$\delta^2\text{H}$ and $\delta^{18}\text{O}$: Water Source Utilization by Plants
Do Water Isotopes Fractionate in Plants?
Patterns of Water Utilization in Plants

Identification and quantification of water source(s).
(groundwater, deep or shallow soil water, fog, rain pulses)

Intra- and interspecific resource competition and community water-use patterns, especially in aridland ecosystems.

Plant effects on hydrological processes.
(hydraulic redistribution, water cycling, transpiration vs. evaporation)
Isotopes Reflect Soil Water Use Patterns

White et al. 1985
How Does Water Use Vary Seasonally?

Adult poplar trees encountering a stream diversion.

Smith et al. 1991
Are All These Plants Using the Same Water Sources?
Can this sort of niche-partitioning among species help explain the high biodiversity on this otherwise water-limited desert?
Intra-Specific Variation in Water-Use?
Soils Act Like Reservoirs

- Water input (rain or snow)
- Water flows through soil column
- Evapo-concentration

But Each Soil Has Their Own Flavor

- Not well mixed
- Flow rate varies widely in space/time
- High resistance to diffusion

Barnes and Allison 1988
Building a Soil Water Profile

1. Start with Dry Soil
2. Add Rain and Saturate
3. Apply Heat (evapo-concentrate)
4. Restore Steady-State by Diffusion

In a Saturated Soil:
Highest $\delta_{\text{soil\ water}}$ at surface,
then exponential decrease to $\delta_{\text{precipitation}}$ in deep part of soil profile.
Isotope analyses of ALL water sources revealed that as trees grew larger, they were not using the most likely water source, but the most reliable one!
What About Soil and Sub-Surface Waters?

Average Precipitation
$\delta^{18}O = -5$ to $-10\%$

Leaf Water
$\delta^{18}O = +16\%$
(evapo-concentrated)

Transpired Water (SS)
$\delta^{18}O = -1$ to $-3\%$

Evaporated Water
(soil-derived)
$\delta^{18}O = -31\%$

Xylem Water
$\delta^{18}O = -3\%$

Soil & Aquifer Water
Surface Soil: $\delta^{18}O = +3\%$
Deep Soil: $\delta^{18}O = -6\%$
Aquifer: $\delta^{18}O = -6$ to $-10\%$

Yakir and Sternberg 2000
Dawson et al. 2002