



Plant Responses to Climate Change in the NCPN

2011

Background

Summertime visitors to low-lying areas of the Northern Colorado Plateau can typically expect to be hot, dry, and thirsty. In July 2010, for instance, the average maximum temperature at Arches National Park was 98.5°F (37°C), and because the Colorado Plateau is at the dry end of moisture-bearing air masses, low-elevation areas typically receive less than 10 inches (250 mm) of annual precipitation. As such, the landscape is dominated by drought-adapted grasslands and shrublands, and pinyon-juniper woodlands.

In contrast, inhabitants of these same areas between 15,000 and 50,000 years ago would have largely found a cool, lush environment characterized by conifer woodlands, as has been shown through examination of packrat middens and ancient pollen samples collected from lakes and wetlands throughout the region (Betancourt et al. 1990). Although the change from cool, wet, and forested to warm, arid, and open occurred gradually, in the wake of naturally shifting climate patterns, global and regional models predict that increasing greenhouse gases will cause temperatures to rise much faster than the historical record shows on the Colorado Plateau (Christensen et al. 2007). While the predictions for precipitation are less conclusive, this temperature rise is likely to increase aridity on the plateau through increased evapotranspiration. Decreased water availability is likely to have a large impact on the growth and survival of grassland and shrubland plants that are already vulnerable to water stress.

To address how past climate variability has affected plant species cover and make predictions of plant community composition under future climate change, scientists from the U.S. Geological Survey and National Park Service examined the relationship between climate and vegetation using monitoring data for the last 20 years (1989–2008) from three national parks on the Northern Colorado Plateau: Arches, Canyonlands, and Natural Bridges (Figure 1). Data were analyzed for three vegetation types: grasslands, shrublands, and woodlands.

Status and Trends

The results of this research found that during the past 20 years, regional mean annual temperature in the study area has increased by 0.05°C per year. Although there was high inter-annual variability in precipitation, evapotranspiration rates increase with rising temperatures, limiting plant water availability. The mean annual temperature in the previous year (pMAT) was the best predictor of canopy cover of perennial plant cover in this study.

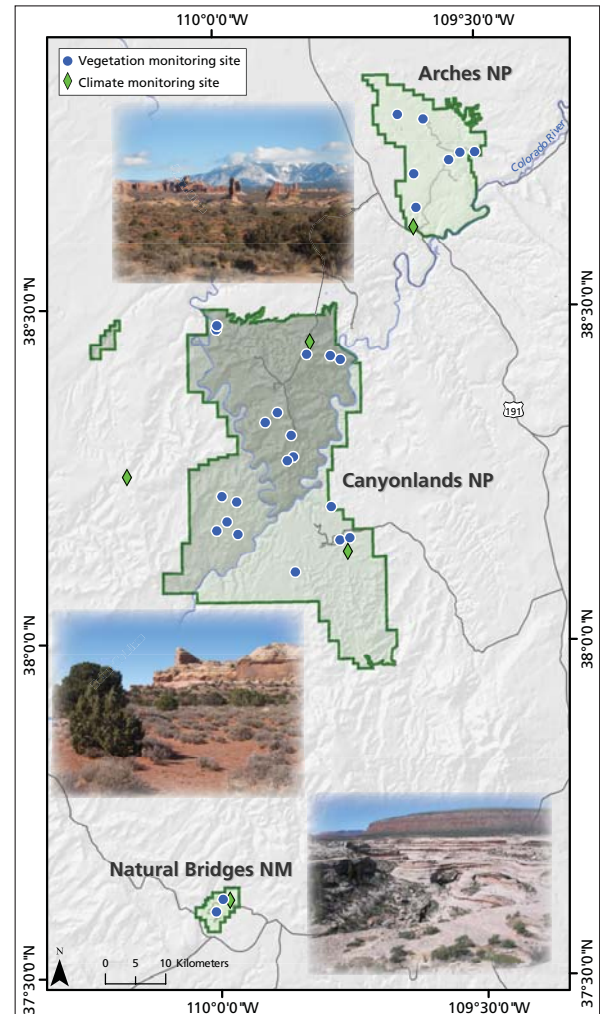


Figure 1. Location of vegetation and climate monitoring sites included in this study.

Grasslands—At sites across the study area, there was an overall decline in cover of cool-season perennial grasses and an increase in cover of the subshrub, Mormon tea (*Ephedra viridis*), with increasing temperature (Figure 2a). Because evaporation rates are higher at the soil surface than at depth, shallow-rooted species, such as grasses, were more vulnerable to increasing temperature than the deeper-rooted subshrub.

Shrublands—Dominant shrubs had a mixed relationship with increasing temperature, which varied with plant-species traits and site factors. Blackbrush (*Coleogyne ramosissima*), a drought-adapted evergreen shrub with roots that can grow between cracks in bedrock, showed no change or increased with increasing temperature. In contrast, saltbushes (*Atriplex* spp.), which

are relatively shallow-rooted and occurred on soils with low water-infiltration rates, decreased with increasing temperature (Figure 2b).

Woodlands—Canopy cover of pinyon pine (*Pinus edulis*) did not change with increasing pMAT. At two sites where Utah juniper (*Juniperus osteosperma*) cover was >5% at lower temperatures, the tree cover increased by 4.0 and 11.6%, respectively, over a 3°C increase in pMAT. Canopy cover of shrubs increased in woodlands by 6.7–8.2% over a 3°C increase in pMAT, with the greatest increase occurring in years following those with high summer temperatures (May–July). Most shrubs that showed an increase in canopy cover were species typically found at lower elevations.

Future Outlook

If warming trends continue as predicted by many global and regional models (Christensen et al. 2007), cool-season perennial grasses may face localized extirpation on the Colorado Plateau. These declines could potentially lead to changes to food and habitat for wildlife. If native annuals or shrubs fail to fill in some of the spaces left by grass loss, then increased soil erosion by wind and water can be expected, reducing soil fertility and water-holding capacity. It is also possible that non-native plants may invade these open spaces.

On the Colorado Plateau, grasses derive ~85% of their moisture from surface soils, compared to ~54% for shrubs (Ehleringer 2001). In shrublands, shrubs with access to deep soil water, such as blackbrush, will likely be the least affected by increasing temperature, while those with limited access, such as saltbushes on soils with low infiltration rates, may experience further declines.

Based on the current minimum elevation required for pinyon pine growth, its occurrence is likely to decline (as has already occurred in many parts of the Southwest) at the lowest end of its elevational distribution and be replaced by Utah juniper as temperatures become warmer. Pinyon-juniper woodlands are likely to become more dominated by shrubs capable of shifting to higher elevations as temperature increases.

Our results suggest that increasing aridity has played a large role in decreasing grass abundance and changing shrub abundance in national parks of the Colorado Plateau, and will likely affect future alterations of plant community composition.

Additional Information

For more information, see:

Munson, S. M., et al. 2011. On the brink of change: Plant responses to climate on the Colorado Plateau. *Ecosphere* 2(6):1–15. (<http://www.esajournals.org/doi/pdf/10.1890/ES11-00059.1>) or contact Seth Munson (smunson@usgs.gov).

References

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Ehleringer, J. R. 2001. Productivity of deserts. Pages 345–362 in H. A. Mooney and J. Roy, eds., *Primary productivity in terrestrial ecosystems*. San Diego, Calif.: Academic Press.

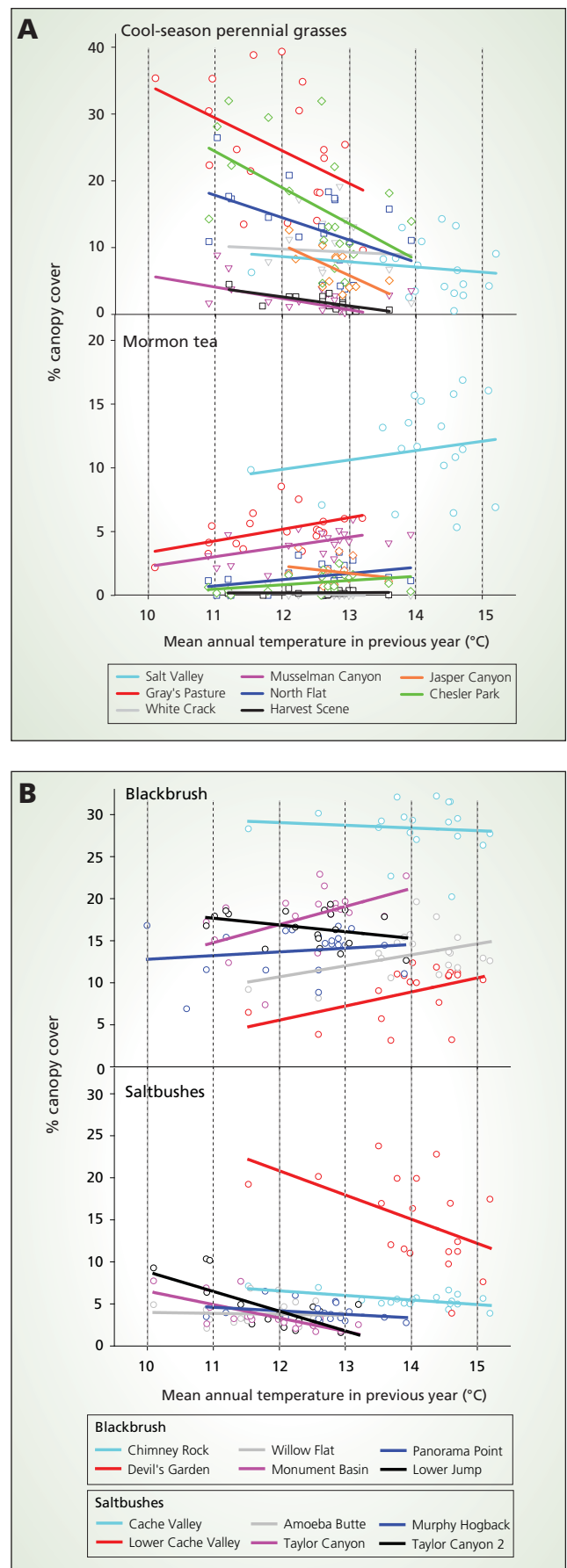


Figure 2. Trends in composition of (a) grassland and (b) shrub systems on the Northern Colorado Plateau over the course of a 20-year mean annual temperature increase of 0.05°C per year.