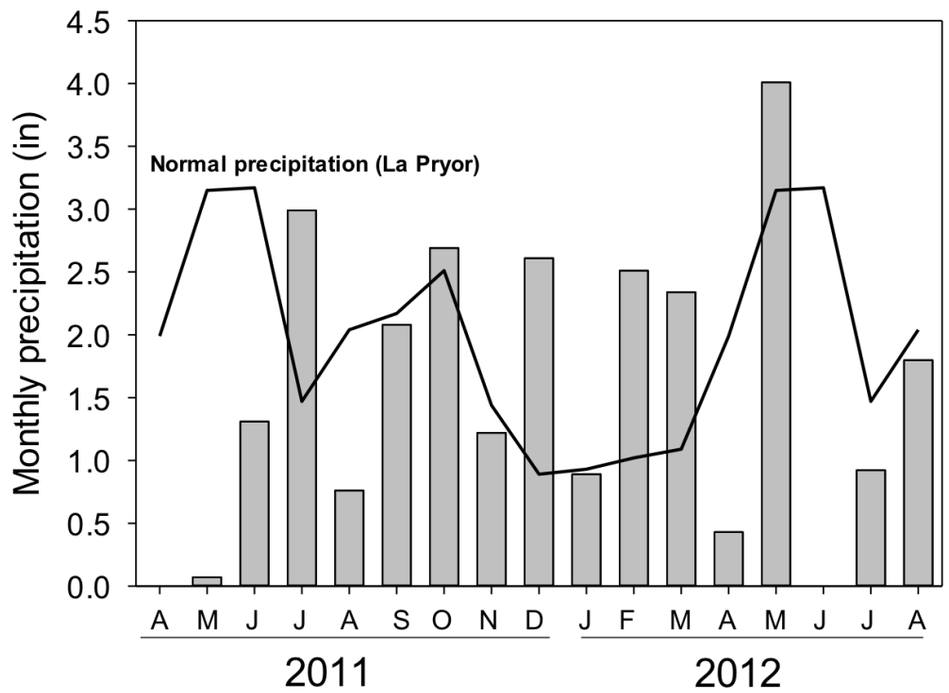

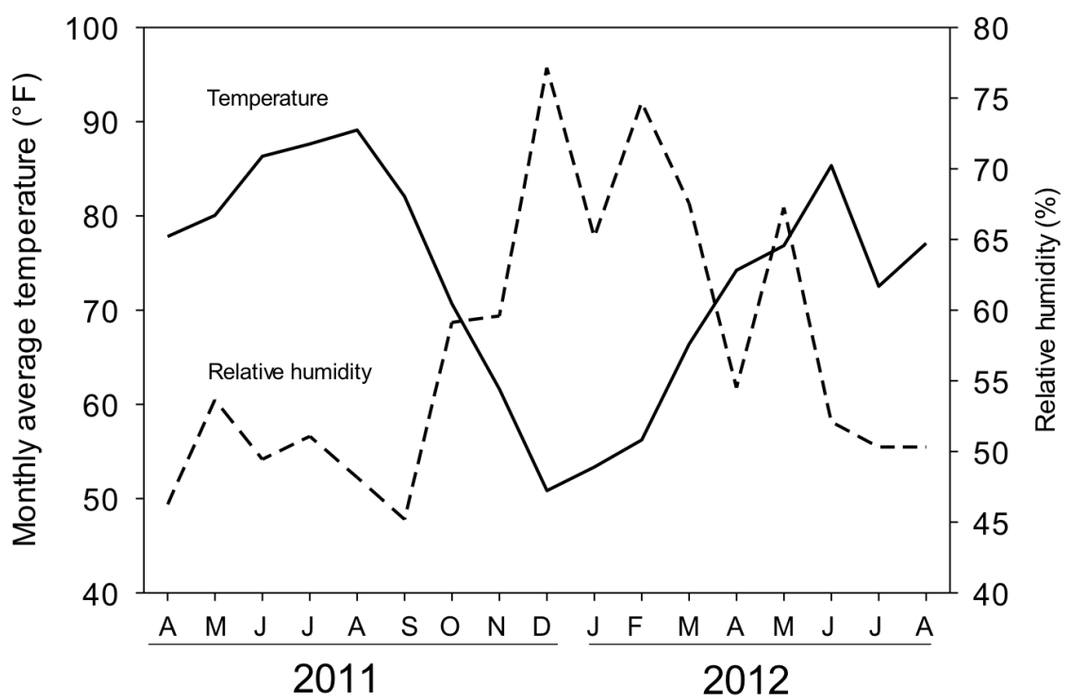

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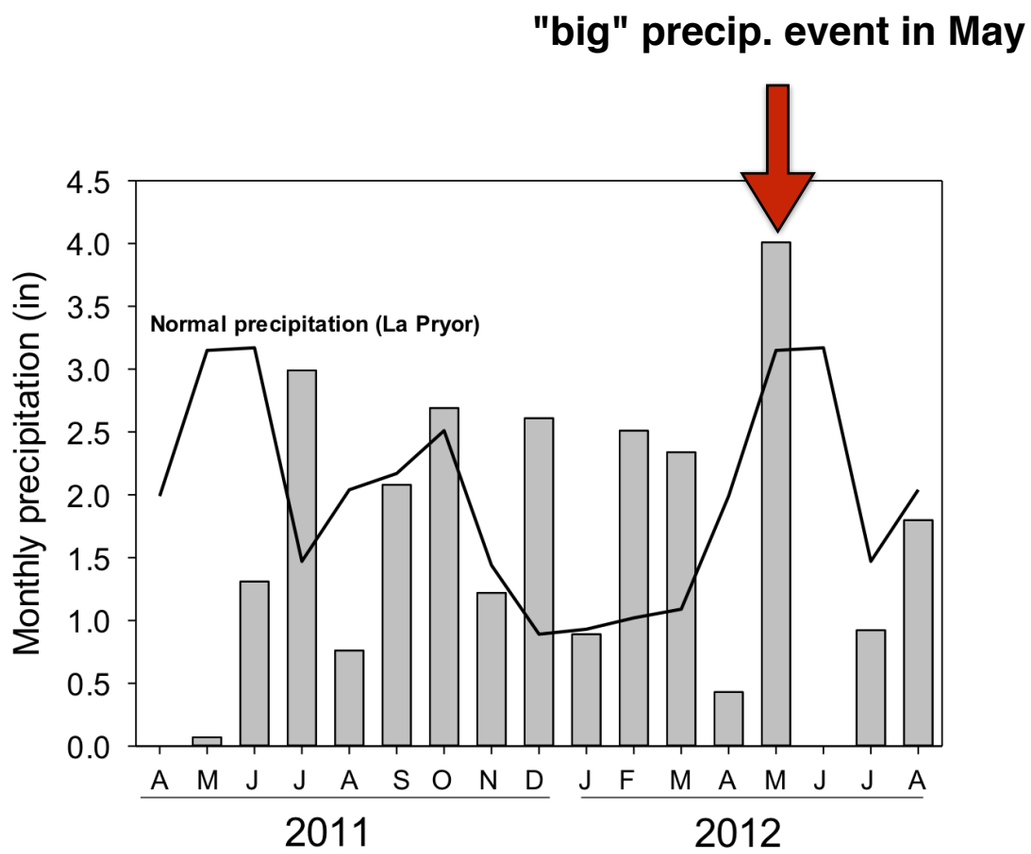

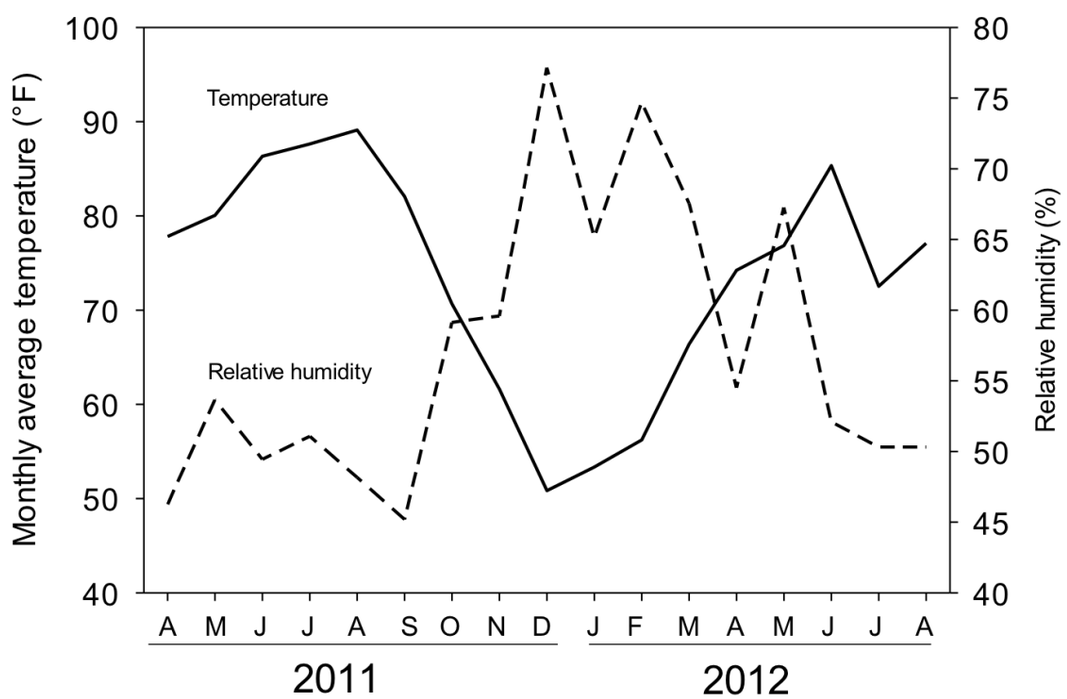

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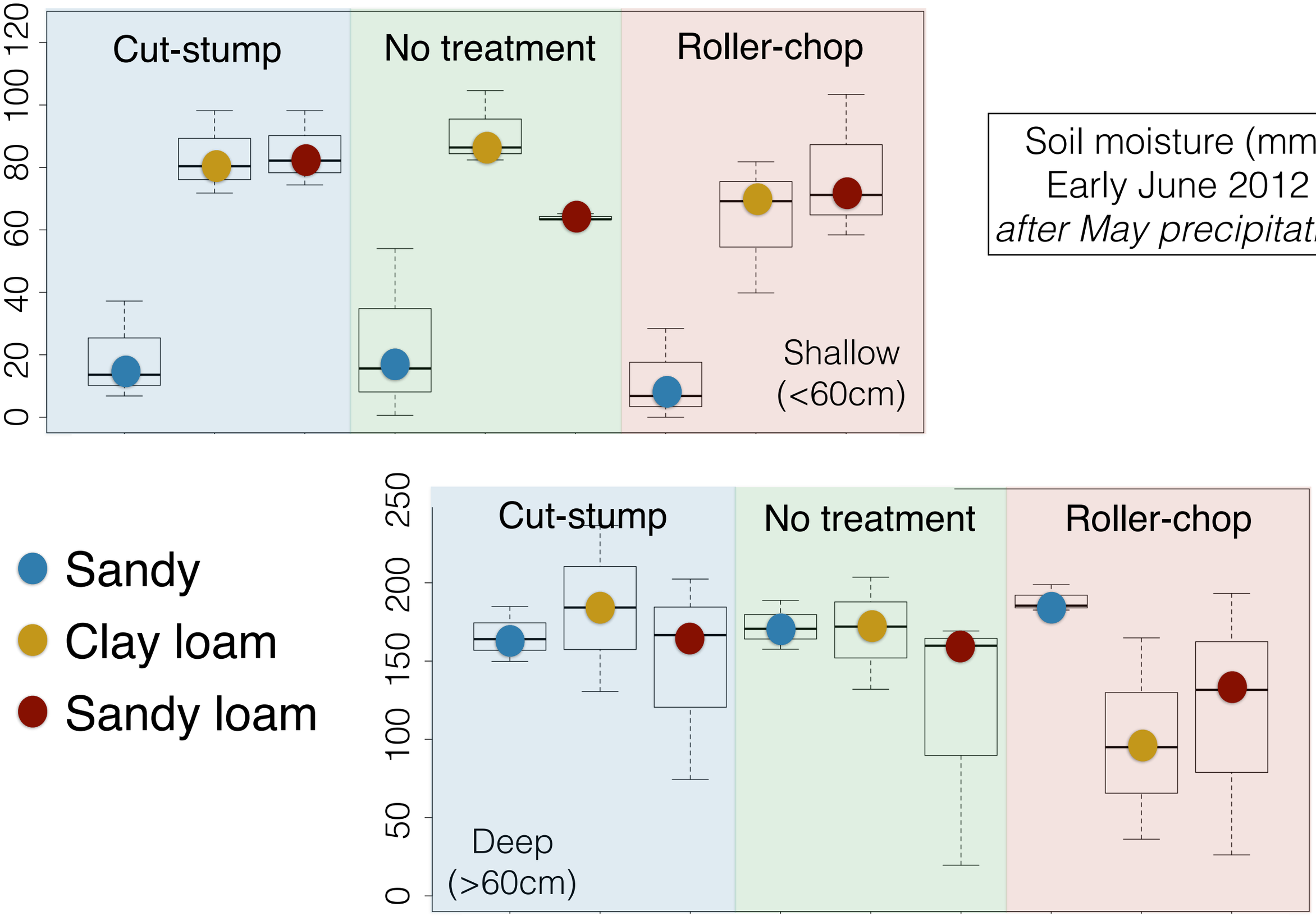
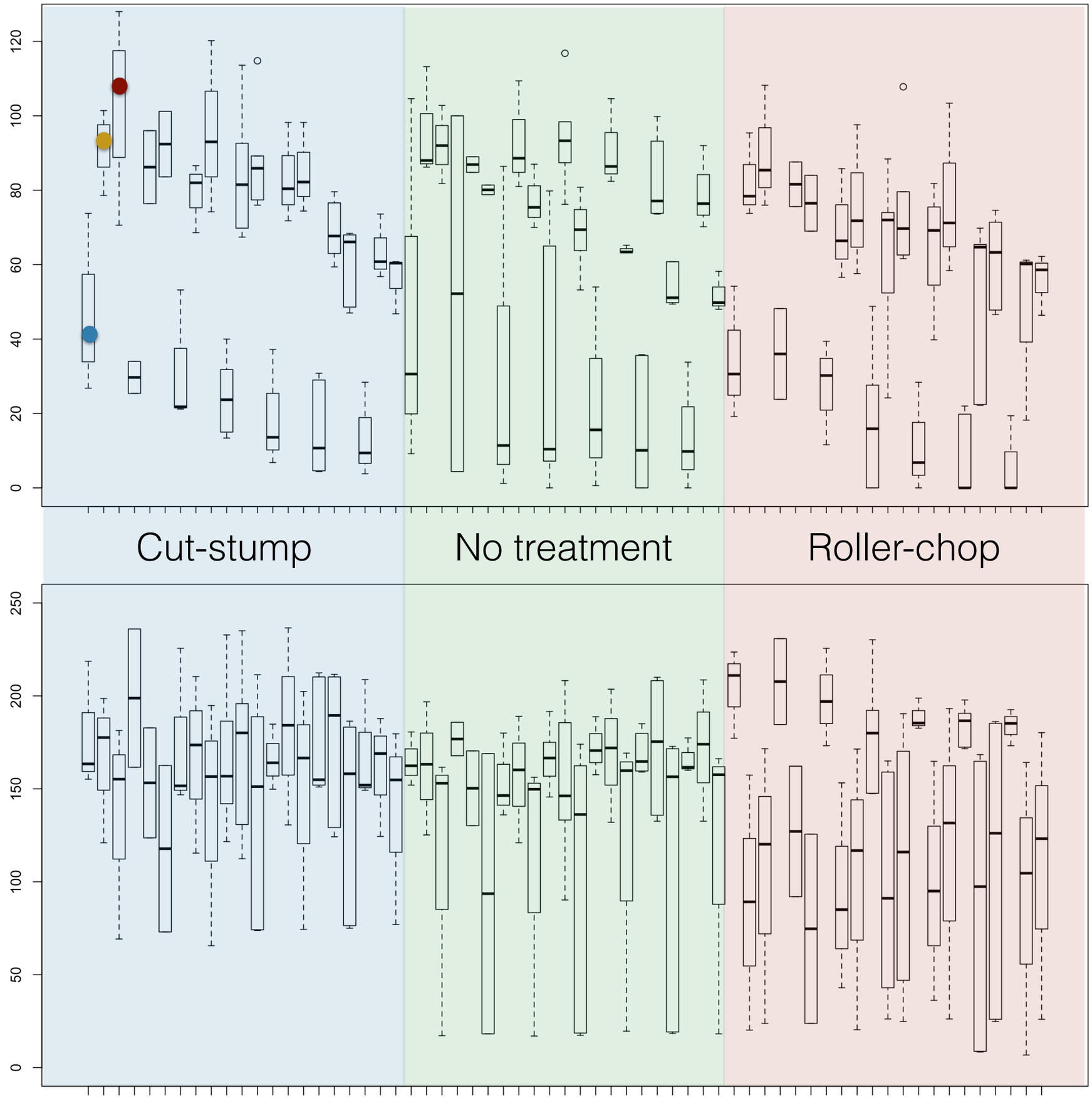
Limited effect on shallow water, R-C caused decline in deep water on clays



Similar patterns observed across months

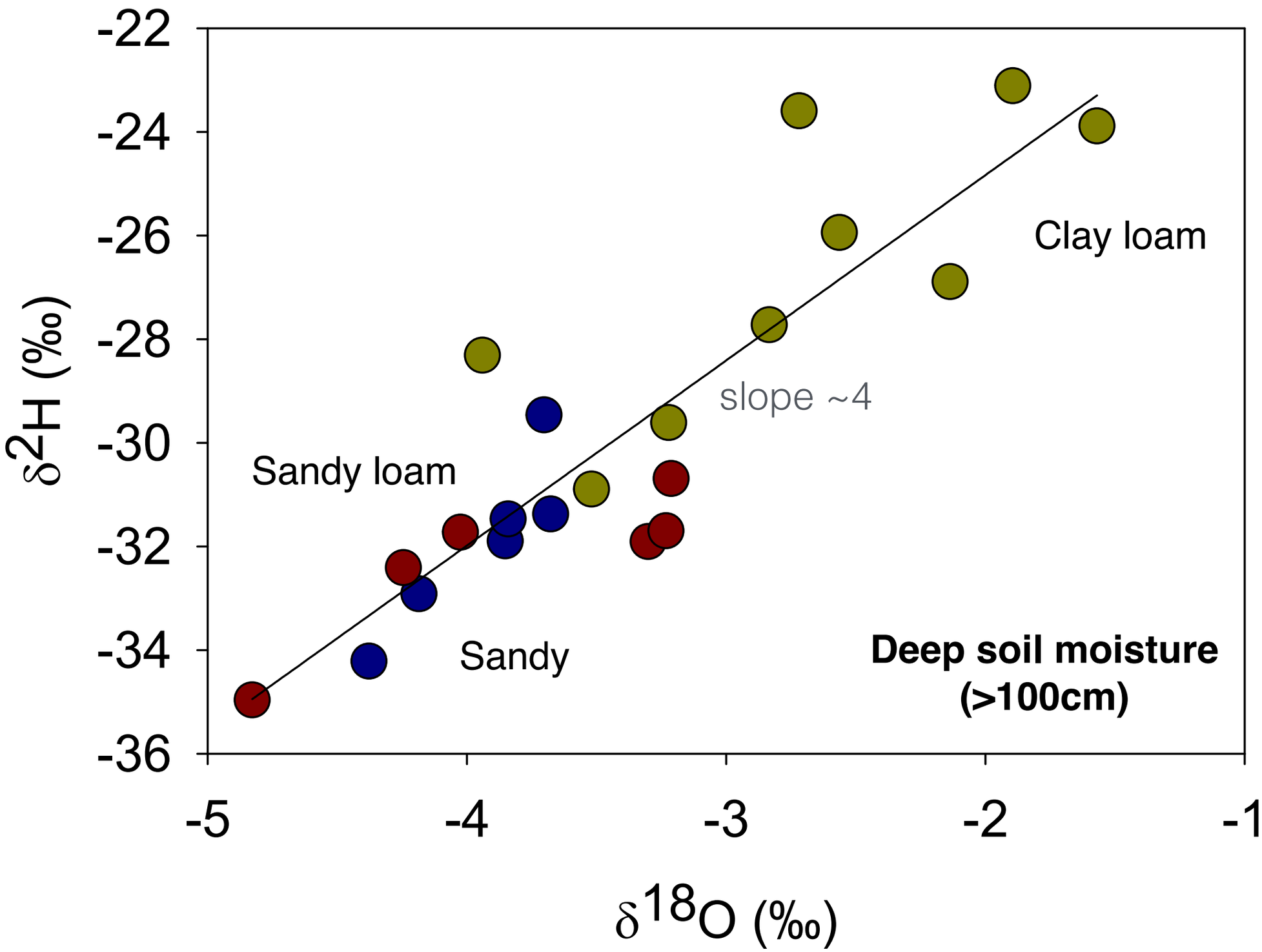


Jan-Sep
2012

Shallow
(<60cm)

Deep
(>60cm)

Isotopes suggest clay soils have distinct hydrology



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suggests additional factors may be important

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While both removal treatments had similar impacts on clay loam vegetation, *no* impact on soil moisture was evident for C-S treatment (-)
suggests additional factors may be important

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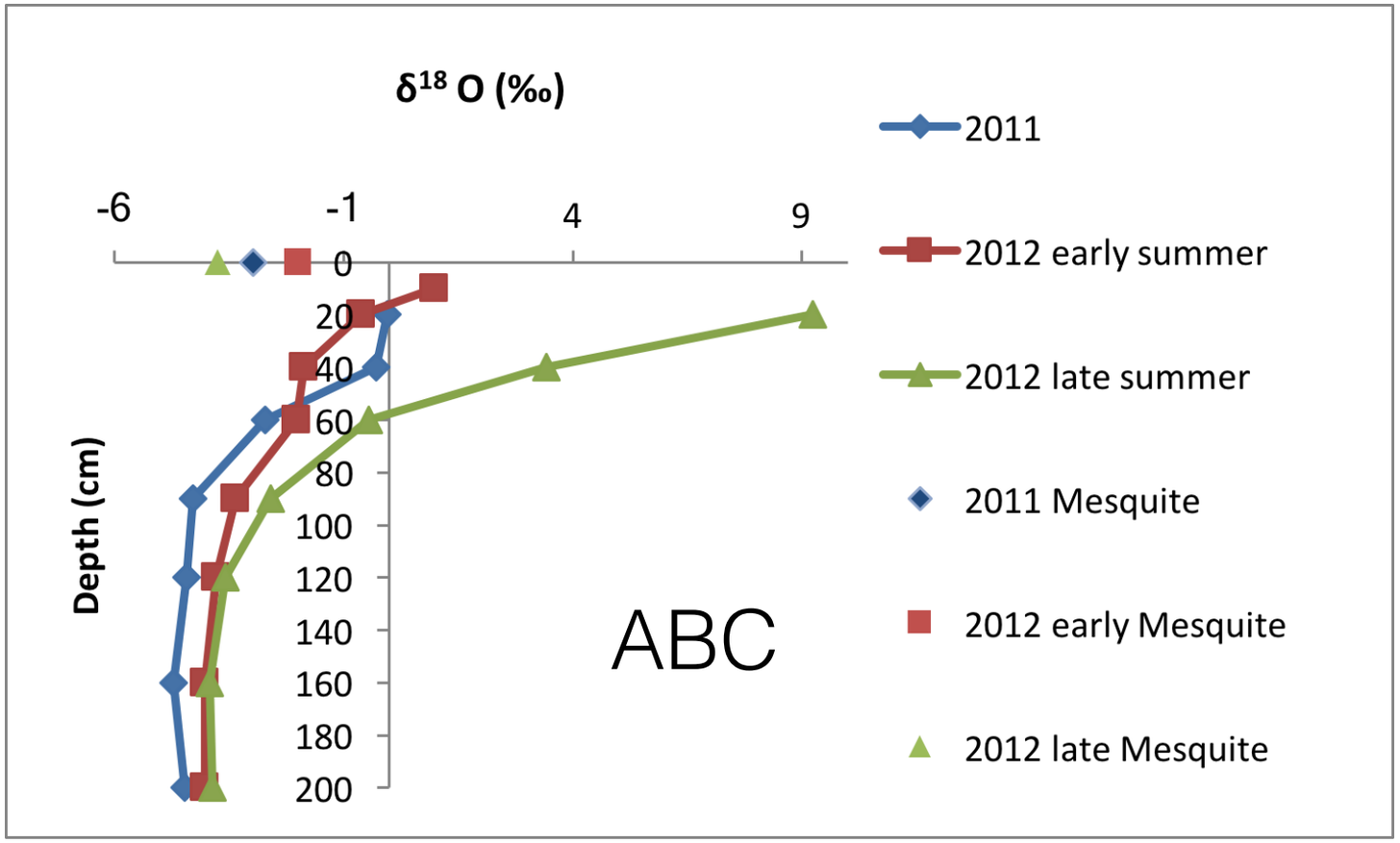
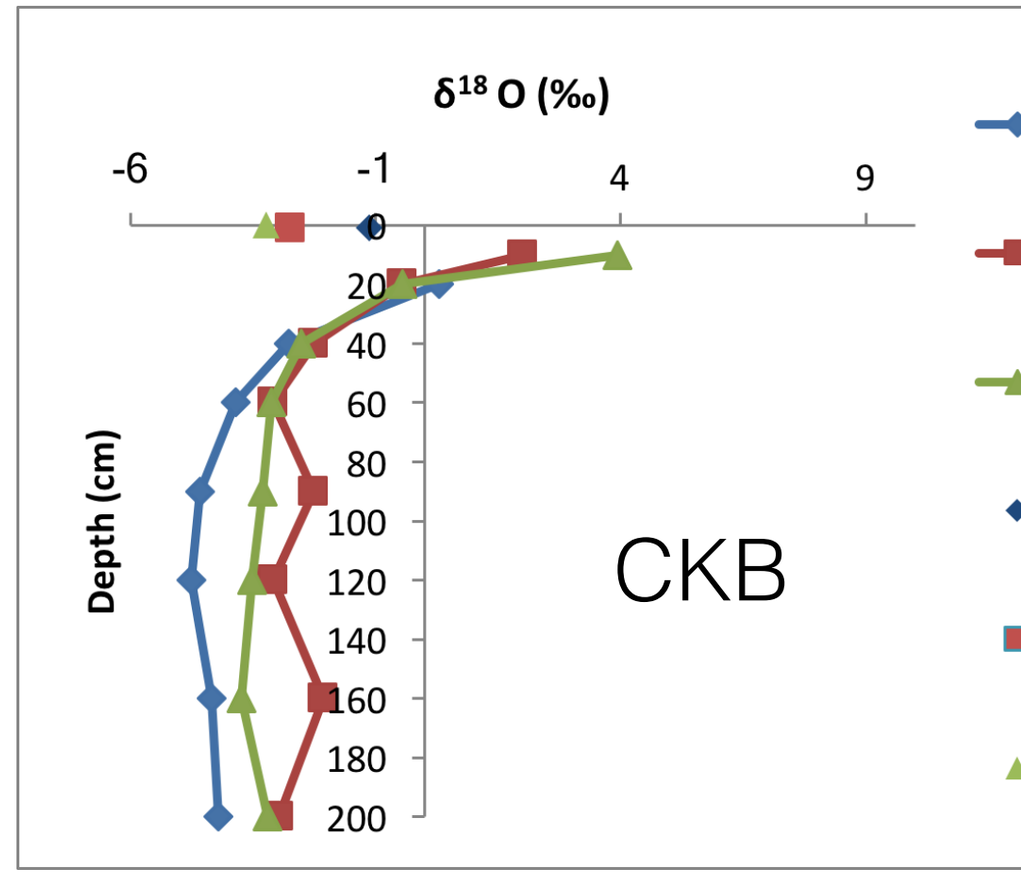
speculate higher hydraulic lift in coarse-textured soils

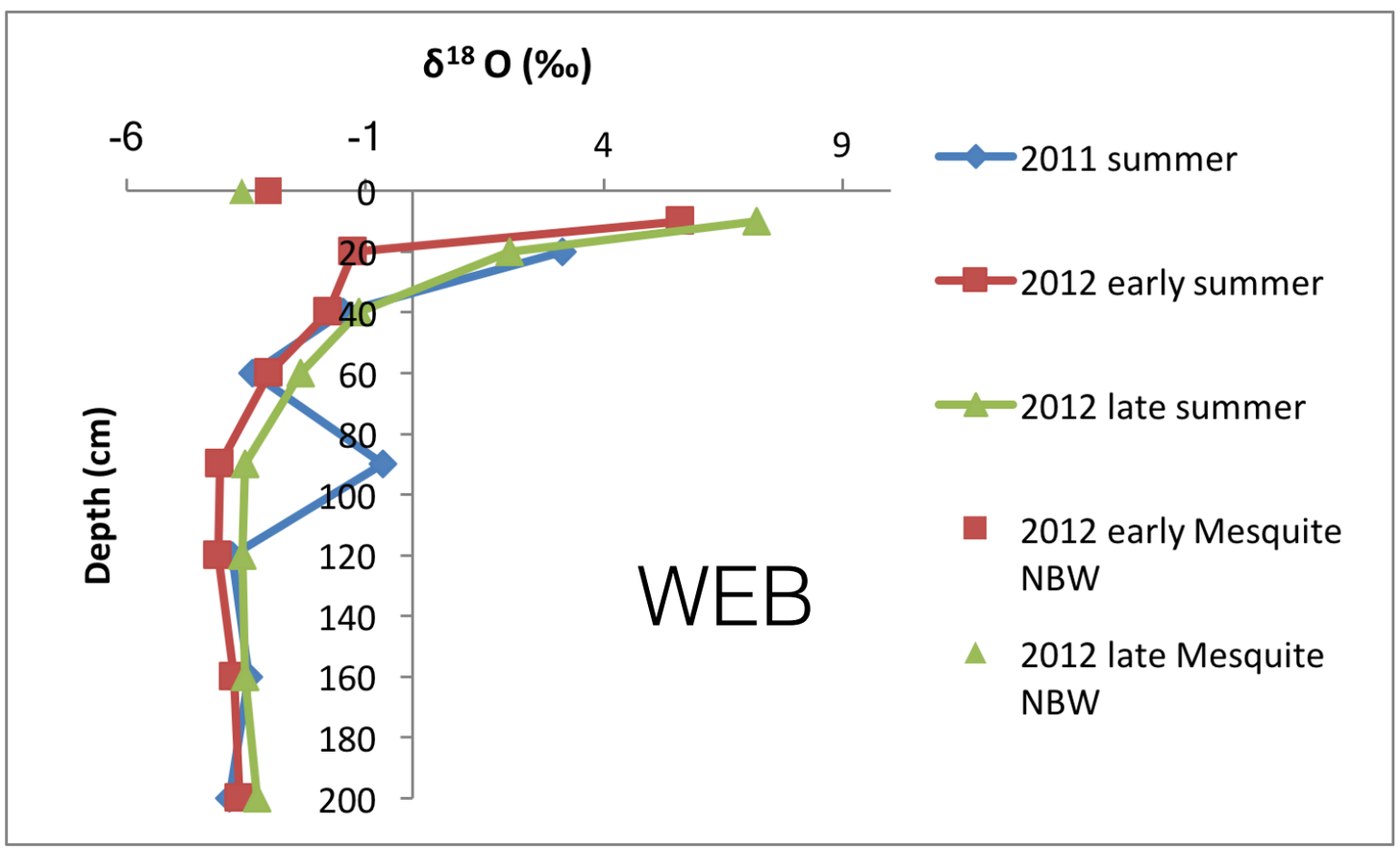
While C-S treatment had *<u>no</u>* apparent impact on soil moisture mean for any treatment, it appeared to attenuate variability

could impact plant water use and other fluxes


Thank you!

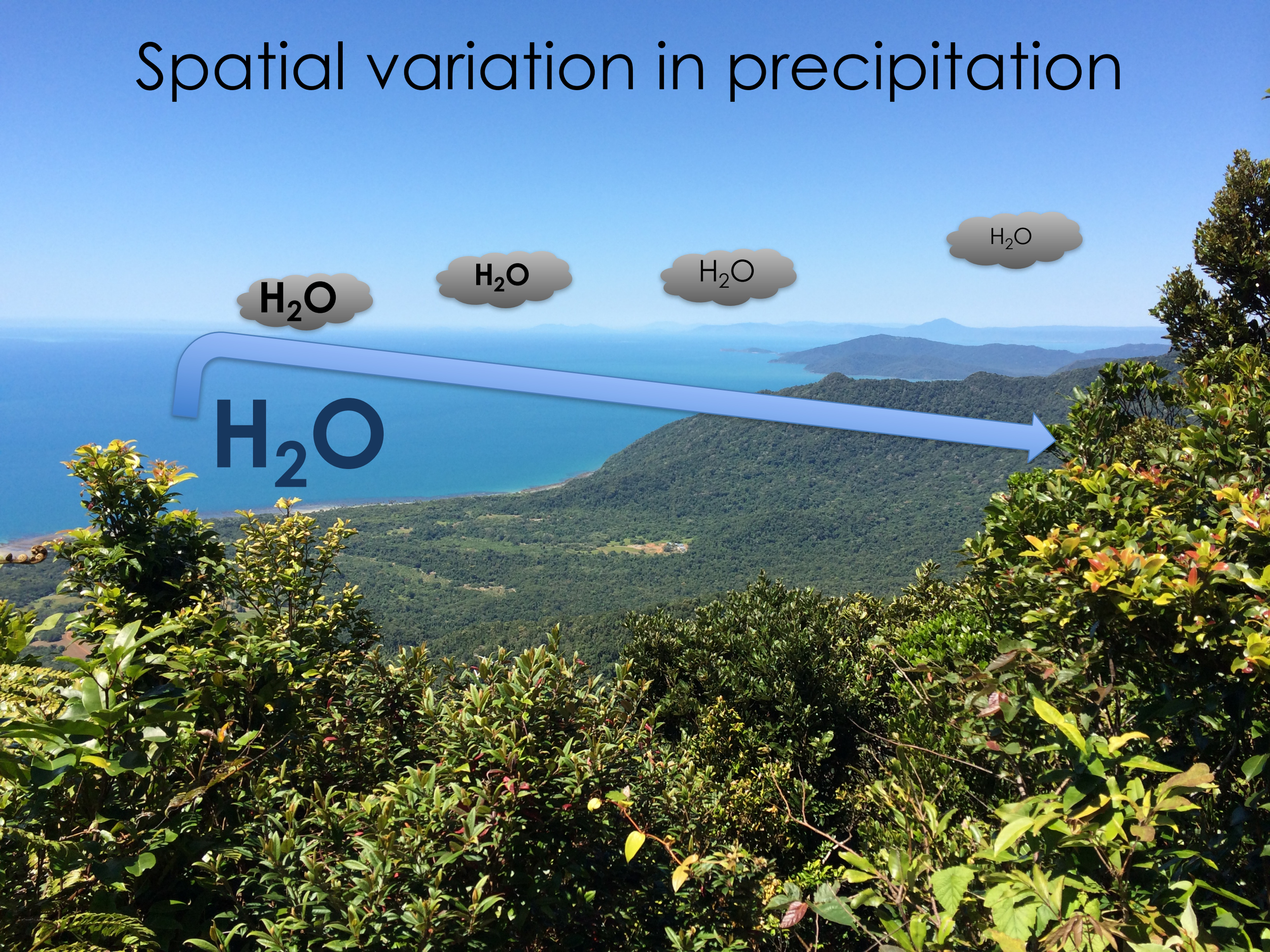






Mesquite deeply rooted

Spatial variation in precipitation



Global observations of meteoric water

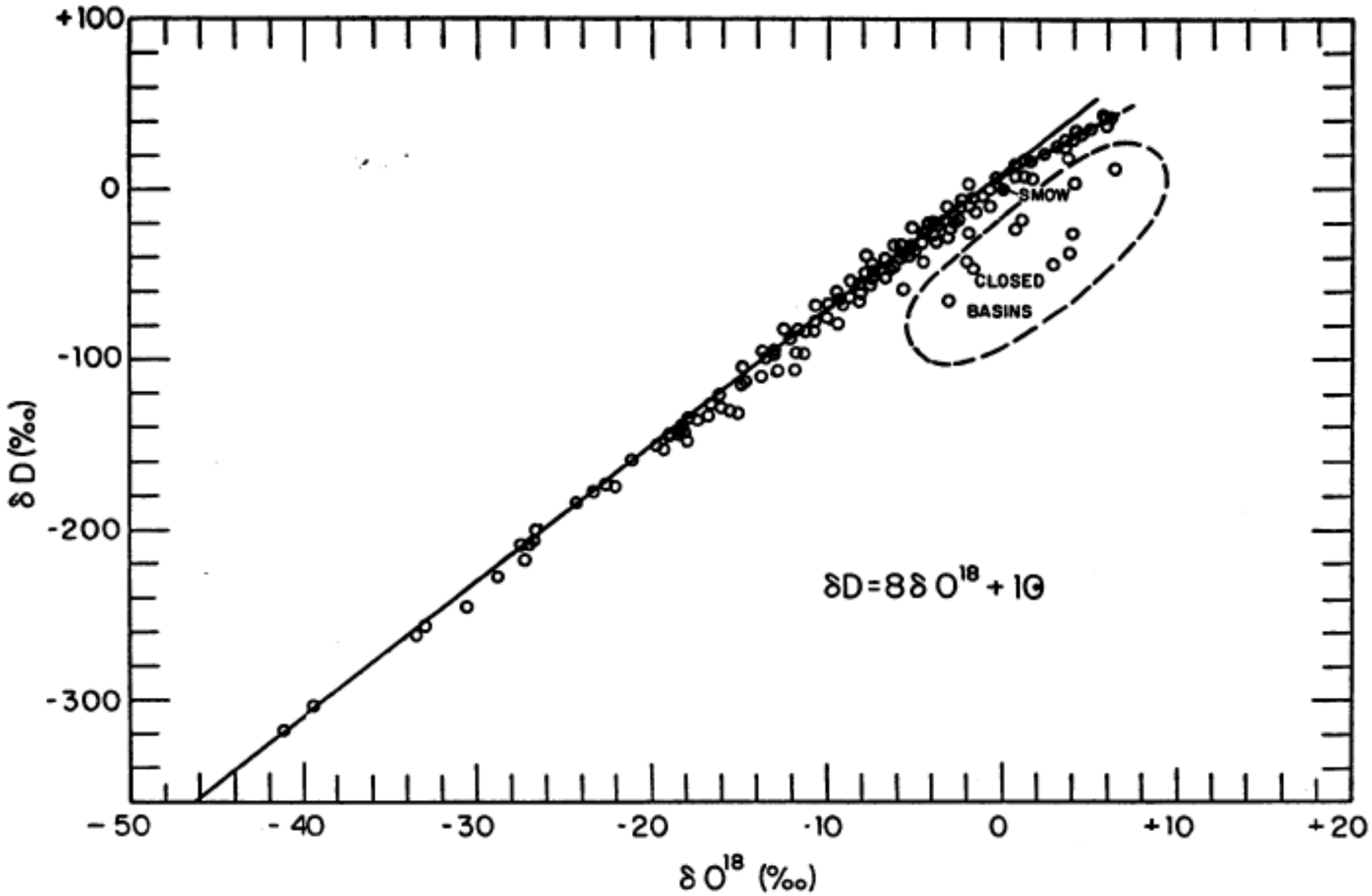


Fig. 1. Deuterium and oxygen-18 variations in rivers, lakes, rain, and snow, expressed as per millage enrichments relative to "standard mean ocean water" (SMOW). Points which fit the dashed line at upper end of the curve are rivers and lakes from East Africa.

Craig.1961.Science

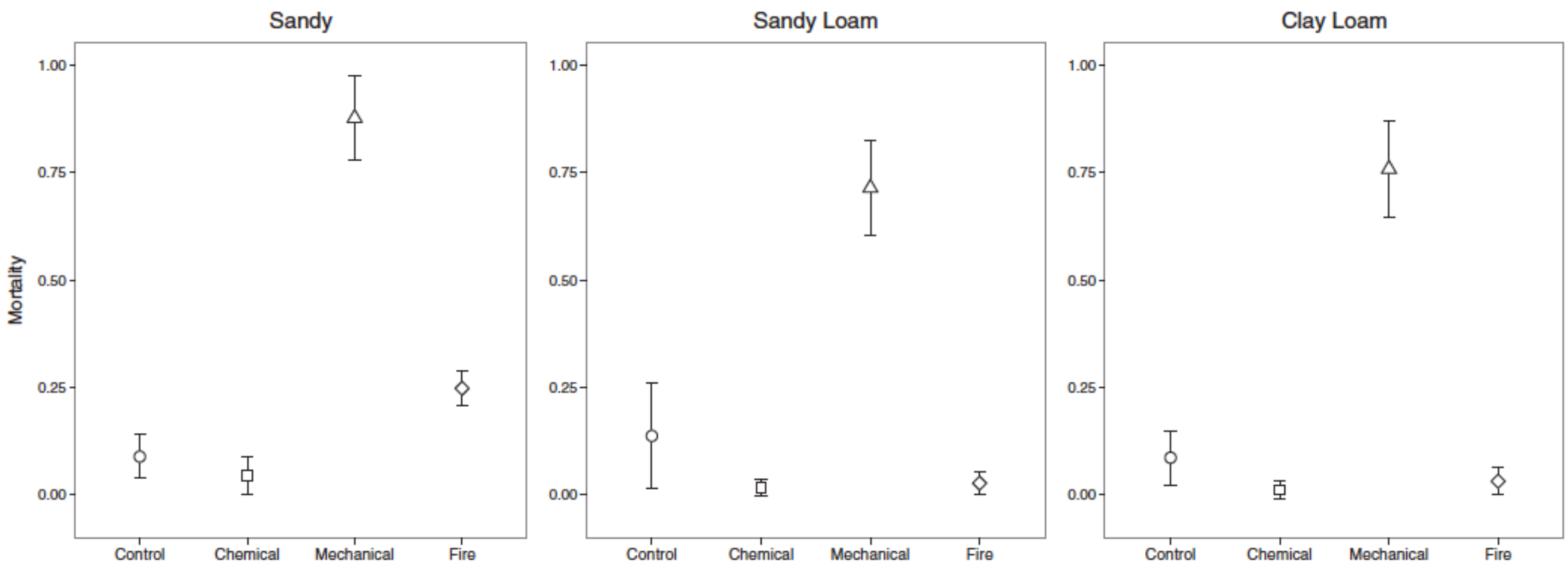


Figure 3. Mortality (mean ± SE) measured 1 yr following treatment (2011) for brush removal treatments (control, cut herbicide, and mechanical) and 1 yr following fire (2013) on three different soil types: sandy, sandy loam, and clay loam.