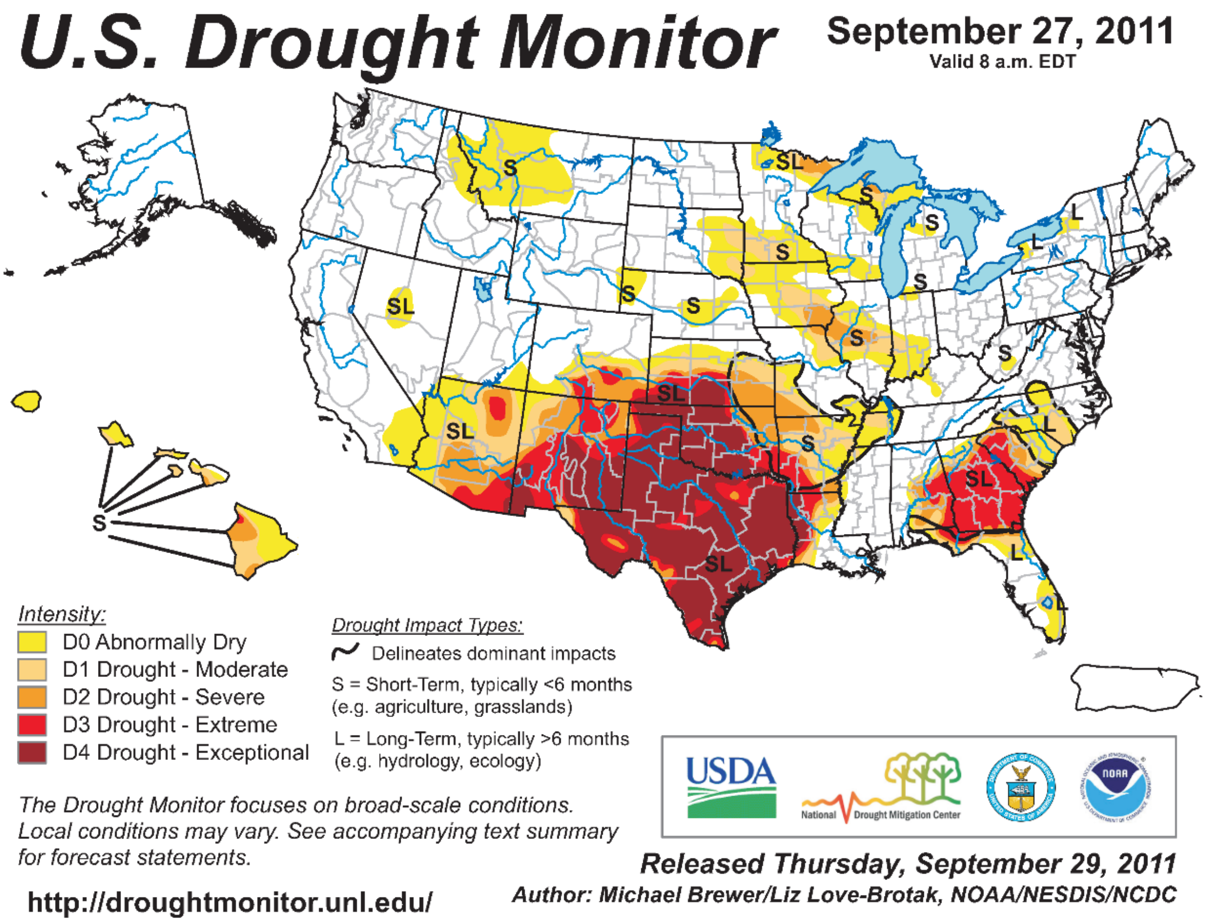
Ecolab Report: Patterns of tree mortality in the aftermath of the 2011 Texas Drought

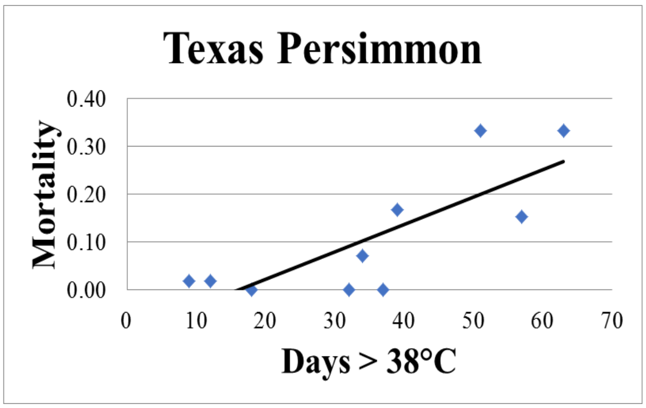
Beth Crouchet and Susan Schwinning, Biology Department, Texas State University

The state of Texas experienced an extreme drought in 2011, extreme in terms of its spatial extent, duration and unusually high temperatures (Nielsen-Gammon 2012). Across the entire state, over 300 million trees died as a result of this drought, an estimated 6% of all trees in Texas according to the Texas Forest Service. We conducted multiple plot surveys on Ecolab properties to determine how the rate of tree mortality changed across the Central Texas landscapes, and which trees were most susceptible to drought conditions.



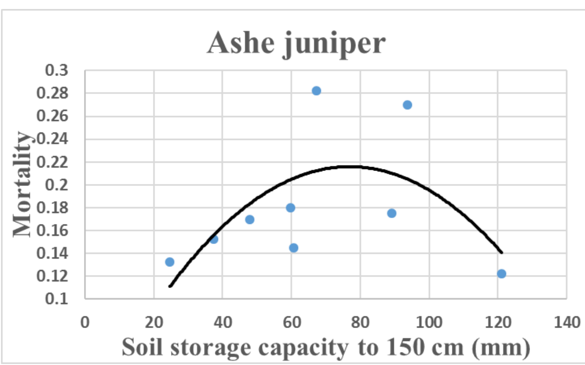
In 2014, Texas State University graduate student Beth Crouchet, with the assistance of several undergraduate students, surveyed 64 30m by 30m plots and a total of nearly 7500 trees. For each plot location, site characteristics in terms of climate, soil and topography were retrieved from geographic data bases. We then tested whether local site factors such as precipitation and temperature in 2011, slope and aspect, species composition and tree density affected the mortality risk of trees. All statistical analyses were conducted using binomial multivariate regression. Here we summarize a few of the most intriguing findings:

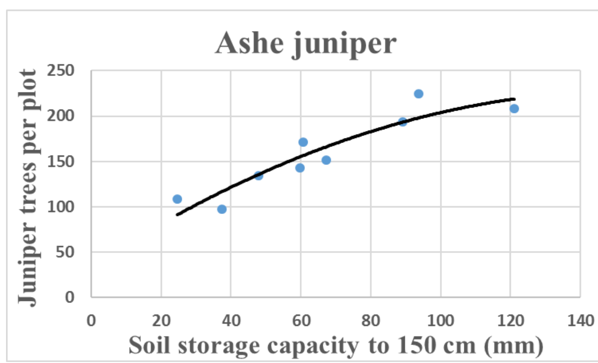
1) **Drought alone does not kill trees, high temperature during drought is a significant risk factor.**



We didn't necessarily expect that local heat exposure in 2011 varied enough across the landscape to influence local rates of tree mortality, but it did. Texas Persimmon (*Diospyros texana*) is an example. The analysis showed that for every additional consecutive day without significant rain (< 5 mm) and temperature above 38°C (100°F), the mortality risk for this tree species increased by 0.5%.

1) **Ashe juniper mortality peaked at sites with intermediate water storage capacity.**

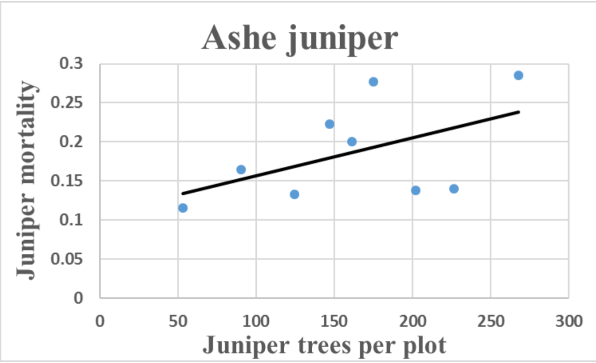


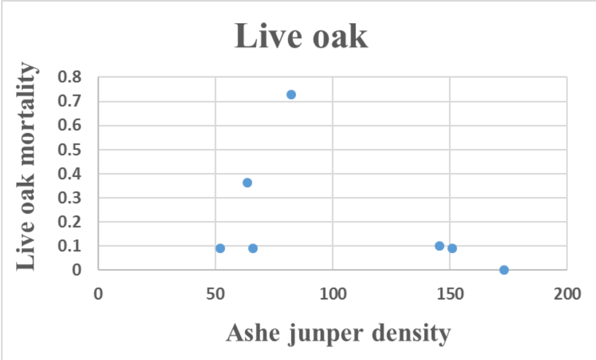


The year 2010 was a wet year in Texas. This made it possible for excess precipitation to carry over into 2011 and perhaps alleviate drought severity on sites with high capacities for water storage. This turned out to be true for Ashe juniper ("cedar", *Juniperus ashei*). Although juniper mortality was also low on sites with the lowest water storage capacity. We think that low tree density protected trees at sites with low storage capacity and access to stored water saved trees on sites with high storage capacity. Intermediate sites may have suffered the highest mortality rates because they had a relatively high tree density with limited amounts of stored water.

2) Ashe juniper does not threaten oak survival.

In the Texas Hill Country, with “cedar breaks” as dense as they are in many places, it would be reasonable to think that juniper trees impose a risk for live oak survival during drought years. However, the data we collected tell a different story: Ashe juniper density increased Ashe juniper mortality but did not significantly affect live oak mortality.





We think that the two species occupy quite different ‘water niches’, so that neither species can do the other much harm. Ashe juniper is a drought-tolerant, shallow rooted species, while live oak tends to avoid drought by growing deep roots into regions of the soil or rock where water remains available for longer during drought periods. We plan to investigate the issue of root system separation among Edwards Plateau tree species in future Ecolab research projects.

Tree die-off events associated with drought and heat waves have occurred on all wooded continents (Allen et al. 2010) and North America is no exception. The link between tree die-off events and high temperature is well established and suggests that these events may become more frequent in the near future because of climate change (Christensen and Christensen 2007). Some climate models predict increases in the frequency of extreme heat waves, even up to 50°C (122°F) in some areas by the end of this century (Sterl et al. 2008). Since it is extreme temperature in combination with drought, rather than drought alone that kills trees, changes in summer temperatures are particularly relevant to the future of woodlands and forests.

Allen, C. D., A. K. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, T. Kitzberger, A. Rigling, D. D. Breshears, E. H. Hogg, P. Gonzalez, R. Fensham, Z. Zhang, J. Castro, N. Demidova, J.-H. Lim, G. Allard, S. W. Running, A. Semerci, and N. Cobb. 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management 259:660-684.

Christensen, J. and O. Christensen. 2007. A summary of the PRUDENCE model projections of changes in European climate by the end of this century. Climatic Change 81:7-30.

Nielsen-Gammon, J. W. 2012. The 2011 Texas drought. Texas Water Journal 3:59-95.

Sterl, A., C. Severijns, H. Dijkstra, W. Hazeleger, G. Jan van Oldenborgh, M. van den Broeke, G. Burgers, B. van den Hurk, P. Jan van Leeuwen, and P. van Velthoven. 2008. When can we expect extremely high surface temperatures? Geophysical Research Letters 35