Ecolab Report: The water sources of common trees in the Texas Hill Country (Edwards Plateau)

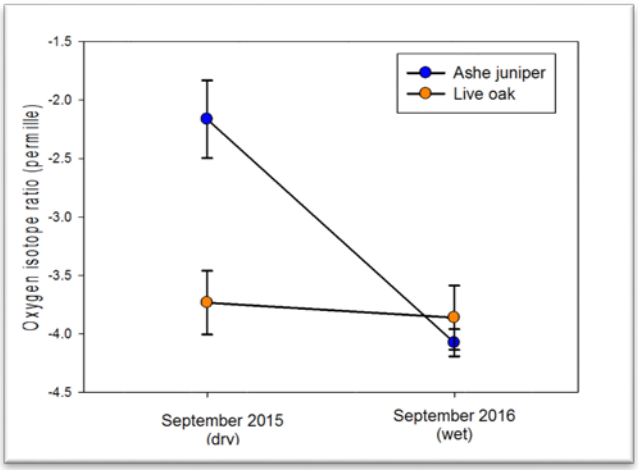
Susan Schwinning, Biology Department, Texas State University

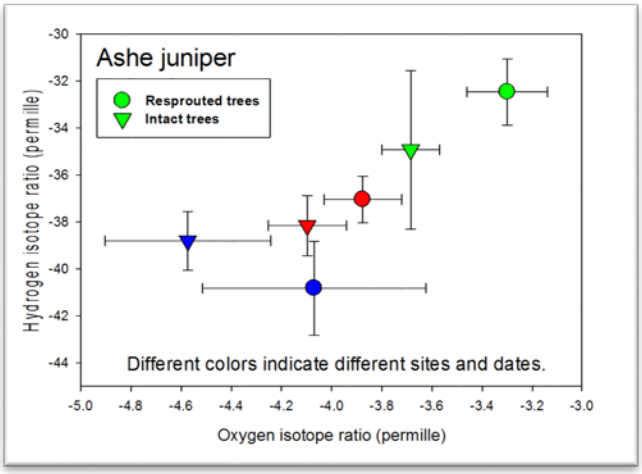
Water is an essential and sometimes scarce resource in the Texas Hill Country. Humans, animals and plants all need water to survive. Trees in particular need to take up large amounts of water every day to avoid desiccation while leaves are taking up CO_2 for photosynthesis. There can be intense competition for water between trees, especially during drought. Since lack of water at high temperature is the most important reason for why trees die during drought, we might expect that denser woodlands have higher tree mortality because they run out of water sooner.

In our previous Ecolab Report we confirmed that juniper mortality increased with juniper density. However, juniper density did not increase mortality of other tree species, including live oak. While live oak mortality was very high in some plots, it was actually lower compared to juniper mortality in the densest woodland plots we surveyed. This appears to contradict the common belief that juniper can somehow 'choke' the life out of oak trees.

We hypothesized that a high juniper density may not be harmful to live oak trees because the two tree species use very different water sources during drought. We investigated this hypothesis by comparing the isotope ratios of water in the stems of juniper and oak trees.

Isotopes are different forms of the same elements differing only in mass. Water in the environment is composed of two isotopes of hydrogen and oxygen. Different soil water sources often have different isotope ratios, in part because the isotope ratios of rain water fluctuates and rain water infiltrates the ground to varying depths. Another reason is that during drought, shallow soil water becomes enriched in heavy isotopes. This isotopic enrichment happens because water composed of lighter isotopes evaporates slightly faster, leaving heavier isotopes behind. Therefore, if we find that the stem water of tree species differ in isotope ratios, we know that they must have taken up water from different places.





At one site, we compared the isotope ratios of Ashe juniper and live oak in September of two years (top graph). In the wet summer of 2016, the stem water oxygen isotope ratios of oak and juniper were very similar, indicating that both species used similar water sources, probably recent rain water. In the dry summer of 2015, the oxygen isotope ratio of juniper was much higher than that of oak, indicating different water sources. Very likely, juniper took up water closer to the surface, while oak took up deeper groundwater.

In 2016, we compared the water sources of Ashe juniper trees that almost died in a previous drought but resprouted with trees that remained intact (bottom graph). There were slight but consistent differences in their isotope ratios, suggesting that intact trees have slightly deeper root systems, and that access to slightly more water could have helped those trees tolerate the drought better.

Analysis of the stable isotope composition of plant stem water allows scientists to examine ecologically important differences in the water use of plants (Ehleringer & Dawson 1992). So far, our investigations have shown that juniper and oak trees avoid competition for water by using different water sources during drought, and that drought survivorship could be linked in part to having slightly deeper roots.

Our research contributes to the growing scientific evidence that juniper trees, being shallow-rooted, interfere relatively little with the recharge of deep ground water in the Texas Hill Country (Dammeyer et al. 2016). Other studies showed that deep groundwater is recharged by bypass flow during heavy storm events. As the name suggests, this flow bypasses the shallow soil and the roots of shallow-rooted species such as juniper (Bazan et al. 2013).

Bazan RA, Wilcox BP, Munster C, Gary M, 2013. Removing woody vegetation has little effect on conduit flow recharge. Ecohydrology 6: 435-443.

Dammeyer HC, Schwinning S, Schwartz BF, Moore GW, 2016. Effect of juniper removal and rainfall variation on tree transpiration in a semi-arid karst: evidence of complex water storage dynamics. Hydrological Processes 30: 4568-4581.

Ehleringer JR, Dawson TE. 1992. Water uptake by plants: perspectives from stable isotope composition. Plant, Cell and Envirnment 15: 1073-1082.