Nitrogen Cycling in Cut Juniper Woodlands

Jon Bates, Tony Svejcar, and Rick Miller

Introduction

Western juniper expansion into sagebrush grassland alters the spatial distribution of soil organic matter and nutrients by concentrating them in litter and soils beneath tree canopies. The concentration of nutrients and organic matter in canopy soil and litter layers is thought to be physiologically advantageous for juniper by enhancing their already strong competitive abilities for water and nutrients with associated vegetation. However, very little research has evaluated how the redistribution of nutrients in juniper woodlands affects nutrient cycling and availability. Another question to address is whether the redistribution of nutrients affects understory recovery of a site after juniper is removed.

Experimental Protocol

The purpose of our study was to assess the effect of the sudden removal of overstory juniper on soil nitrogen (N) availability and N mineralization, and how this may affect understory recovery. Nitrogen availability has received the most attention in the literature because N is assumed to be the most limiting soil nutrient in wildland systems. We evaluated the influence of juniper on soil N dynamics in cut and uncut woodlands by microsite. Microsites in the cut were interspace, debris, and canopy. Microsites in the woodlands were canopy and interspace. Sampling was conducted the first 2 years after cutting. The first sample year was a moderately dry year and the second sample year was a very wet year. Measured parameters included plant extractable N (nitrate [NO_3^-] and ammonium [NO_4^+]),nitrification, N mineralization, total soil carbon and N, and herbaceous biomass and N content.

Results and Discussion

Treatment differences were limited to the first year post-cutting. The initial effect of juniper cutting was an increase in extractable N, but by the second year post-treatment, differences for the N variables among treatments and microsites were not apparent. In the dry year, extractable N and N mineralization were higher in the cut versus the woodland interspaces (Fig. 1). In the wet year, extractable N and N mineralization did not differ among the treatment microsites. Canopy and debris zones had lower N mineralization than intercanopy zones in the dry year.

The effect of year, dry versus wet, tended to overwhelm the effect of juniper removal. There were strong seasonal patterns of N mineralization that were independent of treatment or microsite (Fig. 1). In the dry growing season, N mineralization was higher than other periods and there was a large buildup of available N in soils. The buildup of available N during dry periods is not unusual in arid systems and is caused by lack of plant uptake and large die-offs of soil microorganisms.

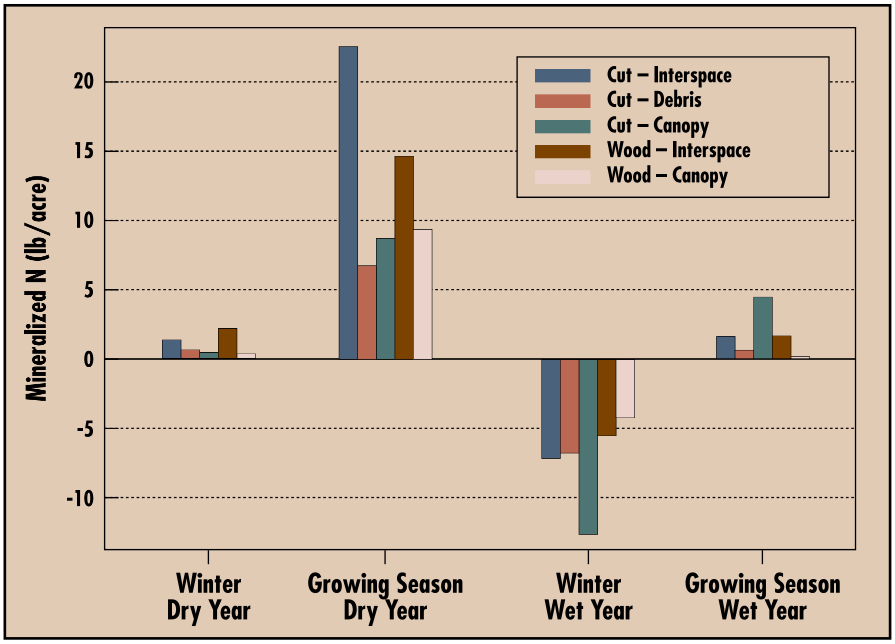

Figure 1. Seasonal soil nitrogen (N) mineralization/immobilization totals by treatment and microsite. Positive values indicate net N mineralization. Negative values (winter-wet year) indicate net N immobilization.

In the second winter (wet year), all zones had high levels of N immobilization or losses. A management concern after tree cutting in woodland and forested systems is the potential for increasing loss of soil N, primarily in the form of NO_3^-, which is highly mobile in soils. However, the methods we used to assess available N fractions and N mineralization indicate that most of the N that was "lost" during the second winter was taken up by soil microorganisms and immobilized on site and not lost by leaching or denitrification.

The effects of felling juniper trees on juniper litter decomposition and N release was examined over the same 2-year period. Litter decomposition was 37 percent greater in the cut treatment than in the woodland. Greater litter inputs and higher litter quality from juniper slash caused a priming effect, resulting in the higher decomposition rates in cut woodlands. The increase in litter decomposition in the cut treatment did not result in an earlier release of litter N. Nitrogen was limiting for decomposers under juniper debris, resulting in the importation and immobilization of litter N. Retention of N in litter in the early stages of decomposition following cutting may serve as an important sink that conserves N on site. In the woodlands, 20 percent of litter N was removed, indicating that N was not limiting during litter decomposition. The results also indicated that there was no fixed carbon/N ratio determining the timing of N release from juniper litter.

Management Implications

Despite the low availability of N in the second growing season and the retention of N in juniper litter, there was no indication that N was limiting for plant growth in the cut treatment. Herbaceous plants in the cut treatment had significantly greater N concentrations, and total biomass N uptake was nine times greater than for plants in the woodland treatment. The formation of resource islands in the woodland did not confer any benefits to the herbaceous and/or shrub understory as long as the trees remained in place. The benefits of higher resource availability were not realized until trees were cut. When trees were removed, herbaceous productivity and cover were significantly greater in canopy (resource island)-influenced soils compared to intercanopy zones.