

**GROWTH RESPONSE AND CHEMICAL  
COMPOSITION OF DOUGLAS-FIR  
SEEDLINGS ON BURNED AND  
UNBURNED SOIL SAMPLES**

by

J. Baker and V. H. Phelps

**FOREST RESEARCH LABORATORY  
VICTORIA, BRITISH COLUMBIA  
INFORMATION REPORT BC-X-29**

**FORESTRY BRANCH  
DEPARTMENT OF FISHERIES AND FORESTRY  
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DOUGLAS-FIR SEEDLINGS ON BURNED AND UNBURNED  
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By J. BAKER <sup>1/</sup> and V. H. PHELPS <sup>1/</sup>

INTRODUCTION

Some consider that Douglas-fir seedlings initially grow better on burned than on similar but unburned soil. The improved growth is attributed to an increase in available nutrients as a result of combustion and to a release from vegetative competition. Since opinions differ regarding the effects of burning, a comparison of growth response and chemical composition of seedlings growing on burned and unburned soil cores was made.

DESCRIPTION OF AREA

Two adjacent areas in a cut-over mature cedar-hemlock forest of good site quality near Reiter Creek, B. C., were selected for study. Physiographic features and drainage patterns were similar, and the soil described as degraded acid brown wooded (4, 6). The following horizon sequence and description is typical for the soils of the area.

Horizon	Depth	Description
(L - H)	2 - 0"	Thin surface litter, partly decomposed, pH 4.2
Ae	0 - 1"	Ash grey podsolized layer, pH 4.2
Bfh	1 - 4"	Dark reddish brown sandy material, loose and porous with scattered stones. Accumulations of iron and humus, pH 5.4

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Bf	4 - 12"	Light brown sandy material, loose and porous with scattered stones. Accumulation of iron, pH 6.2
C	12" +	Grey deposit or mixed sands and silts, pH 6.6

The soil solum was loose and porous and the average depth varied between 12 and 18 inches. Logging slash had been burned on one area in 1963 and on the other in 1965.

#### METHODS

Three locations within each area representing unburned, lightly burned and heavily burned soils were selected for study. Heavily burned areas were those in which the entire organic surface layer had been reduced to charcoal or ash, and lightly burned sites were those in which approximately one half of the original litter layer remained. Since the two burned areas were adjacent, only one control area, in close proximity to both, was sampled for comparative purposes.

Twenty cores of undisturbed soil, 3 inches in diameter and 4 inches deep, were taken from each location and brought to the laboratory. One newly germinated Douglas-fir seedling was planted on each core and maintained under controlled conditions of temperature, light and relative humidity for eight months. Irrigation with distilled water during this growth period was carried out as conditions demanded. Seedlings were harvested and the following measurements recorded: stem height and diameter, number of branches, length of longest branch and the fresh and dry weight of roots and tops.

Dried root and shoot material was ground in a Wiley mill for chemical analysis. Total nitrogen was determined by the micro-Kjeldahl process, potassium by atomic absorption, phosphorus colorimetrically and sulphur gravimetrically as barium sulphate. Perchloric acid was used in

digestion to facilitate the removal of silica from solution and of any interference that the presence of this constituent might have on the evaluation of phosphorus and sulphur.

#### RESULTS AND DISCUSSION

The intensity of the burn experienced by the soil surface greatly influenced its pH value (1). By the termination of the growth period, pH values had decreased on the burned and increased on the unburned soil samples (Table 1). Stem height and diameter, the number and length of branches and the dry weight of roots and tops of the seedlings were greatest on unburned soils and least on heavily burned (Table 1).

The reduction of pH, varying from 0.3 to 1.0 units, that occurred in the burned soils may be attributed to a removal of some of the alkaline ash materials during irrigation of the seedlings. The increase of pH in the unburned soils, averaging 0.8 units, was probably due to increased microbiological activity resulting from the favorable environmental conditions within the plant-growth room, increased mineralization of organic matter and the removal of organic acids during irrigation.

The relation between soil pH at the beginning of the growth period and stem diameter and height expressed by regression equations and correlation "r" values is shown in Figures 1 and 2. These data tend to confirm reports that good quality sites for the growth of Douglas fir frequently have soil pH values of 4 or less (3, 7).

Intensity of burning and the ensuing lapse of time influenced the nitrogen concentration levels in tops and roots but did not change significantly the relative proportions. The increased nitrate-nitrogen levels of the surface soil reported earlier (1), did not appear to greatly influence foliar nitrogen. Possibly much of this soluble nitrogen was



quickly removed from the soil during the early stages of growth by irrigation.

The concentration levels of phosphorus, potassium and sulphur in the seedlings grown on burned soils were considerably increased, and the ratio between the concentration of each nutrient in roots and tops differed from that in seedlings grown on unburned soils; burning only slightly influenced total nitrogen uptake and its distribution in the seedling roots and tops. The concentration of nutrients in roots and tops of seedlings grown under three soil conditions is expressed as ratios to indicate changes in the distribution of nutrients in plant tissues (Table 2). Seedlings growing on heavily burned soils showed the greatest increase in phosphorous and potassium concentration, with the more pronounced increase in the tops. Although increases in soil pH normally do not influence the mobility of potassium in the soil or its uptake by seedlings, the mobility and uptake of phosphorus is largely pH-dependent. The average pH values of the surface soils of lightly and heavily burned cores exceeded those of the control samples by 1.3 to 3.5 units; however, phosphorus concentrations of tops and roots suggest that little immobilization occurred on root surfaces. Phosphorus appeared to be readily translocated from seedling roots to tops. Normally, phosphorus uptake difficulties are expected in soils in which pH values exceed 6.8 or 7.0, yet the highest concentration levels occurred in seedlings grown on such soils. As the availability of potassium is not pH-dependent, its uptake and distribution in the seedling is not a function of availability only.

After burning, the concentration of sulphur in the roots was two to three times greater than that occurring in the tops. The higher sulphur concentrations found in the tops and roots of seedlings grown on burned soil cores probably occurred as a result of the mineralization of organic sulphur compounds during the combustion of woody tissues.

Although soil cores extracted from areas in which slash had been burned produced seedlings with considerably higher concentrations of phosphorus, potassium and sulphur than those grown on unburned soil, all seedlings must be considered nitrogen-deficient (2, 5). Seedlings grown on unburned cores were larger than those grown on burned soils. The results suggest that for optimum growth not only concentration levels of nutrients are important, but also an acceptable balance between these is critical. Changes in the physical properties of the surface soil as a result of burning, although not reported here, probably influenced the growth performance of seedlings grown on burned soil samples.

#### CONCLUSIONS

The effect of burning logging slash on soil properties, especially on those in the surface layer, was immediate and considerable (1). These modifications to soil properties were quickly reflected in seedling growth. Although seedlings grown on burned soils had greater concentrations of some nutrients than those grown on unburned soils, their growth was inferior. Growth appeared to be governed by soil pH; this association, however, may have been indirect. Seedling development was much better on the more acid unburned soil. As a result of burning, some nutrients were accumulated mainly in the tops and others mainly in the roots. The results obtained during the first eight months of growth and the marked changes that occurred in the nutrient levels within the seedling tissue warrant further investigation of the effects of burning on seedling growth and composition, particularly under field conditions and over a greater growth period.

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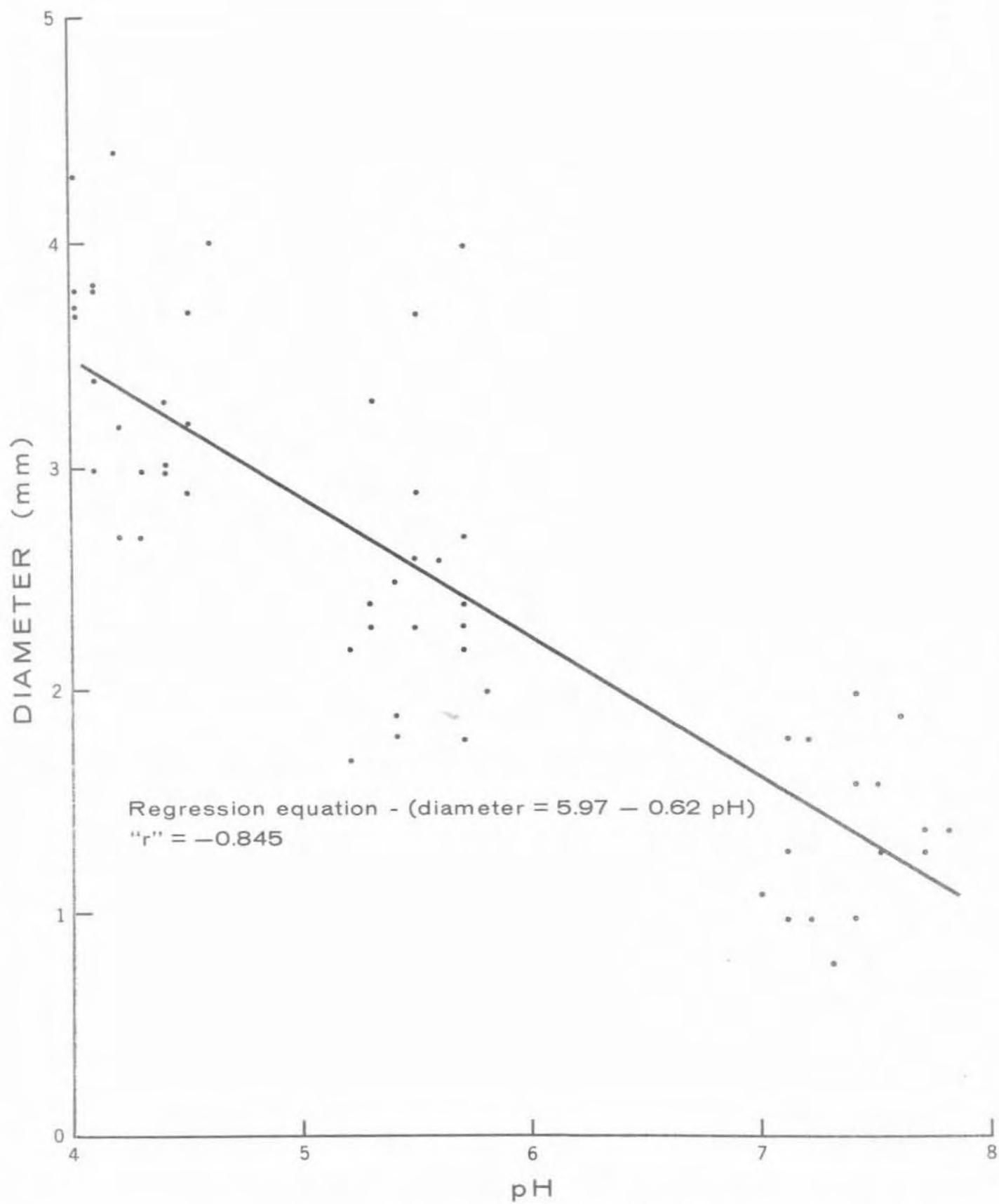


Figure 1. The relation between ster diameter and initial soil  
ph (1965 data).

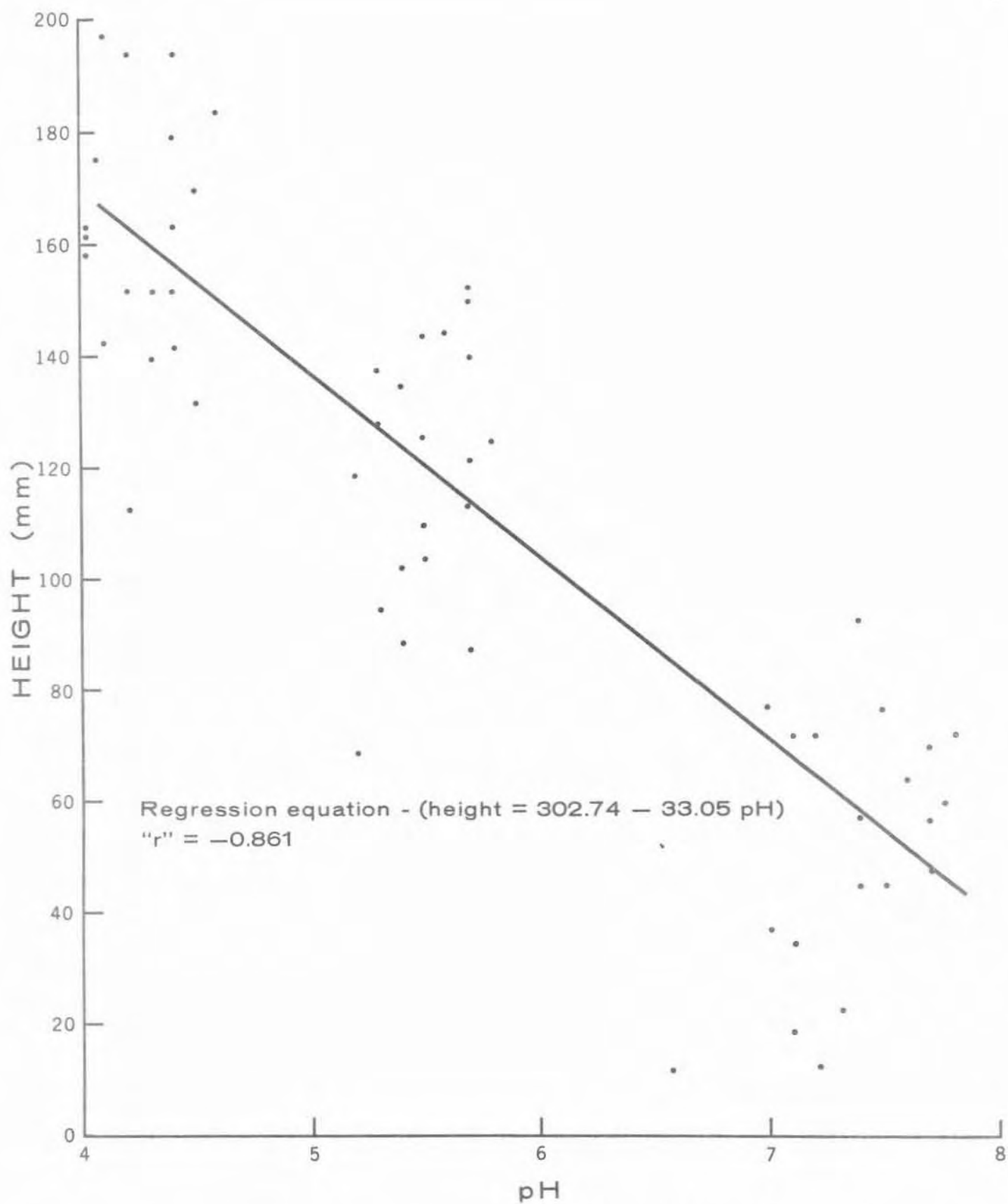


Figure 2. The relation between stem height and initial soil pH (1965 data).

Table 1.

Relationship between burning, soil pH (initial and final) and growth of Douglas-fir seedlings during the first eight months

		Initial pH	Final pH	Stem diameter mm	Stem length mm	Branch length mm	Number of branches	Fresh root weight g	Dry root weight g	Fresh top weight g	Dry top weight g
1965 <sup>1</sup> Control	Avg	4.2 ± 0.2	5.0 ± 0.3	3.4 ± 0.5	164.3 ± 28.6	78.9 ± 15.8	11.2 ± 2.7	6.3 ± 2.3	2.1 ± 0.7	5.7 ± 1.4	2.4 ± 0.6
1965 Light Burn	Avg	5.5 ± 0.2	5.2 ± 0.2	2.5 ± 0.6	120.8 ± 22.1	50.2 ± 17.4	9.1 ± 2.9	3.6 ± 1.0	1.2 ± 0.4	2.9 ± 1.4	1.2 ± 0.5
1965 Heavy Burn	Avg	7.7 ± 0.5	7.1 ± 0.6	1.3 ± 0.4	49.2 ± 27.4	29.8 ± 17.4	3.8 ± 2.5	1.4 ± 0.8	0.4 ± 0.3	0.9 ± 0.5	0.3 ± 0.2
1963 Light Burn	Avg	5.9 ± 0.3	4.9 ± 0.3	2.6 ± 0.8	131.3 ± 46.3	52.9 ± 22.1	8.1 ± 3.2	3.8 ± 1.6	1.1 ± 0.5	3.2 ± 1.2	1.2 ± 0.5
1963 Heavy Burn	Avg	7.3 ± 0.5	6.6 ± 0.5	1.2 ± 0.4	39.4 ± 23.4	23.1 ± 10.5	3.7 ± 1.8	0.9 ± 0.6	0.3 ± 0.2	0.6 ± 0.5	0.2 ± 0.2

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Since the 1963 and 1965 slash burn areas are adjacent, only one control was judged necessary for purposes of comparison.

Table 2.

Tissue analysis of Douglas-fir seedlings grown on soil samples from Reiter Creek (units of concentration - milligrams per kilogram of tissue)

Year	Treatment	Tissue	Nitrogen		Phosphorus		Potassium		Sulphur	
			Total	Top/root ratio	Total	Top/root ratio	Total	Top/root ratio	Total	Top/root ratio
1965	Control	Tops	7400		643		5,020		64	
1965	Control	Roots	6800	1.09	587	1.10	3,159	1.59	64	1.00
1965	Light burn	Tops	6100		825		7,976		64	
1965	Light burn	Roots	5900	1.03	625	1.32	5,301	1.85	192	0.33
1965	Heavy burn	Tops	6600		1,750		15,640		96	
1965	Heavy burn	Roots	6000	1.10	725	2.44	7,694	2.04	256	0.38
1963	Light burn	Tops	8200		650		6,459		96	
1963	Light burn	Roots	7400	1.11	650	1.00	3,753	1.72	256	0.38
1963	Heavy burn	Tops	7100		1,250		14,409		256	
1963	Heavy burn	Roots	5800	1.22	725	1.72	7,069	2.04	640	0.40