Research poster: Tree population dynamics at Ash Meadows National Wildlife Refuge: Influences of environmental stress and disturbance

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Tree population dynamics at Ash Meadows National Wildlife Refuge: Influences of environmental stress and disturbance

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Research Questions

Our overall objective is to quantify the current relationships among climate, fire regimes, hydrology, and tree populations at Ash Meadows, a desert springs complex, and to model ecological dynamics under projected climate change for the next century. The question we address here is:

How are tree populations arranged along water stress gradients?

In the future, we will examine spatial and temporal relationships between tree populations and climate and fire.

Study Area

Ash Meadows National Wildlife Refuge (Fig. 2) has 24 endemic species, the highest terrestrial concentration in the contiguous United States. The climate is typical of the northern Mojave Desert, with high summer temperatures of 40°C, low winter temperatures of -1°C, and annual precipitation of 10 cm. From 1980 to 2008, 25.7% of wetland areas burned at least once.

Plant communities and tree distributions are highly structured along groundwater and salinity gradients. Ash Meadows springs are likely to experience larger declines in water discharge as a result of climate change and associated anthropogenic pressure on water supplies, leading to substantial changes in vegetation. Current refuge management includes hydrological reconfiguration and revegetation of disturbed areas with native grasses and trees.

Methods

We collected field data and performed a greenhouse experiment to determine the relationship between water stress and distribution and establishment of three dominant tree species (Fraxinus velutina, Prosopis glandulosa, and P. pubescens).

In the field, we recorded tree size, sex, and health along gradients in water availability defined by grass composition (Fig. 3).

For the experiment, we recorded size and health of seedlings under factorial combinations of 5 water availabilities and 7 salinities, the two major components of water stress (Fig. 4).

Results

Trees are distributed by species, sex, and health along gradients in groundwater, salinity, and human disturbance history. Groundwater availability is the most important predictor (Fig. 5). Fraxinus velutina trees are more common, larger, and healthier on moister sites, while drier conditions are favorable for both Prosopis species. Functionally female trees are also more common on moister sites for all species (Fig. 6).

In the greenhouse, we confirmed the importance of water stress for tree growth and establishment (Fig. 7). We found that the negative effects of either high salinity or high water availability were mitigated by the presence of both states for all species. Fraxinus velutina had significantly lower establishment and survival than either Prosopis species for all conditions except high water availability – low salinity. Survival varied between high and low water availabilities, with F. velutina positively affected by high water availability, P. glandulosa not significantly affected, and P. pubescens negatively affected (Fig. 8).

Conclusions

Tree distributions and establishment are tightly linked to water stress in artificial and field conditions, implying that changes in water availability and salinity due to climate change and related factors will have large effects on tree distributions through changes in establishment, survival, and seed dispersal (due to shifts in sex ratios). Responses to water availability and salinity, the two components of water stress, differed between species at the seedling stage. Compared to previous studies, we found substantially higher salinity tolerances for F. velutina and much lower salinity tolerances for P. pubescens; since Ash Meadows is geographically isolated from other tree populations, this may represent local adaptation.

Future Directions

We have initiated a field experiment to explore the effects of fire and other vegetation on these relationships between trees and water stress. We hypothesize that a competition and facilitation trade-off occurs along these water stress gradients.

This next year, we will examine historical relationships among tree distributions, climate, human land use, and fire using remote sensing and historical land surveys dating from the 1800s. We will use these relationships to project tree distributions for the next century using future climate scenarios.

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