Influence of grazing and precipitation (amount and timing) on plant production and soil respiration in Ephraim Canyon, UT

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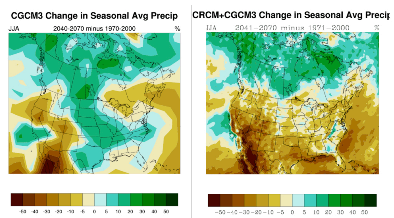
Background



Climate Change: Forecast Impacts on Great Basin Precipitation

For ecologists the challenge of climate change rests in our ability to understand how critical processes will be affected by two fundamental changes in precipitation—(1) a decrease in the amount of summertime rain and (2) the size and frequency of individual rain events.

• *Change in amount of summer precipitation*
Several forecasts suggest a southern migration of the monsoonal boundary leading to *decreases in the amount of summer rains by 5-30%*. With rising temperatures causing earlier snowmelt, the period of summertime water stress is likely to increase.

•*Change in the timing of summer precipitation*
Warming may increase cloudiness, latent heat fluxes, and extreme climate events. As a result, there will be an increase in the frequency and duration of dry periods in much of the monsoonal world in spite of increases in annual precipitation because *rainfall is coming in larger, less frequent storms.*

In addition to concerns about climate change, ecologists and managers need to account for the influence of long-term local management. In particular, grazing in the Great Basin has the potential to influence plant community composition, soil organic matter dynamics, and soil hydrology. These changes have the potential to influence how systems respond to changes in precipitation or temperature.

Hypotheses

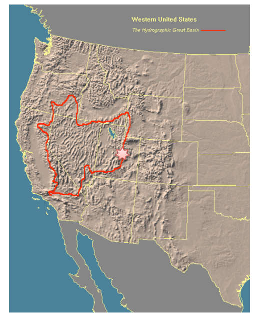
Our *central research hypotheses* are that a decrease in summertime precipitation will cause a shift in the competitive balance between early and late season plant species, decrease plant productivity, and increase carbon storage and that there will be a nonlinear response to changes in precipitation frequency depending on ecosystem water status. Grazing makes the system less sensitive to drought but less productive than ungrazed systems. We began in 2009 to examine these research hypotheses by addressing two specific aims:

1. Determine how decreasing monsoon precipitation by 30-70% alters plant physiology, community interactions and the biophysical environment in grazed and ungrazed plots on the Wasatch Plateau

2. Examine how changing the size and timing of precipitation influences plant physiology, community interactions and the biophysical environment

Site Description

The Great Basin Experimental Range (GBER, 39º 17':-111º 30'; U.S. Department of Agriculture, USFS) on the Wasatch Plateau has been an important ecological research site since the early 1910s. The work reported here focuses on the areas ranging from low-elevation grass-juniper sites (2114 m) to the subalpine, mountain meadow zone (3100 m, Figure 3). Mean annual precipitation for the Wasatch Plateau summit for the past 75 years was 932 mm, with only 19% of precipitation falling in the growing season (June through September). In the valley, mean annual precipitation is 300 mm, with 82 mm falling between June and September (28%). Large grazing exclosures that have excluded domestic livestock for >80 years are present at each of our sites, allowing us to directly examine the influence of land management on responses to precipitation manipulation.



High Elevation Site

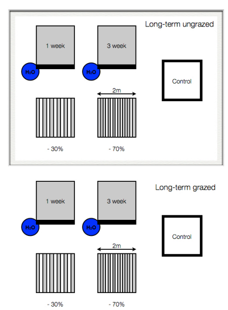
Low Elevation Site

Experimental Design

In summer 2009 we established eight blocks of our experiment in Ephraim Canyon Great Basin Experimental Range on the Wasatch Plateau. The experimental design is a randomized block design with location and year serving as blocking factors. Each site has two grazing treatments. The exclosures are all over 70 years old. Within each grazing treatment there are five precipitation treatments. There are two styles of shelters used, depending on the treatment. In 2009 precipitation treatments were in place from July 1-Oct 1.

• *Reduced Precipitation Shelters*
Reduce incoming precipitation by guttering off either 30% or 70% of incoming precipitation

• *Complete Exclusion Shelters*
Capture all incoming precipitation so that it can be reapplied at either 1 week or 3 week intervals.



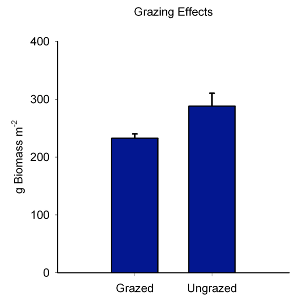
Response Variables

Aboveground Net Primary Production: Measured using a double sampling approach, with NDVI, Leaf Area, and basal cover as proxies for biomass

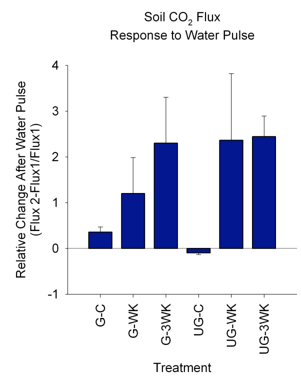
Soil Respiration: measured at permanently installed collars using a continuous flow infrared gas analyzer (Environmental Gas Monitor version 1; PP Systems, Haverhill, MA, USA)

Response to Precipitation Pulse: Soil respiration was measured immediately before and two hours after a simulated rainfall event in our complete exclusion shelters and in control plots

Grazing



Precipitation Pulses

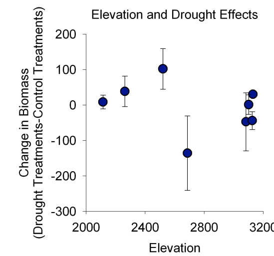


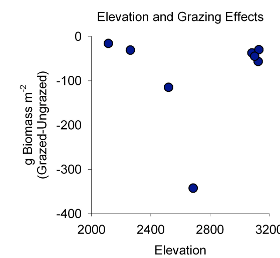
Results & Discussion

The largest and most consistent response was higher aboveground net primary production in ungrazed plots than in long-term grazed plots. All plots were protected from grazing in 2009. The sites most sensitive to grazing were at mid-elevation sites. There was no statistically significant influence of precipitation timing or amount on plant production in the first year of the experiment. Initial responses seem to be higher in the mesic, cooler sites. When we measured soil respiration before and after rain events we found that small and large events increased respiration by over 200% in ungrazed plots. In grazed plots, the small events doubled soil respiration while large events increased respiration by 200%. These initial results suggest that grazing may influence how soil microbial communities utilize rain pulses with potential impacts on nutrient cycling and ecosystem C storage.

These initial results suggest that local land use decisions are at least as important as global change in controlling ecosystem dynamics. Additional research will allow us to examine the cumulative impact of changes in precipitation.

Elevation and Treatment Effects





Abstract

Human activities have resulted in well-documented increases in atmospheric carbon dioxide concentration and mean annual temperature, with forecast future increases of between 1.1 and 6.4 ºC. These increased temperatures will alter patterns of atmospheric circulation and influence hydrologic processes. For ecologists the challenge lies in the ability to understand how critical processes will be affected by two fundamental changes in precipitation—(1) decreases in the amount of summertime rain and (2) the size and frequency of individual rain events. In 2009 we began a rainfall manipulation study at elevations ranging from the valley floor to the crest of the Wasatch Plateau. This work has two specific aims that were addressed at the Great Basin Experimental Range in Ephraim, UT. The first aim was to determine how decreasing monsoon precipitation by 30-70% alters plant physiology, community interactions, and the biophysical environment. The second aim was to examine how changing the size and timing of precipitation influences plant physiology, community interactions, and the biophysical environment. We found grazing history to be a dominant control over plant production. In the first year of the study there was no influence of precipitation manipulation on plant production. Soil respiration increased by over 200% following a single precipitation pulse. The grazed plots had a lesser response than ungrazed sites to a small precipitation pulse but a similar response when experiencing a large pulse. In future years we will assess changes in plant communities, with hypothesized changes in the relative importance of early and late-season species.

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