



Searching for Change in Petrified Forest National Park Grasslands



SCPN field crew reading an upland monitoring quadrat at Petrified Forest National Park.

Highlights

Petrified Forest National Park in northern Arizona protects one of the best remaining examples of a shortgrass prairie grassland in the southwestern US. These grasslands provide critical habitat for birds, reptiles, amphibians, insects, and mammals. However, a changing climate is predicted to bring higher temperatures and less precipitation, which would mean less water available to help plants grow and flourish. How can we measure the effects of climate and other forces on the park's natural resources? To begin, we need to compare the present condition of park vegetation with conditions of the past to see how it has changed.

The Southern Colorado Plateau Network (SCPN) of the National Park Service has been monitoring grasslands in Petrified Forest National Park (NP) since 2007. We analyzed

data collected from the park between 2007 and 2018 to investigate how the condition of the grasslands we monitor changed over time. The good news is that the park's grassland ecosystems are healthy. Although conditions changed from year to year, there was no evidence of a negative trend in the things we monitor. In fact, the data revealed that nonnative species were not common, species richness increased slightly, and soils were stable.

Long-term monitoring of grasslands in Petrified Forest National Park

SCPN monitors two similar but distinct grassland ecosystems within Petrified NP: clayey fan and sandy loam upland (Figure 1). We sampled plots in both types from 2007–2018, collecting data on vegetation and soils. Differences in soil texture and depth contribute to small differences between the two grassland types. The sandy



Figure 1. The clayey fan grassland (left panel) and sandy loam upland grassland (right panel) types at Petrified Forest National Park (NPS/M. SWAN).

loam upland grasslands have deeper soils while soils in the clayey fan grasslands tend to be shallower and more clayey (finer textured).

The two grasslands also differ somewhat in the plants they support. Although they are both dominated by warm season grasses—grasses that depend on summer rains to grow—total cover of vegetation is higher in the sandy loam upland grasslands. The sandy loam upland grassland also has greater cover of shrubs. Annual grass cover is higher in clayey fan grassland.

Over the 11-year monitoring period, SCPN field crews identified 165 plant species across the two grassland types. Only 6 of the 165 plant species identified were non-native. Warm season grasses (primarily blue grama and galleta grass) made up about three-quarters of the total vegetation cover in the grassland ecosystems we monitored. Shrub and forb cover was only a small component of vegetation overall, but very important to grassland diversity.

Modeling change and trends in vegetation communities

To understand how the clayey fan and sandy loam upland grasslands have changed over time, SCPN analyzed the 2007–2018 monitoring data. Analyzing multiple years of monitoring data allows us to detect trends in the condition of resources in the park. We can then provide

park managers with the science that they need to make decisions about how to manage park natural resources. A trend is defined as change through time in the condition of a resource (e.g. vegetation cover) that is increasing or decreasing consistently over time and cannot be explained by short-term changes in the conditions (like weather).

SCPN chose four response variables to analyze: the average number of species found within each plot (species richness—a simple measure of diversity), total abundance (foliar cover) of all live vegetation, perennial grass abundance, and shrub abundance. Using a statistical model, the network examined how the variables changed over time, and how they responded to changes in weather attributes during different times of the year: winter precipitation (November to March), spring precipitation and spring temperature (April to June), and monsoon precipitation (July to September).

What we learned

SCPN's analysis of change over the eleven years of data for the two grassland ecosystem types in Petrified Forest NP revealed that

- In the clayey fan grassland, species richness increased with increased monsoon precipitation, while in the sandy loam upland grassland species richness increased due to increas-

es in both winter and monsoon precipitation. When we removed the effect of changes in precipitation from the model, species richness increased slightly over time in both grassland types. This trend was not explained by yearly fluctuations in seasonal precipitation or spring temperature, but likely reflects changes in the way data were collected over time.

- The amount of total live foliar cover in the clayey fan grassland increased with increased precipitation in winter, spring, and monsoon, but decreased with warmer (increased) spring temperatures. Total foliar cover also showed a very slight increasing trend over time. In the sandy loam upland grassland, total live cover increased with an increase of all four weather covariates, including higher spring temperature, but monsoon precipitation had the strongest effect. No trend was detected.
- Similar to the response of total live foliar cover, perennial grass cover in the clayey fan grassland increased with increasing precipitation in the winter, spring, and monsoon, but decreased with increasing spring temperatures. There was evidence of a slight increasing trend. In the sandy loam upland grassland, perennial grass cover increased with monsoon precipitation and, to a lesser extent, with spring precipitation. However, winter precipitation had a slightly negative effect and spring temperatures had a neutral effect on perennial grass cover. There was little evidence of a trend
- Shrub cover in the clayey fan grassland remained relatively stable during the monitoring period. In the sandy loam upland grassland, shrub cover increased with increased winter and spring precipitation, and higher spring temperatures. There was no trend detected in either grassland type.
- Soil stability declined with increasing winter and monsoon precipitation (the only covariates included in this model) in the clayey fan grassland, and there was evidence of a very

slight negative trend in overall stability. In the sandy loam upland grassland, soil stability increased with increasing winter and spring precipitation (strongest effect), and spring temperature, however, increased monsoon precipitation had a slight negative effect. There was evidence of a slight increase in soil stability in this ecosystem during the monitoring period.

Why is this information significant?

Trend analyses of vegetation and soils in grassland ecosystems of Petrified Forest NP showed that vegetation abundance is very responsive to seasonal precipitation. Knowing how precipitation affects plant growth and soil stability will help scientists predict the effects that climate change will have on grasslands in the park. We know that temperatures are increasing in the southwestern U.S. and patterns of seasonal precipitation are expected to shift towards drier conditions in the spring. However, predicted changes in monsoon and winter precipitation are more uncertain. Understanding how seasonal precipitation affects grassland vegetation, and how these responses vary between the two grassland types will help managers anticipate how park vegetation will respond to climate change over the short and long-term future.

For more information on modeling trends in Petrified Forest National Park Grasslands, see [Swan et al. 2020](#).

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