Does season of burn and burn interval affect soil productivity and processes in a ponderosa pine ecosystem?

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Prescribed burning is a tool used by land managers to reduce fuels and restore ponderosa pine communities by simulating natural low-severity wildfires. The season of burn can control the severity of burn while interval of burning may control the rate at which impacts accumulate. This study provides a very unique opportunity to study the effect of season and interval of burning on ponderosa pine forest soils. Fire has been shown to alter some chemical and physical soil properties which are typically dependent upon the severity of burn. At the Burns JFSP study site, soils are being examined for changes in soil chemical properties and nutrient and water availability to provide managers with fundamental information about long-term effects of burning to restore ponderosa pine ecosystems.

Project Accomplishments:

- Determined soil types present within the treatment area, identified 4 basic soil types with high variability in soil depth and type
- Quantified soil surface properties resulting from burn treatments
- Quantified soil C and N content relative to burn treatments
- Found that site soils are highly fertile, with high total nutrients and available nutrients
- Determined soil CEC and %BS to be high and unaffected by burn treatments
- Monitoring of soil moisture and temperature relative to burn treatments is underway and may indicate some differences in soil moisture availability and temperature

Methods:

In the summer of 2004 soils samples were collected at 8 grid points within each of the 30 treatment plots (6 replicates each of Control, Fall burn-5-year interval, Fall burn-15-year interval, Spring burn-5-year interval, Spring burn-15-year interval) to a depth of 30 cm. When soils work was begun, 2 5-year burns had been completed and 1 15-year burn had been completed. The 3rd 5-year burns are scheduled for autumn of 2007 and spring 2008.

Within each study treatment plot, one soil pit was dug to examine horizonation and determine soil type. In the late summer of 2005 to early summer of 2005, each soil pit was installed with up to 4 soil moisture probes (at depths of 7.5cm, 25cm, 50cm, and 100cm), depending on soil depth. Additionally, a soil temperature probe was installed at 2cm. Soil moisture and temperature probes were attached to a datalogger and monitoring begun in summer of 2005.

Soil surface properties, such as % bare ground and hydrophobicity, were determined at each sampling point. Soil samples were analyzed for pH, total Carbon, total Nitrogen, CEC, and Base Saturation; some available N analyses have been completed.

Results:

Examination of the soil surface yielded 2 important differences by treatment (see Figures 1 and 2). First, the average percent of bare mineral soil was found to be greatest with the Fall-5-year and 15-year burns, with the Spring-5-year burn similar to the Fall-15-year burn. Nearly 30% bare mineral soil was found with the repeated, higher-severity fall burn, whereas in the control areas 10% bare mineral soil is normal. In addition to changes in coverage of the mineral soil by the O horizon, there were also decreases in O horizon depth with the greatest decrease in depth with the Fall-5-year burn. These changes could indicate potential long-term increases in soil erosion, increased soil surface temperature and evaporation, and nutrient loss.

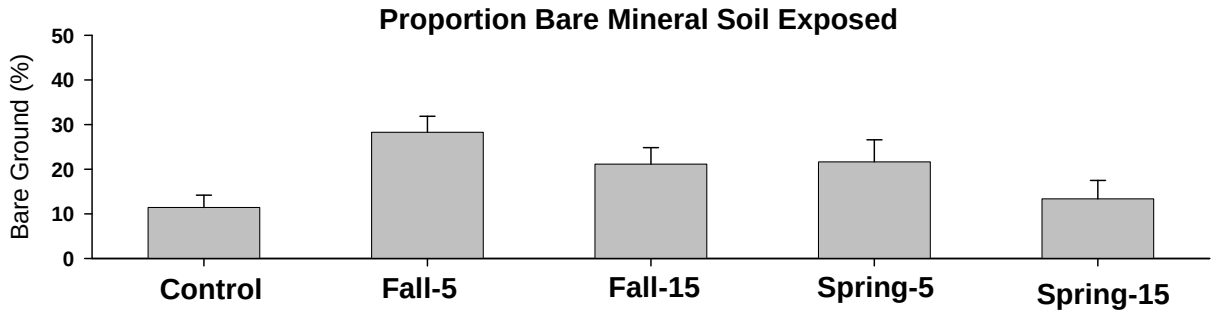


Figure 1. Average and std. error of exposed mineral soil. Proportion of bare mineral soil was changed by season of burn and interval of burn. Fall burns increased bare ground coverage more then Spring burns while burning at 5 year intervals increased bare ground coverage more than the 15 year burn interval treatment. The Spring 15 treatment was not significantly different from the controls.

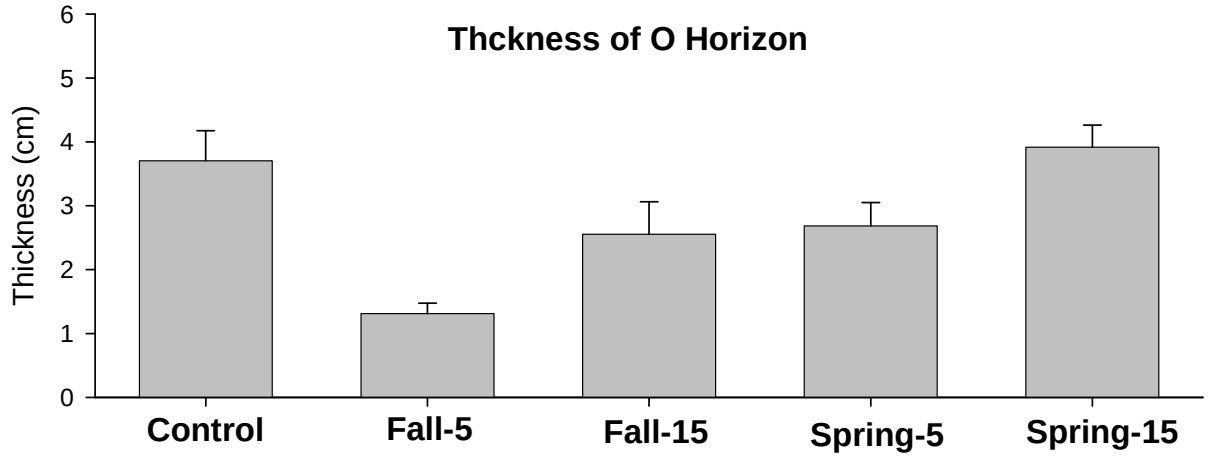


Figure 2. Average and std. error of O horizon thickness. O horizon thickness (in cm) was reduced with Fall burns and 5-year interval burns.

Total soil C and N content (Figure 3) is substantially decreased with the higher-severity fall burns, with an average 35% decrease. Within a season, the 5-year and 15-year burns did not result in substantial differences in either C or N to date. Nevertheless, all burns did decrease soil C and N to some degree. Increased fire severity in the Fall burns caused the soil pH (Figure 4) to increase and this increase has been sustained for nearly 7 years after burning (15 year interval plots). Other soil chemical properties show little treatment effect.

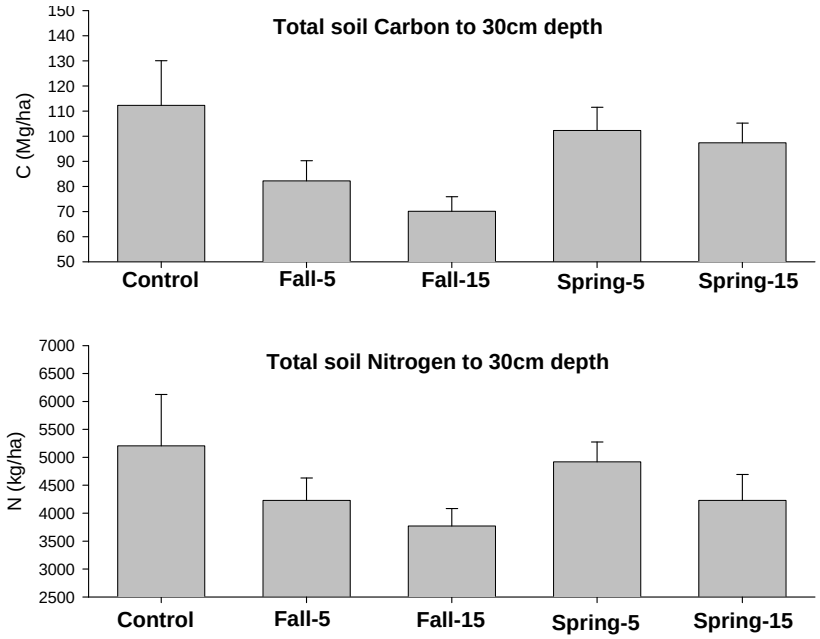


Figure 3. Average and std. error of total C and N content in the O-horizon and first 30 cm of mineral soil.

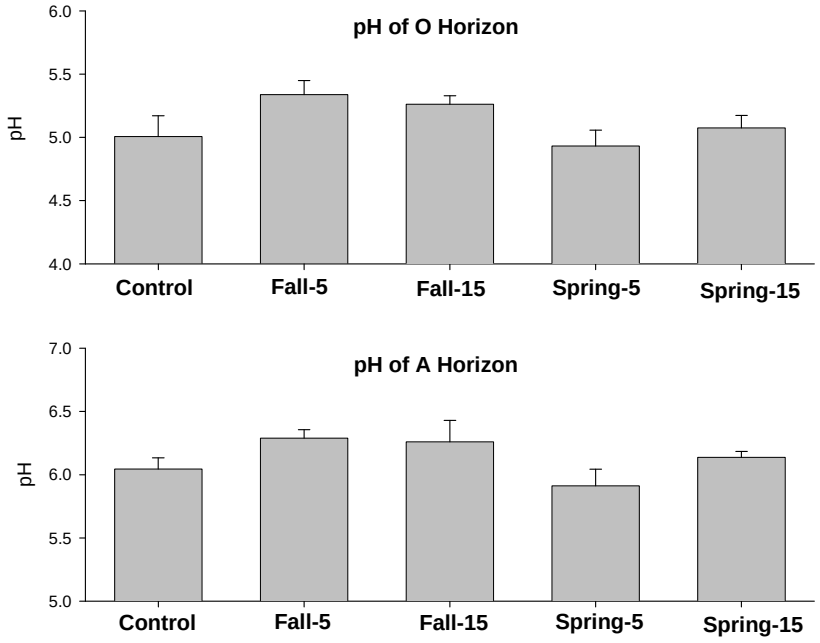


Figure 4. Avewrage and std. error of pH in O and A horizons. Fall burning increased the pH of both the O and A horizons.

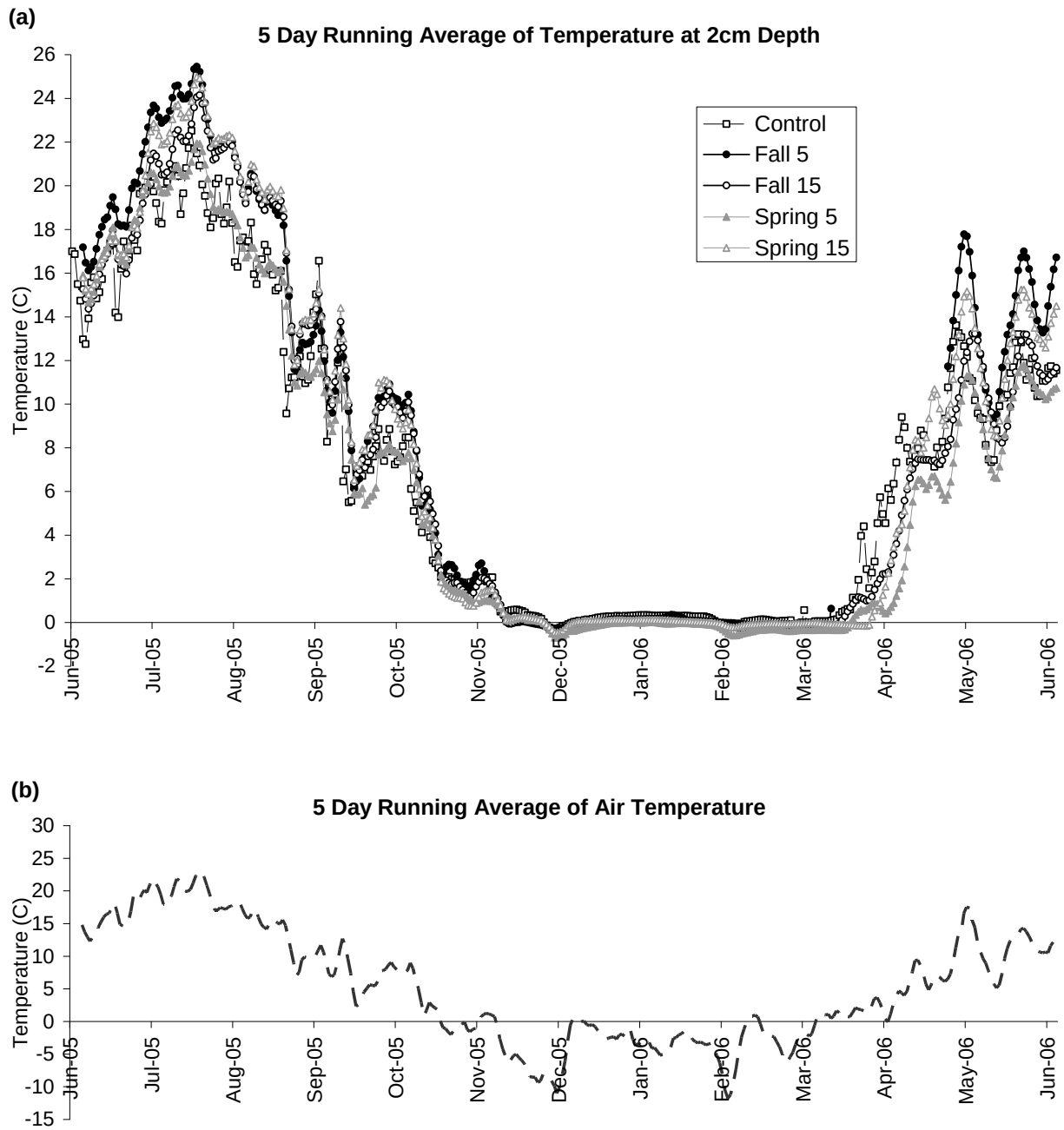


Figure 4. Soil temperature (a) generally follows air temperature of the Rock Springs SNOTEL station (b). Snow pack insulates the soil and keeps it at about 0°C from the late fall into early spring. The Fall 5-year burn treatment the highest soil temperatures during the summer of 2005 and spring 2006, most likely due to increased bare mineral soil and possible changes in soil albedo. The Control, Fall15-year, and Spring 5-year burns all have similar, lower soil temperatures. Surprisingly, the Spring 15-year burn has a somewhat elevated soil temperatures but this may due to Spring 15-year burn pits being located on steeper slopes and more southerly aspects than other treatments.

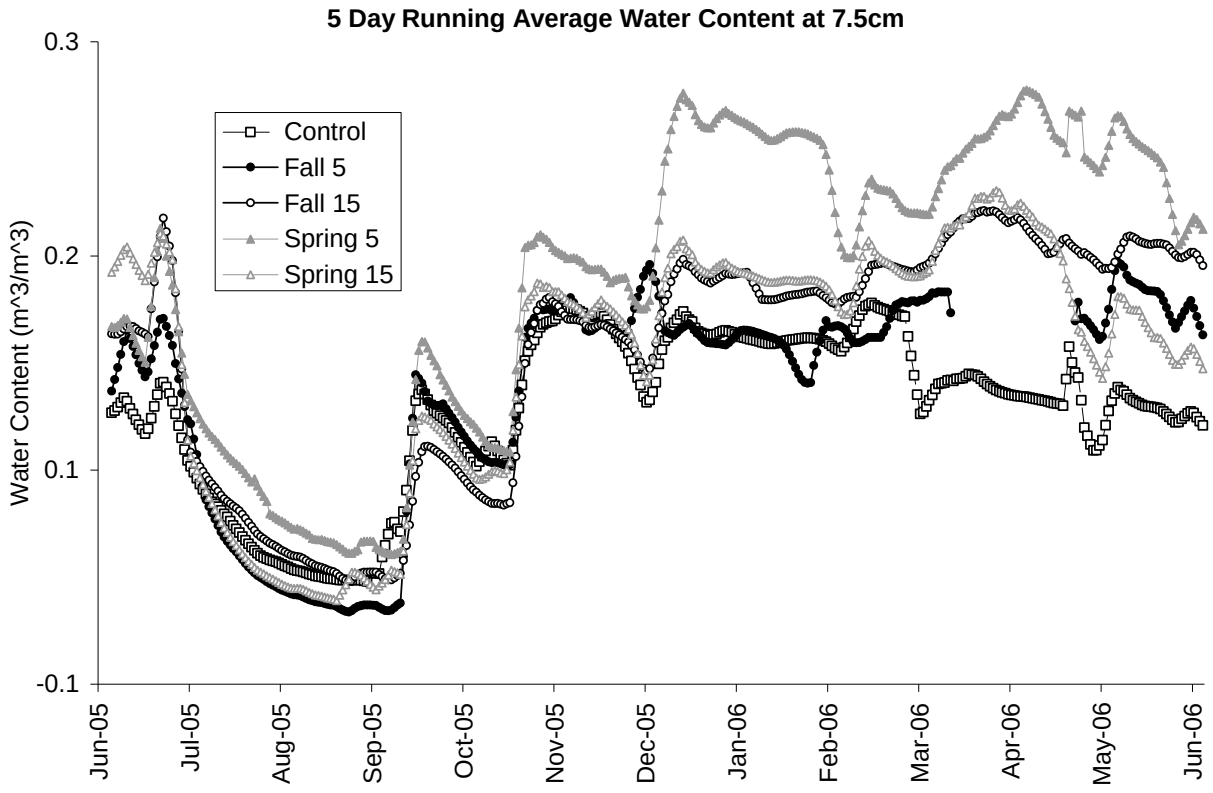


Figure 5. Average water content in the top 7.5 cm of soil may be reduced during the growing season in Control due to higher transpiration. The wettest soil during the growing season is the Spring 5-year treatment which was also the coolest soil (see Figure 4). Overall, soils are extremely dry in mid to late summer but have a moderate water content in late winter and early spring. The Spring 5-year treatment soils are actually quite wet in early spring.

Soil Taxonomy

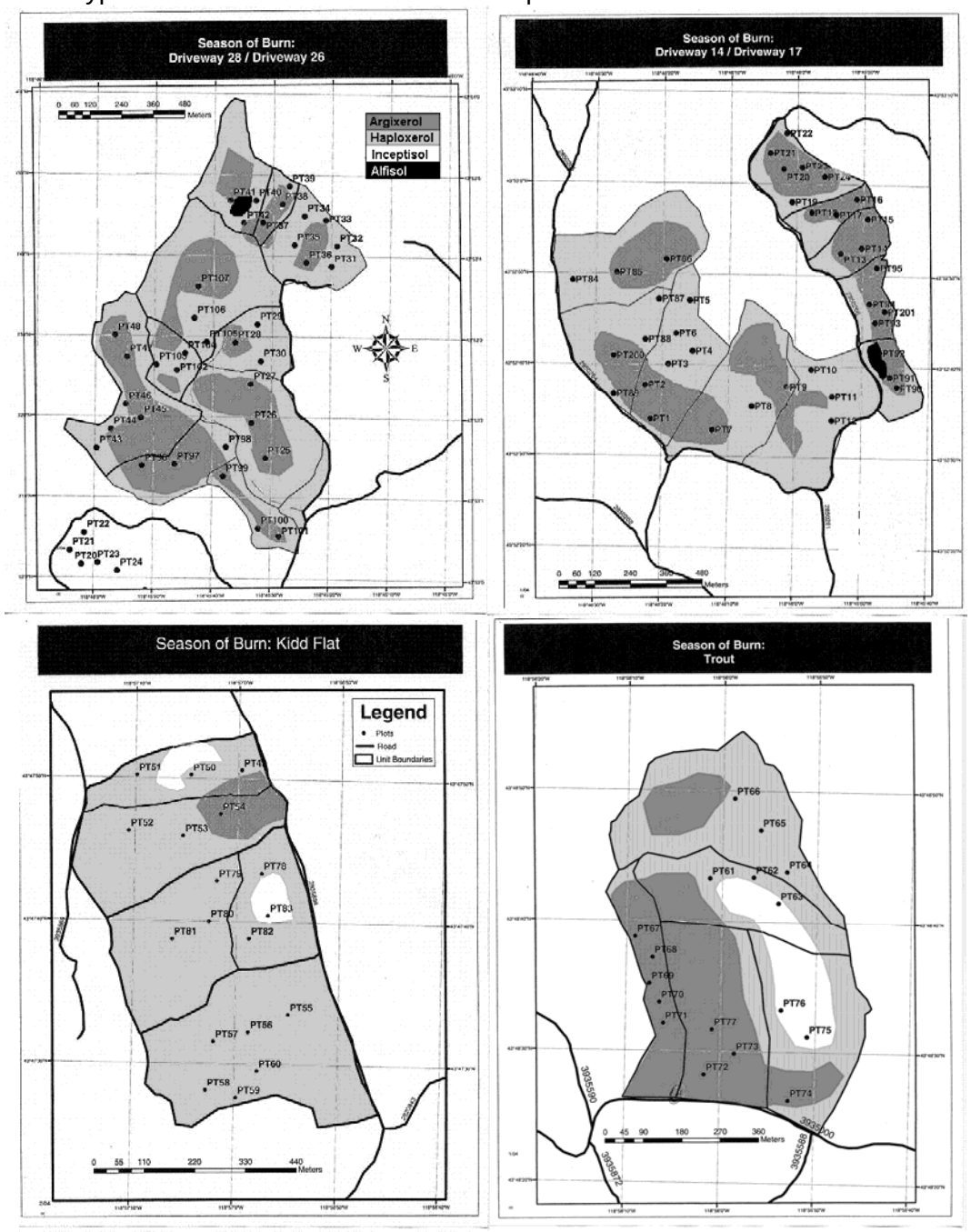
The USDA Soil Taxonomy system recognizes 12 distinct soil orders, with many more distinctly classified soils within each of these orders.

Soil orders of particular interest at the Season of burn and burn interval study site include:

Mollisols: Highly productive soils, with very fertile, deep A horizons; high nutrient availability (high base saturation). These soils are most common in grasslands.

Alfisols: Very productive soils that have B horizons with a high clay content (Bt); moderately high base saturation. These soils are most common under deciduous forests and some grasslands.

Inceptiols: Highly variable, young soils that are still developing; have a B horizon that is often coarse textured. These soils are widespread in areas that are geologically young or disturbed.

The site soils are very fertile with an average carbon (C) concentration of 5.7% in the A horizon and 2.5% in the B horizon, and high average %N (0.31% and 0.13% in the A and B horizons respectively). Base saturation (%BS) is also high averaging well over 50% in both A and B horizons, which leads to the majority of soils classified as Argixeroll (fertile soils with clay-rich Bt horizons) or Haploxeroll (fertile soils with Bw horizons). Argixerolls were found on gentle slopes while Haploxerolls were found on slightly steeper slopes (average slope of 18%). Where soils did not meet the %BS or C concentration, they were classified as either Inceptisols or Alfisols. The Map A indicates approximately where different soil types were found.

Map A. Soil Types of the Burn season and interval plots.