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LIGHT BURNING AND THE NUTRIENT VALUE OF FORAGE

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ABSTRACT

Slash burning in a clearcut under conditions producing very light to light burn intensities (<150°F or 66°C) for a short duration did stimulate resprouting, but resulted in almost no enrichment of biologically essential nutrients in the foliage. Burns of this low temperature range are not suitable for improving the quality and quantity of browse. Exceedingly dry soil conditions during the summer months appear to have resulted in low nutrient contents in clip plots where plants were crowded and dense, but not in controls where spacing was wider.

KEYWORDS: Prescribed burning, wood residues, forage nutrients, browse stimulation.

The use of fire to stimulate browse and subsequently grazing is an accepted practice in many parts of the world (Chamrad and Dodd 1972; Biswell 1972; Kirsch and Kruse 1972). Fire is especially beneficial in stimulating grass production for grazing animals. Fire usually increases the quality and quantity of browse in forest ecosystems (Stark and Steele 1977). At what temperature is a fire too light to release enough nutrients to stimulate increased foliar nutrients? A light fire that crawls through the litter may surface, kill the herbs and some brush, and stimulate resprouting; but the nutrients released may not reach the plant roots. They may be absorbed by the litter, soil organisms, or surface soil.

Silvicultural treatments of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) at the Coram Experimental Forest near Glacier National Park were designed to use fire for slash reduction and site preparation. The overall study is a large scale effort involving several silvicultural treatments, skyline harvesting methods, meteorology, soil water chemistry, microbiology, road construction technology, and economic implications.

The portion reported here covers foliar nutrient contents the first 2 years after burning. Other studies have shown increases in the per gram foliage content of nutrients within 2 years following burning (Stark and Steele 1977).

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[1]This research was conducted as a cooperative project between the Intermountain Forest and Range Experiment Station, Ogden, and the School of Forestry, University of Montana, Missoula. Dr. Nellie Stark is Professor, School of Forestry, University of Montana.

The moderately productive soils have an ash-influenced horizon, but are not truly andic. They are generally andeptic cryochrepts at 3339 to 6370 ft (1018 to 1942 m) elevation. Argillites, or sandy or quartzitic argillites overlie the limestone or dolomite of the Siyeh formation (Klages and others 1976). The topography is steep (35-45 percent) with long slopes.

For the specific study site, the habitat type is *Abies lasiocarpa/Clintonia uniflora* (ABLA/CLUN) (Robert D. Pfister, personal communication). The vegetation was largely Douglas-fir and western larch (*Larix occidentalis* Nutt.).

The area receives about 31 inches (787 mm) of precipitation annually. Much of this is snow. Extreme winter air temperatures reach -29°F (-34°C) and summer maxima reach 90°F (33°C). The mean annual temperature is 42.8°F (6°C). The area is not extremely windy, but occasional windstorms do uproot trees.

The organic layer is variable in depth, often reaching 7.9 inches (20 cm) where old logs have decayed. There was no evidence of recent fire on the area where study of foliage nutrient levels was to be intensive.

METHODS

Only the hottest of the light burns was studied. This was selected for studies of nutrient accumulation in the foliage. The burn in the fall of 1975 was light because of persistent rain. Litter had only 2 or 3 days to dry between storms. Temperatures dropped noticeably in September. As a result, fuels were cold and wet. Fine standing twigs burned well. Logs charred, but did not burn. Litter burned to mineral soil in a few spots. Soil temperatures were measured by Raymond Shearer using Tempilaq[2] melting compounds. Other data included duff reduction plots using bridge spikes to mark the original duff depth (Artley 1978). One and 2 years after the burn, in August of 1976 and again in August 1977, 50 plots 12.2 x 12.2 inches (31 x 31 cm) were clipped of all green, live vegetation from very lightly burned spots. Another 50 plots of the same size were clipped from lightly burned areas. In the control areas, another 50 randomly located plots were clipped in the same manner as for the burns.

In 1976, only 10 foliage samples from each of five herb and shrub species were collected from very lightly and lightly burned areas. Another set of 10 samples each of shrub and herb foliage was collected from the adjacent control area. These samples were analyzed to determine if foliage from burned areas showed significantly different levels of biologically essential nutrients for the same species.

The clip plot samples were air dried, ground to 0.039 inches (1 mm), and homegenized. The leaves of the individual shrub or herb species were dried, ground in the same manner and analyzed. One gram samples from clip plots or foliage were ashed at 977°F (525 ± 2°C) for 2 hours, taken up in heated 6N HCl, and made to 100 ml volume at room temperature (Black 1965). These samples were analyzed by atomic absorption spectroscopy for calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), and zinc (Zn) (Techtron 1974). One ml of 5 percent La was added for the analysis of Ca and Mg. Phosphorus (P) was analyzed colorimetrically using the ammonium molybdate method (Black 1965).

[2]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

The data were processed statistically using t-tests and absolute concentrations were graphed in micrograms per gram on polygrams with 8 axes. Soil temperatures during the burn and summer soil moisture (H. Newman, personal communication) to 3.2 ft (1 m) depth were studied to explain plant behavior. Species composition was measured before, but not the year after a burn (Jack Schmidt, personal communication).

RESULTS AND DISCUSSION

The individual species studied, *Rosa* sp., *Spiraea betulifolia* Pall., *Arnica cordifolia* Hook., *Vaccinium membranaceum* Dougl., and *Berberis repens* Lindl. showed no significant (5 percent) levels of nutrients accumulated on very lightly or lightly burned sites. Nutrient levels for 10 biologically essential nutrients were variable, but usually within the range of variation of the controls. Some species were significantly different from others in nutrient content, especially calcium.

Likewise, the clip plots showed no significant (5 percent) levels of excess nutrients resulting from burn treatments the year after a fire. Figure 1 shows the levels of nutrients from the clip plots in the control, very light burn, and light burn materials. The figures appear as averages, and significant levels of manganese did occur on very lightly and lightly burned clip plots compared to manganese in control clip plots. All other elements were variable, but within the range of concentrations found in the controls.

In the first year after burning, the vegetation on control clip plots and on light and very light burns showed relatively high levels of Zn in the foliage. Manganese was also high in the vegetation. In 1976, the soil was quite wet and in both the burn and control moisture content was favorable for growth (19 percent and 16 percent, respectively). Although there was more moisture in the soil in the clearcut, moisture did not appear to limit growth or nutrient uptake that year. Microsite variability makes it difficult to interpret these data more closely.

In 1977, the second year following burning, zinc and magnesium levels decreased (table 1). For all elements, except iron, the nutrient content was higher in control plot foliage than in foliage from either lightly or very lightly burned plots. Specifically, K, Mg, Mn, N, Na, and P content and total cations were all significantly higher in control foliage as compared to foliage grown on lightly burned sites. Foliage from very light burns was significantly higher in iron and percent ash than that from the light burn (5 percent level, table 1).

These differences are hard to explain. The answer may be that available soil moisture was low during the dry 1977 summer. In July, the root zone 3.2 ft (upper 1 m) in control plots had too low (7.8 percent) moisture to maintain good solution of nutrients. Soils in the clearcut had about 8.4 percent moisture in July, which is also very low. The presence of trees and shrubby vegetation on the undisturbed site drew the available soil moisture down to zero, which could explain the change in foliar zinc and magnesium. Less water would mean that these nutrients were less available than in a wet year, so lower overall foliar levels were reached. The sodium level in foliage on control sites was higher in the dry year than in the wetter year, which verifies the low total moisture measurements. Sodium availability is closely tied to soil moisture. Magnesium and potassium were higher in control clip plots than in clip plots from either burn intensity in the dry year. These elements would be more concentrated in the soil solution on a milligram/liter basis than in a wetter year. Unfortunately, there was not enough mobile water in the soil for chemical analysis; so concentration effects had to be interpreted on the basis of experience. Zinc and manganese would be quite tightly bonded to colloids in a dry soil and would not be readily freed. The standard deviations for the content of elements in foliage from clip plots are understandably high since each clip plot had a different species composition (table 1).

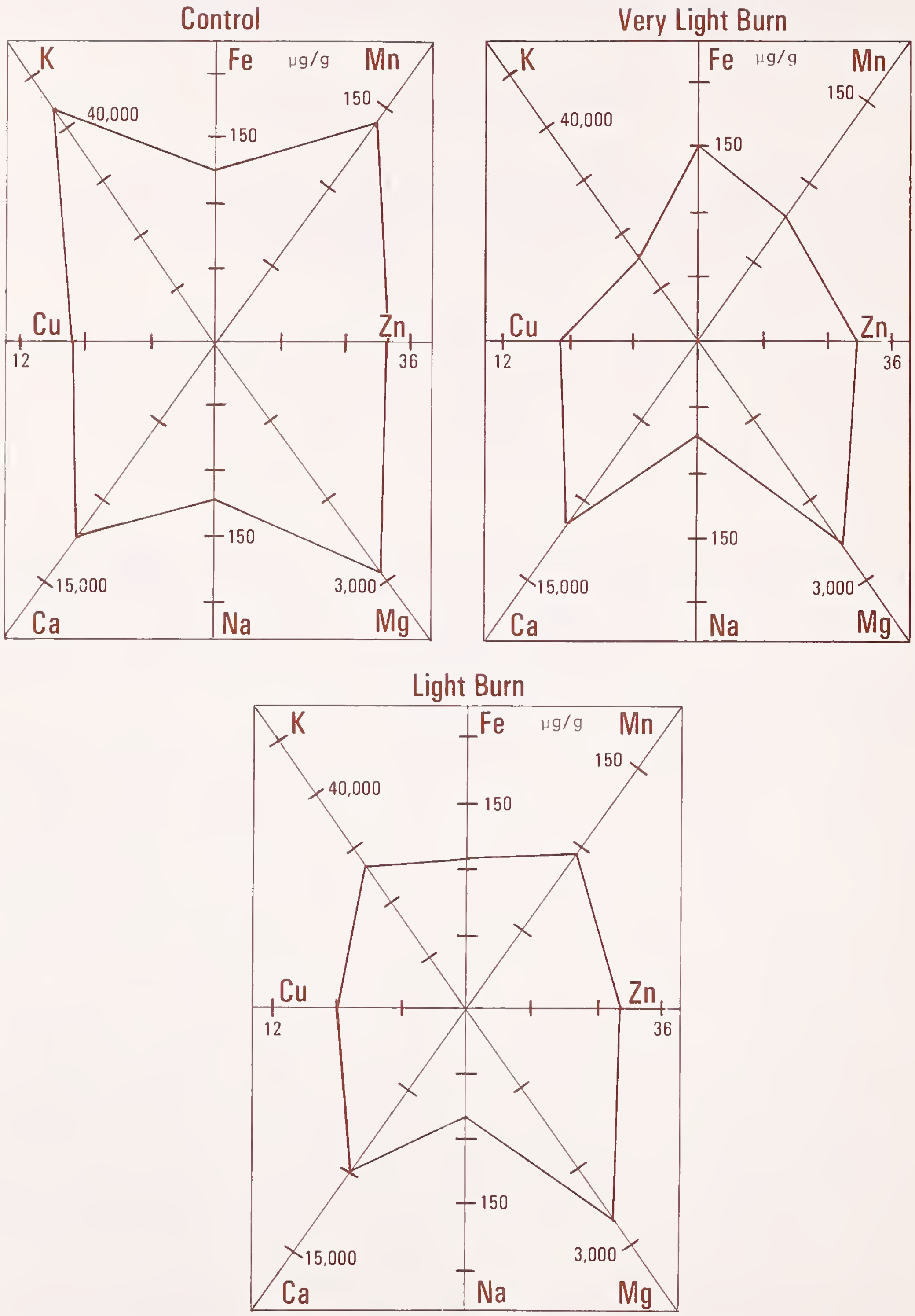

Figure 1.--Total nutrient levels in foliage and stems of controls, light, and very light burns on clip plots on the Coram Experimental Forest.

Table 1.--*Treatment averages and standard deviations for control and 2 burn treatment clip plot vegetation, and statistical comparisons of elemental differences among treatments by element (5 percent level)*

	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	Zn	Percent ash
Control											
$\bar{x}$	10127	[1]9.9	233	[1]42445	[1]2989	[1]133	[1]13622	[1]123	[1]10888	30	10.8
sd	1979	1.7	464	15345	821	87	2351	17	2687	7.5	2.9
Very light burn											
$\bar{x}$	11691	8.3	[2]156	[2]28280	2486	80	10297	70	9196	28	[2]9.7
sd	3292	1.0	89	10739	577	33	1352	22	2230	9.8	2.4
Light burn											
$\bar{x}$	9860	[3]8.0	[3]107	[3]25080	2768	96	13216	[3]78	[3]8982	29	[3]7.7
sd	2749	1.9	43	13650	845	61	2768	24	2334	8.2	2.9

[1]These control averages are significantly greater than the corresponding very light averages at the 5 percent level.

[2]These very light averages are significantly greater than the corresponding light averages at the 5 percent level.

[3]These light averages are significantly less than the corresponding control averages at the 5 percent level.

The foliage from control soils was much higher in nutrients than the foliage from either burn treatment. Resprouting on the burned sites was very vigorous in 1976 after the autumn (1975) fires. Water was abundant, but the burns were very light and had not released large quantities of nutrients; so the nutrient levels in the vegetation were not extremely high. (Few nutrients were shared by a large number of plants per unit area.)

If large amounts of plants existed per unit area in the dry summer of 1977, soil nutrient levels would be low because of the low water content. Competition would be intense; so lower concentrations of nutrients would be available to plants. On the control soils, water was so scarce that the lower density of plants and roots had access to higher absolute concentrations of some elements, such as potassium and manganese, but slightly less total water. Zinc and manganese were readily complexed and scarce in both systems. Iron and copper levels in foliage did not change appreciably between the 2 years. Biomass data were not taken in 1977; so that it is impossible to test this hypothesis against weights of foliage per square meter. Dry conditions in 1977 would have been exaggerated on the soil surface because of exposure and heat. This would retard decay and nutrient recycling.

Although there is nothing in the data to prove conclusively that the available soil water produced the measured foliar nutrient differences, the explanations are logical and supported by previous unpublished observations by the author.

Even if the soil had not been so dry in 1977, it is doubtful that the plants growing in the burns could have accumulated significant concentrations of elements from such light burns. Studies on the Lubrecht Experimental Forest (Stark and Steele 1977) showed that surface soil temperatures usually must reach 572°F (300°C) for significant releases of nutrients that may show up in concentrations in the foliage.

CONCLUSIONS

Fires of low intensity (surface soil <138°F (59°C)) are not likely to produce improved nutrient quality of the foliage, although resprouting may be stimulated. Drought reduces plant growth response to fire.

Litter temperatures did not exceed 150°F (66°C) at 1.9 inches (5 cm) depth on this clearcut. From soil chemistry and foliar data, it is resonable to assume that a burn must exceed 150°F (66°C) to produce measurable foliar nutrient concentrations. In a previous study, significant nutrient concentrations were found in some foliage where burns had exceeded 572°F (300°C). If the objective of burning is to stimulate browse species and improve the quality of browse, not just to initiate resprouting, it would appear that burns should be planned when surface soil temperatures will exceed 572°F (300°C). No studies were made on browse use of this area by large game animals, but the scarcity of tracks and scats suggest that this level of burn and human activity in the area do not attract herds of large game animals.

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