

Introduction

Biogeochemical Effect of Forest Fires on Soils

During July 2002, a lightning caused fire raged through the Fremont/Winema National Forest burning approximately 130,000 acres. The fire, known as the Toolbox Complex, created a desolate landscape of blackened snags, burned out stumps and grey soils in the 203 square mile area. Six years later buckbrush (*Ceanothus velutinus*) and lupine (*Lupinus argenteus*), cover much of the ground, however few trees have returned, except in sparsely planted salvage sites. As pioneering plants, buckbrush and lupine grow in nutrient poor soils. Much research has been conducted on the effect of catastrophic forest fires on soil nitrogen immediately after a fire. Moderately severe forest fires burn duff and litter layers, converting stored nitrogen (ammonia) to nitrogen gas and mineral nitrogen (nitrates) available for plant use. This flush of usable nitrogen stimulates grass and other pioneering plants preferring nitrate-nitrogen to grow rapidly in the first year. The rate of colonization, however, appears to decrease over time. Why is this? “Long term studies of the biogeochemical effects of fires, especially on soils, are very rare” (Giesen, 2006). What biogeochemical changes occur in soils during the years following a catastrophic wildfire? The Toolbox Complex provided an excellent opportunity to take a 6 year old “snapshot” of long term changes in soil biota, structure and chemistry.

Biogeochemical Effects of Salvage Harvest on Soils after Forest Fire

Forest fires devastated over $\frac{3}{4}$ of a million acres in Southern Oregon between 1999 and 2004. Half of these fires occurred in the Fremont/Winema National Forest. Heavy understory, creating ladder fuels, and drought set the stage for the infernos. Following each fire debate raged over the wisdom of carrying out a salvage harvest. Studies of the environmental effects of salvage harvest following catastrophic forest fires are rare, especially on the east side of the Cascade mountains. “Long term studies of the biogeochemical effects of fires, especially on soils, are very rare” (Giesen, 2006). Approximately 10% of the 130,000 acre Toolbox Complex fire of 2002 in the Fremont/Winema National Forest was salvage harvested two years after the burn providing an excellent opportunity to compare the biogeochemical effects of salvage harvest to non harvest on burned soils.

Discussion

Six years after catastrophic fire the soils of the Toolbox Complex remain in degraded condition, though phosphorus and potassium are similar to pre-fire conditions. All other factors remain negatively affected. All of the factors seem to be related to nitrogen cycling in the soil.

Microbes in the soil, often associated with legumes, fix atmospheric nitrogen and make body proteins. Many of the mycorrhizal biota are in symbiotic relationships with plants, scavenging nutrients from the soil, making them available to plants. As long as there is mineral nitrogen in the soil plants can use the nitrogen to create leaves, flowers and other plant parts. Most mineral nitrogen is supplied from litter, duff, waste and detritus in the humus layer of the soil. Microbes break down the humus layer creating nitrate which is then converted to nitrates as a byproduct of respiration.

The crux of the problem is that forest fires, based on their severity, remove a large portion of the sequestered ammonia-nitrogen in the litter layer, leaving little long term nitrogen. My pre-fire data shows low humus, but higher Ammonia levels indicating the presence of sequestered nitrogen. My post-fire data shows more humus but it was in the form of burned woody debris such as limbs. My data showing the 47% drop in nitrite also had a low statistically significant value indicating that nitrite reactions occur randomly and rapidly 6 years after a fire. Large fluctuations in

nitrite-nitrogen would be expected if ammonia is limiting due to lack of storage in the environment.

Annuals and early seral (pioneering) plants tend to prefer nitrate over ammonia. This is beneficial since there is little humus and leaf litter left following fire. Late seral plants (climax), preferring ammonia-nitrogen over nitrate-nitrogen, become established following a buildup of humus and stored ammonia-nitrogen. The rate of succession might be sped up if there were higher soil temperatures, increasing soil biota growth and higher moisture, however the two are contrary. High temperature usually results in the evaporation of water limiting microbe growth.

Treatments that might shade soil, thereby cooling it, increasing moisture and supplying nutrients should be encouraged. I found that areas with the most humus, rhizomes, nutrients and coolest temperatures were covered in buckbrush (*Ceanothus velutinus*) and Silver lupine (*Lupinus argenteus*). These plants not only thrive in hot, dry soils, but soil biota on their roots fix nitrogen. *Ceanothus* is often treated as a weed and sprayed to kill it if the area is to be planted. This may be detrimental to soil chemistry and prolong the rate of succession of forest soils.

Logging has often taken the blame for degrading soils following forest fire. My statistics, however, do not bear out the validity of that claim. Though the data looks impressive and destructive, statistical analysis only showed significance regarding temperature. It may

seem strange that compaction decreased in harvested areas, but the change was insignificant and was probably due to sub-soiling or scarification following harvest. I can see the danger in entering a burned area after plants are becoming established. It would be best to enter the burn during the same summer the fire occurred to minimize damage to restorative vegetation and minimize the erosion of bare mineral soils.