Shallow Soil Thermal and Hydrological Conditions beneath Kentucky Bluegrass Thatch and in Response to Thatch Removal

Caley Gasch, Leslie Gerhard and Kevin Sedivec
School of Natural Resources Sciences, Soil Science Program, North Dakota State University, Fargo, N.D.

We monitored soil temperature and water content in areas with long-term Kentucky bluegrass thatch accumulation and in response to thatch removal. We observed that thatch presence influences thermal and hydrological properties in the top 15 centimeters (cm) of soil.

Specifically, thatch presence keeps soils cooler and buffered from atmospheric conditions, and thatch presence encourages water storage in shallow rooting depths. We suspect that the abiotic conditions associated with thatch presence and accumulation may influence soil biological activity and plant community composition.

Introduction

Kentucky bluegrass (*Poa pratensis* L.) is widespread throughout the Missouri Coteau grasslands of North Dakota. Recent dominance of this non-native species is due to a combination of environmental and land management factors (summarized by Toledo et al., 2014; Printz and Hendrickson, 2015).

Overabundance of Kentucky bluegrass in the region poses concerns related to reduced forage production and shifts in ecosystem function, but it can be managed successfully with fire, grazing, herbicides and their combinations (Hendrickson and Lund, 2010; summarized by Ellis-Felege et al., 2013; Kral et al., 2018).

As a turf-forming grass, Kentucky bluegrass develops a persistent thatch layer on top of the soil surface and a dense, shallow root mat (Etter, 1951). In turf systems, the thatch is managed to However, in an idle wildland or rangeland system, thatch accumulates and it may alter the near-surface abiotic conditions and perpetuate Kentucky bluegrass growth. Thick thatch layers are presumed to suppress emergence of other plant species, including native plant species. We also suspect that thatch accumulation alters near-surface thermal and hydrologic characteristics by acting as a buffer that obstructs water and air exchange between the soil and the atmosphere.

The production and maintenance of thatch is potentially one of many factors behind Kentucky bluegrass success in the region. We conducted a project to monitor and compare shallow soil temperature and water content in soils beneath Kentucky bluegrass thatch and beneath exposed surfaces where thatch had been removed manually.

Methods

We identified four monitoring sites within the Central Grasslands Research Extension Center (CGREC) to investigate soil temperature and water content in thatch-covered soils and in response to thatch removal. The sites were all within long-term (greater than 30-year) grazing exclosures that were dominated by Kentucky bluegrass (average 39% living cover), which allowed dense thatch layers to accumulate (100% litter cover).

Within each exclosure, we installed a set of paired monitoring conditions. The thatch (+Thatch) treatment was not modified from the natural condition, and the no-thatch (-Thatch) treatment

was created by manually removing the thatch in a 0.25 m^2 area.
In the fall of 2017, we installed GS3 sensors (METER Inc., Pullman, Wash.) at 5 cm and 15 cm depths of the mineral soil in each +Thatch treatment at each site. In June 2018, we removed thatch and installed sensors in the -Thatch treatment, which was within a 1-meter distance from the +Thatch sensors.

Sensors were connected to an EM-50 data logger (METER Inc., Pullman, Wash.) and they recorded soil water content (m^3/m^3) and temperature (C) every other hour for the duration of the study. The sensors are factory calibrated and provide accurate measurements of temperature. Absolute volumetric water content readings from the sensors were adjusted based on a single-point bias correction.

Briefly, gravimetric water content was measured in the spring of 2019 near sensor installations and converted to volumetric water content using previously collected bulk density measurements and assuming a particle density of 2.65 grams/cm^3. We then adjusted the sensor record according to the difference between the sensor-obtained volumetric water content and the field volumetric water content.

Sensor readings presented here span from May 1, 2018, to Sept. 30, 2018, although periods of data are missing due to sensor or data logger malfunction. Sensor data are presented in figures as bi-hourly readings to illustrate short-term and seasonal patterns within each site. Additionally, we computed the average monthly mean and coefficient of variation for each treatment by depth (5 cm, 15 cm and their mean). These means then were compared using paired t-tests.

Results

We observed that soil temperature and water content were very different between the +Thatch and -Thatch conditions. Hourly temperature patterns (Figure 1) indicated that the diurnal range of temperature fluctuations were greater when thatch was removed, and this was apparent at both monitoring depths and across all four sites.

Furthermore, average soil temperatures were higher when thatch was removed, and this also was observed at both depths (Table 1). The 5-cm depth experienced larger temperature variability in the -Thatch treatment throughout the season, as indicated by the coefficient of variation values.

Soil water content was variable across sites and within treatments (Figure 2). We observed higher water content at the 5-cm depth but lower water content at the 15-cm depth throughout the season in the +Thatch treatment (Table 2). The average water content across both depths was higher in the -Thatch treatment for all months.

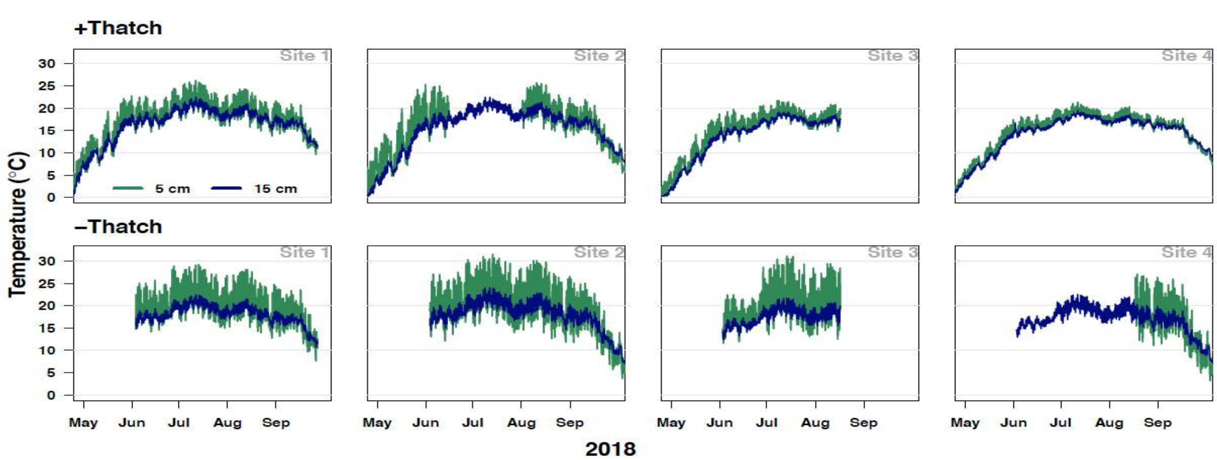

Figure 1: Plots of bi-hourly soil temperature readings at 5-cm and 15-cm depths installed across four exclosure sites at the CGREC, where Kentucky bluegrass thatch was left intact (+Thatch) or manually removed (-Thatch).

Table 1: Mean monthly soil temperature readings (with coefficient of variation in parenthesis) at 5-cm depth, 15-cm depth and their average across +Thatch and -Thatch treatments.

	Temperature (C)				
+Thatch	May	June	July	August	September
5 cm	11.4 (0.38)	17.5 (0.12)	19.3 (0.10)	18.7 (0.12)	15.1 (0.18)
15 cm	9.7 (0.38)	16.6 (0.10)	18.8 (0.08)	17.9 (0.07)	15.1 (0.13)
Average	10.6 (0.38)	17.1 (0.10)	19.1 (0.08)	18.3 (0.09)	15.1 (0.16)
-Thatch					
5 cm	---	19.2 (0.17)*	21.4 (0.19)*	19.8 (0.20)*	15.3 (0.28)*
15 cm	---	17.0 (0.10)*	19.5 (0.08)*	18.5 (0.08)*	15.2 (0.16)*
Average	---	17.8 (0.13)*	20.2 (0.12)*	19.1 (0.13)*	15.3 (0.21)*

*Stars indicate that the -Thatch mean was significantly different ($p < 0.001$) from the +Thatch mean in a paired t-test.

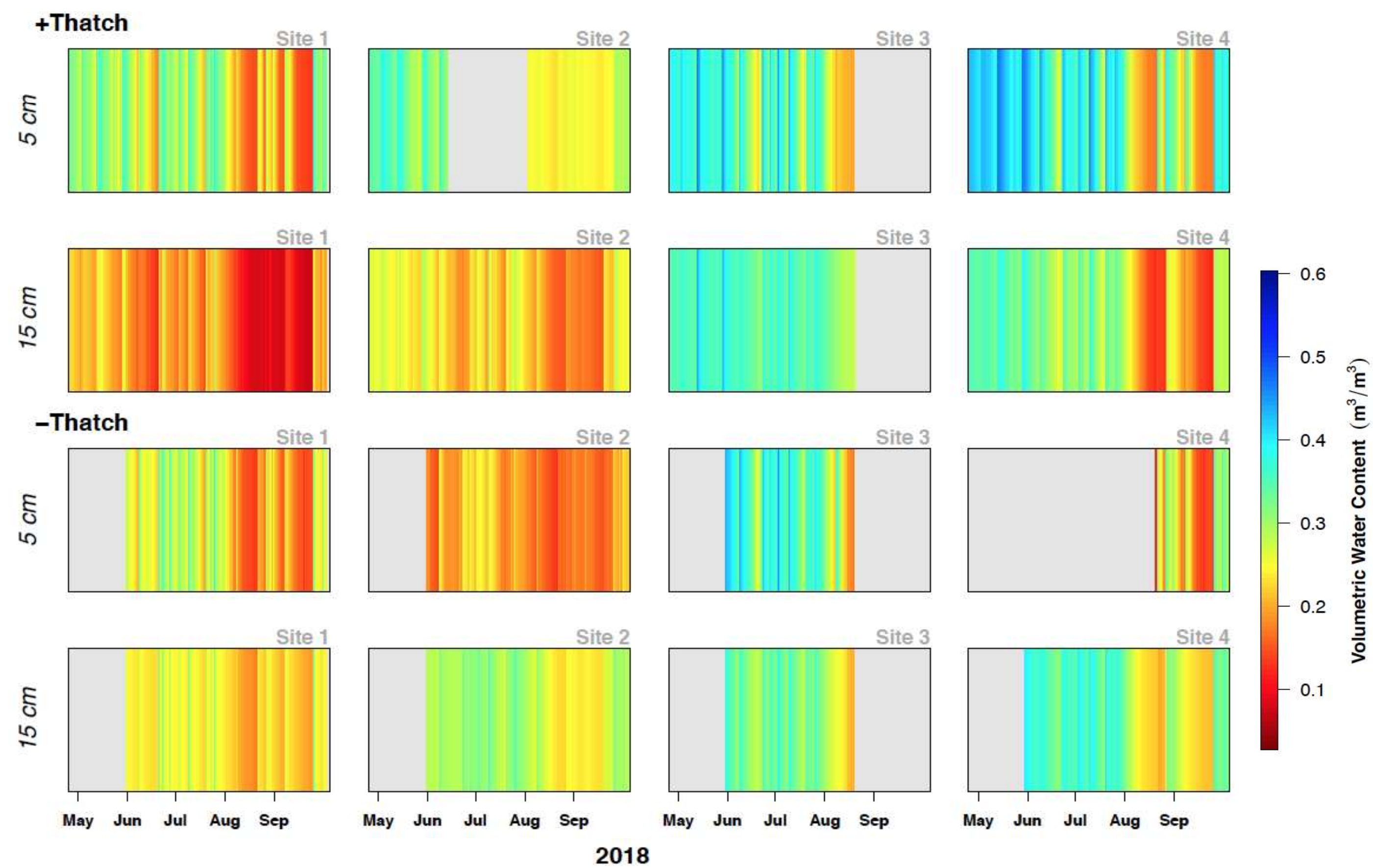

Figure 2: Plots of bi-hourly soil water content readings at 5-cm and 15-cm depths installed across four exclosure sites at the CGREC, where Kentucky bluegrass thatch was left intact (+Thatch) or manually removed (-Thatch).

Table 2: Mean monthly soil water content readings (with coefficient of variation in parenthesis) at 5-cm depth, 15-cm depth and their average across +Thatch and -Thatch treatments.

	Water Content (m^3/m^3)				
+Thatch	May	June	July	August	September
5 cm	0.353 (0.15)	0.331 (0.20)	0.339 (0.16)	0.235 (0.21)	0.250 (0.30)
15 cm	0.293 (0.22)	0.271 (0.28)	0.274 (0.24)	0.183 (0.39)	0.180 (0.36)
Average	0.324 (0.16)	0.296 (0.24)	0.296 (0.20)	0.214 (0.27)	0.215 (0.31)
-Thatch					
5 cm	---	0.281 (0.29)*	0.285 (0.24)*	0.200 (0.26)*	0.201 (0.29)*
15 cm	---	0.309 (0.15)*	0.312 (0.14)*	0.244 (0.14)*	0.252 (0.16)*
Average	---	0.305 (0.19)*	0.307 (0.17)*	0.226 (0.17)*	0.227 (0.21)*

*Stars indicate that the -Thatch mean was significantly different ($p < 0.001$) from the +Thatch mean in a paired t-test.

Discussion and Conclusions

We observed that while seasonal and diurnal temperature fluctuations were apparent in both treatments, the presence of thatch does buffer the soil temperature from the atmospheric conditions. Thatch resulted in a uniformly cooler soil that experiences smaller temperature fluctuations within daily cycles and across the growing season. Conversely, the exposed soil in the -Thatch condition was warmer, especially in the shallow depths, and more variable (within a daily cycle and across the season).

Seasonal soil water content across all sites dried as the season progressed, as expected. When thatch was present, we saw more water content in the shallow soil and less at the 15-cm depth, while we saw more water content in deeper soil when thatch was removed. The average water content across depths was higher in all months in the -Thatch treatment.

These results imply that thatch influences water distribution, with more retention in the very shallow soil and less infiltration to the deeper portions of the rooting zone. When thatch was removed, we saw more water infiltrating into the soil and a more uniform water content distribution in the rooting zone.

These observations imply that basic abiotic conditions on the surface and in shallow soil are strongly influenced by the presence of thatch. Seed and bud emergence and soil organism composition and activity are all sensitive to changes in soil temperature, and the few degrees difference that we observed may be meaningful enough to shift these communities in their phenology or their composition.

Additionally, changes in the distribution of soil water throughout the rooting zone also may influence species composition and activity. Specifically, the presence of thatch may favor shallow-rooting plants (such as Kentucky bluegrass), while suppressing deeper-rooting plants (such as native grass species). The potential cascade of biotic effects that respond to these thermal and hydrologic conditions should be investigated further and may elucidate some mechanisms contributing to the success of Kentucky bluegrass in the region.

References

Ellis-Felege, S.N., C.S. Dixon and S.D. Wilson. 2013. Impacts and management of invasive cool-season grasses in the Northern Great Plains: Challenges and opportunities for wildlife. Wildlife Society Bulletin, 37: 510-516.

Etter, A.G. 1951. How Kentucky bluegrass grows. Annals of the Missouri Botanical Garden, 38: 293-375.

Hendrickson, J.R., and C. Lund. 2010. Plant community and target species affect response to restoration strategies. Rangeland Ecology & Management, 63: 435-442.

Kral, K., R. Limb, A. Ganguli, T. Hovick and K. Sedivec. 2018. Seasonal prescribed fire variation decreases inhibitory ability of *Poa pratensis* L. and promotes native plant diversity. Journal of Environmental Management, 223: 908-916.

Murray, J.J., and F.V. Juska. 1977. Effect of management practices on thatch accumulation, turf quality, and leaf spot damage in common Kentucky bluegrass. Agronomy Journal, 69: 365-369.

Printz, J.L., and J.R. Hendrickson. 2015. Impacts of Kentucky bluegrass invasion (*Poa pratensis* L.) on ecological processes in the Northern Great Plains. Rangelands, 37: 226-232.

Toledo, D., M. Sanderson, K. Spaeth, J. Hendrickson and J. Printz. 2014. Extent of Kentucky bluegrass and its effect on native plant species diversity and ecosystem services in the Northern Great Plains of the United States. Invasive Plant Science and Management, 7: 543-552.