Soil Temperature Controls Microbial Activity in a Desert Ecosystem

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INTRODUCTION

Global climate models forecast different precipitation scenarios for Big Bend National Park in the Chihuahuan Desert in Texas. Depending upon the degree of change in the timing and magnitude of precipitation, soil temperature may also be impacted. For example, greater cloud cover associated with greater precipitation may lead to reduced soil temperatures due to reduced solar heating. Consequently, less soil water will be lost to evaporation, thereby increasing water availability to the microbial community. Changes in soil microbial activity associated with changes in water availability and soil temperature could result in altered nutrient dynamics and ultimately, plant productivity. Therefore, it is important to understand the relationship between climate change impacts on soil temperature and microbial activity.

RESEARCH OBJECTIVES

Determine the impact of reduced soil temperature on soil water and nitrogen dynamics in the lowland creosote bush bajada in the Chihuahuan Desert

Determine the impact of reduced soil temperature, and potentially altered soil physical and nutrient properties, on microbial activity and plant physiological function of the dominant plant (*Larrea tridentata*; creosote bush)

SITE DESCRIPTION AND METHODS

Research was conducted in the lowland creosote bush bajada in Big Bend National Park, Texas (elev. 1010 m) in the Chihuahuan Desert near the Mexican border

Dominant species at this site include *Larrea tridentata, Opuntia* sp., *Agave lechuguilla*

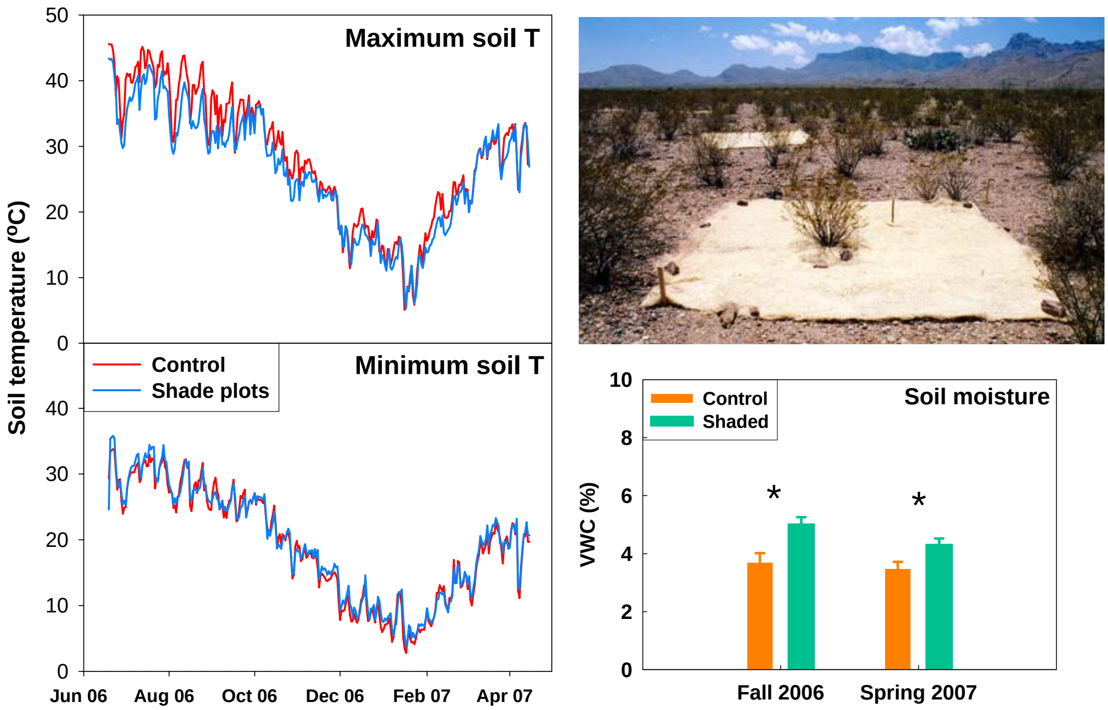
Erosion control blankets (Curlex®, American Excelsior Company) were placed above the soil surface to simulate cloud cover and decrease soil temperature via reduced incoming solar radiation (3x3 m plots; n=4); air flow was maintained between the soil surface and blanket to minimize alteration of other micrometeorological variables

Air and soil (15cm depth) temperatures were continuously monitored (36 min. intervals) using HOBO® data loggers (Onset). Volumetric water content (soil moisture) was determined by oven-drying soils at 60°C for 24 h.

Soil microbial activity was determined by the chloroform fumigation method (Vance *et al*. 1987), NH_4^+ using a colorimetric assay (Miller and Keeney 1982), and NO_3^- using ion-specific probes.

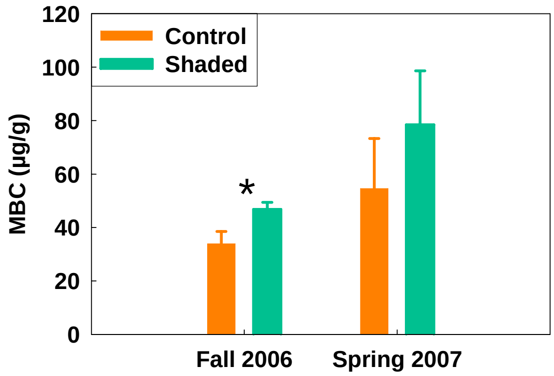
Shoot-level gas exchange (Li-6400) and plant chemistry (leaf [N] and carbohydrates) were measured in the dominant species *Larrea tridentata* (creosote bush) to determine whether plants responded to below-ground changes associated with decreased solar radiation. Total non-structural carbohydrates were analyzed using the technique of Tissue and Wright (1995).

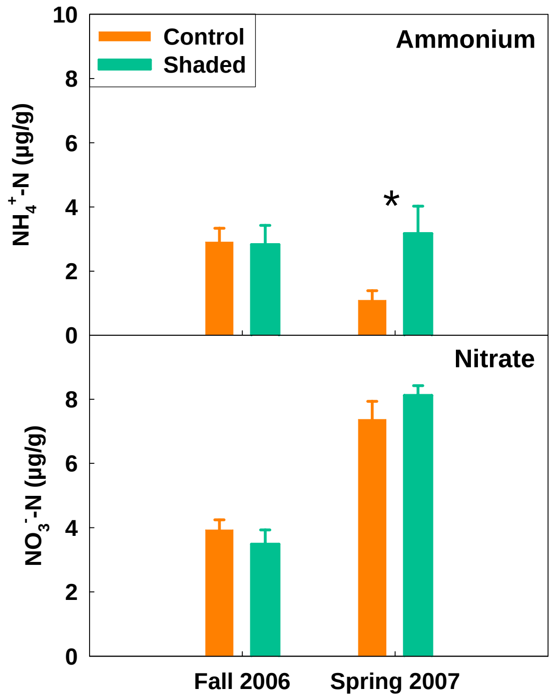
ENVIRONMENTAL SOIL VARIABLES



Figures 1-2: Shaded plots decrease maximum soil T, mainly in summer, but minimum soil T remains similar between treatments. Soil moisture is higher in shaded soils than in soils exposed to full sun.

BELOW GROUND RESPONSES





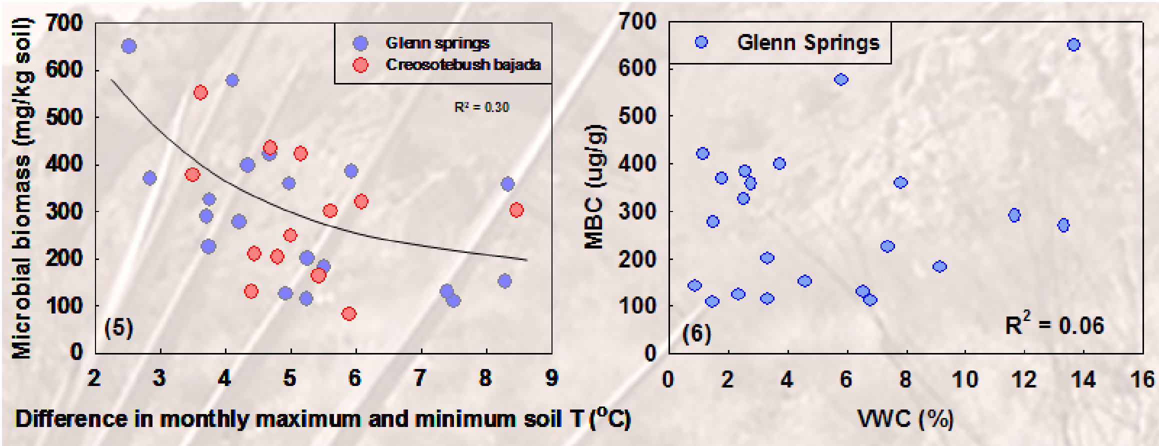
Figs 3-4: Microbial biomass carbon (MBC) was higher in the reduced temperature (shaded) plots compared to control plots in fall, but not spring. Shaded plots had higher ammonium levels in the spring, but not in the previous fall, while shade treatment did not affect nitrate levels.

ABOVE GROUND RESPONSES

Plant parameter	Control	Shade	Significant?
A_{sat} (µmol m^{-2} s^{-1})	6.69 (0.41)	6.30 (0.59)	ns
G_s (mmol m^{-2} s^{-1})	0.080 (0.0067)	0.068 (0.0084)	ns
Photosynthetic use efficiency (A_{sat}/g_s)	84.9 (3.8)	95.1 (4.4)	ns
Leaf water content (%)	46.9 (0.6)	48.7 (0.8)	ns
Leaf [N] (mg/g)	2.70 (0.11)	2.77 (0.15)	ns
C/N	18.6 (0.8)	18.3 (1.0)	ns
Carbohydrates (mg/g)	129.6 (6.1)	137.2 (6.7)	ns

Table 1: Plant physiological or chemical responses in *Larrea tridentata* have not yet responded to changes in summer soil temperatures and microbial biomass carbon.

WHAT IS DRIVING MICROBIAL ACTIVITY?



Figs 5-6: Long-term data (1996-2007) sets from two similar low-desert sites. There was a significant negative relationship between soil temperature fluctuations and microbial biomass carbon (MBC) (5). There was no relationship between soil moisture and MBC.

CONCLUSIONS

Greater monthly soil temperature extremes reduced microbial biomass carbon

Reductions in maximum soil temperature, most notably in the summer, resulted in smaller differences between maximum and minimum monthly temperature and subsequently greater microbial activity in the following Fall. In the Spring, when soil temperatures were not affected by the shade treatment, microbial activity did not differ between treatments. We conclude that greater temperature stability will increase microbial biomass carbon in this ecosystem.

Soil moisture was not a significant predictor of microbial activity

Despite increased soil moisture due to the shade treatment, microbial biomass carbon was independent of changes in soil moisture. This suggests that factors other than soil moisture are primarily impacting soil microbial carbon.

Soil exchangeable ammonium and nitrate levels were not significant predictors of microbial activity

Changes in soil ammonium and nitrate levels do not coincide with changes in microbial biomass indicating that other factors primarily regulate microbial activity, at least over this experimental time period.

Alterations in soil temperature, moisture and ammonium have not yet affected plant physiology or chemistry.

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