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PERIODIC VARIATION IN PHYSICAL AND CHEMICAL PROPERTIES OF TWO CENTRAL WASHINGTON SOILS

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ABSTRACT

Soils derived from two widely distributed parent materials in central Washington were examined periodically during 1968-69 for physical and chemical properties. Basalt soils showed significant periodic variation in cation exchange capacity, pH, and Na and K contents. In sandstone soils, cation exchange capacity and Ca, Na, and K contents varied significantly among sampling dates. Although certain physical properties showed definite trends, none were statistically significant.

These results indicate that, where sampling dates vary, periodic variation in certain chemical properties of these soils may be a confounding factor in evaluating research findings or management prescriptions.

INTRODUCTION

Physical and chemical properties of soils are often used to evaluate the effect of research treatments or the impact of management prescriptions on the microenvironment of wildland areas. For example, changes in physical and chemical properties have been used to evaluate the effect of grazing animals on the soil (Reed and Peterson 1961; Linnartz, Hse, and Duvall 1966; and Laycock and Conrad 1967). Physical properties have also been used to indicate the effect of prescribed burning (Tarrant 1956) and to compare the effect of two different types of logging on the soil (Dyrness 1967). In addition, chemical properties have been studied (Isaac and Hopkins 1937) as an indicator of the effect of logging and burning on the soil. When samples comparing one treatment or prescription with another one are taken at different points in time, periodic variation in physical and chemical properties of the soil may be a confounding factor.

This study was conducted to determine if periodic variation in these properties exists and is significant in two central Washington soils.

METHODS

Two homogeneous soil areas of approximately 1 acre were selected on representative, well-vegetated soil derived from sandstone and basalt--two parent materials common to central Washington (Wooldridge 1964). The basalt area, located near Blewett Pass in Washington, was situated on a north-facing slope at approximately 6,000-foot elevation (fig. 1). The dense overstory consisted of subalpine fir *(Abies lasiocarpa)*, Engelmann spruce *(Picea engelmannii)*, and lodgepole pine *(Pinus contorta)*. The understory was a sparse cover of grouse whortleberry *(Vaccinium scoparium)*. The soil contained approximately 46 percent sand, 45 percent silt, and 9 percent clay. The litter layer was 3 to 4 inches deep.

The sandstone site was located near Leavenworth, Wash., on a NNE slope at an elevation of 2,600 feet (fig. 2). The overstory consisted of grand fir *(Abies grandis)* and Douglas-fir *(Pseudotsuga menziesii)*, whereas the sparse understory was comprised of elk sedge *(Carex geyeri)*, Oregon grape (*Mahonia* spp.), and snowberry (*Symphoricarpos* spp.). The soil consisted of approximately 64 percent sand, 25 percent silt, and 11 percent clay, and the litter layer was from 1 to 2 inches deep.

Each site was divided graphically into milacre plots from which six were randomly selected for sampling. These 6- by 7-foot plots served as sample locations (replications) for the entire period of study. On any one sampling occasion, a random 1-square-foot area on each of the six milacre plots was sampled. Sampling was started in late May of 1968 on the sandstone site and early June on the basalt site and was continued periodically until mid-August. Final samples were taken in June 1969. Three cores were taken at each of the six milacre locations on each date for physical analysis of porosity

Figure 1.--*Study site on basalt parent material.*

Figure 2.--*Study site on sandstone parent material.*

by the air pycnometer method (Wooldridge 1968) and bulk density (Black *et al.* 1965). One loose sample was taken on each of the six milacre plots on each date for determination of moisture content and for analysis of chemical properties. These properties included: pH in a 1 to 2.5 water suspension measured by glass electrode pH meter (Jackson 1958); total nitrogen using a Coleman analyzer (Keeney and Bremner 1967); organic matter by Walkley-Black wet digestion method (Jackson 1958); cation exchange capacity by the ammonium acetate method using acidified sodium chloride (Chapman and Pratt 1961) with iodometric titration of ammonia in the sodium chloride extract (Ballentine and Gregg 1947); exchangeable Ca, Mg, Mn, Na, and K by atomic absorption using a 1-percent lanthanum chloride solution of the extract from the cation exchange capacity determination; and available P by bicarbonate extraction (Chapman and Pratt 1961) with ascorbic acid substituted for stannous chloride. All determinations were done in duplicate.

Data were evaluated by analysis of variance using a completely randomized design.

RESULTS AND DISCUSSION

In soil derived from basalt parent material, both physical and chemical properties fluctuated throughout the sampling period. However, only pH, cation exchange capacity, Na, and K varied significantly ($P = 0.05$) among dates (table 1). At the 10-percent level of testing, organic matter, Ca, and Mg were also significant. The extreme fluctuation in organic matter content appears to be unrealistic. Detection of significant differences among dates may have resulted from bias in the sampling procedure or a type I error in the statistical interpretation of the data.

In addition to significant variation among dates, there were trends in the data which indicate that the chemical properties were interrelated. Organic matter, cation exchange capacity, N, Ca, K, Mg, and Mn all showed distinct peaks on July 8, 1968. The peak in cation exchange capacity and N on this date probably resulted from the increase in organic matter. Similarly, peaks in exchangeable cations were likely the result of the increased cation exchange capacity on July 8. None of these changes appeared to be related to soil reaction or moisture content.

Variations in porosity and bulk density were not significant. However, the declining trend for porosity from June 1968 to August 1968 was probably the result of the decline in soil moisture and shrinking of the soil upon drying.

Soils derived from sandstone parent material showed significant differences ($P = 0.05$) in cation exchange capacity, N, Ca, Na, and K among dates

Table 1.--*Variation in physical and chemical properties of soil derived from basalt parent material on seven sampling dates*

Sampling date	Porosity	Bulk density	Organic matter	N	Cation exchange capacity	Exchangeable					Avail-able P	pH	Moisture content
						Na	K	Ca	Mg	Mn			
	Percent	*g./cm.*^{3}	--*Percent*--		---------------*Milliequivalent/100 g.*--------------						*p.p.m.*		*Percent*
June 10, 1968	77.6	0.61	10.61	0.257	29.71	0.183	0.441	1.37	0.173	0.034	14.16	4.85	--
June 24, 1968	76.4	.64	12.11	.292	32.74	.194	.424	1.72	.207	.029	13.73	4.80	67.67
July 8, 1968	75.1	.61	14.73	.305	37.20	.176	.481	2.47	.247	.046	15.45	4.81	43.64
July 22, 1968	74.3	.59	9.84	.246	27.49	.173	.322	1.23	.116	.026	11.95	5.02	36.49
Aug. 5, 1968	75.0	.59	10.66	.261	29.00	.165	.375	1.10	.147	.028	12.25	5.06	29.26
Aug. 20, 1968	72.8	.65	10.97	.237	29.16	.135	.340	1.28	.141	.022	14.54	5.06	41.31
June 26, 1969	75.6	.64	14.42	.252	44.15	.160	.322	1.79	.243	.043	16.16	5.29	71.89
Mean	75.3	.62	11.91	.264	32.80	.169	.386	1.57	.182	.032	14.10	4.98	--
Coefficient of variation in percent	4	14	27	32	22	6	25	53	46	62	24	4	--
F test			†		**	**	*	†	†			*	

** Significant at P = 0.01.
* Significant at P = 0.05.
† Significant at P = 0.10.

(table 2). In addition, Mg varied significantly at the 10-percent level of testing. As in the basalt soil, cation exchange capacity and N trends followed organic matter fluctuations. However, exchangeable cations in the sandstone soil did not appear to be as strongly related to cation exchange capacity as in the basalt soil. Calcium, Mg, Mn, and K all showed a peak on July 8, 1968--the same date a peak in cation exchange capacity occurred. Of these, only Ca and Mn followed the decline in cation exchange capacity to the August 1968 sampling date.

Although not significant, the variation in porosity of sandstone appears to follow the trend of organic matter. Apparently, organic matter regulates porosity in the sandstone soil to some extent. The fluctuation in bulk density showed an inverse relationship to organic matter and porosity.

In addition to significant periodic variation, most of the physical and chemical properties in both soils were at a different level on the June 1969 sampling date than on June 10, 1968. This is probably the result of a different sequence of climatic events in the 2 years.

CONCLUSIONS

The significant periodic variation in chemical properties of these two soils is likely to be a confounding factor when these properties are used to interpret results of research treatments or management prescriptions. In addition, when interpretations are based on samples collected on the same date in different years, confounding is even more likely.

Since meteorological data were not taken, it was not possible to relate changes observed in this study to rainfall or air temperature.

The results may suggest a need to relate climatic and microclimatic characteristics to periodic variations in physical and chemical properties of the soil.

Table 2.--*Variation in physical and chemical properties of soil derived from sandstone parent material on seven sampling dates*

Sampling date	Porosity	Bulk density	Organic matter	N	Cation exchange capacity	Exchangeable					Avail-able P	pH	Moisture content
						Na	K	Ca	Mg	Mn			
	Percent	*g./cm.*^{3}	---*Percent*---		---------------*Milliequivalent/100 g.*---------------						*p.p.m.*		*Percent*
May 27, 1968	57.5	1.06	3.70	0.102	15.74	0.190	0.666	8.31	1.00	0.062	71.70	5.92	23.47
June 10, 1968	60.7	1.03	3.80	.101	14.81	.187	.532	8.53	.92	.047	64.62	6.10	24.29
June 24, 1968	62.6	1.01	3.42	.079	13.31	.318	.671	6.62	.91	.050	77.79	5.62	11.47
July 8, 1968	61.8	1.01	3.76	.083	14.09	.227	.725	7.97	.99	.061	74.99	5.81	8.87
July 22, 1968	61.6	1.00	3.25	.073	12.61	.194	.665	6.76	.81	.050	75.83	5.90	6.71
Aug. 20, 1968	59.2	1.04	2.89	.074	12.78	.118	.820	6.85	1.00	.034	76.27	5.71	17.19
June 3, 1969	59.0	1.09	3.13	.071	15.40	.136	.592	7.42	.95	.028	74.44	6.25	12.41
Mean	60.3	1.03	3.42	.083	14.10	.196	.667	7.49	.94	.047	73.52	5.90	--
Coefficient of variation in percent	5	8	20	17	10	17	13	16	12	51	42	7	--
F test				**	**	**	**	*	⨍				

** Significant at P = 0.01.
 * Significant at P = 0.05.
 ⨍ Significant at P = 0.10.

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