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Nitrogen Availability on Fall-Burned Oak-Mountainmahogany Chaparral[1]

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Highlight

Nitrogen availability, as shown by short-term uptake by barley, was significantly higher on soils from burned than from unburned areas 10 months after burning. Increased soil-nitrogen concentrations were observed at all depths on the burned as compared with the unburned treatment.

Management practices of chaparral vegetation in the Southwestern U. S. A. have included burning as a means to alter density and, to some extent, composition of chaparral stands. Chemical and physical properties of soils also may be altered by burning. The extent of such changes is generally related to the fire intensity.

Nitrogen in litter is generally unavailable for plant use and may remain so until the litter is decomposed by soil microorganisms. Burning hastens litter decomposition, but forms nitrogenous compounds which may be lost by volatilization, and total nitrogen in the biosphere may be expected to decrease as a result of burning. On the other hand, total nitrogen in the mineral soil may be increased as a combined result of burning litter and standing vegetation and leaching of nitrogen-containing compounds. The relative availability of soil nutrients, especially nitrogen, may be enhanced as a result of burning (Kucera and Ehrenreich, 1962; Sampson, 1944).

Fire effect on nitrogen, phosphorus, and sulfur availability has been evaluated on soils under burned and unburned California chamise *(Adenostoma fasciculatum* and *Ceanothus cuneatus)* by Vlamis and Gowans (1961). The soil, sampled shortly after burning, gave a higher bioassay to all three elements on the burned than on an adjacent unburned area. Miller and FitzPatrick (1959) have shown that this increased availability of nutrients may be temporary however.

Nitrogen performs an important role in forage production. Its availability may mean the difference between success or failure in a revegetation program. The present study determined nitrogen availability one season after burning of defoliated Arizona chaparral.

Experimental Methods and Materials

The study site was on the Sierra Ancha Experimental Forest near Globe, Arizona at 5300-foot elevation. The chaparral type was shrub liveoak *(Quercus turbinella)* and true mountainmahogany *(Cerocorcarpus montanus)*. Alternate 50-foot strips across a small watershed were treated with a defoliant in August 1961, and 6 weeks later subjected to controlled burning (Pase and Glendening, 1965).

Soil and litter or ash samples were obtained 10 months after the burn, immediately before the summer rainy season. Composited samples were collected from each of three unburned and three burned treatments. Surface litter or ash, 0- to 1.5-inch and 1.5- to 4-inch mineral soil depths were sampled separately. In addition, samples were taken from the 0- to 1.5-inch depth on bare areas on both burned and unburned treatments where little or no vegetation had grown. The latter represented about 5% of the total area and, statistically, was treated as a fourth depth.

The soil samples were air dried and passed through a 2-mm sieve. Saturated soil paste pH was determined by use of a glass electrode. Total soil and plant nitrogen was determined by the Kjeldahl procedure using a selenium catalyst, but not modified to include nitrate nitrogen.

Nitrogen availability was determined using the Stanford-DeMent-Hunt (1959) technique with Arivat barley (92% germination) as the indicator crop. One hundred seeds were planted in 12-oz cartons containing 400 g of coarse, acid-washed sand. Deionized water was added as necessary and growth continued for 3 weeks, at which time the plants were well rooted. The previously prepared false barley-pot bottoms were removed and the pots stacked on similar containers having 50 g of soil to be tested in triplicate. The barley, then in contact with the test soil, was watered with a minus-nitrogen nutrient solution. Soil water was maintained between ⅓ and 5 bars. The plants were grown in contact with the test soil for 20 days. Above-ground portions were harvested and analyzed for total nitrogen.

The experimental design of N-availability included four depths on three burned and three unburned plots. The analysis of variance for a three-factor experiment with 3 replications was used to analyze the nitrogen yield data.

Results

Total nitrogen. — Total nitrogen concentration in ash and mineral soil increased as a result of burning chaparral (Table 1). Litter on unburned strips contained an average of 0.48% nitro-

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gen compared to 0.59% nitrogen in the litter and ash remaining after the burn. Pase and Glendening (1965) reported 6.8 tons of litter on this same site with a 28.6% reduction by burning. Direct calculation of total nitrogen in litter yielded 65 lb/acre nitrogen before burning and 57 lb/acre in ash after burning, resulting in an apparent net loss of 8 lb/acre nitrogen in the surface organic matter.

Two factors complicate the interpretation of these data. First, ash on the soil after burning represented the oxidation products of some of the previously defoliated stems and twigs which burned as a result of the fire. This addition of ash probably added some nitrogen to the soil surface. The amount of nitrogen in the standing vegetation was not determined. Secondly, oxidation products containing nitrogen were leached into the lower depths of soil during the 10-month period following the fire. This amount was greater on the burned treatments than on the unburned (Table 1). Greater nitrogen concentrations on bare spots were found on the burned treatment than on the unburned. This small watershed had a 15-25% slope and oxidation products or ash components may have been transported by water, wind, or gravity through and across the soil. In revegetation management, this would be important in improving the nitrogen status of the small bare spots.

Table 1. Mean total nitrogen concentration, pH values and nitrogen uptake by barley of burned and unburned chaparral soils.

Item and Treatment	Litter or ash	Depth in inches 0 to 1.5	1.5 to 4	bare soil[1]
% Total N[2]				
Burned	0.59	0.21	0.11	0.14
Unburned	0.48	0.20	0.08	0.09
pH[3]				
Burned	7.1	7.2	7.0	6.8
Unburned	6.4	6.6	6.7	6.3
mg N uptake[4]				
Burned	27.93 a	26.29 ab	25.07 abc	25.14 abc
Unburned	22.18 c	23.83 bc	23.57 bc	24.08 bc

[1] Represents 0- to 1.5-inch soil from nonvegetated areas within treatment areas.

[2] $s_x = \pm 0.014\%$ N.

[3] $s_x = \pm 0.12$ pH units.

[4] Means followed by the same letters are not statistically different (F = .05).

Table 2. Analysis of variance for nitrogen availability of burned and unburned chaparral soils.

Source		d. f.	M. S.
Burned vs. unburned	(A)	1	106.82**
Soil depths	(B)	3	4.38
Blocks	(C)	2	4.54
Interaction			
AB		3	26.26**
AC		2	4.45
BC		6	7.30
ABC		6	4.52
Error		48	4.04

** Significant at the 1% level.

Nitrogen availability. — Nitrogen was significantly more available on the burned than on the unburned soils (Table 2). Nonsignificant differences are presented by the analysis of variance for soil depth because of nitrogen contribution to the lower profiles by the burning but not by the nonburning treatment.

The above interaction between treatment and soil depth is more easily explained by the appropriate Duncan's multiple range test (Table 1). Nitrogen was consistently more available in the burned than the unburned mineral soil but the differences were not always significant. The unburned litter contained a significantly lower amount of available nitrogen than the burned ash or the 0- to 1.5-inch soil layer under the ash.

pH.—Ten months after burning, soil pH was 0.5 unit higher than on the unburned soils (Table 1). The bases contributing to the pH increase were leached into the mineral soil as well as transported across to soil previously bare of vegetation. Accumulation of oxidation products, change in pH, and in the physical structure of the soil after burning could be important in establishment of vegetation. Reduced moisture competition is also an important factor. Glendening and Pase (1964) and Pase (1965) have shown that burning does in fact influence revegetation.

Conclusion

Nitrogen availability measured by short-term nitrogen uptake by barley was significantly greater on soils from burned than from unburned areas 10 months after burning. These differences, however, were not statistically different for the three depths of mineral soil. The burned ash contained significantly more available nitrogen than the litter and also had a higher concentration of total nitrogen. The apparent net nitrogen loss by burning of 8 lb/acre, was confounded by the contribution of nitrogen contained in the ash from shrub-stems and by leaching of some soluble nitrogen into the mineral soil. The pH of burned soils averaged 0.5 unit higher than that of unburned soils.

Nitrogen may be frequently limiting on brush-supporting soils (Hellmers et al., 1955). Burning may increase the nitrogen available for plant growth in the nitrate form (Sampson, 1944), or in generally available nitrogen as demonstrated in the present study. Revegetation could be encouraged by increasing the amount of available nitrogen through burning. Burning could also improve the accessibility where the chaparral type is grazed by livestock or game animals. Burning decreases the total nitrogen by volatilizing certain fractions and this probably increases as the fire intensity increases. This nitrogen loss could be minimized by fires of low intensity and infrequent intervals, or offset by supplemental fertilization.

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