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Edaphic prairie arthropods, with the exception of Diptera, show no reaction to seasonal burns

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Abstract

Fire is an important tool used in prairie restoration because it stimulates grass and forb production as well as influencing the animal communities of the prairie. Prescribed burns have a varying effect on prairie communities depending on the season. Edaphic arthropods are an important part of the prairie ecosystem, aiding in the decomposition and distribution of organic matter, and it is important to understand how they are affected by seasonal burning. This study tested below-ground arthropod response to fall, spring and summer burns. Our results indicate that soil arthropods are not significantly affected by the season of burning with the exception of Dipterans, which were more abundant in summer burn plots than spring burn plots.

Introduction

Fire is an important management tool used on prairies to create disturbance, keep out woody species, and increase grass and flowering forb production (Hulbert 1969). Relatively infrequent fires support the productivity of the prairie by helping to eliminate plant litter, open canopy space and recycle nutrients (Knapp 1995). Periodic fires also increase the foliage, rhizome and root production of dominant grasses (Seastedt, 1984). The diversity and abundance of prairie plant species has a direct impact on subsequent animal species in each prairie community. For example, increased densities of foliage results in increased densities of aboveground arthropods (Seastedt, 1984).

Soil dwelling arthropods are a diverse group of herbivores, predators, scavengers and parasites. They perform many important functions for the prairie ecosystem such as aiding in decomposition of and distribution of organic matter (Paquin, 1997). It has also been suggested that particular soil arthropods, specifically Diptera, may be ideal bio-indicators because they represent a large portion of the soil arthropod population; their responses to changes in the factors that influence its habitat can act as an indicator of pollution. (Frouz 1999). There are, however, very few studies which examine soil arthropods, especially in the tallgrass prairie (Seastedt, T.R. 1984). For example, soil arthropod responses to burning are not well understood and there is concern that some controlled burning regimes may damage or endanger certain species because of the varying effects burning has on their habitat (Reed, 1997). In grasslands, burning affects soil arthropods by directly influencing the soil conditions, soil moisture and input of dead organic matter and indirectly by influencing plant species composition (Frouz, 1999). It is important to understand arthropod responses to fire and which burning regimes preserve and support maximum diversity and abundance of this necessary community.

The timing of burns is important to prairie restoration projects. Most range managers prefer late spring burns because they often yield the greatest forage production (Davison and Kindscher, 1999). The goal of most prairie restorationists, however, is to approximate the burning patterns that existed prior to European settlement, and as Davison et al. (1999) also noted, both summer lightning fires and dormant-season fires are considered to be natural. Plant responses to burning depend heavily on the timing of the burn relative to their physiological development. Plants that are just developing tend to benefit the most, whereas plants that are actively flowering, growing, or seeding tend to decline over time (Davison and Kindscher, 1999).

Variations in burning regimes affect soil arthropods both immediately and on a longer time scale in the prairie ecosystem (Kustritz, 1999; Frouz, 1999). Typically spring fires have a negative affect on arthropod abundance and diversity because more arthropods emerge during the spring season (Sgardelis, 1993). Because the burn causes a reduction in the typically high soil moisture levels that is compounded by the drought of the summer season, arthropod diversity and abundance are lower after spring burns (Reed, 1997).

We investigated the effect of seasonal burning on the soil arthropod community at CERA (Conrad Environmental Research Area) in southeastern Iowa. We looked at the effects of fall, summer, and spring burns on the diversity and abundance of edaphic arthropods and hypothesized that the spring burn would exhibit the lowest abundance and diversity.

Materials and Methods

The seasonal burn experiment was begun in late December of 1999 with eighteen 10x20m plots. The six fall plots were burned at this late date because of burn restrictions due to a particularly dry summer that year. Six more were burned in late March of 2000, representing the spring designation. The cycle was completed in late August of 2000 when the six summer plots were burned. On October 9, 2000, using 16cm x 2cm core samplers, we collected soil samples from two random points within each of these seasonally burned plots.

We combined the two samples and placed them in Berlese funnels beneath 40-watt light bulbs for fourteen days. As the soil dried, the arthropods moved downward, eventually dropping through the funnel into a beaker containing 70% ethanol. We classified the insects to Order using dissecting microscopes. In an attempt to better understand any possible relationships between the different treatment types, we also recorded the soil moisture levels and the carbon content of the soil. For the soil moisture, we used a moisture probe and for the carbon content of the soil, we utilized the Loss on Ignition method detailed in the handout by Professors Brown and Caruso. We later compared abundance, species richness, carbon content, moisture levels and Simpson's index among plot burn types using the one-way Analysis of Variance (ANOVA) and Tukey's tests.

Results

We found a total of twelve orders in the eighteen seasonally burned plots at CERA. There were only four orders of arthropods which were common among all of the plots:

Diptera, Coleoptera, Hymenoptera, and Thysanoptera (Fig 1). The most abundant was Diptera, comprising 60% of the total individual insects found. Although each of the different burn treatments supported arthropod populations, the type of treatment had no significant effect on overall arthropod abundance ($F_{2,15} = 0.58$; $P = 0.571$; Fig 2). Diptera abundance was, however, significantly higher in the Summer burn plots than in the Spring plots ($F_{2,15} = 3.77$; $P = 0.047$; Figs 3 and 1).

Even though the Spring burn treatment had the highest number of insect orders out of the three treatments (Spring 9 orders; Fall 8; Summer 5), there was no significant variation in the Simpson's diversity index among the three treatments ($F_{2,15} = 1.83$; $P = 0.194$; fig 4).

The moisture levels were consistently higher on the second day; however, there was not a significant difference between them ($F_{2,15} = 0.66$; $P_{1st\ day} = 0.536$; $F_{2,15} = 0.529$; $P_{2nd\ day} = 0.529$; fig 5). Similarly, the carbon content varied between the treatment types, but the differences were not significant ($F_{2,15} = 1.23$; $P = 0.340$; fig 6).

Discussion

Contrary to our hypothesis, we found that the abundance and diversity of the edaphic arthropod population does not significantly vary between the spring, summer, and fall burned plots of CERA. One possible explanation of the low arthropod diversity levels may be that the moisture levels in each of the plots were not significantly affected by the seasonal burns.

McCullough et al.'s (1998) study of the effect of fire on edaphic arthropods may help to explain why there was no significant difference in arthropod abundance among the three treatments. They found that although burning had an immediate effect on edaphic arthropods, their quick reproduction rates and ability to migrate allowed populations to repopulate burned sites. Migration is most definitely a concern at CERA; the seasonal plots are very close together (two meters), making migration between plots very easy. Another study done on soil arthropods in October 1999 by Kustritz et al. may provide insight into our results. Kustritz et al. examined how burning and mowing affect soil arthropod abundance and diversity on annually burned spring plots. As in our experiment, they found that burning had no significant effect on arthropod abundance. However, they also site the close proximity of the plots as a possible explanation for the lack of significance in their results.

Another possible explanation for our lack of significant results may be the relative newness of the experiment. The seasonal burn experiment has only been going for one year, and at the time of our sampling only one cycle of seasonal burns had been completed. Thus, enough time may not have passed for significant trends to develop among soil arthropods. Once soil arthropods have established a firm biological base within the plots, they will be more affected by any environmental changes, such as burning. It is quite possible that reproducing this experiment a few years from now would turn up more significant differences among the three treatments.

While our results did not show a significant difference in diversity and abundance levels among the three treatments, separate analysis of Diptera abundance showed a significant difference between the spring and summer treatments; the summer burn plots had twice the number of Diptera than the spring burn plots. Fires in the spring may have a more negative affect on Diptera because of the combined effects of a reduction in soil moisture and the subsequent drought of the summer season. Soil moisture and input of organic matter are the main factors that influence Diptera abundance (Frouz, 1999). Our analysis of the soil conditions showed insignificant difference in soil moisture and organic levels between the three treatments. Thus, the difference in Diptera abundance may not be caused by variations in soil moisture or organic levels, but perhaps some other factor such as soil temperature or the density of the canopy cover.

Burning is a commonly used tool in prairie restoration and reconstruction because of its inherent value to the prairie ecosystem. For humans to effectively reconstruct nature, as is often the case with prairies, it is necessary that we understand the affects of a disturbance like burning on not only the grass, but on the organisms which depend on the grass as well. At CERA, independently assessing the affect of seasonal burning on arthropods is especially difficult because of the close proximity of the plots and the newness of the experiment. We recommend that this experiment be repeated in a few years, giving the experiment time to develop variances based on the time of the burning. The new experiment should also include analysis of other factors that may influence the soil conditions such as soil temperature. These changes may provide more useful results that will help to assess the effect of fire on soil arthropods and help prairie managers to determine the optimal burning time to encourage maximum diversity and abundance among this important community.

Acknowledgments

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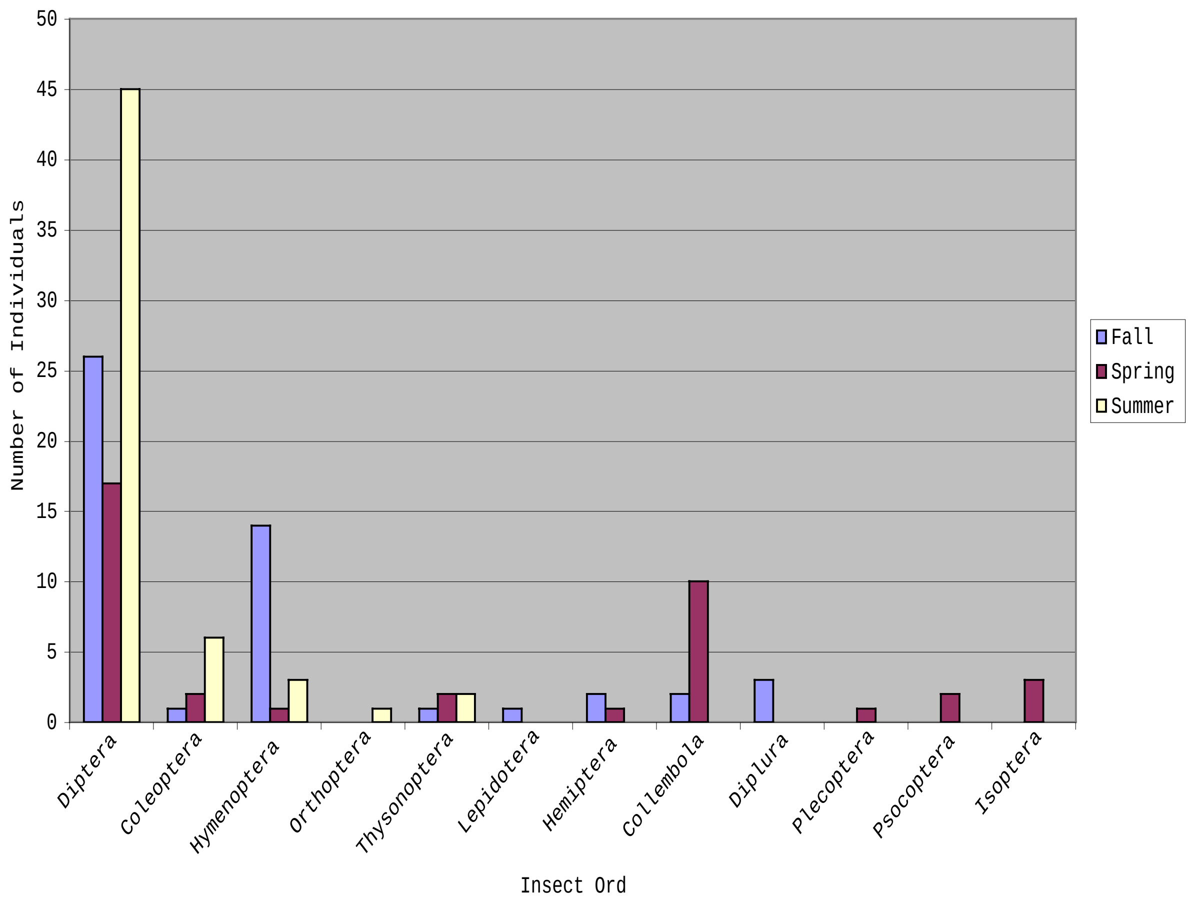
Figure 1. Comparison of number of individuals of each order found in
seasonally burned plots. Sampling done at CERA on 10/9/200



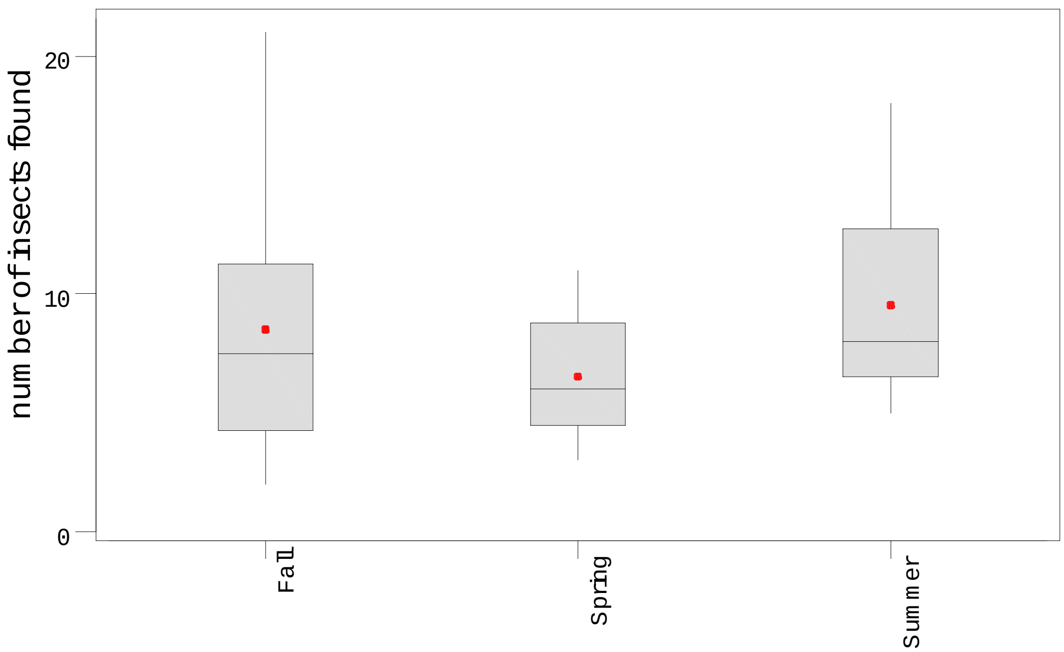


Figure 2. Median (indicated by horizontal line contained within grey box), range (indicated by vertical line through grey box), and mean (indicated by dot within grey box) of number of insects found in the Spring, Summer and Fall burn plots at CERA on 10/9/2000).

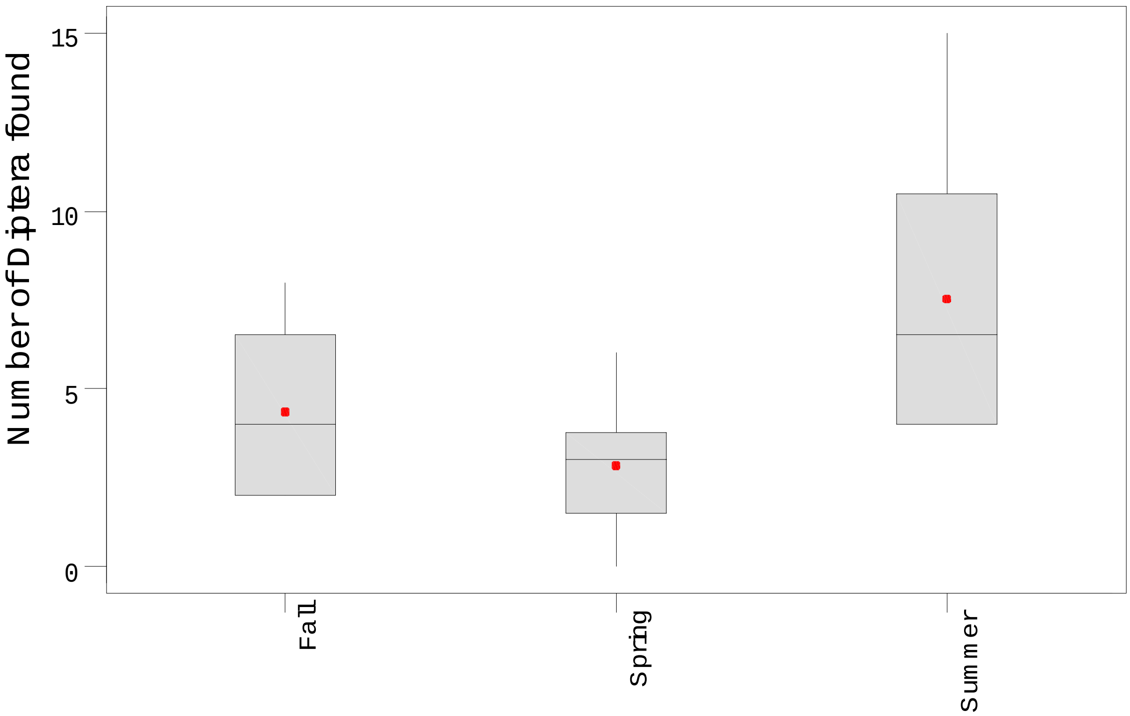


Figure 3. Median (indicated by horizontal line contained within grey box), range (indicated by vertical line through grey box), and mean (indicated by dot within grey box) of number of number of Diptera found in the Spring, Summer and Fall burn plots at CERA on 10/9/2000).

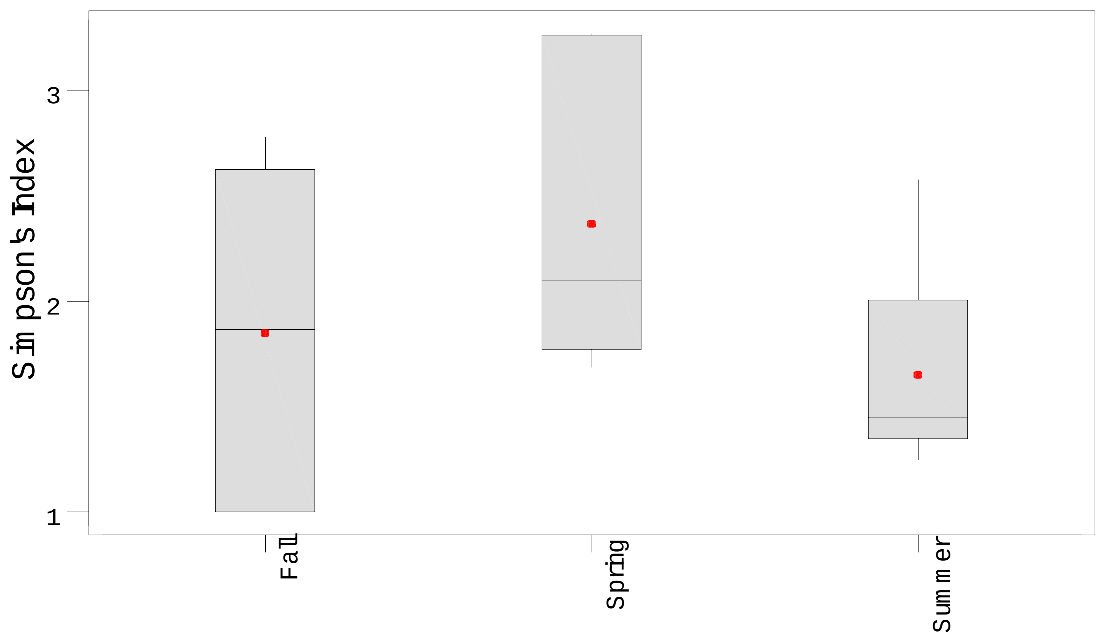
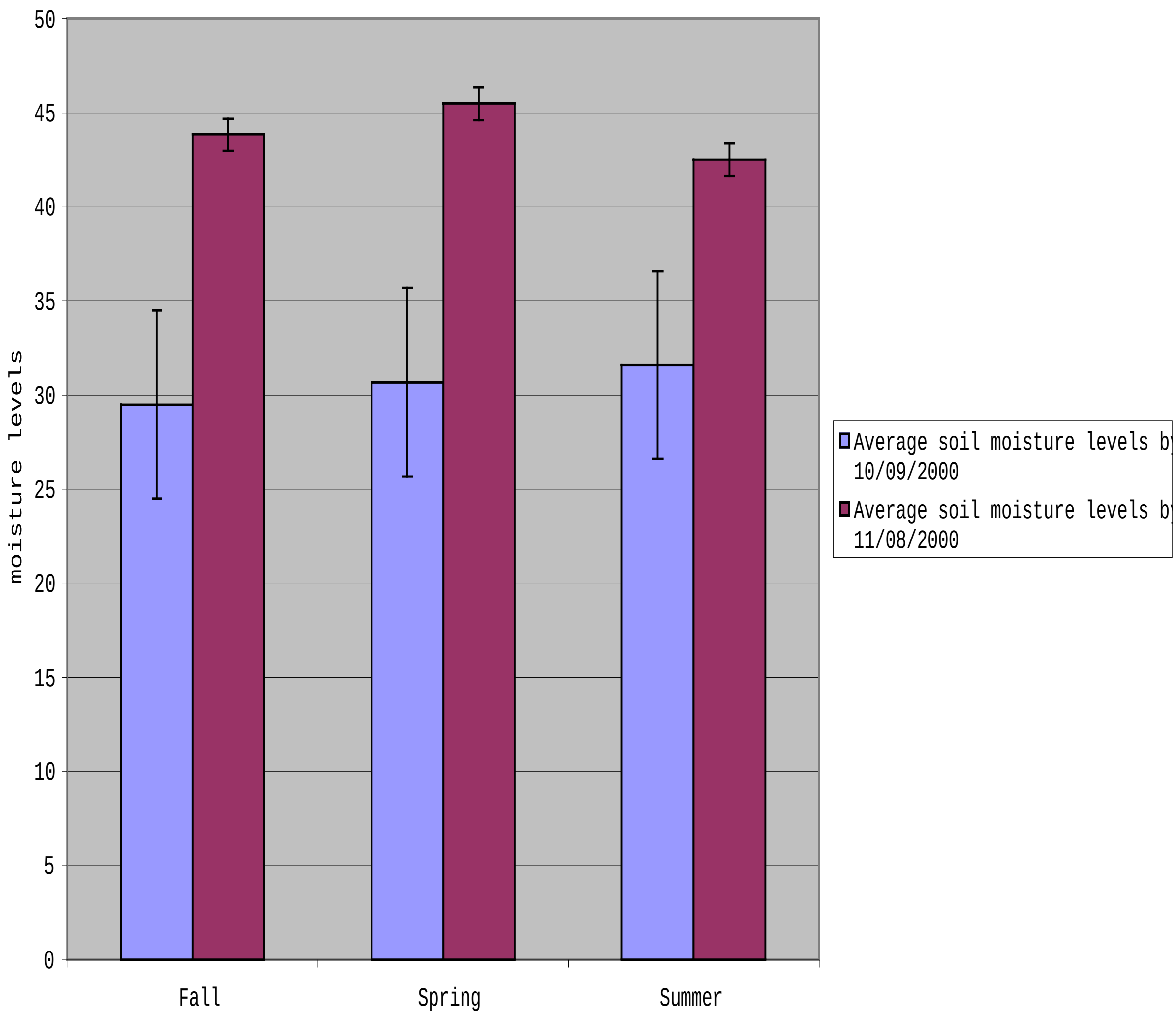


Figure 4. . Median (indicated by horizontal line contained within grey box), range (indicated by vertical line through grey box), and mean (indicated by dot within grey box) of arthropod diversity in the Spring, Summer and Fall burn plots at CERA on 10/9/2000).

Figure 5. Average soil moisture levels for each of the three seasonally bu
Data taken at CERA on 10/9/2000 and 11/8/2000



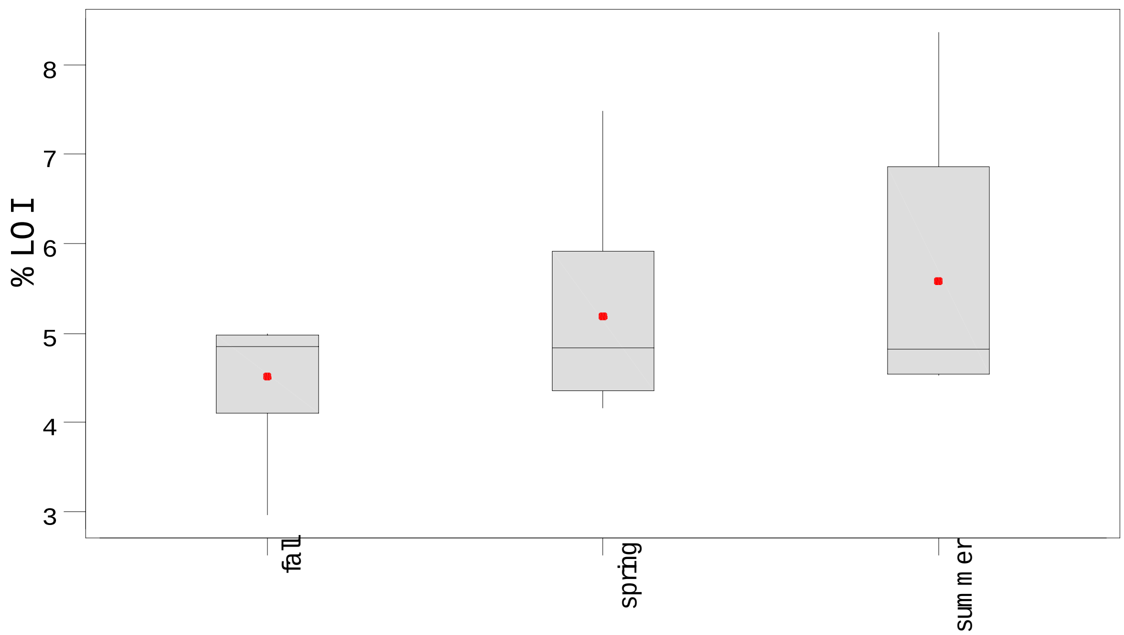


Figure 6. Median (indicated by horizontal line contained within grey box), range (indicated by vertical line through grey box), and mean (indicated by dot within grey box) of carbon content in the Spring, Summer and Fall burn plots at CERA on 10/9/2000). Carbon Measurements found using the Loss on Ignition method.