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Soil Organic Carbon and Mineralization Rates at the Woolsey Wet Prairie Mitigation Site in Fayetteville, Arkansas

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Abstract

Atmospheric carbon dioxide (CO_2) levels are higher than ever recorded, surpassing 400 ppm in 2013, from a pre-industrial revolution level of around 280 ppm. Researchers have been looking at methods to mitigate high CO_2 levels in the atmosphere, including promoting carbon sequestration in soils. Carbon sequestration is the process where CO_2 is naturally or artificially transferred out of the atmosphere and stored in the ocean, plant biomass, soils, and geologic formations. Seemingly contradictory to the notion of carbon sequestration, is the use of fire as a management treatment for the restoration of native prairie grass ecosystems. Fire combusts plant biomass and produces CO_2 as one of its products, potentially leading to increased atmospheric CO_2 concentrations. The first objective of this research was to determine particulate (labile) and total (labile plus stable) soil organic matter content and CO_2 respiration in Woolsey Wet Prairie Sanctuary (WWPS) soil that has been restored and managed with annual burning for 10 years compared to soil from non-restored adjacent fields growing tall fescue. The first objective was accomplished by taking soil samples and CO_2 respiration measurements before the 2017 annual prescribed burn. The second objective was to determine short-term temporal impacts of the 2017 annual prescribed burn on soil carbon release and storage. The second objective was accomplished by comparing CO_2 respiration before the fire management in the spring, then comparing to CO_2 respiration measurements taken 2, 7, 16, and 29 days post-treatment, and taking soil samples. Soil samples were taken before the 2017 annual prescribed burn, two weeks after the burn, and two months after the burn to compare short-term temporal changes to particulate organic matter (POM) and stable organic matter (OM). Results indicated high productivity in the wetland low areas with statistically greater levels of POM and OM compared to the other sample sites. Additionally, there was no statistically significant change measured in

POM following the annual prescribed burn at any sample site, nor a statistically significant increase in CO_2 respiration. The results indicate that the managed wetland area is functioning as a highly-productive carbon sink.

Keywords: carbon sequestration, fire management, prairie restoration, soil respiration

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Introduction

Carbon Cycling

While the continual use of fossil fuels as an energy source plays a role in global warming, understanding the carbon cycle and promoting carbon storage in soil is important to the goal of reducing atmospheric carbon dioxide (CO_2) levels (Stout et al. 2016). Soils store roughly three times more carbon than the atmosphere by capturing plant and animal matter residues which break down and transform into soil organic matter (SOM) (Ontl 2012). The SOM is beneficial to plant growth by improving soil structure, which also protects against erosion, providing micro and macronutrients to plants, and helps retain water (Murphy 2015). Carbon sequestration in SOM has the potential to reduce the levels of atmospheric CO_2 and mitigate the negative effects of global warming (Post et al. 2004, Lal 2004). Carbon sequestration in plant biomass is beneficial; however, burning biomass and thus releasing carbon as CO_2, is promoted as a tool for prairie management to reduce invasive species and promote native seed germination (Rook et al. 2011). Soil CO_2 is produced by plant root respiration, soil microorganisms around the rhizosphere, and microorganisms free in the soil metabolizing plant litter and SOM. Carbon mineralization, flux, or CO_2 respiration, includes microbial respiration and material decomposition. Flux measurements of CO_2 vary widely with location sampled, time of day, temperature, and soil moisture content.

Fire as a Management Tool

Arkansas is covered in large areas of deciduous forest, but before major European settlement Northern Arkansas was primarily tallgrass prairie naturally sustained by fire (Brye et al. 2008). Fire can be used as a management tool in ecosystem restoration by burning back invasive plants, providing bare mineral soil and sunlight to native seeds for establishment. Various intensities of fire happen naturally depending on the amount of biomass available. The prescribed fire utilized on the Woolsey Wet Prairie Sanctuary (WWPS) is a low-intensity, quickly moving fire. The WWPS stewards wait for ideal conditions by monitoring wind speed, ground wetness, and relative humidity. Low-intensity burning can have beneficial results on treatment sites such as increased nutrient availability and a decreased threat of pathogens (Neary et al. 1999). Conversely, high-intensity fires can result in disturbances to a system such as disruption of microbial communities and volatilization of nutrients (Neary et al. 1999).

The two concepts of carbon storage in the soils and burning of OM to promote prairie restoration seem to be contradictory in terms of soil carbon management. However, research suggests that in tallgrass prairie systems specifically above-ground biomass can be significantly increased for up to three years after a fire, resulting in greater amounts of carbon storage in plant residues (Docherty et al. 2011). The increase in nitrogen and other nutrient deposits after a fire can increase plant biomass (Docherty et al. 2011). Other research suggests that the removal of ground litter and increase in soil temperature have positive effects on biomass production (Hulbert 1986). Zhao et al. (2012) reported that organic carbon levels were higher in burned wetland areas than unburned areas, mainly in above-ground biomass, up to two growing seasons after a burn treatment. A potential negative to fire management is that with soil temperature increases soil microbial activity increases causing higher mineralization rates in soil, thus releasing CO_2 (Zhao et al. 2012).

Tallgrass Prairie Restoration

Prairie ecosystems evolved under a frequent low-intensity natural fire regime, but due to human-interference in this fire regime, prairie ecosystem have been long deprived of fire leading to problems such as invasive species monoculture and total ecosystem shifts (Docherty et al. 2011). Efforts are ongoing to promote using fire as a management tool to restore native tallgrass prairies. Native prairie ecosystems are home to thousands of plants and animals, and due to the deep-rooting nature of prairie grasses, these biomes have been shown to sequester a substantial amount of carbon (Brye et al. 2008). Native plant restoration has also been reported to increase microbial biomass and rebalance nitrogen cycling (Brockway et al. 2001).

A successful example of species restoration in tallgrass prairie is the WWPS located in Fayetteville, AR. The 46-acre WWPS was established as a wetland mitigation project following the construction of a regional wastewater treatment facility in 2006 (ECO, Inc n.d.). Engineers and city planners created a mosaic ecosystem area using earthen berms to include basin wetlands, open water, marsh, and forested wetland areas. The berms and non-wetland areas were restored in native prairie grass and forb species. The area was settled by Samuel Gilbert Woolsey in 1830 and was used for cattle grazing, but from soil horizon sampling, the land did not appear to have been plowed (ECO, Inc n.d.). Further evidence of the land not being plowed is the integrity of the mound/intermound system in the fescue field. The mound/intermound systems are of unique interest because of their symmetric properties; early origin hypotheses suggested that the mounds were created by Native Americans (Quinn 1961). Many hypotheses have been published as to the origin of the mounds, but scientists suspect they developed from accumulation of aeolian deposits and are at a state of “environmental equilibrium” with grasses protecting from erosion and soil organisms seeking slightly elevated soil to reside in dryer conditions (Allgood and Gray 1974). Fire suppression and cattle grazing greatly depreciate the biodiversity of the land with the primary planted grass at this site prior to restoration being tall fescue (*Schedonorus arundinaceus*).

Stewards of the WWPS use a prescribed burn treatment to remove invasive grasses and emergent woody vegetation annually in the spring around mid-March (ECO, Inc n.d.). Burning in the spring kills primarily cool-season invasive grasses prior to emergence of warm-season grasses and creates a mineral bed in which native plants thrive (ECO, Inc n.d.). The approach and continual management plan has been successful in restoring aboveground biodiversity. Forty-seven plant species were counted between 2001 and 2005, and one bird species was counted in December 2006. In contrast, 431 plant species were recorded in November 2013 and 90 bird species counted in 2013 (ECO, Inc n.d.). The establishment and/or reestablishment of these species resulted solely through management to promote growth of native seed that had been lying dormant in the WWPS soil (ECO, Inc n.d.).

Research Question

While restoration has been successful above-ground, the effect of management on soil carbon has not been studied at this site. Thus, we used this site to research the following questions:

1) How has restoration including fire management influenced soil CO_2 respiration and carbon storage after 10 years of prairie restoration management, and

2) What is the immediate versus temporal impact of the 2017 annual prescribed burn on soil carbon release and storage?

Objectives

1) Determine particulate (labile) and total SOM content and CO_2 respiration rates on soil from WWPS that has been restored and managed with annual burning for 10 years compared to non-restored adjacent field soil growing tall fescue.
2) Determine immediate versus temporal impacts of burning on particulate OM content and CO_2 respiration rates starting from two days after the 2017 annual burn treatment to two months post-burn from WWPS compared to adjacent field soil growing tall fescue.

Materials and Methods

Study Site

Designed by ecologists from Environmental Consulting Operations, Inc. (ECO) and engineers from McGoodwin, Williams, and Yates Consulting Engineers, Inc., the WWPS is located in Fayetteville, Arkansas (36.062595, -94.231882). Located adjacent to the West Side Wastewater Treatment Facility, the WWPS was created as a wetland mitigation site for the 9.88-acres of wetlands impacted or lost in the construction of the wastewater treatment facility (ECO, Inc n.d.). Two treatment sites were selected for the study, one being a section of the berm and wetland which received fire, and the other being an adjacent fescue mound/intermound system that did not receive fire as a management tool. The wetland soil type is anthropogenic in nature, being a blend of the primary soil type for the area (Taloka complex, mounded) and possibly neighboring soil types (Taloka silt loam, 0 to 1 percent slopes, Leaf silt loam, Jay silt loam, 1 to 3 percent slopes, and Pickwick silt loam 3 to 8 percent slopes eroded) as mapped by the WEB Soil Survey. Taloka complex, mounded, is the primary soil type for the fescue control sample area (Figure 1). In the fescue unburned control area, four transects were established and samples were taken on representative mounds, microtopological features with a higher elevation than the surrounding area and adjacent intermounds, low points of elevation between mounds (Figure 2). For the wetland area, due to time and logistical sample access constraints, sample sites were selected along the main trails between the fescue control area and parking lot. Four samples were collected immediately adjacent to the trail but on top of the constructed berm areas. Four samples were collected downslope of the berm sample sites in the wetland cells themselves. The samples were designated by their location, and henceforth will be abbreviated as the following: WL = Wetland Low, WB = Wetland Berm, FL = Fescue Inter-mound (Low), and FM = Fescue Mound with wetland being the treatment site, fescue being the control, and low/intermound vs berm/mound designating the microtopography level. It is important to note that while designations are assigned to landscape positions for both treatment areas, landscape positions cannot be assumed to be at the same elevation at all sample sites.

Timeline

Samples were collected between February 10 and May 18, 2017. The first CO_2 respiration measures occurred on February 22. The prescribed burn was conducted on February 25, and CO_2 respiration samples were measured on February 27, March 4, March 13, and March 26. Soil samples were collected February 10, and adjacent to locations of soil respiration measurements on March 12 and May 18.

Bulk Density

Bulk density (dry soil mass divided by total soil volume) was determined by using one 5-cm diameter, 5-cm long soil core to collect soil at each site type (WL, WB, FL, FM) on February 10, March 12, and May 18 for a total of 48 soil samples. The known volume of the soil was removed from the soil core and dried in a pre-weighted container at 55°C for 5-7 days until a constant weight was reached. The dry soil weight was measured and subtracted from the container weight to calculate bulk density.

Soil Organic Matter

Oven-dry soil (from the determination of bulk density) was ground with a mortar and pestle and passed through a 2-mm sieve. Ten grams of soil was transferred into a pre-weighed crucible. Crucibles were placed in an oven at 55ºC for 5 days. After five days, the samples were removed from the oven and weighed again. Crucibles were then placed into a muffle furnace and combusted at 450 ºC for 8 hours. Crucibles were weighed again, and percent organic matter was calculated using the following equation: % OM = ([oven-dry soil (g) after 5 days at 55ºC – ash weight (g) after being combusted in the muffle furnace] / [oven-dry soil (g) after 5 days at 55ºC]) * 100%.

Particulate Organic Matter

Oven-dry soil was ground with a mortar and pestle and passed through a 2-mm sieve. Particulate OM, or sand-sized fraction (SSF) between 0.053-mm and 2-mm, was determined using the oven-dried soil. Sieved soil (25g) was transferred to a 250-mL bottle and mixed with 100-mL of 5 g sodium hexametaphosphate ($(NaPO_3)_6$), shaken for 16 hours, poured through a 53-µm sieve, and rinsed with DI water. The retained fraction was dried overnight in a pre-weighed container at 55ºC and again weighed. After weighing, dried SSF samples were transferred into pre-weighted crucibles, re-weighed, and combusted in a furnace at 450 ºC for 8 hours. Samples were cooled in a desiccator and the weight of the crucible and ash was determined and used to calculate percent OM in the SSF. The weight of the SSF after drying overnight was divided by 25g to determine the fraction of SSF to soil sample. That value was multiplied by % POM in the SSF to determine % POM in the initial 25g soil sample. The % POM SSF was then divided by % OM determined by using the above-mentioned methods to calculate % POM as part of the total organic matter.

Carbon Mineralization

In-situ respiration, or CO_2 flux, was determined using a LI-COR LI-8100A automated soil gas flux system (LI-COR, Lincoln, Nebraska, USA). A 20-cm survey chamber fitted over 20-cm dia. PVC soil collars which were installed 2-5 cm into the soil surface to create a seal. Collars were installed at least 24 hours prior to CO_2 respiration measurements to allow the soil to normalize after the disturbance. Additionally, plant matter on the soil surface within the soil collars was cut and removed 24 hours before measuring soil flux. Flux is calculated by an infrared analyzer located in the survey chamber. The rate of CO_2 being released from the soil into the survey chamber is used to model CO_2 diffusing into the air outside of the chamber. Soil temperature and moisture were determined by inserting both a temperature probe (Omega Soil Temperature Probe 6000-09TC) and theta probe (Delta-T ML2 ThetaProbe) into the soil adjacent to the survey chamber. The temperature probe was inserted 15.24 cm into the soil, while the theta probe was inserted 6 cm into the soil. The soil surface area within the 20-cm soil collar is 317.8 cm^2. The headspace between the soil surface and top of the soil collar was measured in five locations around the inside of the collar, averaged, and entered into the LI-8100A measurement software as chamber offset in cm to calculate chamber volume. The LI-8100A device was set with a one-minute pre-purge time in between measurements to allow normalization of gasses, while the observation time was set for two minutes. Three measurements one minute apart were collected at each site. Measurements were analyzed using the SoilFluxPro version 4.0 software provided by LI-COR. Soil flux rates F_c were reported by the LI-8100A in μmol CO_2 m^{-2} s^{-1} determined by the following equation.

$$Fc = \frac{10VP_0(1 - \frac{W_0}{1000})}{RS(T_0 + 273.15)} \frac{\partial C'}{\partial t}$$

Where V is volume inside the survey chamber (cm^3), initial pressure is denoted by P_0 (kPa), W_0 is initial water vapor mole fraction (mmol mol^{-1}), S is soil surface area (cm^2), T_0 is initial air temperature (°C), and $\frac{\partial C'}{\partial t}$ is the initial rate of change in the water-corrected CO_2 mole fraction (μmol mol^{-1}). The variables P_0, T_0, and W_0 are calculated by the LI-8100A after the chamber closed. Within the two-minute observation time, for analysis purposes, the initial 15-seconds were not included in the flux calculation and are considered a “dead band”. This dead band was set at the beginning of the observation to mitigate errors in flux calculations from initial changes in chamber pressure due to the closing of the device. The mean was calculated for the three measurements of exponential flux for each sample site. Flux was adjusted using the Q_{10} temperature coefficient provided by the following equation:

$$R_2 = R_1 {Q_{10}}^{(T_2 - T_1)/10°C}$$

with R_2 being the new rate of exponential CO_2 flux (μmol m^{-2} s^{-1}), R_1 being the original exponential CO_2 flux (μmol m^{-2} s^{-1}), Q_{10} being a unit-less temperature coefficient, T_2 being a temperature chosen as a standard, for this study 25 °C, and T_1 as the soil temperature determined by Omega Soil Temperature Probe during sampling. Based on a study by Mahecha et al. (2010), a Q_{10} temperature coefficient of 1.4 was selected for use in this equation. The Mahecha et al. (2010) study emphasizes a strong relationship between photosynthesis and respiration, while concluding that Q_{10} is independent of mean annual temperature, consistent across different biomes, and that a Q_{10} value of 1.4 is more appropriate for use in measurements of whole ecosystem processes.

Temperature and Water Content

During CO_2 respiration measurements, adjacent to each collar, soil temperature and water content measurements were recorded adjacent to the chamber using a temperature and theta probe inserted into the soil. Daily mean air temperature (°C) (Figure 3) and precipitation (Figure 4) during sample dates were taken from the National Weather Service website (weather.gov).

Data Analysis

Preliminary organization of data was performed in Microsoft Excel 2016. Statistical analysis was performed using SPSS Statistics 24.0.0.2 (Armonk, New York) and SAS 9.4 (Cary, North Carolina). Repeated measures ANOVAs were run individually for each dependent variable (bulk density, OM, POM, temperature, water content, flux) to determine significance with $\alpha = 0.05$ of values within and across groups.

Results

To better understand our sample areas and explore our research questions we first performed statistical analysis to determine if our measurements changed with time, followed by comparing means across the two treatment sites (fescue, wetland) and four microtopography levels (WL, WB, FL, FM). Several of our parameters did not change with time (bulk density, SOM, POM) while soil CO_2 respiration did change with time and we attempted to explain flux variation over time by comparing values measured to soil moisture content and soil temperature measurements recorded at the time of CO_2 respiration sampling.

Bulk density did not change with time (Table 1); however, WL was statistically lower from WB, FL, and FM and WB was statistically higher from WL, FL, and FM (Table 2, Figure 5, $P < 0.05$). The bulk density in FL and FM values were not statistically different from each other. The bulk density was lowest in the WL (0.917 g/cm^3) and highest in the WB (1.295 g/cm^3) while the FL and FM means were both 1.13 g/cm^3.

Soil OM did not change with time (Table 3); however, WL was statistically from the other three sample sites higher, while the other three sample sites (WB, FL, FM) were not statistically different from each other (Table 4, Figure 6, $P < 0.05$). The WL had the highest SOM (8.94%), WB had the lowest (5.34%), and FL and FM measured 6.4%, and 6.19% respectively.

Particulate OM of the total OM did not change with time (Table 5). The WL samples are significantly higher on all three dates compared to other sample sites (Table 6, Figure 7, $P < 0.05$). The WL had the highest percent POM of SOM values measured (46.6%), while the WB was 25.58%, and FL and FM were 29.18% and 34.49%, respectively. There was no significant change in WL or WB POM samples between pre-burning and March 12 (15 days after burning) measurements.

The WL and WB CO_2 respiration measurements were not statistically different between February 22 (pre-burn) and February 27 (2 days after the burn); however, FL and FM measurements statistically decreased between these time intervals ($P < 0.05$; Table 7). Respiration in WL did not change statistically across any of the time intervals, while respiration in WB increased statistically from March 13 to March 26 ($P < 0.05$). For FL, only the mean differences between February 22 and February 27 were statistically significant ($P < 0.05$). For FM respiration decreased statistically from February 22 to February 27 and between March 4 and March 13 ($P < 0.05$).

For February 22 pre-burn CO_2 respiration measurements, WL and WB were not statistically different from each other, and FL and FM were not statistically different from each other (Table 8, Figure 8). Both WL and WB measurements were statistically lower to FL and FM measurements ($P < 0.05$). On February 27, two days following the burn, CO_2 respiration measurements among the four sites were not statistically different from each other. On March 4, the WB sites were statistically lower compared to FL ($P < 0.05$), and WL, FL, and FM were not statistically different from each other. On March 13, respiration in WB was greater than the two fescue sites, and on March 26, respiration was greater in WB than WL, FM, and FB ($P < 0.05$), while the other three sites were not statistically different from each other (WL, FL, FM). On the dates following March 4, there were several major rain events (Figure 4), resulting in a corresponding decrease in soil temperature (Figure 9), increase in soil water content (Figure 10), and decrease in CO2 flux (Figure 8) on March 13. Precipitation events in late March (Figure 4) resulted in wetter soil in the lower elevation sites (FL, WL, Figure 9), but respiration increased with warmer soil temperatures (Figure 9) in the higher elevation locations, especially WB (Figure 8).

Temperature over time was statistically different with WL statistically higher on March 26 from March 13, WB higher on February 27 from February 22 and lower on March 13 from

March 4. Additionally, FL was statistically higher on February 27 from February 22, lower on March 13 from March 4, and higher on March 26 from March 13, while FM was statistically lower on March 13 from March 4, and higher on March 26 from March 13 (Table 9, $P < 0.05$). Regarding within date statistical variation, differences were only measured on February 27 with WL having a statistically higher temperature compared to FL, while WB and FM were not statistically different from the other two sample sites (Table 10, Figure 9, $P < 0.05$). No other dates showed within date statistical differences between the four sample sites.

Soil water content statistically changed over time with WL lower on February 27 from February 22, and higher on March 13 from March 4. WB was statistically higher on March 13 from March 4, FL was lower on February 27 from February 22 and higher on March 13 from March 4, while FM was higher on March 13 from March 4 (Table 11, $P < 0.05$). Regarding within date statistical variation, on February 22 WL had a statistically higher water content then WB and FM which were statistically similar, while FL was not different from the other three sample sites. On March 13 and March 26 WL and FL were observed to be statistically similar, and higher than WB and FM which were statistically similar to each other. No statistical variation was observed on February 27 and March 4 (Table 12, Figure 10, $P < 0.05$).

Discussion

The first objective was to determine POM and SOM content and compare CO_2 respiration on soil from WWPS that has been restored and managed with annual burning for 10 years compared to non-restored adjacent field soil growing tall fescue. This was accomplished by analyzing pre-burn data measured from the treatment and control areas. Soil POM is beneficial to soil functioning by providing a food source for microorganisms, promoting soil aggregation and can be considered as an initial catalyst to C sequestration (Kravchenko et al. 2014). The results of this study suggest the WL to be highly productive with soil aggregation (low bulk density) and metabolic conversion of POM into more stable forms of SOM (greater measured OM levels). Decomposition of organic matter in soils releases CO_2 into the atmosphere (Keiluweit et al. 2017); however, pre-burn flux values were measured as lower in the wetland area than in the fescue fields. This could be explained by the higher water content measured in the WL sample sites compared to the other sample sites. The sample sites chosen for WL and FL were at the lowest point of the landscape, and after rain events soil collars had to be retrieved from underwater and relocated to above the water line. Keiluweit et al. (2017) reported that while mineralization occurs during anaerobic conditions, mineralization rates decrease by 60-95% compared to aerobic conditions. Anaerobic conditions are typical for a wetland system.

The second objective was to determine immediate versus temporal impacts of burning on POM content and C mineralization rates on wetland (burned) soil. Since there was no measured change in POM before the burn and 15 days after the burn, it appears from these samples that there was no change in POM immediately following the burn. Regarding flux, measurements taken 2 days after the burn all decreased from pre-burn levels and were not significantly different from each other regardless of microtopography. It is possible that the heat from the fire and increased solar radiation resulting from the removal of surface biomass disrupted the microbiological functions in the wetland area as soil temperature in WL increased significantly 2 days after the burn compared to FL. However, flux measurements from the fescue areas were not statistically different from the wetland 2 days after the burn, suggesting that biological functions were not altered by the prescribed fire. Additionally, major disruptions to proteins and plant tissue occur around 40-70°C (Neary et al. 1999). Reports from the prescribed fire indicate that the fire moved very quickly through the system at a low intensity and after the burn was completed, the ground was cool enough to walk on. Fire can have a wide range of effects on the soil system depending on intensity and duration of the fire, with duration being the main factor in how much damage a soil system receives belowground (Neary et al. 1999). Low-intensity fire events typically do not burn hotter than 100°C at the surface and 50 °C at 5 cm below the soil surface (Neary at al. 1999). These types of low-intensity fire can break down nutrients into similar forms for plant and microbial consumption, thin overcrowded biomes, and is popular as an ecological restoration practice (Neary et al. 1999). The annual burning schedule at the WWPS limits large amounts of fuel loading, thus limiting the intensity of fires and damage to the soil system.

Besides the expected variability in flux measurements, a potential source of error was introduced into the system because the PVC soil collars had to be moved several times. The pre-burn collars were removed after initial measurements, so they were not damaged by the prescribed fire treatment. Additionally, the WL and FL collars had to be relocated to slightly higher elevation on March 12 because they were completely submerged after a rainstorm. Another potential source of analysis error is that soil temperature readings were taken at 15cm, while the PVC soil collars used for hosting the LI-8100A in CO_2 respiration measurements were inserted shallowly into the soil at a depth of 2-5cm. This may have resulted in improper analysis of the effect of temperature on flux as the temperatures measured were not exactly at the same depth as major microbial activity. In a study by Zhou et al. (2013), they reported nearly twice the microbial biomass to be residing at a 0-10cm depth compared to 10-20cm at their grassland study site. Additionally, the 0-10cm microbial community had a higher response (increasing respiration) to temperature and moisture changes.

Future studies should include soil texture analysis of the wetland area to measure the texture as a result of anthropogenic mixture. Additionally, C:N measurements might allow researchers to gain more insight regarding total ecosystem health.

Based on the measurements of this study, the WL area is functioning as a highly productive carbon sink with greater C retention in OM and lower CO_2 respiration. Organic matter (particulate and total) and respiration measurements in the spring before and after an annual prescribed burn did not indicate that fire management is detrimental to carbon sequestration; therefore, prescribed annual fire appears to be a positive influence on soil carbon storage at the WWPS.

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Tables and Figures

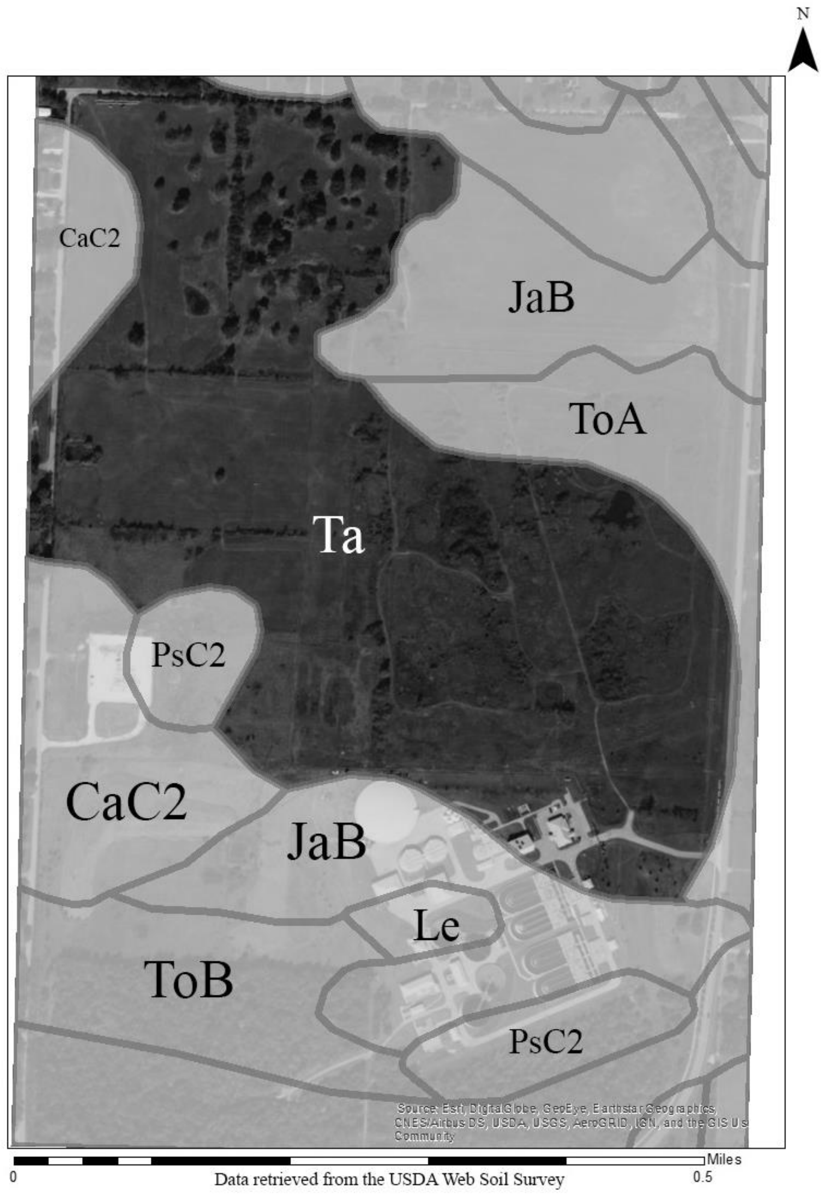

Figure 1. Primary soil type map for the Woolsey Wet Prairie Sanctuary in Fayetteville, AR. Ta = Taloka complex, mounded. ToA = Taloka silt loam, 0 to 1 percent slopes. ToB = Taloka silt loam, 1 to 3 percent slopes. PsC2 = Pickwick silt loam, 3 to 8 percent slopes, eroded. Le = Leaf silt loam. JaB = Jay silt loam, 1 to 3 percent slopes. CaC2 = Captina silt loam, 3 to 6 percent slopes, eroded.

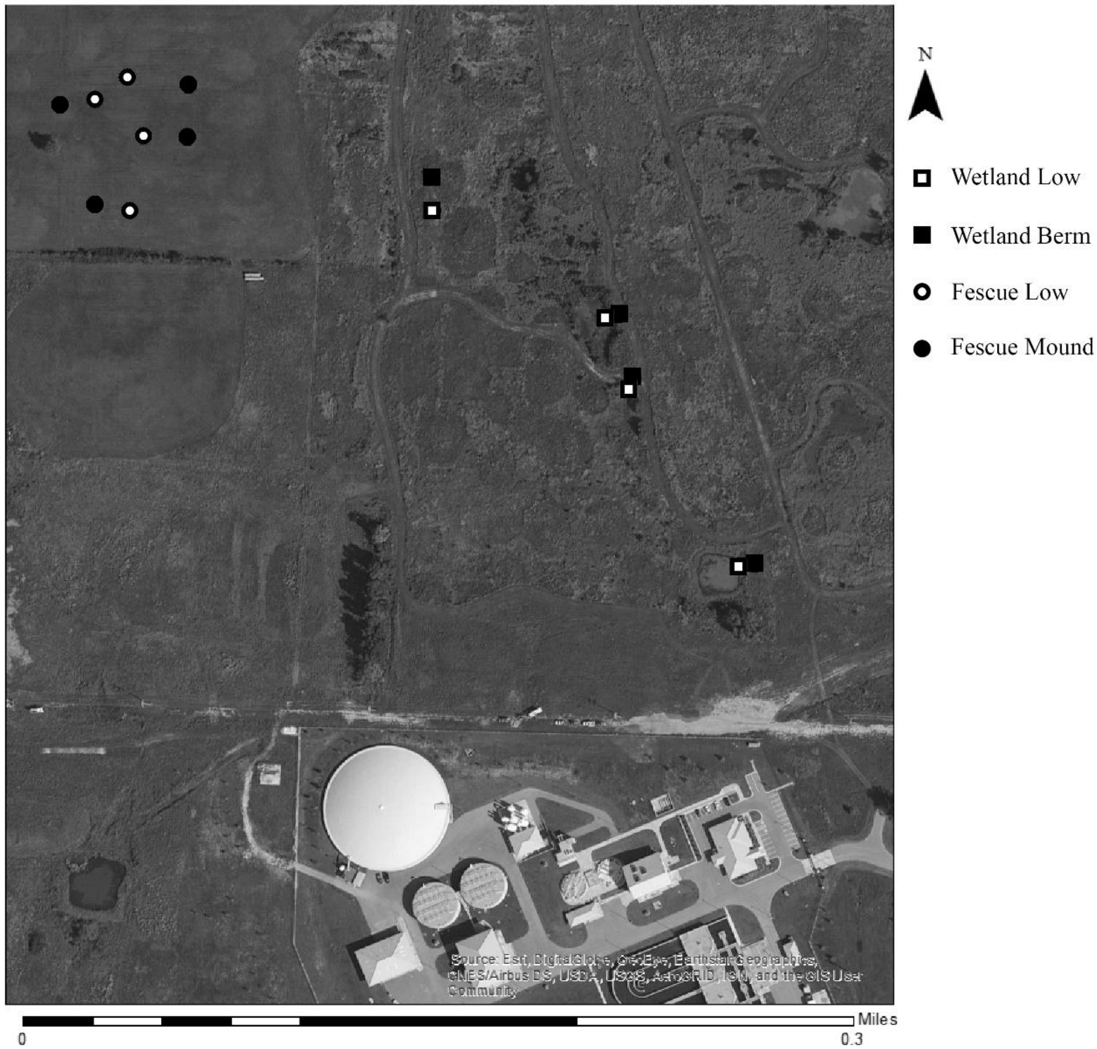

Figure 2. Woolsey Wet Prairie Sanctuary location map for Wetland Low, Wetland Berm, Fescue Low, and Fescue Mound sample sites.

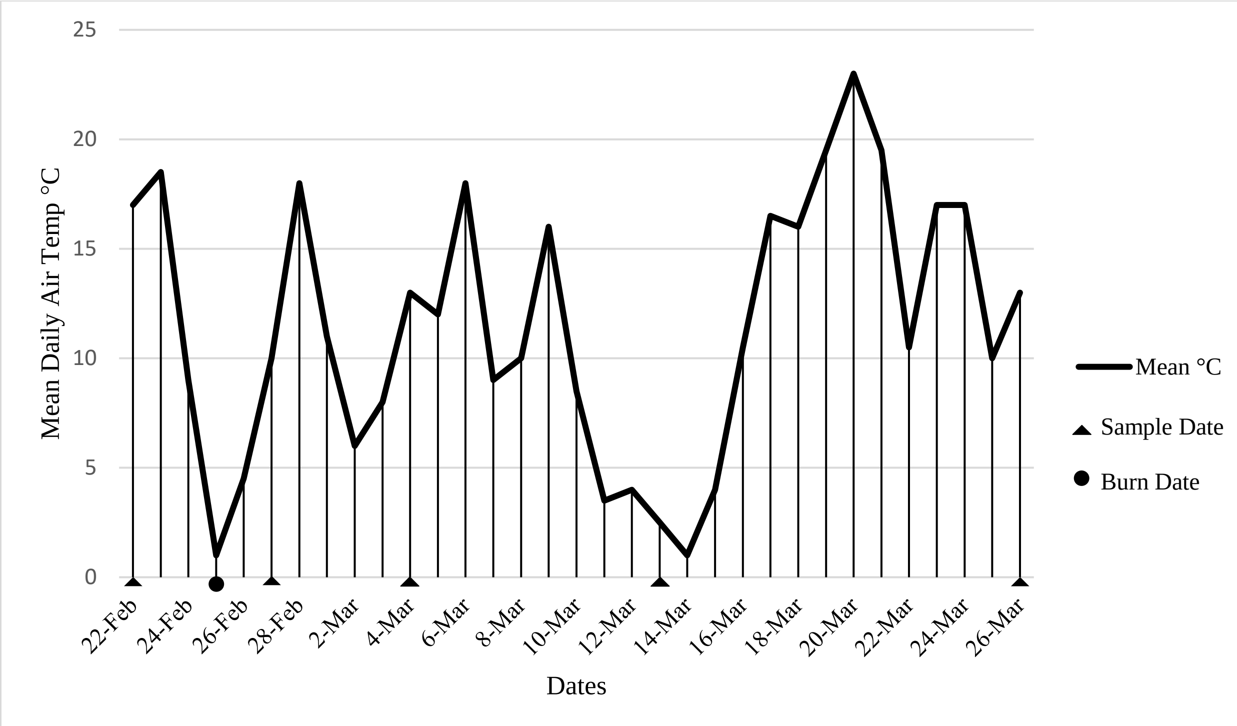

Figure 3. Mean daily air temperature (°C) during the time measurements were taken at the Woolsey Wet Prairie Sanctuary.

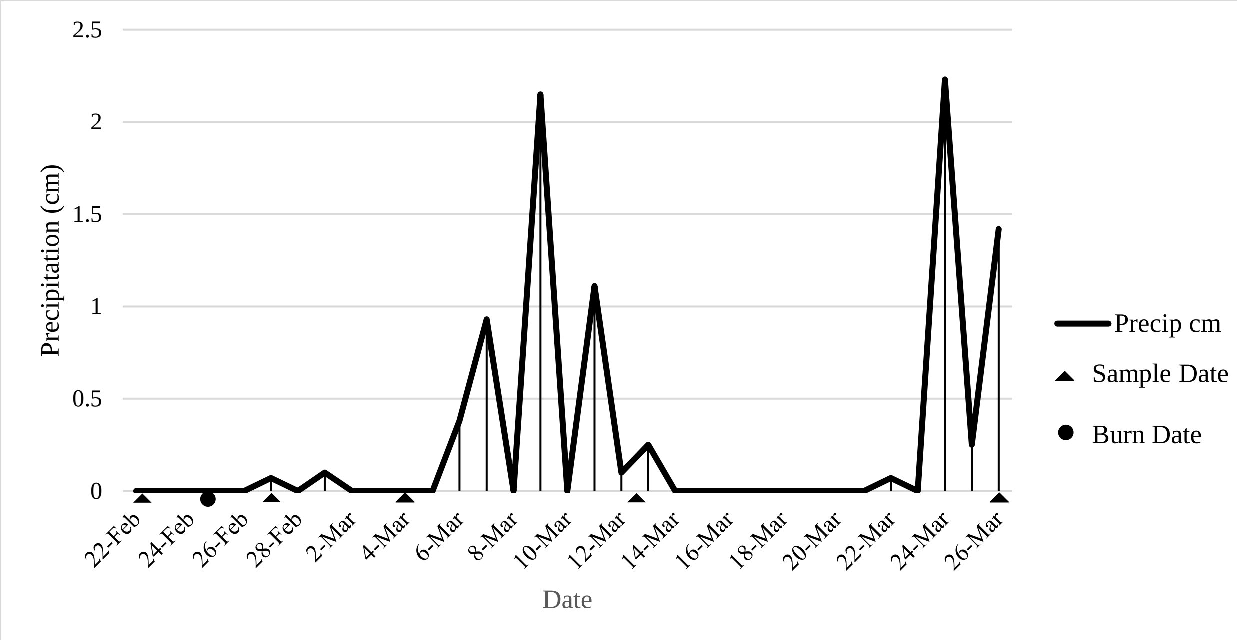

Figure 4. Precipitation (cm) during the time measurements were taken at the Woolsey Wet Prairie Sanctuary.

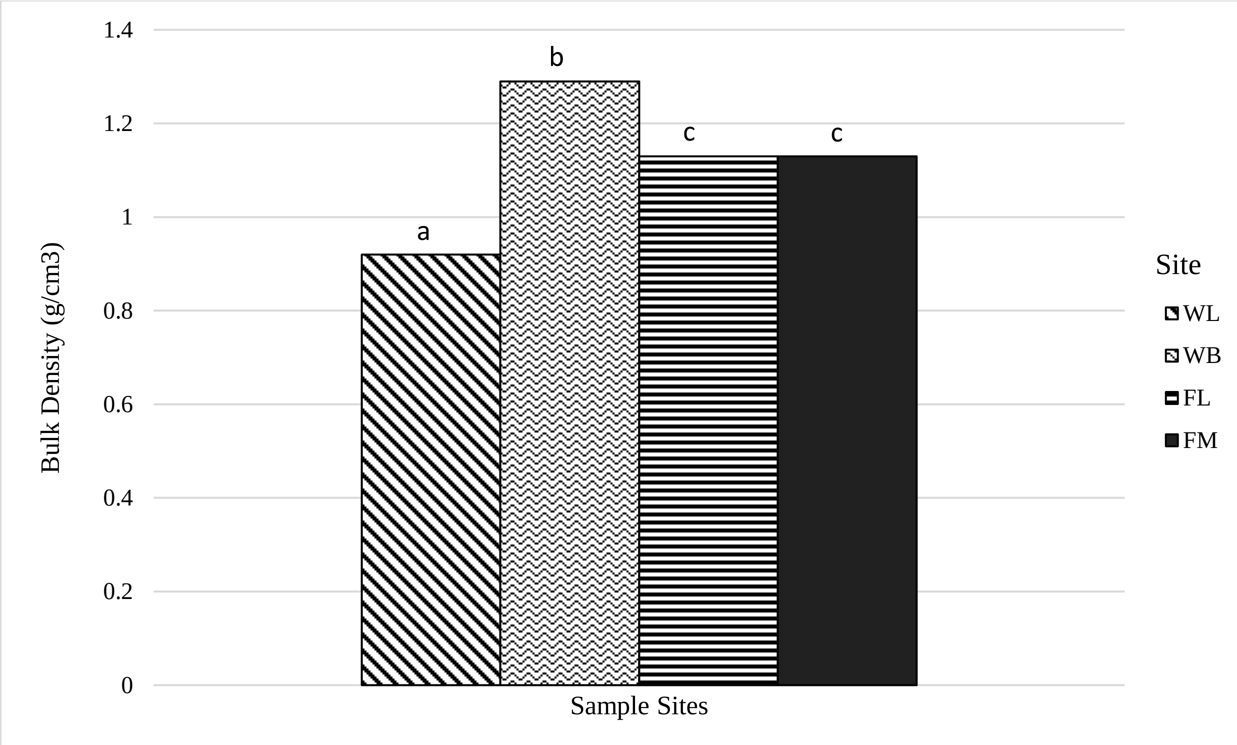

Figure 5. Bulk density (g/cm^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR from February 10, March 12, and May 18, 2017. Bulk density did not change with time and samples were averaged together (n = 12). Means with the same letters are not statistically different ($\alpha = 0.05$). Fire management was applied to the wetland area on February 25.

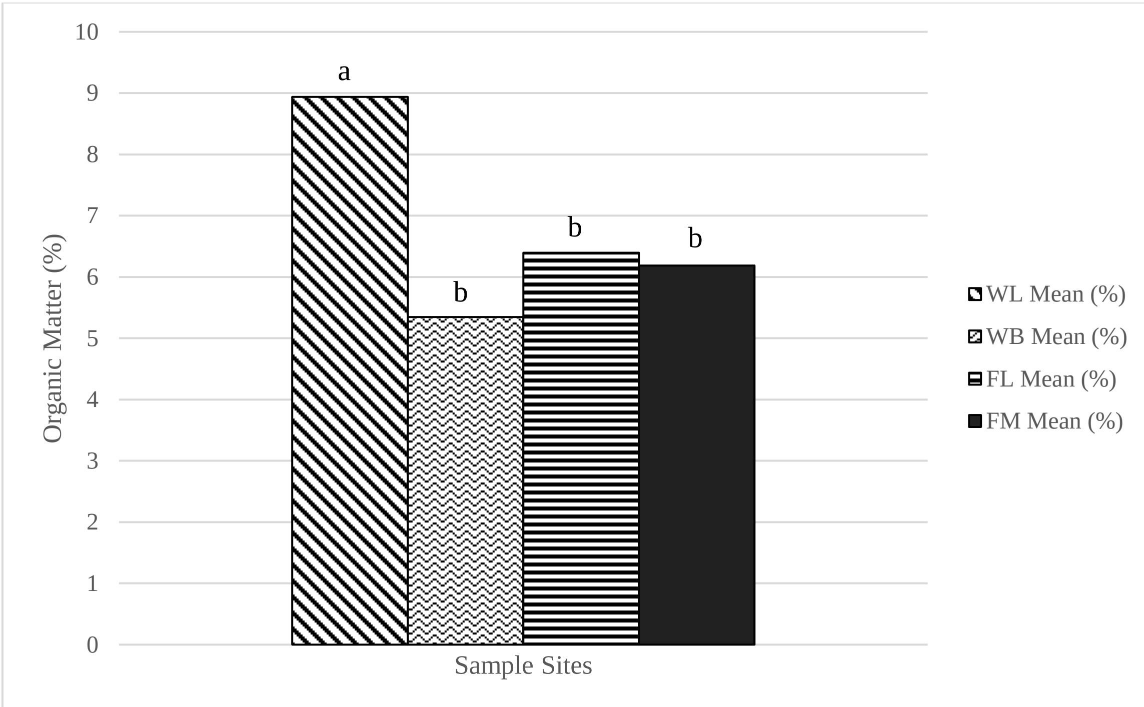

Figure 6. Organic matter (%) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR from February 10 to May 18, 2017. Means with the same letters are not statistically different ($\alpha = 0.05$). Organic Matter did not significantly change over time and values across dates are averaged together ($n = 12$). Fire management was applied to the wetland area on February 25.

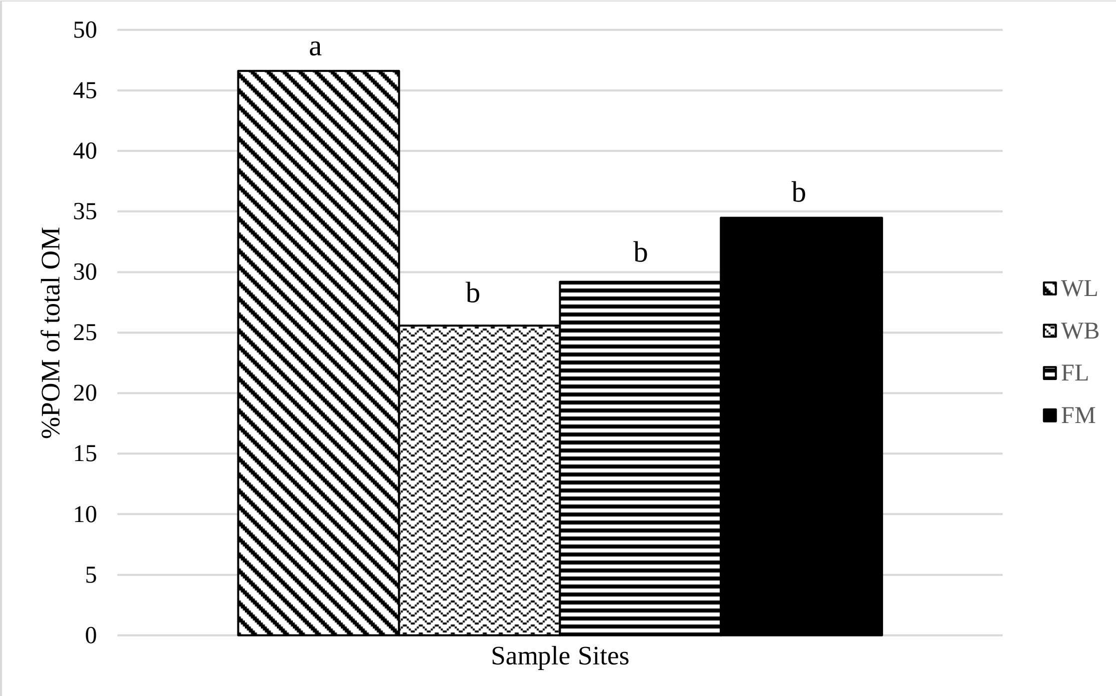

Figure 7. Particulate organic matter of the total organic matter (%) in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 10, March 12, and May 18, 2017. On each date, means with the same letters are not statistically different ($\alpha = 0.05$). Particulate organic matter did not significantly change over time and values across dates are averaged together ($n = 12$). Fire management was applied to the wetland area on February 25.

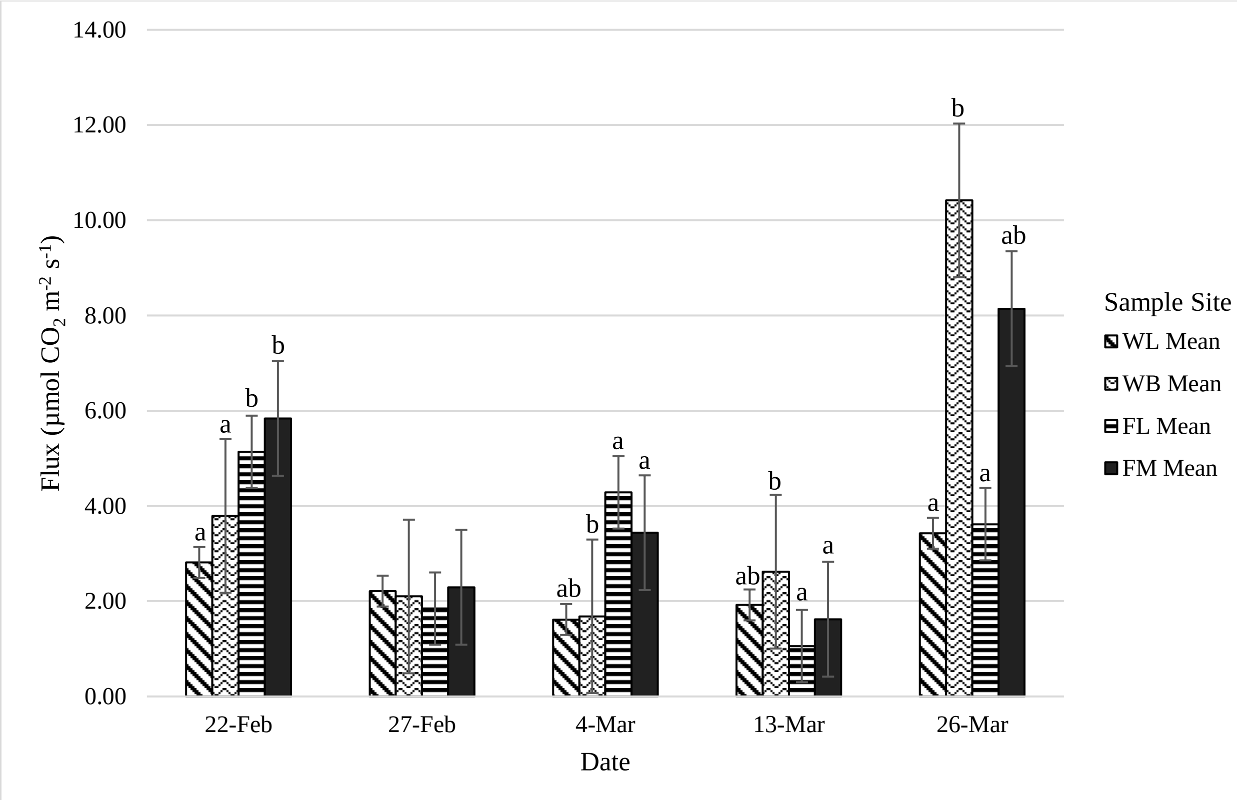

Figure 8. Carbon respiration measurements (µmol CO_2 m^{-2} s^{-1}) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26, 2017 (n = 12). On each date, means with the same letters are not statistically different (α = 0.05). Statistical differences were not observed on February 27. Fire management was applied to the wetland area on February 25.

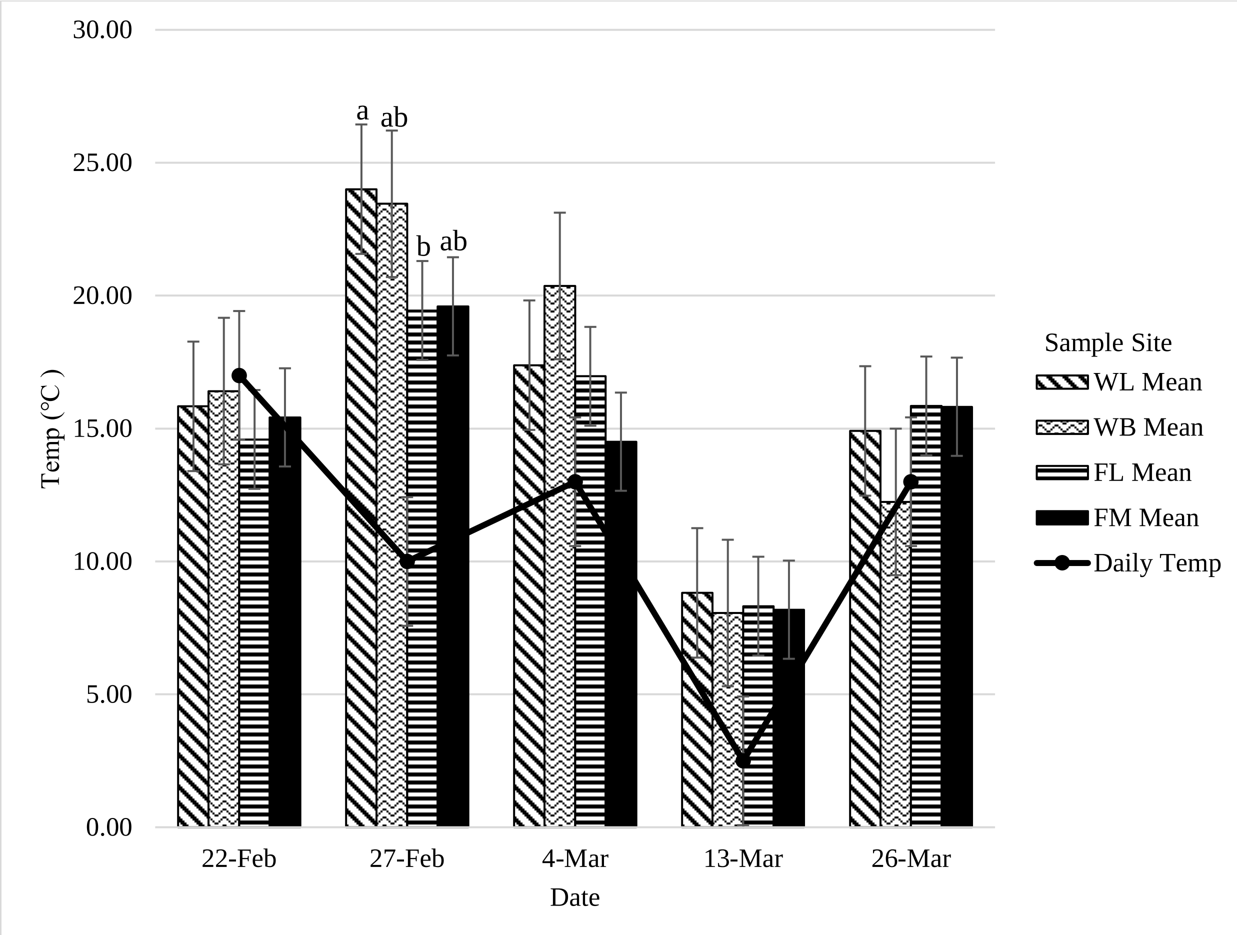

Figure 9. Soil temperature measurements (°C) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26, 2017 (n = 4). On each date, means with the same letters are not statistically different (α = 0.05). Statistical differences were only observed on February 27. Fire management was applied to the wetland area on February 25.

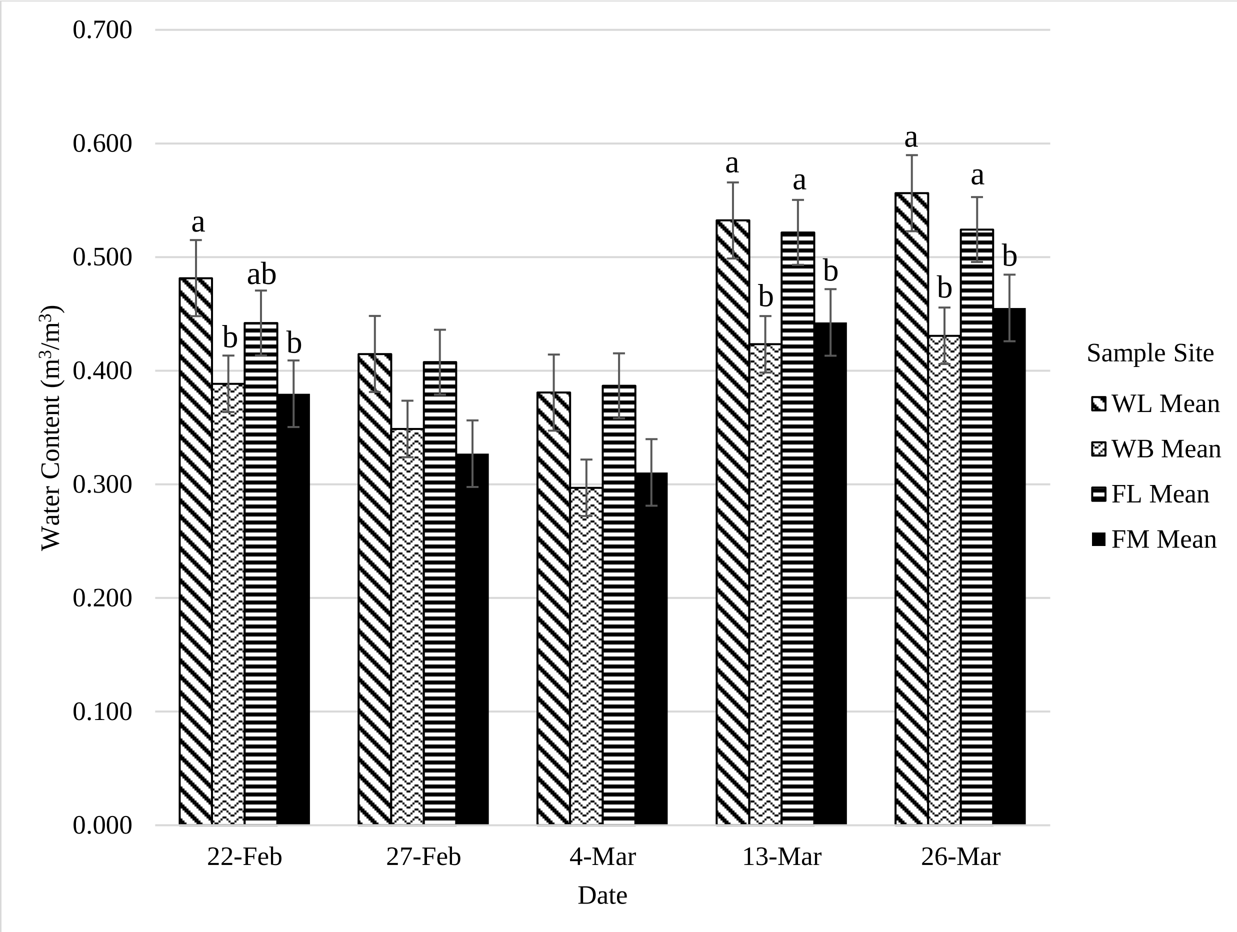

Figure 10. Water content measurements (m^3/m^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26, 2017 ($n = 4$). On each date, means with the same letters are not statistically different ($\alpha = 0.05$). Statistical differences were not observed on February 27 or March 4. Fire management was applied to the wetland on February 25.

Table 1. Bulk density (g/cm^3) repeated measured ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	0.01	0.09	0.7854
	Diff 2	0.08	0.59	0.4978
WB	Diff 1	0.01	0.02	0.8916
	Diff 2	0.11	1.69	0.2849
FL	Diff 1	0.06	0.61	0.4905
	Diff 2	0.02	0.09	0.7873
FM	Diff 1	0.09	8.95	0.0581
	Diff 2	-0.06	1.84	0.2680

n = 12

Note: The dependent variable is bulk density (g/cm^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field mounds (FM) and intermounds (FL) in Fayetteville, AR. Diff 1 is the difference in means between February 10 and March 12. Diff 2 is the difference in means between March 12 and May 18. All differences are not significantly different from 0 at $\alpha = 0.05$. Fire management was applied to the wetland area on February 25.

Table 2. Bulk density (g/cm^3) one-way ANOVA Post-Hoc (LSD) test

Dependent Variable	(I) site	(J) site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Bulk density	WL	WB	-0.373*	0.043	0.000	-0.459	-0.288
		FL	-0.203*	0.043	0.000	-0.288	-0.117
		FM	-0.208*	0.043	0.000	-0.294	-0.123
	WB	WL	0.373*	0.043	0.000	0.288	0.459
		FL	0.171*	0.043	0.000	0.085	0.257
		FM	0.165*	0.043	0.000	0.079	0.251
	FL	WL	0.203*	0.043	0.000	0.117	0.288
		WB	-0.171*	0.043	0.000	-0.257	-0.085
		FM	-0.006	0.043	0.891	-0.092	0.080
	FM	WL	0.208*	0.043	0.000	0.123	0.294
		WB	-0.165*	0.043	0.000	-0.251	-0.079
		FL	0.006	0.043	0.891	-0.080	0.092

*$P < 0.05$; n = 12

Note: The dependent variable is bulk density (g/cm^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 10, March 12, and May 18, 2017. Time was not statistically significant; therefore, measurements are averaged across the three days for each site. Fire management was applied to the wetland area on February 25.

Table 3. Soil organic matter (%) repeated measures ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	1.13	0.20	0.6865
	Diff 2	-2.48	3.04	0.1797
WB	Diff 1	1.09	5.90	0.0933
	Diff 2	-1.39	4.74	0.1178
FL	Diff 1	0.13	0.36	0.5888
	Diff 2	0.06	0.01	0.9330
FM	Diff 1	0.38	1.54	0.3031
	Diff 2	0.20	0.14	0.7296

n = 12

Note: The dependent variable is organic matter (%) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field mounds (FM) and intermounds (FL) in Fayetteville, AR. Diff 1 is the difference in means between February 10 and March 12. Diff 2 is the difference in means between March 12 and May 18. All differences are not significantly different from 0 at $\alpha = 0.05$. Fire management was applied to the wetland area on February 25.

Table 4. Organic matter (%) one-way ANOVA Post-Hoc (LSD) test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
OM	WL	WB	4.337*	0.679	0.000	2.969	5.704
		FL	3.263*	0.679	0.000	1.896	4.631
		FM	3.474*	0.679	0.000	2.107	4.842
	WB	WL	-4.337*	0.679	0.000	-5.704	-2.969
		FL	-1.073	0.679	0.121	-2.441	0.294
		FM	-0.863	0.679	0.210	-2.230	0.505
	FL	WL	-3.263*	0.679	0.000	-4.631	-1.896
		WB	1.073	0.679	0.121	-0.294	2.441
		FM	0.211	0.679	0.757	-1.157	1.578
	FM	WL	-3.474*	0.679	0.000	-4.842	-2.107
		WB	0.863	0.679	0.210	-0.505	2.230
		FL	-0.211	0.679	0.757	-1.578	1.157

*$P < 0.05$; n = 12

Note: The dependent variable is bulk density (g/cm^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 10, March 12, and May 18, 2017. Time was statistically significant; therefore, measurements are averaged across the three days for each site. Fire management was applied to the wetland area on February 25.

Table 5. Particulate organic matter of the total organic matter (%) of soil repeated measures ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	10.07	0.79	0.4392
	Diff 2	-24.61	2.03	0.2496
WB	Diff 1	7.49	2.00	0.2522
	Diff 2	-16.84	4.12	0.1354
FL	Diff 1	12.51	3.43	0.1612
	Diff 2	-7.82	2.14	0.2394
FM	Diff 1	-3.23	0.60	0.4950
	Diff 2	3.23	0.60	0.4950

n = 12

Note: The dependent variable is particulate organic matter of the total organic matter (%) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR. Diff 1 is the difference in means between February 10 and March 12. Diff 2 is the difference in means between March 12 and May 18. All differences are not significantly different from 0 at $\alpha = 0.05$. Fire management was applied to the wetland area on February 25.

Table 6. Particulate organic matter of the total organic matter (%) one-way ANOVA Post-Hoc (LSD) test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
POM	WL	WB	12.800*	2.572	0.000	7.197	18.403
		FL	11.910*	2.572	0.001	6.307	17.513
		FM	11.620*	2.572	0.001	6.017	17.223
	WB	WL	-12.800*	2.572	0.000	-18.403	-7.197
		FL	-0.890	2.572	0.735	-6.493	4.713
		FM	-1.180	2.572	0.655	-6.783	4.423
	FL	WL	-11.910*	2.572	0.001	-17.513	-6.307
		WB	0.890	2.572	0.735	-4.713	6.493
		FM	-0.290	2.572	0.912	-5.893	5.313
	FM	WL	-11.620*	2.572	0.001	-17.223	-6.017
		WB	1.180	2.572	0.655	-4.423	6.783
		FL	0.290	2.572	0.912	-5.313	5.893

*$P < 0.05$; n = 12

Note: The dependent variable is particulate organic matter of total organic matter (%) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 10, March 12, and May 18, 2017. Time was not statistically significant; therefore, measurements are averaged across the three days for each site. Fire management was applied to the wetland area on February 25.

Table 7. CO_2 respiration (μmol CO_2 m^{-2} s^{-1}) repeated measures ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	-0.84	1.16	0.3597
	Diff 2	0.08	0.02	0.8866
	Diff 3	-0.13	0.12	0.7521
	Diff 4	2.03	3.45	0.1604
WB	Diff 1	-1.28	1.55	0.3018
	Diff 2	-0.42	3.89	0.1433
	Diff 3	1.43	3.52	0.1572
	Diff 4	7.74*	14.55	0.0317
FL	Diff 1	-3.24*	398.72	0.0003
	Diff 2	2.16	2.61	0.2044
	Diff 3	-2.95	6.37	0.0859
	Diff 4	2.56	5.53	0.1001
FM	Diff 1	-3.60*	30.73	0.0116
	Diff 2	1.15	4.83	0.1154
	Diff 3	-1.82*	12.06	0.0403
	Diff 4	3.76	5.57	0.0994

*$P < 0.05$; n = 12

Note: The dependent variable is CO_2 respiration (μmol CO_2 m^{-2} s^{-1}) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR. Diff 1 is the difference in means between February 22 and February 27. Diff 2 is the difference in means between February 27 and March 4. Diff 3 is the difference in means between March 4 and March 13. Diff 4 is the difference in means between March 13 and March 26. Fire management was applied to the wetland area on February 25.

Table 8. CO_2 respiration measurements (μmol CO_2 m^{-2} s^{-1}) one-way ANOVA Post-Hoc test

						95% Confidence Interval	
Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
22-Feb	WL	WB	-0.562	0.939	0.560	-2.608	1.483
		FL	-2.277*	0.939	0.032	-4.322	-0.230
		FM	-3.076*	0.939	0.007	-5.122	-1.031
	WB	WL	0.562	0.939	0.560	-1.483	2.608
		FL	-1.714	0.939	0.093	-3.759	0.332
		FM	-2.514*	0.939	0.020	-4.560	-0.468
	FL	WL	2.276*	0.939	0.032	0.230	4.322
		WB	1.714	0.939	0.093	-0.332	3.759
		FM	-0.800	0.939	0.411	-2.846	1.245
	FM	WL	3.076*	0.939	0.007	1.031	5.122
		WB	2.514*	0.939	0.020	0.468	4.560
		FL	0.800	0.939	0.411	-1.245	2.846
27-Feb	WL	WB	-0.130	0.422	0.764	-1.050	0.790
		FL	0.124	0.422	0.774	-0.796	1.044
		FM	-0.323	0.422	0.459	-1.243	0.597
	WB	WL	0.130	0.422	0.764	-0.790	1.050
		FL	0.254	0.422	0.559	-0.666	1.174
		FM	-0.193	0.422	0.655	-1.113	0.726
	FL	WL	-0.124	0.422	0.774	-1.044	0.796
		WB	-0.254	0.422	0.559	-1.174	0.666
		FM	-0.448	0.422	0.310	-1.367	0.472
	FM	WL	0.323	0.422	0.459	-0.597	1.243
		WB	0.193	0.422	0.655	-0.726	1.113
		FL	0.448	0.422	0.310	-0.472	1.367
4-Mar	WL	WB	0.368	0.954	0.707	-1.712	2.447
		FL	-1.955	0.954	0.063	-4.034	0.125
		FM	-1.388	0.954	0.172	-3.467	0.691
	WB	WL	-0.368	0.954	0.707	-2.447	1.712
		FL	-2.323*	0.954	0.032	-4.402	-0.243
		FM	-1.756	0.954	0.091	-3.835	0.324
	FL	WL	1.955	0.954	0.063	-0.125	4.034
		WB	2.323*	0.954	0.032	0.243	4.402
		FM	0.567	0.954	0.564	-1.513	2.646
	FM	WL	1.388	0.954	0.172	-0.691	3.467
		WB	1.756	0.954	0.091	-0.324	3.835
		FL	-0.567	0.954	0.564	-2.646	1.513

Table 8 (Continued). CO_2 respiration measurements (μmol CO_2 m^{-2} s^{-1}) one-way ANOVA Post-Hoc test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
13-Mar	WL	WB	-1.184	0.662	0.099	-2.628	0.259
		FL	0.869	0.662	0.214	-0.574	2.312
		FM	0.305	0.662	0.653	-1.138	1.748
	WB	WL	1.184	0.662	0.099	-0.259	2.628
		FL	2.053*	0.662	0.009	0.610	3.497
		FM	1.489*	0.662	0.044	0.046	2.933
	FL	WL	-0.869	0.662	0.214	-2.312	0.574
		WB	-2.053*	0.662	0.009	-3.497	-0.610
		FM	-0.564	0.662	0.411	-2.007	0.879
	FM	WL	-0.305	0.662	0.653	-1.748	1.138
		WB	-1.489*	0.662	0.044	-2.933	-0.046
		FL	0.564	0.662	0.411	-0.879	2.007
26-Mar	WL	WB	-6.897*	2.889	0.034	-13.191	-0.603
		FL	0.339	2.889	0.909	-5.956	6.633
		FM	-4.526	2.889	0.143	-10.820	1.768
	WB	WL	6.897*	2.889	0.034	0.603	13.191
		FL	7.236*	2.889	0.028	0.942	13.530
		FM	2.371	2.889	0.428	-3.923	8.665
	FL	WL	-0.339	2.889	0.909	-6.633	5.956
		WB	-7.236*	2.889	0.028	-13.530	-0.942
		FM	-4.865	2.889	0.118	-11.159	1.429
	FM	WL	4.526	2.889	0.143	-1.768	10.820
		WB	-2.371	2.889	0.428	-8.665	3.923
		FL	4.865	2.889	0.118	-1.429	11.159

*$P < 0.05$; n = 12

Note: The dependent variable is CO_2 respiration measurements (μmol CO_2 m^{-2} s^{-1}) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26. Fire management was applied to the wetland area on February 25th.

Table 9. Soil temperature (ºC) repeated measures ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	8.17	5.60	0.0988
	Diff 2	-6.62	3.37	0.1637
	Diff 3	-8.56	5.65	0.0980
	Diff 4	6.09*	150.10	0.0012
WB	Diff 1	7.04*	28.79	0.0127
	Diff 2	-3.09	1.79	0.2737
	Diff 3	-12.30*	21.66	0.0187
	Diff 4	4.18	1.24	0.3464
FL	Diff 1	4.85*	71.61	0.0035
	Diff 2	-2.47	1.01	0.3898
	Diff 3	-8.64*	22.50	0.0178
	Diff 4	7.53*	3511.86	0.0001
FM	Diff 1	4.17	5.61	0.0986
	Diff 2	-5.09	4.05	0.1377
	Diff 3	-6.32*	13.50	0.0349
	Diff 4	7.63*	936.56	0.0001

*$P < 0.05$; n = 12

Note: The dependent variable is soil temperature (ºC) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR. Diff 1 is the difference in means between February 22 and February 27. Diff 2 is the difference in means between February 27 and March 4. Diff 3 is the difference in means between March 4 and March 13. Diff 4 is the difference in means between March 13 and March 26. Fire management was applied to the wetland area on February 25.

Table 10. Soil temperature (ºC) one-way ANOVA Post-Hoc test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
22-Feb	WL	WB	-0.575	1.858	0.762	-4.622	3.472
		FL	1.245	1.858	0.515	-2.802	5.292
		FM	0.415	1.858	0.827	-3.632	4.462
	WB	WL	0.575	1.858	0.762	-3.472	4.622
		FL	1.820	1.858	0.347	-2.227	5.867
		FM	0.990	1.858	0.604	-3.057	5.037
	FL	WL	-1.245	1.858	0.515	-5.292	2.802
		WB	-1.820	1.858	0.347	-5.867	2.227
		FM	-0.830	1.858	0.663	-4.877	3.217
	FM	WL	-0.415	1.858	0.827	-4.462	3.632
		WB	-0.990	1.858	0.604	-5.037	3.057
		FL	0.830	1.858	0.663	-3.217	4.877
27-Feb	WL	WB	0.550	2.054	0.793	-3.926	5.026
		FL	4.562*	2.054	0.046	0.087	9.038
		FM	4.408	2.054	0.053	-0.068	8.883
	WB	WL	-0.550	2.054	0.793	-5.026	3.926
		FL	4.013	2.054	0.074	-0.463	8.488
		FM	3.858	2.054	0.085	-0.618	8.333
	FL	WL	-4.562*	2.054	0.046	-9.038	-0.087
		WB	-4.013	2.054	0.074	-8.488	0.463
		FM	-0.155	2.054	0.941	-4.631	4.321
	FM	WL	-4.408	2.054	0.053	-8.883	0.068
		WB	-3.858	2.054	0.085	-8.333	0.618
		FL	0.155	2.054	0.941	-4.321	4.631
4-Mar	WL	WB	-2.980	3.483	0.409	-10.569	4.609
		FL	0.420	3.483	0.906	-7.169	8.009
		FM	2.880	3.483	0.424	-4.709	10.469
	WB	WL	2.980	3.483	0.409	-4.609	10.569
		FL	3.400	3.483	0.348	-4.189	10.989
		FM	5.860	3.483	0.118	-1.729	13.449
	FL	WL	-0.420	3.483	0.906	-8.009	7.169
		WB	-3.400	3.483	0.348	-10.989	4.189
		FM	2.460	3.483	0.493	-5.129	10.049
	FM	WL	-2.880	3.483	0.424	-10.469	4.709
		WB	-5.860	3.483	0.118	-13.449	1.729
		FL	-2.460	3.483	0.493	-10.049	5.129

Table 10 (Continued). Soil temperature (ºC) one-way ANOVA Post-Hoc test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
13-Mar	WL	WB	0.758	0.374	0.066	-0.057	1.572
		FL	0.500	0.374	0.206	-0.315	1.315
		FM	0.633	0.374	0.116	-0.182	1.447
	WB	WL	-0.758	0.374	0.066	-1.572	0.057
		FL	-0.258	0.374	0.504	-1.072	0.557
		FM	-0.125	0.374	0.744	-0.940	0.690
	FL	WL	-0.500	0.374	0.206	-1.315	0.315
		WB	0.258	0.374	0.504	-0.557	1.072
		FM	0.133	0.374	0.729	-0.682	0.947
	FM	WL	-0.633	0.374	0.116	-1.447	0.182
		WB	0.125	0.374	0.744	-0.690	0.940
		FL	-0.133	0.374	0.729	-0.947	0.682
26-Mar	WL	WB	2.670	2.558	0.317	-2.903	8.243
		FL	-0.940	2.558	0.720	-6.513	4.633
		FM	-0.910	2.558	0.728	-6.483	4.663
	WB	WL	-2.670	2.558	0.317	-8.243	2.903
		FL	-3.610	2.558	0.184	-9.183	1.963
		FM	-3.580	2.558	0.187	-9.153	1.993
	FL	WL	0.940	2.558	0.720	-4.633	6.513
		WB	3.610	2.558	0.184	-1.963	9.183
		FM	0.030	2.558	0.991	-5.543	5.603
	FM	WL	0.910	2.558	0.728	-4.663	6.483
		WB	3.580	2.558	0.187	-1.993	9.153
		FL	-0.030	2.558	0.991	-5.603	5.543

*$P < 0.05$; n = 12

Note: The dependent variable is soil temperature (ºC) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26. Fire management was applied to the wetland area on February 25. Statistical differences were only observed on February 27.

Table 11. Soil water content (m^3/m^3) repeated measures ANOVA of contrast variables

		Diff	F	P-value
WL	Diff 1	-0.067*	10.83	0.0460
	Diff 2	-0.034	1.16	0.3605
	Diff 3	0.152*	20.54	0.0201
	Diff 4	0.024	8.07	0.0656
WB	Diff 1	-0.039	0.50	0.5323
	Diff 2	-0.052	7.82	0.0680
	Diff 3	0.126*	167.67	0.0010
	Diff 4	0.007	0.14	0.7355
FL	Diff 1	-0.035*	37.89	0.0086
	Diff 2	-0.021	6.20	0.0884
	Diff 3	0.135*	53.76	0.0052
	Diff 4	0.002	0.04	0.8632
FM	Diff 1	-0.053	7.46	0.0719
	Diff 2	-0.017	0.21	0.6795
	Diff 3	0.132*	13.62	0.0345
	Diff 4	0.013	0.31	0.6150

*$P < 0.05$; n = 12

Note: The dependent variable is soil temperature (ºC) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR. Diff 1 is the difference in means between February 22 and February 27. Diff 2 is the difference in means between February 27 and March 4. Diff 3 is the difference in means between March 4 and March 13. Diff 4 is the difference in means between March 13 and March 26. Fire management was applied to the wetland area on February 25.

Table 12. Soil water content (m^3/m^3) one-way ANOVA Post-Hoc test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
22-Feb	WL	WB	0.093*	0.034	0.017	0.020	0.166
		FL	0.0395	0.034	0.263	-0.034	0.113
		FM	0.102*	0.034	0.011	0.029	0.175
	WB	WL	-.093*	0.034	0.017	-0.166	-0.020
		FL	-0.054	0.034	0.138	-0.127	0.020
		FM	0.009	0.034	0.799	-0.065	0.082
	FL	WL	-0.039	0.034	0.263	-0.113	0.034
		WB	0.054	0.034	0.138	-0.020	0.127
		FM	0.062	0.034	0.089	-0.011	0.136
	FM	WL	-0.102*	0.034	0.011	-0.175	-0.029
		WB	-0.009	0.034	0.799	-0.082	0.065
		FL	-0.062	0.034	0.089	-0.136	0.011
27-Feb	WL	WB	0.066	0.041	0.134	-0.023	0.155
		FL	0.007	0.041	0.863	-0.082	0.097
		FM	0.088	0.041	0.054	-0.002	0.177
	WB	WL	-0.066	0.041	0.134	-0.155	0.023
		FL	-0.059	0.041	0.178	-0.148	0.031
		FM	0.022	0.041	0.606	-0.068	0.111
	FL	WL	-0.007	0.041	0.863	-0.097	0.082
		WB	0.059	0.041	0.178	-0.031	0.148
		FM	0.081	0.041	0.073	-0.009	0.170
	FM	WL	-0.088	0.041	0.054	-0.177	0.002
		WB	-0.022	0.041	0.606	-0.111	0.068
		FL	-0.081	0.041	0.073	-0.170	0.009
4-Mar	WL	WB	0.084	0.042	0.069	-0.008	0.175
		FL	-0.006	0.042	0.888	-0.097	0.085
		FM	0.070	0.042	0.119	-0.021	0.162
	WB	WL	-0.084	0.042	0.069	-0.175	0.008
		FL	-0.089	0.042	0.053	-0.181	0.002
		FM	-0.014	0.042	0.753	-0.105	0.078
	FL	WL	0.006	0.042	0.888	-0.085	0.097
		WB	0.089	0.042	0.053	-0.002	0.181
		FM	0.076	0.042	0.094	-0.015	0.168
	FM	WL	-0.070	0.042	0.119	-0.162	0.021
		WB	0.014	0.042	0.753	-0.078	0.105
		FL	-0.076	0.042	0.094	-0.168	0.015

Table 12 (Continued). Soil water content (m^3/m^3) one-way ANOVA Post-Hoc test

Dependent Variable	(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
13-Mar	WL	WB	0.109*	0.037	0.012	0.028	0.190
		FL	0.011	0.037	0.782	-0.070	0.091
		FM	0.089*	0.037	0.032	0.009	0.171
	WB	WL	-0.109*	0.037	0.012	-0.190	-0.028
		FL	-0.099*	0.037	0.021	-0.179	-0.018
		FM	-0.019	0.037	0.613	-0.100	0.062
	FL	WL	-0.011	0.037	0.782	-0.091	0.070
		WB	0.099*	0.037	0.021	0.018	0.179
		FM	0.079	0.037	0.054	-0.002	0.160
	FM	WL	-0.089*	0.037	0.032	-0.171	-0.009
		WB	0.019	0.037	0.613	-0.062	0.100
		FL	-0.079	0.037	0.054	-0.160	0.002
26-Mar	WL	WB	0.126*	0.024	0.000	0.073	0.178
		FL	0.032	0.024	0.206	-0.020	0.084
		FM	0.101*	0.024	0.001	0.049	0.153
	WB	WL	-0.126*	0.024	0.000	-0.178	-0.073
		FL	-0.094*	0.024	0.002	-0.146	-0.041
		FM	-0.025	0.024	0.326	-0.077	0.028
	FL	WL	-0.032	0.024	0.206	-0.084	0.020
		WB	0.094*	0.024	0.002	0.041	0.146
		FM	0.069*	0.024	0.014	0.017	0.121
	FM	WL	-0.101*	0.024	0.001	-0.153	-0.049
		WB	0.025	0.024	0.326	-0.028	0.077
		FL	-0.069*	0.024	0.014	-0.121	-0.017

*$P < 0.05$; n = 12

Note: The dependent variable is soil water content (m^3/m^3) of soil in the Woolsey Wet Prairie Sanctuary wetland low (WL), wetland berm (WB), and adjacent fescue field intermounds (FL) and mounds (FM) in Fayetteville, AR on February 22, February 27, March 4, March 13, and March 26. Fire management was applied to the wetland area on February 25.