Plant Community and Biogeochemical Responses to Fire Exclusion and Location in Puget Prairies

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Abstract

A series of paired fire-exclusion treatments within an actively managed fire restoration matrix were used to evaluate the effect of prescribed fire and fire exclusion on prairie plant communities, as well as soil carbon (C), nitrogen (N), and mercury (Hg) dynamics. In 2011. 22 paired modified Whittaker plots were established across the Johnson, and Upper Weir prairies at Joint Base Lewis-McChord (JBLM). Paired plots consisted of a fire treated area, as part of larger prescribed burn efforts, and an adjacent control in which fire had been excluded starting in 2011. Vegetation sampling occurred during the summer of 2012 and 2013 at each of the 11 burned and unburned pairs. Plant community structure differed significantly between burned and unburned sites following two years of treatments. Soil cores collected at each of the sites in the summer of 2013 showed an over all increase in C and N while the ratio of C:N decreased. Mercury analysis showed minimal variation between burned and unburned treatments, however, variation was evident between prairie locations. Ongoing research will continue to elucidate the effects of fire in these complex ecosystems.

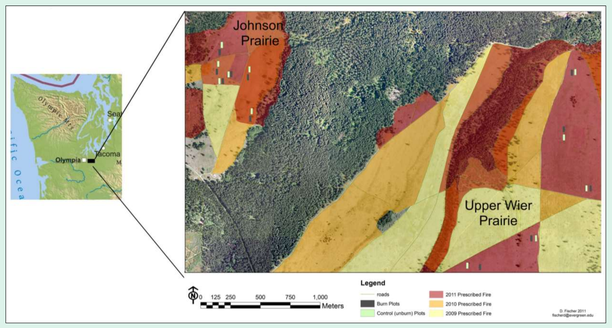


Figure 1. Study Location. Johnson and Upper Weir prairie sites shown relative to their location in Washington State. Color variations indicate burn history and rectangles represent burned and unburned paired plots.

Introduction

- Fire-reintroduction has become a important tool to increase the health of prairie ecosystems (Hamman et al 2011).
- Studies suggest that prescribed burning can improve prairie heath by:
  - Halting forest encroachment
  - Reducing fuel loads
  - Depleting weed seed banks
  - Promoting germination
  - spreading native vegetation (Dennehy et al 2011).
- We evaluated:
  - The effects of burn treatment on plant species abundance and diversity
  - How C and N dynamics are effected by burning
  - What, if any, Hg is being volatilized during these treatments
- We hypothesize that areas where burn treatment is applied will have a higher overall plant diversity relative to the control plots that where fire excluded. In regards to biogeochemical responses we predict C & N values would be lower in burned plots and no variation in the amount of mercury between burned and unburned treatments.

Methods

Field Methods

- A matrix of paired plots were established randomly at the Johnson and Upper Weir prairies on Joint-Base Lewis-McChord.
- Pairs were established consisting of a burned and unburned plot.
- Modified Whittaker Plots were used to conduct vegetation surveys at each plot (see figure 2).
- Within 10 0.5x2m ($1m^2$) subplot, each species was identified and the percent of cover was determined.
- Twenty replicate soil cores were taken from each plot at a 0-5cm depth using PVC corers.
- Each set of 20 replicates were homogenized in the field based on plot.

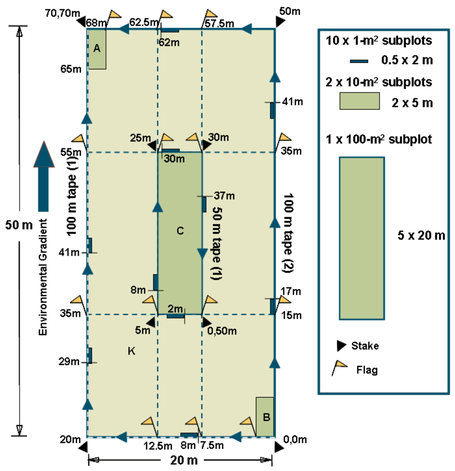


Figure 2. Diagram of a Modified Whittaker Plot. These plots were used to measure plant communities and determine a structured randomized sampling procedure for soils in each plot. Soil samples were collected at two corners in each small dark blue sub-plot.

Lab Methods

- Vegetation data was compiled and statistically analyzed using PC-ORD.
- All soil cores were air dried for roughly 2 weeks
- Soils were sieved using a 2mm mesh sieve
- Sediment <2mm was homogenized using a ball mill
- Subsamples of homogenized soil was then analyzed for C and N using a PerkinElmer Series II CHNS/O 2400 Analyzer .
- Remaining soil was then freeze dried and analyzed for Hg concentrations by atomic absorption using Nippon MA:3000

Results

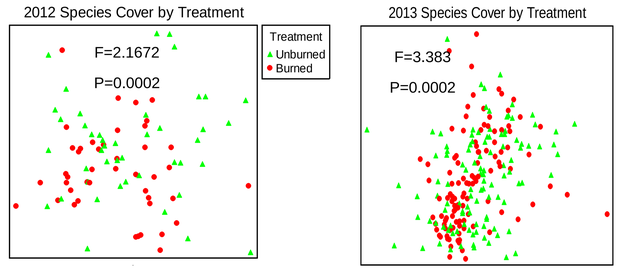
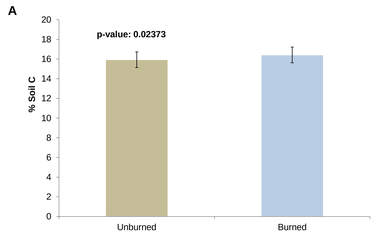
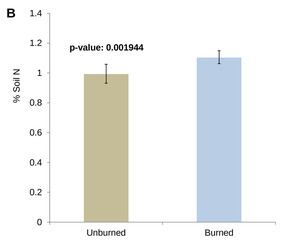


Figure 3. NMS ordination of the 2012 and 2013 species coverage showing variation by treatment. PerMANOVA tests confirmed our hypothesis that burned and unburned communities would vary (2012: F=2.1672, P=0.0002; 2013: F=3.383, P=0.0002)





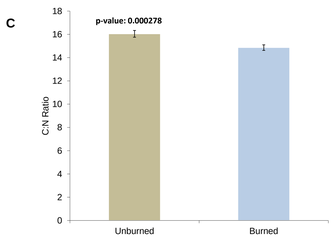


Figure 4. Comparison of soil C (A), N (B), and soil C:N (C) among paired burned and unburned plots (note figures are not on same scale)

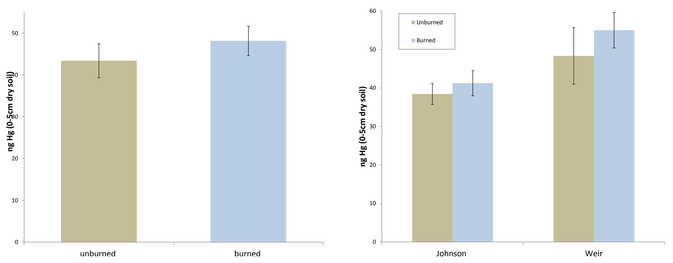


Figure 5. Mercury storage in burned & unburned surficial soils (0-5cm cores). Burned and unburned plots where characterized by similar Hg storage (left panel). Mercury storage was slightly greater at the Weir prairie site than the Johnson prairie site irrespective of burn treatment (right panel).

Discussion

There are three major findings from this work:

1) Burning affects plant community composition in respect to species cover.
2) Burning increased the amount of soil carbon and nitrogen in all cases. However, total soil nitrogen was increased to a greater degree than carbon causing a decrease in the overall C:N ratio of burned soils.
3) While soil mercury did not differ significantly between either burned or unburned plot types a pattern did immerge in regards to prairie location.

Current work

- Evaluation plant species composition relative to precise burn histories for each plot
- Determining the cation exchange capacity of the soils.

Future work

- We will continue to monitor these plots into future years to allow patterns between burned and unburned plots to become more clear.

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