Fire Effect on Soil Nutrients and Soil Properties

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From Clain Jones, Montana State University soil fertility Extension

Hundreds of thousands of acres of forest, rangeland and cropland have sadly gone up in smoke this summer in Montana. In addition to the devastating effect on personal property and direct loss of crops and livestock, fire can affect soil properties and soil nutrients. The impact is highly dependent on the fire intensity/duration and the proportion of plant material that is burned. Timber and shrubs will burn hotter and longer with greater impact on soil than range- or crop land. Fast moving grass fires have minimal impact on soil nutrients and soil health compared to slow moving, intense fires in moderate to heavy fuels.

In general, fires reduce the pool of nutrients stored in organic matter, release a flush of plant available nutrients in the short term, and redistribute nutrients through the soil profile. The availability of nutrients, especially nitrogen, is increased after low intensity fires, yet, a portion of nitrogen and sulfur is lost to the air. Although these losses are not trivial and are similar to removal by harvest and losses to wind erosion, they are small compared to the average pool of nutrients in the top six-inches of soil.

Nitrogen can additionally be lost through nitrate leaching, as the burned plant matter creates a large pool of nitrate and few active plant roots are left to take up either the nitrate or soil water. This can have long term impact on the productivity of forest and rangeland ecosystems, but can be minimized or remediated on croplands. The other nutrients such as phosphorus, potassium, magnesium, zinc and manganese are more stable and not lost directly through combustion, but rather through blowing ash, and post-fire soil erosion.

Cropland fires rarely burn hot enough to affect soil organic matter. The bigger concern is loss of surface plant residue, which is very important to reduce wind erosion, and protect against the physical sealing impact of raindrops. Ash particles also contribute to reduced water infiltration as they plug soil pores. All these factors increase the risk of water runoff and soil erosion.

Intense forest and shrubland fires can burn soil organic matter, reducing the pool of nutrients in the soil, soil aeration and water infiltration/retention, and the soil's ability to hold nutrients coming from ash or fertilizer.

In addition, forest and shrubland fires can create a water repellent layer within the top 2 inches of soil that comes from compounds in the burnt litter, coating soil aggregates or minerals. The depth and thickness of this layer can vary greatly, and it can affect infiltration for several months to years. This layer should not form on grassland or stubble fires.

Fire kills bacteria and fungi at the soil surface but microbes rapidly recolonize from deeper soil layers, except in severe fires where the soil is sterilized several inches deep. Microbial activity can actually increase with the flush of nutrients available after a fire. However, new input of plant material is important to sustain their populations.

Post-fire management includes soil testing to determine nutrient availability, and establishing ground cover where possible. Test for nitrogen, phosphorus, and potassium to calculate fertilizer needs. Because drought preceded fire, it’s likely that many fields have nitrogen that wasn’t used this summer,

so less might be needed next spring. When soil sampling burned fields, be sure to select representative sites, avoid areas where there may have been a windrow, bale, or other high accumulation of straw or residue. Spreading manure can be very beneficial post-fire but this is rarely available or reasonable at large scales.

The MSU Soil Fertility Extension website http://landresources.montana.edu/soilfertility/ has several publications and presentations on soil testing and calculating fertilizer rates. Contact Clain Jones at clainj@montana.edu or 406-994-6076 if you have questions.