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T.L. Troth, F.J. Deneke and L.M. Brown

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Studies were completed in several black spruce and aspen/birch communities of the Caribou Creek Watershed. Frequency and basal area or percent cover are detailed for tree, sapling, shrub, herbaceous, moss, and lichen species. Organic layer mass was greatest beneath a north slope black spruce community. Carbon and nitrogen levels were higher in litter layers beneath the hardwood stands, whereas carbon/nitrogen ratios were higher in the living and decaying organic mat beneath black spruce. Concentrations of P, Ca, Mg, Mn and Zn were higher in hardwood than in conifer organic layers. K and Fe concentrations in organic

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layers were similar beneath hardwoods and conifers. Soils beneath conifer and hardwood stands could not be separated on the basis of pH, %C, %N or C/N ratios. Cation exchange capacity closely reflected %C in all soils. More exchangeable bases were present in soils beneath hardwood communities than beneath black spruce communities. Increases in extractable P were found near the soil surface in aspen-dominated communities. Extractable soil P increased below 15 cm in conifer stands.

## PREFACE

This report was prepared by John L. Troth, forester, Frederick J. Deneke, forester, and Lloyd M. Brown, agronomist, of the Alaskan Division, U.S. Army Cold Regions Research and Engineering Laboratory. The work was performed under the OCE Civil Works program, work unit CWIS 31003, *Watershed Studies in Cold Regions*.

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# SUBARCTIC PLANT COMMUNITIES AND ASSOCIATED LITTER AND SOIL PROFILES IN THE CARIBOU CREEK RESEARCH WATERSHED, INTERIOR ALASKA

by

J.L. Troth, F.J. Deneke and L.M. Brown

## INTRODUCTION

The Caribou-Poker Creeks Research Watershed was established in 1969 as a site for investigation of all aspects of the upland, subarctic, taiga ecosystem. Research in this watershed is directed toward the ultimate goal of developing a comprehensive understanding of environmental processes and relationships in the taiga. This study represents the initial steps in updating the existing vegetation map by Vogel and Slaughter (1972) and providing baseline information on undisturbed plant communities within the watershed and their associated litter and soil profiles. In the plant community descriptions eight stands are represented, five coniferous and three deciduous. Organic layer and soil descriptions represent the deciduous stand and four of the coniferous areas. Organic layer descriptions include mass and pH, and levels of carbon, nitrogen, phosphorus, calcium, magnesium, potassium, iron, manganese and zinc for two depths within each stand. Soil descriptions include texture, pH, carbon, nitrogen, phosphorus, cation exchange capacity, calcium, magnesium, potassium and percent base saturation in each of four depths within a stand.

## STUDY AREA

The research watershed is located in the Yukon-Tanana uplands about 50 km north of Fairbanks (Fig. 1). The area has a continental climate characterized by large diurnal and annual temperature variations, low humidity, low mean annual precipitation of 20 to 50 cm, and annual snowfall of about 130 cm (Johnson and Hartman 1969, Dingman 1971).

Soils have developed from the underlying mica schist of the Birch Creek formation. A thin cap of loess derived from the same parent material covers the area but no sharp boundary exists between it and the underlying soil (Rieger et al. 1972). South-facing slopes are usually silt loams or gravelly silt loams (Typic cryochrepts, Typic cryorthents), free from permafrost. Soils of north slopes (Histic lithic cryaquepts, Histic pergelic cryaquepts) are characterized by permafrost interspersed with unfrozen loams (Rieger et al. 1972).

Within the watershed, the most frequent tree species on north slopes is black spruce (*Picea mariana* (Mill.) B.S.P.). Important shrub species are Labrador tea (*Ledum groenlandicum* Oeder) and shrub birch (*Betula glandulosa* Michx.). The forest floor under black spruce usually consists of a thick mat of numerous moss and lichen species. Paper birch (*Betula papyrifera* Marsh.) and quaking aspen (*Populus tremuloides* Michx.) predominate on south-facing slopes with occasional

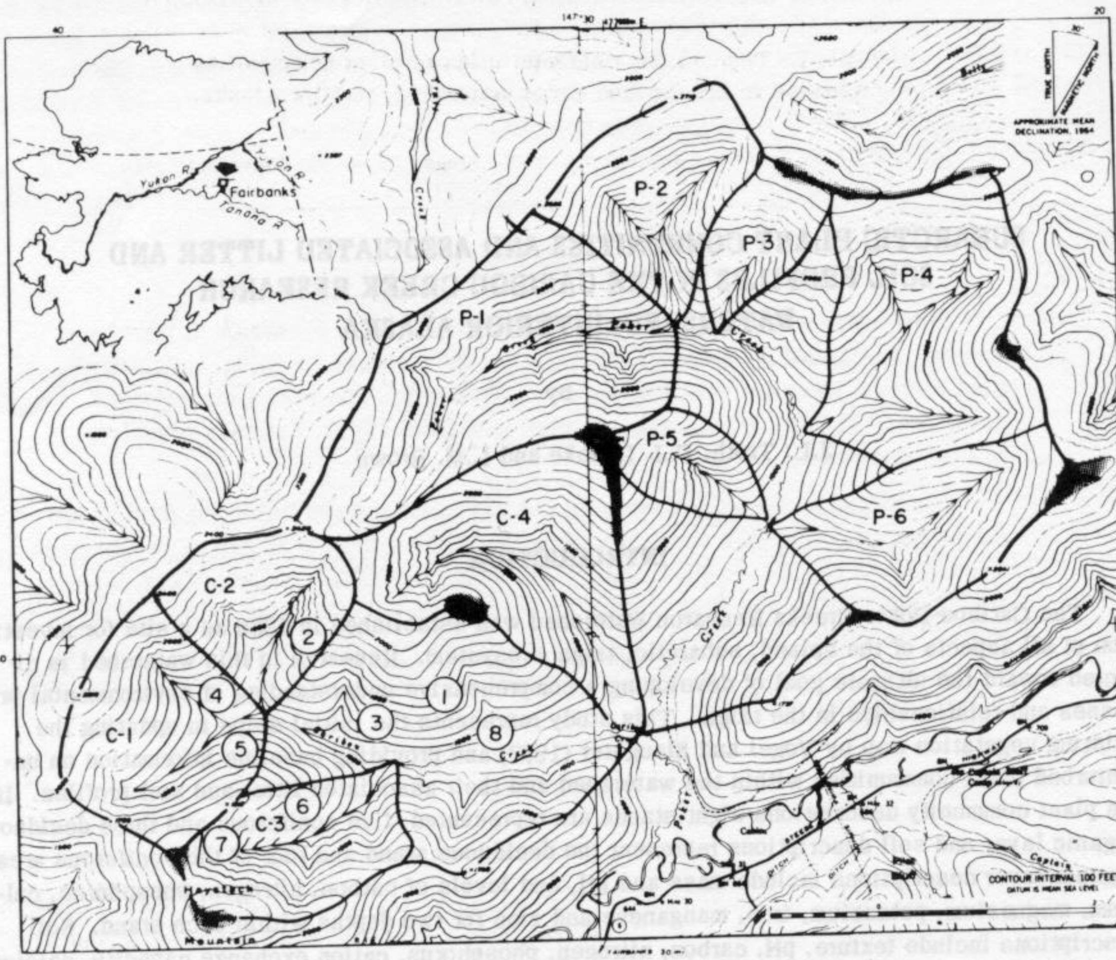


*Figure 1. Location of plant communities studied in Caribou-Poker Creeks Watershed, interior Alaska.*

stands of mountain alder (*Alnus crispa* (Ait.) Pursh.). Understories beneath aspen and birch are not usually characterized by moss, but instead by numerous herbaceous and perennial shrub species. Scattered white spruce (*Picea glauca* (Moench) Voss) are found on south slopes and adjacent to drainages. Numerous willow (*Salix* spp.) species occur as occasional understory throughout the area. Valley bottoms may be occupied by either riparian communities of willow and arctic dwarf birch (*Betula nana* L.), or stunted stands of black spruce and tamarack (*Larix laricina* (DuRoi) K. Koch). Alpine tundra occurs at the highest elevations.

Eight locations were selected within the Caribou Creek watershed for detailed analysis of plant communities or stands (Fig. 1). These sites were chosen to include examples of the most widely distributed community types and topographic positions found within the study area. Each stand was located within a uniform topographic site with no major discontinuities in vegetation.

Stands 1, 2 and 3 are birch and aspen stands on similar topographic sites (Table I). The remaining stands represent black spruce communities on varying topographic positions. Stand 4 has a southeast exposure at low elevation. Stand 6 has a similar slope and aspect, but is at a higher elevation. The microclimate of this site is probably dominated by its proximity to Haystack Mountain (elevation 770 meters) immediately to the south. Stand 7 has an eastern exposure and is dominated by the same mountain. Stand 5 occurs on a steep, north-facing slope. Stand 8 is located

**Table I. Topographic characteristics of plant communities sampled in the Caribou Creek Watershed, interior Alaska.**

| *Stand* | *Aspect* (°) | *Slope* (%) | *Elevation* (m) |
|---|---|---|---|
| 1 | 197 | 24 | 457 |
| 2 | 220 | 20 | 457 |
| 3 | 196 | 19 | 457 |
| 4 | 127 | 15 | 427 |
| 5 | 13 | 28 | 457 |
| 6 | 149 | 20 | 518 |
| 7 | 99 | 9 | 610 |
| 8 | 144 | 6 | 274 |

in the valley bottom and, in addition to black spruce, has an occasional occurrence of larch. In Stand 5 permafrost occurred from 40-65 cm below the ground surface in mid July 1972, at several sample points where *Sphagnum* species were present. Depth to permafrost was greater than 1 m at all other points in this stand. Average depth to permafrost below stand 8 was 57.5 cm at the end of August 1972. Permafrost was not found within 1 m of the ground surface in any other stands.

## METHODS

### Field methods

*Community analysis.* Stands were described in detail using procedures similar to those suggested by Ohmann and Ream (1971a, b). Taxonomy followed Hultén (1968) for herbaceous species and Viereck and Little (1972) for shrub and tree species. Nomenclature of mosses and lichens followed Crum, Steere and Anderson (1973), and Hale and Culberson (1966) respectively. Twenty sample points (plots) were established within each stand on a 4 × 5 spacing with 60 ft (19.6 m) between points. A border strip at least 60 ft wide surrounded each stand. At each sample point percent cover of mosses, lichens and litter was estimated in a 1-m² quadrat. The projected ground cover of all herbaceous and shrub species was also estimated.

At each point trees and saplings* were sampled by the point-centered quarter method. The four quadrants were formed by one line running parallel to the aspect of the site and a second line perpendicular to it. Distance to the first tree and sapling encountered in each quadrant was recorded, with the species name and dbh. In several black spruce stands few stems exceeded 3.5 in. dbh. In these communities only the first stem $\geq$ 1 in. dbh in each quadrant was recorded. Within each stand a minimum of five dominant or codominant trees were selected for height and age measurements. Height was measured with a Haga altimeter and distance tape. Age was determined by obtaining increment cores 1 ft (30.5 cm) above ground level.

*Organic matter and soil sampling.* At four predetermined sample points within each stand, three samples of the organic layer, down to mineral soil, were obtained using a 0.09-m² steel sampling frame. The samples were separated into upper and lower layers. In black spruce communities the upper layer of living mosses and lichens and loose litter material surrounding their bases was separated from the underlying, more compacted humus at the time of sample collection. In birch-aspen communities the upper layer consisted of litter (L) and some of the least decomposed (F) layer material, which was not yet compacted with the more decomposed humus below. Material from each

* Trees: stems $\geq$ 3.5 in. (88.9 mm) diameter at breast height (dbh). Saplings: stems 1.0 to 3.5 in. (25.4 to 88.9 mm) dbh.

layer was composited in the field at each sampling location and stored in polyethylene bags after removal of living roots. In each stand two pits were dug into mineral soil and samples were collected from the 0-7.5 cm, 7.5-15 cm, 15-30 cm and 30-45 cm depths. All soil samples were transported to the laboratory in polyethylene bags and analyzed separately. No organic or soil samples were collected in the valley bottom community, stand 8.

**Laboratory methods**

Organic layer samples were oven-dried at 70°C to a constant weight. Material from each sample was then ground in a Wiley mill to pass a 1-mm sieve. Samples were heated at 550°C for four hours in a muffle furnace to determine volatile matter content. The pH of the organic samples was measured by glass electrode in a saturation paste. Two grams of the ground material was digested in a nitric-perchloric acid mixture. Total phosphorus was measured colorimetrically in an aliquot of the acid digest using ammonium molybdate with aminonaphthosulfonic acid as the reducing agent. Total Ca, Mg, K, Fe, Mn and Zn were determined by atomic absorption spectrophotometery, with $La_2O_3$ added to control ionic interferences during Ca and Mg determinations. Total N was determined by a modified Kjeldahl digestion procedure followed by colorimetric measurement of $NH_4^+$-N with a Technicon AutoAnalyzer as described by Warner and Jones (1970), with the additional step of making all samples up to 50 ml before analysis. Total carbon was determined using a Leco high frequency induction furnace and Automatic Carbon Determinator. Iron chips, granular tin and copper wire accelerators were used to maximize carbon recovery (Young and Lindbeck 1964). All analyses were conducted in duplicate.

*Soil.* Soil samples were air-dried and sieved to pass a 2-mm (10-mesh) screen prior to analysis. Particle size distribution was analyzed by the hydrometer method (Bouyoucos 1951). Surface layer soils were treated with $H_2O_2$ prior to particle size analysis. Soil pH was measured by glass electrode in a 1:1 soil/distilled water suspension. Total N was determined by the macro Kjeldahl method (Bremner 1965). Phosphorus was extracted with 0.03 N $NH_4F$ + 0.02 N NHl and determined colorimetrically using ammonium molybdate with $SnCl_2$ as the reducing agent (Olsen and Dean 1965). Cation exchange capacity was determined by ammonium saturation with neutral 1 N $NH_4OAc$ (Chapman 1965). Exchangeable bases were measured in the $NH_4OAc$ extract with an atomic absorption spectrophotometer. Lanthanum was added to control ionic interferences during determination of Ca and Mg. Sodium was added during determination of exchangeable K. Total carbon was determined in the same manner as for litter samples and considered to be equivalent to organic carbon because of soil acidity. Soils were ground to pass a 100-mesh sieve prior to carbon determination. All chemical analyses were conducted on air-dry samples and results corrected to an oven-dry basis. All analyses were conducted in duplicate.

*Statistical analysis.* Data collected in the vegetation survey were summarized for each species and community. Frequency of occurrence values for each species in each stand were then used to group stands by polythetic agglomerative clustering analysis (Orloci 1967). This analysis fuses two stands or groups only if the resultant increase in the within-group sum of squares is less than it would be by fusing either of the two with any other entity in the sample. Clustering is repeated in successive cycles until a hierarchy of the sample stands is completed. Results are presented as a dendrogram using average within-group dispersion as a percent of sample dispersion.

Results of analyses of litter and soil characteristics were subjected to two-way analysis of variance using the assumptions of Model I (Fryer 1966). The analysis was first run using data from all stands. Subsequently, hardwood and conifer stands were grouped and data from each group analyzed separately. Following significant F-tests, differences among mean stand and depth values for each soil and litter characteristic were tested at the 0.05 level of confidence with Duncan's New Multiple Range Test (Fryer 1966).

## RESULTS AND DISCUSSION

### Community analysis

Agglomerative clustering analysis separated the plant communities into coniferous and hardwood stands as expected (Fig. 2). The first clustering cycle grouped the two black spruce communities on southeastern aspects (stands 4 and 6), and the two communities with primarily aspen overstories (stands 2 and 3). In successive cycles the birch community, stand 1, was clustered with the two aspen stands and the additional spruce stands were fused with the first two. The valley bottom community was the last stand added to the black spruce community groupings.

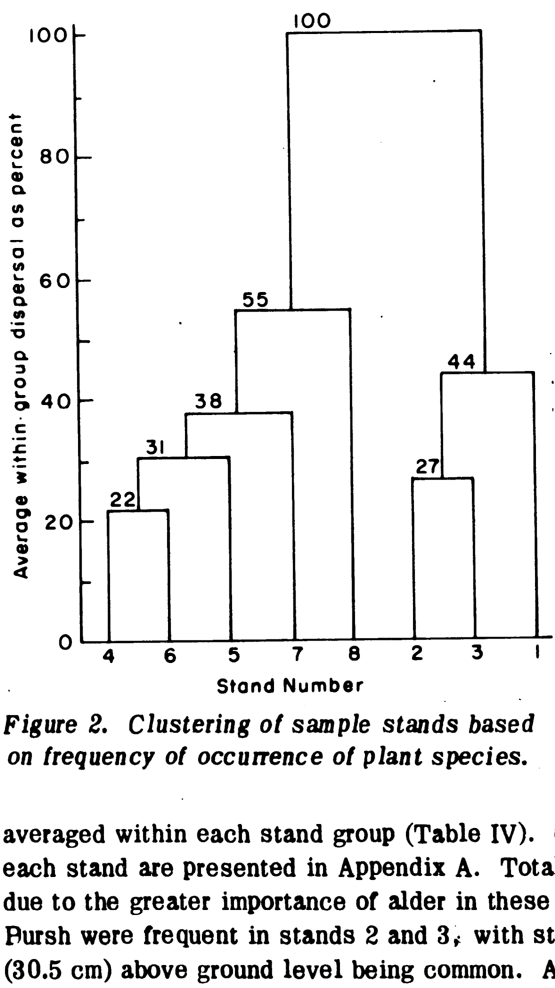


*Figure 2. Clustering of sample stands based on frequency of occurrence of plant species.*

Stand data for the tree and sapling species in each community are summarized in Table II. Scattered birch and aspen were present within two of the black spruce stands, but their basal area and importance values were always small. Larch was present only in the valley bottom, stand 8. In both stands dominated by aspen, birch was also present. In stand 3 birch and aspen were the same age, but the more scattered birch present in stand 2 were considerably older than the aspen. Accurate age determinations on these birch were prevented by heart rot. Stand 1 was a pure birch stand with good stocking and basal area. All hardwood stands were dominated by trees about 41 to 47 years old. Average age of the black spruce stands varied from 43 to 172 years. The oldest community included in this study was stand 5. All stands were even-aged except for the older birch found in stand 2 and all were probably of fire origin.

Percent occurrence and percent cover of each understory species were averaged within the coniferous and hardwood stand groups (Table II). Total percent cover of each shrub and herb layer was also calculated for each community and values averaged within each stand group (Table IV). Occurrence and percent cover of each species in each stand are presented in Appendix A. Total cover of tall shrubs was highest in hardwood stands due to the greater importance of alder in these communities. Large clumps of *Alnus crispa* (Ait.) Pursh were frequent in stands 2 and 3, with stem diameters up to 4 in. (10 cm) at a height of 1 ft (30.5 cm) above ground level being common. Age of alder stems in stand 3 varied from 29 to 42 years 1 ft above ground level. Percent cover of the medium and low shrub species was highest in black spruce communities due to the prominence of *Vaccinium vitis-idaea*, *Vaccinium uliginosum* and *Ledum groenlandicum*. The most important species in this layer beneath hardwoods were *Vaccinium vitis-idaea*, *Spiraea beauverdiana* and *Rosa acicularis*. Dwarf shrub and herbaceous species were most frequent in hardwood communities. Most prominent were *Graminae* spp., *Cornus canadensis*, *Lycopodium complanatum* and *Epilobium angustifolium*. Most frequent species in this layer in coniferous stands were *Graminae* spp., *Rubus chamaemorus*, *Empetrum nigrum* and *Geocaulon lividum*, but no shrub or herb species was very frequent or had large percent cover in black spruce stands.

**Table II. Stand summary data for tree species in Caribou Creek communities, interior Alaska.**

1 acre = 4047 $m^2$; 1 inch = 25.4 mm; 1 ft = 304.8 mm

| *Species** | *Freq (%)* | *Stems/ acre* | *Basal area/ acre (ft)* | *Import-ance† value* | *DBH (in.) Avg* | *DBH (in.) Range* | *Height (ft) Avg* | *Height (ft) Range* | *Age (yr) Avg* | *Age (yr) Range* |
|---|---|---|---|---|---|---|---|---|---|---|
| **Stand 1** | | | | | | | | | | |
| *Betula papyrifera* | 100 | 656 | 77.1 | 100.0 | 4.6 | 3.5-7.8 | 53.7 | 50.0-57.6 | 41 | 39-43 |
| *Betula papyrifera* (SA) | 100 | 948 | 27.0 | 97.4 | | | | | | |
| *Picea glauca* (SA) | 5 | 12 | 0.5 | 2.6 | | | | | | |
| **Stand 2** | | | | | | | | | | |
| *Populus tremuloides* | 100 | 349 | 59.9 | 85.9 | 5.6 | 3.5-10.3 | 47.7 | 43.5-52.5 | 47 | 45-52 |
| *Betula papyrifera* | 20 | 23 | 14.4 | 14.1 | 10.7 | 7.0-12.1 | 57.2 | 57.0-57.5 | | |
| *Populus tremuloides* (SA) | 100 | 162 | 6.6 | 95.8 | | | | | | |
| *Betula papyrifera* (SA) | 5 | 2 | <0.1 | 2.1 | | | | | | |
| *Picea glauca* (SA) | 5 | 2 | <0.1 | 2.1 | | | | | | |
| **Stand 3** | | | | | | | | | | |
| *Populus tremuloides* | 95 | 221 | 42.0 | 60.1 | 5.9 | 3.5-9.8 | 48.2 | 44.0-54.0 | 45 | 44-46 |
| *Betula papyrifera* | 80 | 133 | 24.1 | 39.9 | 5.8 | 3.5-10.7 | 48.3 | 44.5-56.0 | 45 | 41-49 |
| *Populus tremuloides* (SA) | 90 | 79 | 3.4 | 60.1 | | | | | | |
| *Betula papyrifera* (SA) | 70 | 39 | 1.8 | 35.6 | | | | | | |
| *Picea glauca* (SA) | 10 | 3 | 0.1 | 3.3 | | | | | | |
| **Stand 4** | | | | | | | | | | |
| *Picea mariana* | 100 | 112 | 9.8 | 75.3 | 4.0 | 3.5-6.5 | 31.1 | 25.5-38.5 | 62 | 52-67 |
| *Populus tremuloides* | 45 | 17 | 1.7 | 18.3 | 4.3 | 3.5-5.2 | 37.1 | 34.0-39.5 | 60 | 53-65 |
| *Betula papyrifera* | 15 | 5 | 0.8 | 6.4 | 5.3 | 5.0-5.5 | | | | |
| *Picea mariana* (SA) | 100 | 1077 | 20.9 | 91.6 | | | | | | |
| *Betula papyrifera* (SA) | 20 | 57 | 0.8 | 8.4 | | | | | | |
| **Stand 5** | | | | | | | | | | |
| *Picea mariana* | 100 | 346 | 37.6 | 100.0 | 4.4 | 3.5-6.3 | 32.9 | 30.0-38.0 | 172 | 142-185 |
| *Picea mariana* (SA) | 100 | 352 | 10.6 | 100.0 | | | | | | |
| **Stand 6** | | | | | | | | | | |
| *Picea mariana* | 100 | 398 | 8.7 | 97.8 | 2.0 | 1.0-4.1 | 24.0 | 20.5-27.8 | 47 | 41-54 |
| *Betula papyrifera* | 5 | 5 | <0.1 | 2.2 | 1.3 | | | | | |
| **Stand 7** | | | | | | | | | | |
| *Picea mariana* | 100 | 634 | 35.6 | 100.0 | 3.2 | 1.0-7.8 | 25.3 | 22.8-27.8 | 108 | 84-124 |
| **Stand 8** | | | | | | | | | | |
| *Picea mariana* | 100 | 472 | 5.7 | 89.1 | 1.5 | 1.0-2.7 | 18.4 | 15.0-21.0 | 43 | 41-67 |
| *Picea glauca* | 5 | 6 | 1.4 | 8.1 | 2.4 | | 20.8 | 18.0-23.5 | 41 | 38-44 |
| *Larix laricina* | 5 | 6 | 0.2 | 2.8 | 6.4 | | 31.8 | | 39 | |

* (SA) denotes sapling category.

† Importance value = average of relative frequency + relative dominance + relative density (Ohmann and Ream 1971).

**Table III. Occurrence and percent cover of understory and ground cover species in Caribou Creek black spruce and aspen/birch communities, interior Alaska.**

| Species | *Black spruce* Occurrence (%) | Cover (%) | *Aspen/birch* Occurrence (%) | Cover (%) | *Total no. of stands* |
|---|---|---|---|---|---|
| **Tall shrubs** | | | | | |
| *Alnus* spp. Mill. | 16 | 1.9 | 45 | 17.0 | 6 |
| *Salix* spp. L. | 17 | 2.0 | 22 | 7.1 | 7 |
| **Medium and low shrubs** | | | | | |
| *Betula glandulosa* Michx. | 18 | 2.4 | -- | -- | 2 |
| *Betula nana* L. | 3 | 0.2 | -- | -- | 1 |
| *Ledum groenlandicum* Oeder | 65 | 8.7 | 13 | 1.3 | 6 |
| *Ledum decumbens* (Ait.) Lodd. | 17 | 2.0 | -- | -- | 1 |
| *Rosa acicularis* Lindl. | -- | -- | 25 | 1.6 | 3 |
| *Rubus idacus* (Michx.) Maxim | -- | -- | 2 | <0.1 | 1 |
| *Spiraea beauverdiana* Schneid. | 10 | 0.2 | 32 | 2.0 | 6 |
| *Vaccinium uliginosum* L. | 80 | 9.6 | 10 | 0.7 | 6 |
| *Vaccinium vitis-idaea* L. | 97 | 9.9 | 47 | 5.4 | 8 |
| **Dwarf shrubs and herbs** | | | | | |
| *Cornus canadensis* L. | 4 | 0.1 | 53 | 7.1 | 4 |
| *Empetrum nigrum* L. | 18 | 1.1 | 2 | 0.2 | 4 |
| *Epilobium angustifolium* L. | -- | -- | 45 | 2.1 | 3 |
| *Equisetum silvaticum* L. | 13 | 0.3 | 8 | 0.1 | 4 |
| *Geocaulon lividum* (Richards.) Fern. | 23 | 0.5 | 2 | 0.1 | 4 |
| *Linnaea borealis* L. | -- | -- | 20 | 3.2 | 2 |
| *Pedicularis labradorica* Wirsing | -- | -- | 2 | 0.1 | 1 |
| *Pedasites hyperboreus* Rydb. | 11 | 0.2 | -- | -- | 1 |
| *Polygonum alaskanum* (Small) Wight | 9 | 0.2 | 8 | 0.1 | 3 |
| *Pyrola secunda* L. | -- | -- | 3 | 0.1 | 2 |
| *Rubus chamaemorus* L. | 26 | 1.0 | -- | -- | 2 |
| *Stellaria* spp. L. | -- | -- | 23 | 0.5 | 3 |
| *Vaccinium oxycoccos* L. | 5 | 0.1 | -- | -- | 2 |
| *Lycopodium annotinum* L. | 6 | 0.1 | 2 | <0.1 | 3 |
| *Lycopodium clavatum* L. | 1 | <0.1 | -- | -- | 1 |
| *Lycopodium complanatum* L. | 4 | 0.2 | 47 | 5.5 | 4 |
| *Carex* L. | 7 | 0.2 | -- | -- | 2 |
| *Eriophorum* L. | 6 | 0.4 | -- | -- | 1 |
| *Graminae* | 75 | 1.0 | 100 | 9.2 | 8 |
| **Mosses** | | | | | |
| *Aulacomnium palustre* (Hedw.) Schwaegr. | 23 | 5.9 | -- | -- | 2 |
| *Dicranum* spp. Hedw. | 75 | 5.2 | 23 | 0.4 | 8 |
| *Hylocomium splendens* (Hedw.) B.S.G. | 52 | 3.9 | 37 | 0.9 | 8 |
| *Pleurozium schreberi* (Brid.) Mitt. | 92 | 33.4 | 47 | 3.7 | 8 |
| *Polytrichum* spp. Hedw. | 91 | 5.2 | 72 | 6.7 | 8 |
| *Sphagnum* spp. L. | 30 | 9.6 | -- | -- | 3 |
| Other mosses | 17 | 0.5 | 69 | 4.4 | 6 |
| **Lichens** | | | | | |
| *Cetraria cucullata* (Bell.) Ach. | 27 | 1.0 | -- | -- | 5 |
| *Cetraria islandica* (L.) Ach. | 74 | 1.7 | -- | -- | 5 |
| *Cladonia alpestris* (L.) Rabenh. | 6 | 0.3 | -- | -- | 3 |
| *Cladonia arbuscular* (Wallr.) Rabenh. | 77 | 10.2 | 5 | <0.1 | 6 |
| *Cladonia rangiferina* Wigg. | 75 | 5.5 | -- | -- | 5 |
| Other *Cladonia* spp. Wigg. | 81 | 7.7 | 50 | 0.8 | 8 |

**Table III (cont'd). Occurrence and percent cover of understory and ground cover species in Caribou Creek black spruce and aspen/birch communities, interior Alaska.**

| Species | Black spruce Occurrence (%) | Black spruce Cover (%) | Aspen/birch Occurrence (%) | Aspen/birch Cover (%) | Total no. of stands |
|---|---|---|---|---|---|
| **Lichens (cont'd)** | | | | | |
| *Peltigera aphthosa* (L.) Willd. | 34 | 1.4 | 15 | 0.5 | 6 |
| *Peltigera canina* (L.) Willd. | 39 | 7.8 | 2 | -- | 6 |
| Other *Peltigera* spp. Willd. | 66 | 2.0 | 10 | <0.1 | 6 |
| *Stereocaulon* spp. Hoffm. | 10 | 0.2 | -- | -- | 3 |
| **Ground cover** | | | | | |
| Total live ground cover (mosses and lichens) | 100 | 85 | 100 | 17.2 | 8 |
| Total moss cover | 100 | 63 | 95 | 16.3 | 8 |
| Total lichen cover | 97 | 33 | 50 | 1.5 | 8 |
| Total fruticose lichens | 89 | 22 | 50 | 0.8 | 8 |
| Total foliose lichens | 86 | 11 | 22 | 0.7 | 8 |
| Total leaf & twig litter | 99 | 11 | 100 | 81.5 | 8 |

**Table IV. Percent cover of understory layers in Caribou Creek plant communities, interior Alaska.**

| Stand | All shrubs and herbs | Medium and low shrubs | Dwarf shrubs and herbs | Alnus and Salix |
|---|---|---|---|---|
| 1 | 44.9 | 3.6 | 32.3 | 9.0 |
| 2 | 74.7 | 11.5 | 28.8 | 34.4 |
| 3 | 60.0 | 17.4 | 24.0 | 18.6 |
| 4 | 38.6 | 32.5 | 1.9 | 4.2 |
| 5 | 35.8 | 31.9 | 3.9 | 0.0 |
| 6 | 53.6 | 44.5 | 5.1 | 4.0 |
| 7 | 31.6 | 21.6 | 8.0 | 2.0 |
| 8 | 50.9 | 30.8 | 10.9 | 9.2 |
| **Average values** | | | | |
| Aspen/birch | 59.9 | 10.8 | 28.4 | 20.7 |
| Black spruce | 42.1 | 32.3 | 6.0 | 3.9 |

Total moss and lichen cover averaged 85% in coniferous communities as compared to 17% in hardwoods. Total leaf and twig litter averaged 11% in conifer stands and 82% in hardwoods. Mosses and lichens formed a nearly continuous ground cover in all coniferous communities. Average percent cover of mosses was 63% in these stands. *Pleurozium schreberi* was the most prominent moss species in all spruce communities except the valley bottom, stand 8. In the valley bottom, *Sphagnum* spp. and *Aulacomnium palustre* were the most frequent mosses. These two species were also found on the steep, north-facing slope beneath stand 5. *Polytrichum* spp., *Dicranum* spp. and *Hylocomium splendens* were also frequently encountered in black spruce communities. Lichens were an important component of all conifer communities with species of *Cladonia*, *Cetraria* and *Peltigera* predominating. *Cladonia arbuscula* was the single most prevalent species.

Although percent occurrence of mosses and lichens was also high in hardwood stands, these species were relatively unimportant in terms of percent cover. The most important moss beneath hardwoods was *Polytrichum* spp.

VEGETATION TYPES

- A Aspen (*Populus tremuloides*)
- BP White birch (*Betula papyrifera*)
- BN Dwarf birch (*Betula nana*): used for all above-tree-line areas
- PG White spruce (*Picea glauca*)
- PM Black spruce (*Picea mariana*)
- C Sedge (*Carex* sp., *Eriophorum* sp.); commonly includes sparse overstory of black spruce, occasional tamarack (*Larix laricina*)
- S Alder/willow (*Alnus* sp., *Salix* sp.)
- R Riparian species (*Salix* sp., *Betula nana*, *Vaccinium* sp., *Populus balsamifera*, etc.)

DENSITY CLASSES

- 1 High
- 2 Medium
- 3 Low

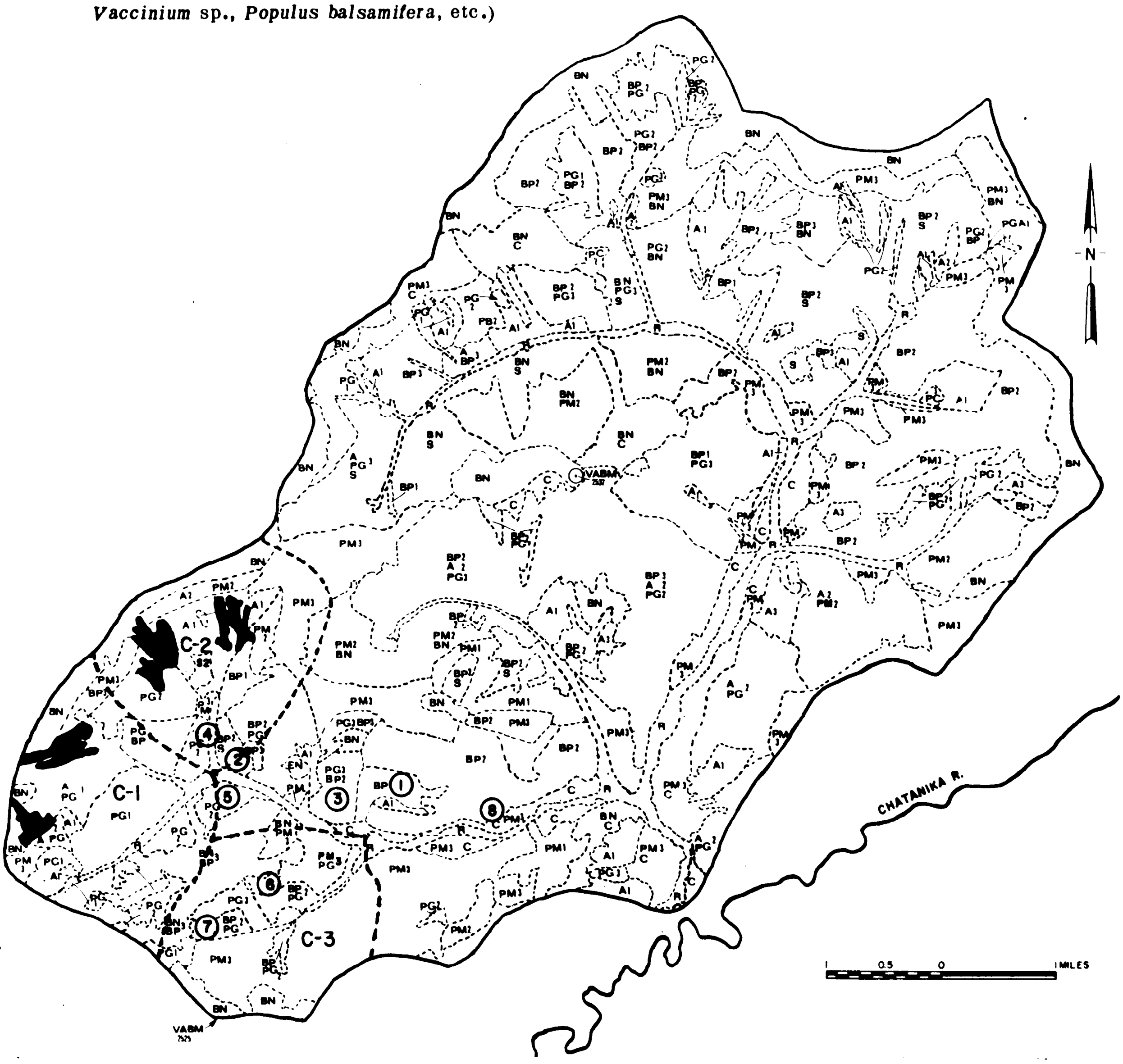


***Figure 3. Preliminary vegetation map of Caribou-Poker Creeks Research Watershed, interior Alaska, November 1971 (Vogel and Slaughter 1972).***

Community analysis data and field observations were compared to the existing vegetation map of the Caribou Creek Watershed (Fig. 3). Several major inconsistencies were apparent. The map, based entirely on interpretation of aerial photography, shows large areas of white spruce on both north- and south-facing slopes. Field observations did not verify this. With the exception of the shaded areas in C-1 and C-2 (Fig. 3), conifer stands were primarily black spruce. White spruce occurred in pure stands only as stringers in C-1 and C-2. In the rest of the study area, white spruce was found only as single trees or as small groups of trees.

There was also frequent incorrect identification of quaking aspen and paper (white) birch on the initial map. With the exception of the stand 1 area, sites denoted on the map as paper birch were generally aspen/birch mixtures with aspen predominating. The map does not fully indicate the frequent occurrence of nearly pure alder communities. Several alder stands of various sizes were found in C-2 and along the south-facing slope on which stands 1-3 were located. Alder communities were generally included in areas labeled as paper birch or aspen. A large alder/willow community outlined in the center of C-2 was nearly pure alder with scattered old birch. These birch were apparent survivors of a previous fire. A large area previously mapped as dwarf birch and paper birch along the C-1 to C-3 boundary was thinly stocked black spruce with scattered inclusions of paper birch and alder. Shrub birch was locally present in this area. The species was generally *Betula glandulosa*, rather than *Betula nana*.

**Organic matter analysis**

Mass of the organic layers in the three hardwood stands varied from 44,810 kg/ha to 67,343 kg/ha (Table V). Van Cleve and Noonan (1971) reported average forest floor masses of 40,000 and 42,000 kg/ha in birch and aspen stands, respectively, spanning a wide range of stand ages in interior Alaska. Alway and Kittredge (1933) reported litter masses varying from 9,340 to 48,160 kg/ha beneath aspen and birch stands in northern Minnesota. Rodin and Bazilevich (1965) state that litter mass beneath birch forests of the south taiga subzone and the deciduous forest zone of the Russian plane and West Siberia varies from about 22,500 kg/ha in early spring to 7,500 kg/ha in late summer. Litter depth varied from about 7 to 11 cm in the hardwood stands sampled.

Total mass of organic layers in black spruce communities varied from 80,322 kg/ha to 120,318 kg/ha. The greatest values were encountered in stand 5. This stand, located on a relatively steep north slope, is the oldest stand included in the study. Depth of the organic layers varied from about 15 to 25 cm.

The pH of organic layers was significantly higher in hardwood stands than beneath black spruce communities (Table VI). Organic matter was more acidic in stand 5 than in any other black spruce community. Litter was also more acidic beneath the birch stand than beneath aspen stands. Lower layer samples were more acidic than upper layer samples in all stands.

Total carbon, as a percent of volatile matter, and percent nitrogen were significantly higher in organic layers from each hardwood stand than in black spruce stands (Table VI). Statistical analysis showed an increase in %C in the lower layer in black spruce stands, but no difference between layers over the three hardwood stands. Only the mixed aspen/birch community, stand 3, has less C in lower samples. Nitrogen concentrations found in hardwood litter layers were higher than those reported in other birch and aspen stands in interior Alaska (Van Cleve and Noonan 1971). Alway and Kittredge (1933) report N concentrations in aspen and birch litter in northern Minnesota similar to those encountered in this study when all levels are expressed as a percent of volatile matter. Comparable values have also been reported in forest floors of birch stands with grass in Russia (Rodin and Bazilevich 1965). Litter N concentrations encountered in this study may have been increased by the presence of alders and grasses in these communities. Grasses characteristically have high concentrations of mineral elements, including N (Rodin and Bazilevich 1965). Nitrogen concentrations in the organic layers of black spruce stands were

**Table V. Mass and volatile matter content of forest floor organic layers.**

| *Stand* | *Layer* | *Total depth (cm)* | *Mass (kg/ha)* | | *Volatile matter (%)* |
|---|---|---|---|---|---|
| | | | *Oven-dry* | *Ash-free* | |
| 1 | 1 | | 7414 | 6961 | 93.89 |
| | 2 | | 59929 | 45690 | 76.24 |
| | Total | 10.9 | 67343 | 52651 | |
| 2 | 1 | | 10031 | 9409 | 98.30 |
| | 2 | | 34779 | 29534 | 84.92 |
| | Total | 9.6 | 44810 | 38943 | |
| 3 | 1 | | 7023 | 6546 | 93.21 |
| | 2 | | 43509 | 34942 | 80.31 |
| | Total | 7.3 | 50532 | 41488 | |
| 4 | 1 | | 16025 | 15019 | 93.72 |
| | 2 | | 64297 | 51585 | 80.23 |
| | Total | 15.1 | 80322 | 66604 | |
| 5 | 1 | | 15826 | 15167 | 95.84 |
| | 2 | | 104492 | 90208 | 86.33 |
| | Total | 25.3 | 120318 | 105375 | |
| 6 | 1 | | 13236 | 12708 | 96.01 |
| | 2 | | 73431 | 64634 | 88.02 |
| | Total | 15.2 | 86667 | 77342 | |
| 7 | 1 | | 14939 | 14197 | 95.03 |
| | 2 | | 70752 | 58745 | 93.03 |
| | Total | 15.9 | 85691 | 72942 | |

**Table VI. Chemical properties of organic layers in Caribou Creek forest stands, interior Alaska.**

| *Stand* | *Layer* | *pH* | *C* | *N* | *N* | *C/N* | *P* | *K* | *Ca* | *Mg* | *Fe* | *Mn* | *Zn* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *% volatile* | | *% ovendry* | | *% of oven-dry weight* | | | | | | |
| 1 | 1 | 5.10 | 49.35 | 2.50 | 2.34 | 20.1 | .142 | .198 | .939 | .269 | .078 | .221 | .0124 |
| | 2 | 4.28 | 51.29 | 2.92 | 2.17 | 19.2 | .143 | .229 | .488 | .208 | .844 | .159 | .0050 |
| 2 | 1 | 5.19 | 49.58 | 2.31 | 2.16 | 22.7 | .152 | .253 | 1.178 | .201 | .075 | .117 | .0105 |
| | 2 | 4.55 | 50.73 | 2.55 | 2.16 | 20.2 | .182 | .241 | .688 | .153 | .444 | .110 | .0046 |
| 3 | 1 | 5.42 | 51.14 | 2.04 | 1.90 | 26.6 | .146 | .202 | 1.547 | .215 | .093 | .085 | .0117 |
| | 2 | 4.75 | 49.52 | 2.98 | 2.40 | 16.8 | .205 | .244 | .959 | .199 | .728 | .127 | .0061 |
| 4 | 1 | 3.99 | 45.41 | 1.13 | 1.06 | 40.8 | .085 | .203 | .338 | .072 | .194 | .056 | .0026 |
| | 2 | 3.72 | 49.45 | 1.37 | 1.08 | 36.9 | .153 | .206 | .211 | .108 | .702 | .015 | .0022 |
| 5 | 1 | 3.87 | 46.71 | 1.34 | 1.28 | 35.7 | .066 | .211 | .306 | .064 | .121 | .060 | .0033 |
| | 2 | 3.29 | 46.83 | 1.22 | 1.05 | 38.9 | .087 | .156 | .152 | .078 | .473 | .013 | .0016 |
| 6 | 1 | 4.16 | 47.23 | 1.58 | 1.51 | 32.1 | .087 | .208 | .331 | .089 | .102 | .076 | .0027 |
| | 2 | 3.69 | 48.88 | 1.88 | 1.62 | 26.8 | .106 | .163 | .244 | .099 | .573 | .023 | .0042 |
| 7 | 1 | 4.00 | 45.78 | 1.17 | 1.11 | 39.9 | .080 | .278 | .245 | .083 | .171 | .050 | .0032 |
| | 2 | 3.46 | 48.68 | 1.36 | 1.13 | 36.0 | .117 | .165 | .160 | .121 | .731 | .018 | .0029 |

**Table VII. Mass (kg/ha) of nutrient elements in organic layers beneath forest communities in the Caribou Creek Watershed, interior Alaska.**

| *Stand* | *N* | *P* | *K* | *Ca* | *Mg* | *Fe* | *Mn* | *Zn* | *Total* |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1474.0 | 96.2 | 151.9 | 262.1 | 144.6 | 511.6 | 111.7 | 3.9 | 2756.0 |
| 2 | 967.9 | 78.6 | 109.2 | 357.5 | 73.4 | 161.9 | 50.0 | 2.6 | 1801.1 |
| 3 | 1177.7 | 99.4 | 120.5 | 525.9 | 101.9 | 323.3 | 61.2 | 3.5 | 2413.4 |
| 4 | 864.3 | 112.0 | 165.0 | 189.8 | 81.0 | 482.4 | 18.6 | 1.8 | 1914.9 |
| 5 | 1299.7 | 101.4 | 196.4 | 207.3 | 91.6 | 513.4 | 23.1 | 2.2 | 2435.1 |
| 6 | 1389.4 | 89.4 | 147.2 | 223.0 | 84.5 | 434.3 | 26.9 | 3.4 | 2398.1 |
| 7 | 965.3 | 81.3 | 198.6 | 180.2 | 84.6 | 344.6 | 31.5 | 2.6 | 1888.7 |

considerably lower. Concentrations were highest in stand 6 and lowest in stand 5. Nitrogen concentrations were significantly higher in the lower litter depth in hardwood stands, but did not differ statistically between depths in the coniferous stands. Only in stand 5 did %N decrease in the lower layer.

C/N ratios were significantly lower in litter layers beneath hardwood stands. C/N ratios in these three stands varied from 20.0 to 26.6 in the upper litter layer and from 16.8 to 20.2 in the lower layer. Ratios varied between 32.1 and 40.8 in the living mosses and lichens of black spruce stands and from 16.8 to 38.9 in the litter. In general, when organic material with a C/N ratio greater than 30 is added to soil, there will be immobilization of soil N. If the ratio is between 20 and 30, neither net immobilization nor mineralization of N may occur. If the ratio is less than 20, a release of mineral N to the soil can be expected (Tisdale and Nelson 1966).

Phosphorus concentrations in organic layers beneath hardwood stands were significantly greater than in all spruce stands except stand 4. Phosphorus concentrations were lower in stand 5 than in organic layers of any other stand. P levels were greater in the lower layer of all stands except the birch stand, where no difference was found between layers.

Levels of all cations determined, except potassium and iron, were higher in organic layers beneath hardwoods than under black spruce. In general, levels of each cation were similar between spruce stands, but several significant differences existed between hardwood communities. Concentrations of Mg and Mn were highest in litter from the birch forest, whereas Ca levels were highest in the two aspen stands. Differences between Ca and Mn levels in birch and aspen litter correspond to those found by Van Cleve and Noonan (1971). These investigators reported higher Mg levels in H layers of aspen litter than in H layers from birch stands, but no differences in Mg concentration of L or F material from the two forest types.

Total mass of organic layer N, P, Fe and Zn was similar beneath hardwood and coniferous stands (Table VII). Greatest mass of Ca and Mn was present beneath hardwoods. Only K had a greater mass in organic layers beneath black spruce.

Results of all analyses conducted on individual litter samples are shown in Appendix B. Statistically significant differences in litter properties among stands and depths are summarized in Appendix D.

**Soil analyses**

Soil physical and chemical properties are summarized in Table VIII. All soils, other than in stand 5, were silt loams. Soils beneath stand 5 had a somewhat higher sand content and were classified as loams. Silt plus clay content of most samples varied between 65% and 85%, with highest values generally found in the surface layer.

**Table VIII. Chemical and physical properties of soil profiles in Caribou Creek forest stands, interior Alaska.**

| Stand | Depth (cm) | % Sand (2.0-.05 mm) | % Silt (.05-.002 mm) | % Clay (<.002 mm) | pH | Organic C (%) | Total N (%) | C/N | Extractable P (ppm) | Exchangeable bases (meq/100 g) CEC | Ca | Mg | K | Ca+Mg+K saturation (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0-7.5 | 15 | 63 | 22 | 4.44 | 7.22 | .322 | 22.4 | 4.50 | 33.40 | 2.552 | .645 | .228 | 10.23 |
| | 7.5-15 | 36 | 50 | 14 | 4.54 | 2.74 | .164 | 16.7 | 4.52 | 26.38 | 1.466 | .342 | .134 | 7.36 |
| | 15-30 | 26 | 58 | 16 | 4.89 | 1.86 | .136 | 13.7 | 5.05 | 16.10 | 1.376 | .376 | .104 | 11.49 |
| | 30-45 | 27 | 58 | 15 | 5.09 | 1.64 | .106 | 15.5 | 4.62 | 16.96 | 1.456 | .464 | .125 | 11.92 |
| 2 | 0-7.5 | 14 | 63 | 23 | 4.62 | 5.22 | .386 | 13.5 | 37.26 | 31.88 | 2.134 | .726 | .464 | 10.72 |
| | 7.5-15 | 25 | 61 | 14 | 4.82 | 1.43 | .112 | 12.8 | 5.60 | 16.77 | .784 | .331 | .179 | 8.23 |
| | 15-30 | 24 | 61 | 15 | 4.94 | .76 | .070 | 10.9 | 5.50 | 16.11 | .784 | .360 | .110 | 7.57 |
| | 30-45 | 24 | 60 | 16 | 5.17 | .64 | .058 | 11.0 | 4.24 | 14.81 | 1.128 | .487 | .074 | 10.40 |
| 3 | 0-7.5 | 18 | 62 | 20 | 4.72 | 4.34 | .260 | 16.7 | 59.53 | 26.76 | 2.664 | 1.142 | .477 | 16.62 |
| | 7.5-15 | 24 | 60 | 16 | 4.88 | .84 | .064 | 13.1 | 9.18 | 12.76 | .809 | .352 | .162 | 10.51 |
| | 15-30 | 27 | 59 | 14 | 5.11 | .76 | .055 | 13.8 | 7.20 | 11.05 | .906 | .390 | .088 | 12.70 |
| | 30-45 | 25 | 60 | 15 | 5.18 | .54 | .054 | 10.0 | 7.17 | 10.[illegible] | 1.068 | .476 | .068 | 15.21 |
| 4 | 0-7.5 | 22 | 63 | 15 | 4.50 | 2.16 | .114 | 18.9 | 2.79 | 19.43 | .681 | .265 | .121 | 5.43 |
| | 7.5-15 | 25 | 61 | 14 | 5.24 | 1.07 | .075 | 14.3 | 5.97 | 11.70 | .410 | .146 | .090 | 5.48 |
| | 15-30 | 36 | 52 | 12 | 5.44 | 0.35 | .044 | 8.0 | 13.25 | 8.02 | .685 | .291 | .064 | 12.90 |
| | 30-45 | 34 | 54 | 12 | 5.41 | 0.63 | .046 | 13.7 | 9.70 | 8.42 | .636 | .283 | .069 | 13.50 |
| 5 | 0-7.5 | 19 | 63 | 18 | 3.80 | 18.40 | .672 | 27.4 | 6.73 | 65.94 | .364 | .326 | .325 | 1.51 |
| | 7.5-15 | 45 | 42 | 13 | 4.22 | 2.87 | .196 | 14.6 | 10.17 | 17.55 | .166 | .104 | .064 | 1.94 |
| | 15-30 | 45 | 45 | 10 | 4.64 | 2.12 | .179 | 11.8 | 13.90 | 14.01 | .206 | .060 | .056 | 1.99 |
| | 30-45 | 42 | 47 | 11 | 4.92 | 1.68 | .108 | 15.6 | 20.76 | 15.02 | .244 | .066 | .060 | 2.53 |
| 6 | 0-7.5 | 22 | 62 | 16 | 4.32 | 10.88 | .518 | 21.0 | 1.65 | 48.02 | 1.733 | .750 | .205 | 5.56 |
| | 7.5-15 | 24 | 63 | 13 | 4.62 | 3.68 | .179 | 20.6 | 5.48 | 22.05 | .708 | .270 | .085 | 4.70 |
| | 15-30 | 30 | 57 | 13 | 4.90 | 1.13 | .086 | 13.1 | 9.39 | 12.24 | .364 | .124 | .052 | 4.42 |
| | 30-45 | 30 | 56 | 14 | 4.86 | .80 | .071 | 11.3 | 6.04 | 11.28 | .364 | .129 | .050 | 4.83 |
| 7 | 0-7.5 | 24 | 55 | 21 | 4.62 | 3.18 | .184 | 17.3 | 4.72 | 20.51 | .284 | .122 | .083 | 2.39 |
| | 7.5-15 | 18 | 69 | 13 | 5.14 | 1.90 | .107 | 17.8 | 2.96 | 14.66 | .223 | .048 | .052 | 2.21 |
| | 15-30 | 21 | 66 | 13 | 5.37 | 1.12 | .079 | 14.2 | 3.43 | 13.13 | .281 | .070 | .046 | 3.17 |
| | 30-45 | 33 | 55 | 12 | 5.61 | .32 | .049 | 6.5 | 11.56 | 8.40 | 1.081 | .343 | .052 | 17.71 |

Soils were moderately to strongly acidic beneath all stands, with pH values differing significantly among both conifer and hardwood communities. The most acidic soils were encountered beneath stand 5, where pH of the 0-7.5 cm layer had decreased to 3.80. Among hardwood communities, pH was significantly lower beneath the birch stand than beneath either of the stands dominated by aspen. Soil pH increased with depth beneath all stands. Hardwood and conifer communities could not be clearly separated on the basis of soil pH.

Soil carbon and nitrogen levels differed significantly among both hardwood and black spruce communities. Levels of both elements were highest in soils beneath the black spruce communities in stands 5 and 6, and lowest beneath the black spruce communities in stands 4 and 7. Intermediate levels were found beneath the hardwood stands. Soil C was higher beneath the birch community than beneath either aspen stand. Levels of the two elements generally decreased down to 30 cm beneath both conifers and hardwoods. C/N ratios did not differ significantly among conifer stands. In hardwood stands the ratio was widest beneath the birch in stand 1. Wider C/N ratios below the birch stand were associated with the higher levels of soil C present. C/N ratios in the 0-7.5 cm depth varied from 27.4 beneath stand 5 to 13.5 beneath stand 2.

Extractable phosphorus increased with depth beneath black spruce stands. Beneath the aspen stands, much more P was extractable in the 0-7.5 cm layer than in lower layers. Levels of extractable P were similar over all depths beneath the birch stand. These differences in profile distribution of extractable P may reflect differences in release of P from litter debris and in P uptake within differing plant communities.

Cation exchange capacities of all soils closely paralleled differences in soil C. Values were highest in spruce stands 5 and 6, and lowest in spruce stands 7 and 4, with hardwood stand values being intermediate. Highest levels of exchangeable Ca, Mg and K were found beneath hardwood communities. In general, concentrations of exchangeable bases were highest in the 0-7.5 cm depth beneath all communities. Percent base saturation was very low beneath all communities. Values averaged over all depths varied from 2.1% to 13.7% in stands 5 and 3 respectively. Data reported by Scotter (1971) indicate base saturations of Ca+Mg+K varying from 5.1 to 9.4% beneath mature black spruce and jack pine/black spruce forests in northern Saskatchewan.

Results of analyses on each soil sample collected during the study are listed in Appendix C. Statistically significant differences in soil properties between stands and depths are summarized in Appendix E.

## CONCLUSIONS

An agglomerative clustering technique fused the plant communities studied into two groups. Black spruce and hardwood communities were separated in the two groups. Frequent shrub species encountered in the various forest stands generally corresponded to those indicated by Viereck and Little (1972). Shrub species frequently encountered in interior Alaska, but not encountered within any sample stand, were *Shepherdia canadensis* (L.) Nutt., *Arctostaphylos uva-ursi* (L.) Spreng., and *Viburnum edule* (Michx.) Raf. The medium and low shrub layer was best developed in black spruce communities, due to the importance of several ericaceous species. These ericaceous shrubs may form a nearly continuous layer in black spruce/sphagnum climax communities (Viereck 1970). Herbaceous and dwarf shrub species were most important in hardwood communities. Viereck (1970) also found this layer better developed under balsam poplar than under spruce in river bottom successional communities.

Vegetation analysis results indicate a need for major revisions in the existing watershed vegetation map. Many species designations were found to be incorrect when ground-checked.

Failures to correctly distinguish between black and white spruce on other than north-facing slopes and between birch and aspen were frequent.

Litter and soil analyses indicated several differences between forest types, but conclusions must be drawn with caution because of the limited number of stands sampled. Organic layers in black spruce communities were more acidic and generally contained lower nutrient concentrations than did those in hardwood stands. The open nature of black spruce stands suggested that the character of organic layers was primarily determined by the moss and lichen species present. Hardwood litter, however, was composed primarily of organic debris from the overhead tree species. Higher pH values were found in hardwood litter, but values were somewhat lower than found in birch and aspen stands on deeper loess in interior Alaska (Van Cleve and Noonan 1971). Ca concentrations in hardwood litter were considerably lower than encountered by Van Cleve and Noonan (1971); but, as these authors reported, levels were higher beneath aspen than birch.

Differences found between spruce and hardwood organic layers were not generally apparent in mineral soil profiles. Soils beneath many stands in the study area may not reflect stand species characteristics because of relatively recent fire origin, particularly if previous community composition differed. Following a disturbance, species composition may change much more rapidly than soil characteristics (Grigal and Arneman 1970). It is also well established that fires frequently alter soil properties. Common changes include a reduction in soil acidity and an increase in exchangeable cations and available P. The magnitude and duration of these effects depend, of course, upon intensity of burn. Scotter (1971) found increases in soil pH, available P, and exchangeable Ca still apparent 22 years after a fire in northern Saskatchewan jack pine/black spruce. In the present study a marked increase in soil surface acidity associated with conifer and moss species was found only beneath stand 5. In this community black spruce were approximately 172 years old. Despite increased acidity beneath this stand, more available P was encountered than beneath younger black spruce communities. Soil N and CEC were closely related to soil carbon content under all stands. Soil C content is undoubtedly related to site fire history, particularly time since previous fires and burn intensity. C, N and CEC levels were highest in the 0-7.5 cm layer beneath the 172-year-old black spruce community. Exchangeable Ca, Mg and K levels were highest in soil profiles beneath hardwoods and generally decreased with depth. These higher soil levels may reflect higher element concentrations in litter layers or more rapid release from litter. Higher pH of hardwood organic debris should provide more suitable conditions for decomposition.

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**Appendix A: Frequency of Occurrence (a) and Cover (b) Summary for Understory and Ground Cover in Caribou Creek Communities, Interior Alaska.**

| Species | Stand 1 (a) | Stand 1 (b) | Stand 2 (a) | Stand 2 (b) | Stand 3 (a) | Stand 3 (b) | Stand 4 (a) | Stand 4 (b) | Stand 5 (a) | Stand 5 (b) | Stand 6 (a) | Stand 6 (b) | Stand 7 (a) | Stand 7 (b) | Stand 8 (a) | Stand 8 (b) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | | | | | | | | | | | | | | | |
| Tall shrubs | | | | | | | | | | | | | | | | |
| *Alnus* spp. Mill. | 25 | 5.6 | 70 | 33.4 | 40 | 11.9 | 5 | 3.0 | - | - | 15 | 1.8 | - | - | 60 | 4.5 |
| *Salix* spp. L. | 15 | 3.4 | 5 | 1.0 | 45 | 6.7 | 5 | 1.2 | - | - | 5 | 2.2 | 10 | 2.0 | 65 | 4.7 |
| Medium and low shrubs | | | | | | | | | | | | | | | | |
| *Betula glandulosa* Michx. | - | - | - | - | - | - | - | - | - | - | - | - | 85 | 7.8 | 5 | 0.1 |
| *Betula nana* L. | - | - | - | - | - | - | - | - | 15 | 1.1 | - | - | - | - | - | - |
| *Ledum groenlandicum* Oeder | - | - | - | - | 40 | 3.8 | 65 | 11.0 | 50 | 2.3 | 100 | 22.6 | 30 | 1.2 | 80 | 6.4 |
| *Ledum decumbens* (Ait.) Lodd. | - | - | - | - | - | - | - | - | 85 | 9.8 | - | - | - | - | - | - |
| *Rosa acicularis* Lindl. | 30 | 2.2 | 5 | 0.2 | 40 | 2.3 | - | - | - | - | - | - | - | - | - | - |
| *Rubus idaeus* L. var. *strigosus* (Michx.) Maxim. | - | - | - | - | 5 | 0.1 | - | - | - | - | - | - | - | - | - | |
| *Spiraea beauverdiana* Schneid. | 5 | 0.2 | 45 | 4.2 | 45 | 1.6 | - | - | 25 | 0.6 | 20 | 0.3 | 5 | 0.2 | - | - |
| *Vaccinium uliginosum* L. | - | - | - | - | 30 | 2.0 | 75 | 12.2 | 40 | 3.1 | 100 | 13.2 | 85 | 7.2 | 100 | 12.5 |
| *Vaccinium vitis-idaea* L. | 25 | 1.2 | 35 | 7.1 | 80 | 7.6 | 90 | 9.3 | 100 | 15.0 | 100 | 8.4 | 100 | 5.2 | 95 | 11.8 |
| Dwarf shrubs and herbs | | | | | | | | | | | | | | | | |
| *Cornus canadensis* L. | 55 | 9.8 | 30 | 2.6 | 75 | 9.0 | - | - | - | - | - | - | 20 | 0.6 | - | - |
| *Empetrum nigrum* L. | - | - | 5 | 0.5 | - | - | 5 | 0.5 | - | - | - | - | 75 | 5.0 | 10 | 0.2 |
| *Epilobium angustifolium* L. | 30 | 0.9 | 35 | 2.8 | 70 | 2.6 | - | - | - | - | - | - | - | - | - | - |
| *Equisetum silvaticum* L. | - | - | 5 | 0.1 | 20 | 0.2 | - | - | - | - | 30 | 0.7 | - | - | 35 | 0.6 |
| *Geocaulon lividum* (Richards.) Fern. | - | - | - | - | 5 | 0.4 | 10 | 0.2 | 25 | 0.7 | 80 | 1.8 | - | - | - | - |
| *Linnaea borealis* L. | 55 | 6.0 | 5 | 3.5 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pedicularis labradorica* Wirsing | - | - | 5 | 0.2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Petasites hyperboreus* Rydb. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 55 | 1.0 |
| *Polygonum alaskanum* (Small) Wight | 20 | 0.3 | - | - | - | - | - | - | 10 | 0.7 | 35 | 0.5 | - | - | - | - |
| *Pyrola secunda* L. | - | - | 5 | 0.2 | 5 | 0.2 | - | - | - | - | - | - | - | - | - | - |
| *Rubus chamaemorus* L. | - | - | - | - | - | - | - | - | 40 | 0.5 | - | - | - | - | 90 | 4.6 |
| *Stellaria* spp. L. | 40 | 0.6 | 10 | 0.6 | 20 | 0.4 | - | - | - | - | - | - | - | - | - | - |
| *Vaccinium oxycoccos* L. | - | - | - | - | - | - | - | - | 10 | 0.2 | - | - | - | - | 15 | 0.4 |
| *Lycopodium annotinum* L. | 5 | 0.1 | - | - | - | - | 5 | 0.1 | - | - | 25 | 0.5 | - | - | - | - |
| *Lycopodium clavatum* L. | - | - | - | - | - | - | 5 | 0.1 | - | - | - | - | - | - | - | - |
| *Lycopodium complanatum* L. | - | - | 70 | 8.9 | 70 | 7.6 | 10 | 0.6 | - | - | 10 | 0.2 | - | - | - | - |
| *Carex* spp. L | - | - | - | - | - | - | - | - | - | - | - | - | 20 | 0.8 | 15 | 0.2 |
| *Eriophorum* spp. L | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30 | 1.9 |
| *Graminae* | 100 | 14.6 | 100 | 9.4 | 100 | 3.6 | 35 | 0.4 | 75 | 1.8 | 90 | 1.4 | 80 | 1.6 | 95 | 2.0 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mosses | | | | | | | | | | | | | | | | |
| *Aulacomnium palustre* (Hedw.) Schwaegr. | - | - | - | - | - | - | - | - | - | - | 20 | 0.5 | - | - | 95 | 28.8 |
| *Dicranum* spp. Hedw. | 35 | 0.6 | 20 | 0.5 | 15 | 0.2 | 60 | 3.4 | 95 | 6.2 | 75 | 2.9 | 95 | 11.2 | 50 | 2.2 |
| *Hylocomium splendens* (Hedw.) B.S.G. | 45 | 1.4 | 20 | 0.3 | 45 | 1.0 | 65 | 7.6 | 70 | 4.9 | 45 | 1.8 | 30 | 2.4 | 50 | 2.2 |
| *Pleurozium schreberi* (Brid.) Mitt. | 35 | 1.4 | 75 | 8.7 | 30 | 1.0 | 90 | 39.1 | 95 | 22.5 | 100 | 41.2 | 100 | 50.9 | 75 | 13.4 |
| *Polytrichum* spp. Hedw. | 55 | 3.8 | 80 | 9.6 | 80 | 6.8 | 90 | 6.8 | 90 | 5.4 | 90 | 1.7 | 100 | 9.6 | 85 | 2.4 |
| *Sphagnum* spp. L. | - | - | - | - | - | - | - | - | 45 | 16.2 | 30 | 1.0 | - | - | 75 | 30.6 |
| Other mosses | 100 | 3.3 | 19 | 4.0 | 90 | 6.0 | - | - | 10 | 0.3 | 25 | 0.6 | - | - | 50 | 1.4 |
| Lichens | | | | | | | | | | | | | | | | |
| *Cetraria cucullata* (Bell.) Ach. | - | - | - | - | - | - | 5 | 0.1 | 80 | 4.5 | 5 | 0.1 | 30 | 0.3 | 15 | 0.2 |
| *Cetraria islandica* (L.) Ach. | - | - | - | - | - | - | 50 | 2.1 | 90 | 1.4 | 90 | 2.5 | 100 | 2.3 | 40 | 0.4 |
| *Cladonia alpestris* (L.) Rabenh. | - | - | - | - | - | - | - | - | 15 | 0.6 | 5 | 0.1 | 10 | 0.6 | - | - |
| *Cladonia arbuscula* (Wallr.) Rabenh. | - | - | 15 | 0.2 | - | - | 80 | 13.6 | 95 | 11.8 | 100 | 18.4 | 90 | 6.2 | 20 | 0.9 |
| *Cladonia rangiferina* Wigg. | - | - | - | - | - | - | 80 | 7.5 | 90 | 9.1 | 100 | 4.8 | 90 | 5.6 | 15 | 0.4 |
| Other *Cladonia* spp. Wigg. | 40 | 0.5 | 55 | 0.8 | 55 | 1.0 | 60 | 2.7 | 95 | 17.4 | 95 | 11.9 | 95 | 4.4 | 60 | 2.0 |
| *Peltigera aphthosa* (L.) Willd. | - | - | 20 | 0.6 | 25 | 1.0 | 50 | 2.8 | - | - | 45 | 2.1 | 20 | 0.2 | 55 | 1.8 |
| *Peltigera canina* (L.) Willd. | - | - | - | - | 5 | 0.2 | 20 | 3.4 | 85 | 22.6 | 5 | 0.3 | 80 | 12.4 | 5 | 0.1 |
| Other *Peltigera* spp. Willd. | 5 | 0.1 | 25 | 0.1 | - | - | 75 | 2.0 | 25 | 0.9 | 45 | 0.8 | 45 | 1.2 | 90 | 5.0 |
| *Stereocaulon* spp. Hoffm. | - | - | - | - | - | - | 15 | 0.2 | - | - | 5 | 0.1 | 30 | 0.6 | - | - |
| Ground cover characteristics | | | | | | | | | | | | | | | | |
| Total live ground cover: mosses and lichens | 100 | 10.8 | 100 | 24.6 | 100 | 16.3 | 100 | 77.2 | 100 | 88.8 | 100 | 89.7 | 100 | 90.0 | 100 | 89.8 |
| Total moss cover | 100 | 10.2 | 95 | 24.0 | 90 | 14.7 | 100 | 57.4 | 100 | 54.9 | 100 | 49.2 | 100 | 73.8 | 100 | 80.0 |
| Total lichen cover | 40 | 0.8 | 55 | 1.6 | 55 | 2.2 | 95 | 33.6 | 95 | 49.2 | 100 | 41.8 | 100 | 29.3 | 95 | 9.8 |
| Total fruticose lichens | 40 | 0.5 | 55 | 0.9 | 55 | 1.0 | 85 | 22.8 | 95 | 29.6 | 100 | 38.8 | 100 | 16.2 | 65 | 3.8 |
| Total foliose lichens | 15 | 0.3 | 20 | 0.7 | 30 | 1.2 | 90 | 10.8 | 85 | 23.6 | 75 | 3.0 | 90 | 13.1 | 90 | 6.0 |
| Total leaf and twig litter | 100 | 87.9 | 100 | 74.1 | 100 | 82.5 | 100 | 19.6 | 100 | 9.3 | 100 | 10.2 | 95 | 8.8 | 100 | 9.5 |

## Appendix B: Chemical and Physical Properties of All Litter Samples Collected in Caribou Creek Forest Communities.

| Stand | Sample point | Layer | Ash free mass | Volatile matter | pH | C/N ratio | C | N | P | K | Ca | Mg | Fe | Mn | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (kg/ha) | % | | | % volatile matter | % of oven dry weight | | | | | | | |
| 1 | 1 | 1 | 209.4 | 93.73 | 5.21 | 19.0 | 48.36 | 2.39 | .153 | .230 | 1.047 | .286 | .080 | .282 | .0098 |
| | | 2 | 1423.7 | 88.36 | 4.10 | 30.2 | 52.51 | 1.54 | .124 | .165 | .431 | .127 | .438 | .078 | .0030 |
| | 2 | 1 | 202.5 | 94.00 | 5.05 | 19.8 | 49.74 | 2.36 | .144 | .203 | .944 | .274 | .084 | .175 | .0137 |
| | | 2 | 1607.4 | 77.01 | 4.02 | 18.1 | 50.34 | 2.14 | .157 | .279 | .428 | .210 | 1.097 | .090 | .0053 |
| | 3 | 1 | 182.4 | 93.02 | 5.04 | 17.2 | 48.58 | 2.63 | .141 | .179 | .864 | .242 | .078 | .246 | .0117 |
| | | 2 | 1079.2 | 68.16 | 4.45 | 14.5 | 51.41 | 2.42 | .140 | .230 | .474 | .237 | 1.048 | .278 | .0048 |
| | 4 | 1 | 182.3 | 94.80 | 5.11 | 24.2 | 50.71 | 1.99 | .130 | .179 | .900 | .274 | .070 | .180 | .0145 |
| | | 2 | 1003.2 | 71.44 | 4.56 | 14.1 | 50.90 | 2.57 | .151 | .243 | .620 | .256 | .794 | .190 | .0070 |
| 2 | 1 | 1 | 249.3 | 93.89 | 5.15 | 24.5 | 50.36 | 1.93 | .134 | .167 | 1.254 | .185 | .071 | .185 | .0143 |
| | | 2 | 824.5 | 83.43 | 4.59 | 24.1 | 53.23 | 1.84 | .138 | .246 | .615 | .152 | .485 | .151 | .0052 |
| | 2 | 1 | 191.1 | 93.52 | 5.30 | 22.9 | 50.09 | 2.05 | .159 | .272 | 1.223 | .229 | .072 | .094 | .0104 |
| | | 2 | 852.5 | 83.50 | 4.53 | 17.5 | 49.43 | 2.35 | .193 | .256 | .890 | .187 | .401 | .116 | .0056 |
| | 3 | 1 | 265.4 | 92.95 | 5.18 | 15.3 | 50.35 | 3.06 | .156 | .151 | 1.402 | .208 | .082 | .133 | .0104 |
| | | 2 | 982.2 | 84.16 | 4.66 | 18.4 | 51.47 | 2.36 | .180 | .192 | .609 | .140 | .517 | .091 | .0041 |
| | 4 | 1 | 345.0 | 94.86 | 5.12 | 28.1 | 47.50 | 1.60 | .157 | .423 | .834 | .180 | .075 | .055 | .0069 |
| | | 2 | 623.7 | 88.59 | 4.40 | 20.7 | 48.69 | 2.08 | .216 | .269 | .636 | .133 | .372 | .084 | .0035 |
| 3 | 1 | 1 | 176.7 | 93.85 | 5.40 | 38.4 | 51.46 | 1.26 | .116 | .176 | 1.388 | .177 | .064 | .041 | .0098 |
| | | 2 | 1051.7 | 81.89 | 4.66 | 17.9 | 49.50 | 2.27 | .205 | .240 | .933 | .209 | .804 | .085 | .0058 |
| | 2 | 1 | 179.0 | 93.09 | 5.46 | 23.3 | 51.31 | 2.05 | .148 | .177 | 1.801 | .252 | .100 | .114 | .0137 |
| | | 2 | 866.6 | 74.75 | 4.78 | 18.9 | 50.23 | 1.99 | .209 | .262 | .871 | .199 | .828 | .116 | .0058 |
| | 3 | 1 | 212.3 | 93.00 | 5.36 | 24.5 | 51.05 | 1.93 | .148 | .177 | 1.569 | .185 | .127 | .068 | .0156 |
| | | 2 | 689.8 | 80.04 | 4.89 | 14.2 | 47.10 | 2.66 | .224 | .268 | 1.086 | .197 | .730 | .184 | .0079 |
| | 4 | 1 | 162.4 | 92.90 | 5.44 | 20.0 | 50.74 | 2.36 | .171 | .278 | 1.430 | .244 | .083 | .116 | .0076 |
| | | 2 | 1309.7 | 84.56 | 4.67 | 16.1 | 51.24 | 2.69 | .180 | .206 | .947 | .190 | .550 | .124 | .0049 |
| 4 | 1 | 1 | 374.6 | 95.45 | 4.16 | 47.2 | 42.99 | 0.87 | .058 | .171 | .485 | .063 | .110 | .063 | .0029 |
| | | 2 | 1622.4 | 73.04 | 3.51 | 38.2 | 50.74 | 0.97 | .146 | .251 | .205 | .129 | .831 | .013 | .0027 |
| | 2 | 1 | 417.1 | 95.59 | 3.94 | 35.4 | 44.66 | 1.20 | .105 | .234 | .335 | .083 | .119 | .052 | .0027 |
| | | 2 | 2098.0 | 91.40 | 3.93 | 42.3 | 50.28 | 1.09 | .148 | .170 | .203 | .082 | .491 | .014 | .0018 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 1 | 473.8 | 95.81 | 4.07 | 43.2 | 45.35 | 1.01 | .068 | .255 | .321 | .065 | .114 | .055 | .0025 |
| | | 2 | 1463.0 | 93.49 | 3.72 | 38.9 | 47.09 | 1.13 | .127 | .168 | .161 | .068 | .365 | .019 | .0014 |
| | 4 | 1 | 409.1 | 88.03 | 3.78 | 37.4 | 48.65 | 1.14 | .108 | .151 | .211 | .078 | .434 | .054 | .0024 |
| | | 2 | 687.9 | 62.98 | 3.70 | 28.2 | 49.67 | 1.11 | .190 | .234 | .273 | .152 | 1.120 | .013 | .0027 |
| 5 | 1 | 1 | 475.8 | 96.15 | 3.66 | 40.4 | 45.22 | 1.08 | .071 | .212 | .358 | .061 | .106 | .066 | .0038 |
| | | 2 | 4310.6 | 85.09 | 3.11 | 42.9 | 43.31 | 0.86 | .077 | .160 | .137 | .081 | .412 | .012 | .0013 |
| | 2 | 1 | 441.1 | 95.31 | 3.78 | 39.4 | 46.46 | 1.12 | .058 | .160 | .214 | .062 | .140 | .043 | .0028 |
| | | 2 | 780.1 | 84.33 | 3.20 | 34.9 | 48.06 | 1.16 | .104 | .156 | .093 | .077 | .537 | .010 | .0012 |
| | 3 | 1 | 395.8 | 95.76 | 4.17 | 28.3 | 47.78 | 1.62 | .080 | .298 | .470 | .077 | .110 | .087 | .0045 |
| | | 2 | 3005.7 | 90.97 | 3.36 | 39.9 | 48.67 | 1.11 | .087 | .146 | .185 | .072 | .377 | .019 | .0025 |
| | 4 | 1 | 379.5 | 96.13 | 3.88 | 34.8 | 47.36 | 1.31 | .054 | .174 | .181 | .055 | .127 | .043 | .0024 |
| | | 2 | 2006.7 | 84.92 | 3.50 | 37.7 | 47.46 | 1.07 | .079 | .163 | .193 | .083 | .567 | .010 | .0012 |
| 6 | 1 | 1 | 458.8 | 96.83 | 4.00 | 39.1 | 46.18 | 1.14 | .066 | .182 | .238 | .064 | .081 | .045 | .0017 |
| | | 2 | 1721.7 | 86.23 | 3.54 | 30.0 | 48.35 | 1.39 | .098 | .183 | .290 | .095 | .578 | .016 | .0081 |
| | 2 | 1 | 321.9 | 95.54 | 4.22 | 22.1 | 47.97 | 1.66 | .104 | .242 | .381 | .105 | .094 | .090 | .0045 |
| | | 2 | 1484.3 | 89.49 | 3.87 | 20.5 | 50.39 | 1.87 | .111 | .147 | .247 | .104 | .455 | .033 | .0037 |
| | 3 | 1 | 362.8 | 95.91 | 4.25 | 40.0 | 46.78 | 1.12 | .104 | .237 | .374 | .097 | .128 | .077 | .0018 |
| | | 2 | 1901.9 | 89.06 | 3.69 | 30.8 | 50.20 | 1.45 | .100 | .150 | .250 | .095 | .514 | .022 | .0028 |
| | 4 | 1 | 275.1 | 95.76 | 4.18 | 27.0 | 47.98 | 1.70 | .075 | .169 | .331 | .089 | .104 | .090 | .0031 |
| | | 2 | 2096.9 | 87.30 | 3.66 | 25.9 | 46.59 | 1.57 | .115 | .173 | .187 | .101 | .743 | .020 | .0020 |
| 7 | 1 | 1 | 410.5 | 95.50 | 4.09 | 43.3 | 45.87 | 1.01 | .081 | .314 | .324 | .094 | .140 | .063 | .0038 |
| | | 2 | 1814.8 | 84.04 | 3.46 | 40.1 | 48.12 | 1.01 | .113 | .180 | .208 | .131 | .668 | .015 | .0028 |
| | 2 | 1 | 392.6 | 94.54 | 3.94 | 38.1 | 46.43 | 1.15 | .079 | .277 | .169 | .082 | .196 | .030 | .0036 |
| | | 2 | 1508.2 | 79.24 | 3.58 | 34.4 | 49.12 | 1.13 | .121 | .165 | .160 | .154 | .869 | .016 | .0035 |
| | 3 | 1 | 413.8 | 95.28 | 4.04 | 33.2 | 46.10 | 1.32 | .084 | .316 | .365 | .091 | .142 | .089 | .0032 |
| | | 2 | 1790.1 | 86.10 | 3.34 | 34.9 | 48.55 | 1.20 | .106 | .159 | .162 | .100 | .560 | .033 | .0029 |
| | 4 | 1 | 367.1 | 94.79 | 3.91 | 44.8 | 44.80 | 0.95 | .074 | .206 | .123 | .064 | .206 | .019 | .0020 |
| | | 2 | 1450.0 | 82.75 | 3.44 | 34.7 | 48.91 | 1.17 | .129 | .157 | .109 | .100 | .827 | .009 | .0022 |

## Appendix C: Chemical and Physical Properties of all Soil Samples from Caribou Creek Vegetation Survey Stands.

| Rep | Depth | % Sand | % Silt | % Clay | pH | % Carbon | % Nitrogen | C/N | Extractable P | CEC | Exchangeable Bases Ca | Mg | K | Ca+Mg+K Saturation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cm | | | | | | | | ppm | meq/100g | | | | % |
| | | | | | | | | Stand 1 | | | | | | |
| 1 | 0-7.5 | 19.0 | 61.5 | 19.5 | 4.32 | 8.68 | .347 | 25.01 | 4.54 | 32.88 | 2.007 | .524 | .256 | 8.48 |
| | 7.5-15 | 43.0 | 45.6 | 11.4 | 4.48 | 2.68 | .156 | 17.18 | 5.34 | 26.15 | 1.136 | .240 | .129 | 5.76 |
| | 15-30 | 23.2 | 60.6 | 16.2 | 4.98 | 1.77 | .113 | 15.66 | 6.87 | 15.06 | 1.191 | .319 | .080 | 10.56 |
| | 30-45 | 23.6 | 60.4 | 16.0 | 5.07 | 1.55 | .109 | 14.22 | 5.96 | 15.97 | 1.135 | .306 | .086 | 9.56 |
| 2 | 0-7.5 | 10.3 | 65.3 | 24.4 | 4.55 | 5.75 | .298 | 19.30 | 4.47 | 33.91 | 3.097 | .766 | .201 | 11.98 |
| | 7.5-15 | 30.0 | 54.9 | 15.1 | 4.60 | 2.81 | .173 | 16.24 | 3.50 | 26.60 | 1.797 | .445 | .139 | 8.95 |
| | 15-30 | 29.0 | 54.6 | 16.4 | 4.80 | 1.94 | .160 | 12.13 | 3.23 | 17.13 | 1.562 | .434 | .129 | 12.41 |
| | 30-45 | 29.9 | 55.6 | 14.6 | 5.11 | 1.73 | .104 | 16.64 | 3.28 | 17.94 | 1.776 | .621 | .164 | 14.27 |
| | | | | | | | | Stand 2 | | | | | | |
| 1 | 0-7.5 | 8.1 | 68.5 | 23.4 | 4.52 | 6.63 | .438 | 15.14 | 16.63 | 38.94 | 2.501 | .779 | .379 | 9.40 |
| | 7.5-15 | 17.0 | 67.0 | 16.0 | 4.74 | 2.29 | .155 | 14.77 | 6.61 | 21.23 | .860 | .306 | .172 | 6.30 |
| | 15-30 | 20.3 | 64.0 | 15.7 | 4.80 | .95 | .085 | 11.18 | 5.66 | 14.82 | .434 | .184 | .101 | 4.85 |
| | 30-45 | 26.2 | 61.2 | 12.6 | 5.02 | .64 | .061 | 10.49 | 3.58 | 11.21 | .469 | .158 | .072 | 6.24 |
| 2 | 0-7.5 | 20.4 | 56.5 | 23.0 | 4.72 | 3.81 | .335 | 11.37 | 57.90 | 24.83 | 1.766 | .672 | .550 | 12.03 |
| | 7.5-15 | 32.2 | 55.2 | 12.5 | 4.90 | .57 | .070 | 8.14 | 4.58 | 12.31 | .707 | .356 | .186 | 10.15 |
| | 15-30 | 27.2 | 58.2 | 14.6 | 5.08 | .58 | .054 | 10.75 | 5.35 | 17.40 | 1.134 | .537 | .119 | 10.29 |
| | 30-45 | 21.9 | 58.9 | 19.2 | 5.32 | .63 | .056 | 11.25 | 4.91 | 18.41 | 1.787 | .816 | .077 | 14.56 |
| | | | | | | | | Stand 3 | | | | | | |
| 1 | 0-7.5 | 24.6 | 52.9 | 22.5 | 4.81 | 2.96 | .217 | 13.64 | 53.00 | 22.19 | 2.811 | 1.238 | .452 | 20.28 |
| | 7.5-15 | 25.0 | 59.2 | 15.8 | 4.91 | .69 | .063 | 10.95 | 9.93 | 11.78 | .861 | .391 | .180 | 12.16 |
| | 15-30 | 28.9 | 57.9 | 13.2 | 5.16 | .62 | .053 | 11.70 | 6.67 | 10.48 | 1.135 | .470 | .091 | 16.18 |
| | 30-45 | 24.0 | 60.1 | 15.9 | 5.26 | .57 | .053 | 10.76 | 6.91 | 10.39 | 1.301 | .571 | .078 | 18.77 |
| 2 | 0-7.5 | 11.7 | 70.1 | 18.2 | 4.62 | 5.72 | .303 | 18.79 | 66.06 | 31.34 | 2.516 | 1.045 | .502 | 12.96 |
| | 7.5-15 | 24.2 | 60.0 | 15.8 | 4.84 | 1.00 | .066 | 15.15 | 8.44 | 13.73 | .757 | .314 | .145 | 8.86 |
| | 15-30 | 25.1 | 60.5 | 14.4 | 5.06 | .91 | .057 | 15.97 | 7.74 | 11.62 | .676 | .309 | .086 | 9.22 |
| | 30-45 | 25.3 | 60.3 | 14.4 | 5.11 | .79 | .054 | 14.63 | 7.43 | 10.93 | .834 | .381 | .057 | 11.64 |
| | | | | | | | | Stand 4 | | | | | | |
| 1 | 0-7.5 | 23.7 | 62.2 | 14.1 | 4.48 | 1.904 | .113 | 16.85 | 4.00 | 19.92 | .971 | .399 | .141 | 7.58 |
| | 7.5-15 | 25.3 | 59.5 | 15.2 | 5.15 | .968 | .075 | 12.91 | 3.32 | 12.22 | .467 | .192 | .104 | 6.24 |
| | 15-30 | 33.8 | 56.2 | 10.1 | 5.40 | .309 | .043 | 7.19 | 13.25 | 7.94 | .401 | .118 | .072 | 7.44 |
| | 30-45 | 46.3 | 44.9 | 8.8 | 5.44 | .158 | .030 | 5.28 | 10.11 | 6.38 | .836 | .420 | .070 | 20.78 |
| 2 | 0-7.5 | 20.1 | 63.4 | 16.2 | 4.52 | 2.437 | .114 | 21.30 | 1.58 | 18.94 | .390 | .130 | .101 | 3.28 |
| | 7.5-15 | 25.1 | 62.7 | 12.7 | 5.33 | 1.176 | .075 | 15.68 | 8.62 | 11.18 | .352 | .100 | .075 | 4.71 |
| | 15-30 | 39.2 | 47.2 | 13.6 | 5.49 | .400 | .045 | 8.89 | 13.25 | 8.11 | .968 | .464 | .056 | 18.35 |
| | 30-45 | 21.2 | 64.1 | 14.7 | 5.38 | 1.096 | .062 | 17.68 | 9.29 | 10.46 | .436 | .146 | .068 | 6.21 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Stand 5 | | | | | | |
| 1 | 0-7.5 | 17.4 | 61.3 | 21.3 | 4.00 | 16.55 | .594 | 27.86 | 8.84 | 69.52 | .556 | .468 | .411 | 2.06 |
| | 7.5-15 | 42.1 | 46.9 | 11.0 | 4.21 | 3.18 | .213 | 14.93 | 9.20 | 19.15 | .146 | .079 | .063 | 1.50 |
| | 15-30 | 45.1 | 45.2 | 9.7 | 4.38 | 3.32 | .194 | 17.11 | 14.18 | 17.49 | .209 | .041 | .055 | 1.74 |
| | 30-45 | 35.2 | 52.0 | 12.8 | 4.80 | 2.34 | .138 | 16.96 | 23.86 | 19.32 | .293 | .086 | .063 | 2.29 |
| 2 | 0-7.5 | 20.1 | 64.1 | 15.8 | 3.60 | 20.25 | .749 | 27.04 | 4.62 | 62.37 | .172 | .184 | .239 | .95 |
| | 7.5-15 | 46.9 | 37.5 | 15.6 | 4.23 | 2.56 | .180 | 14.22 | 11.14 | 15.95 | .187 | .128 | .064 | 2.37 |
| | 15-30 | 44.3 | 45.1 | 10.6 | 4.89 | .92 | .164 | 5.61 | 13.61 | 10.53 | .204 | .080 | .057 | 3.23 |
| | 30-45 | 47.7 | 42.6 | 9.7 | 5.04 | 1.02 | .079 | 12.91 | 17.65 | 10.73 | .194 | .047 | .056 | 2.77 |
| | | | | | | | | Stand 6 | | | | | | |
| 1 | 0-7.5 | 25.6 | 55.7 | 16.7 | 4.30 | 8.53 | .452 | 18.87 | 2.14 | 38.58 | 1.233 | .670 | .178 | 5.39 |
| | 7.5-15 | 28.9 | 58.1 | 13.0 | 4.63 | 1.84 | .095 | 19.37 | 9.60 | 13.53 | .366 | .165 | .059 | 4.36 |
| | 15-30 | 26.7 | 58.8 | 14.5 | 4.90 | .95 | .076 | 12.50 | 12.81 | 11.19 | .335 | .114 | .052 | 4.48 |
| | 30-45 | 28.3 | 58.3 | 13.4 | 5.03 | .81 | .074 | 10.95 | 8.67 | 10.88 | .393 | .129 | .048 | 5.24 |
| 2 | 0-7.5 | 18.4 | 66.5 | 15.1 | 4.33 | 13.24 | .585 | 22.63 | 1.16 | 57.47 | 2.233 | .830 | .232 | 5.73 |
| | 7.5-15 | 19.7 | 67.5 | 12.8 | 4.61 | 5.52 | .263 | 20.99 | 1.35 | 30.57 | 1.050 | .376 | .111 | 5.03 |
| | 15-30 | 32.2 | 55.7 | 12.1 | 4.90 | 1.31 | .096 | 13.65 | 5.97 | 13.30 | .392 | .135 | .053 | 4.36 |
| | 30-45 | 31.0 | 55.1 | 13.9 | 4.70 | .80 | .068 | 11.77 | 3.40 | 11.68 | .336 | .129 | .051 | 4.42 |
| | | | | | | | | Stand 7 | | | | | | |
| 1 | 0-7.5 | 26.6 | 55.5 | 17.9 | 4.63 | 2.83 | .160 | 17.69 | 6.30 | 19.73 | .307 | .120 | .088 | 2.61 |
| | 7.5-15 | 21.3 | 65.5 | 13.2 | 5.12 | 2.00 | .104 | 19.23 | 2.84 | 13.92 | .217 | .047 | .060 | 2.33 |
| | 15-30 | 15.4 | 70.7 | 13.9 | 5.32 | 1.05 | .076 | 13.82 | 3.01 | 15.73 | .249 | .088 | .046 | 2.43 |
| | 30-45 | 25.2 | 60.8 | 14.0 | 5.56 | .35 | .048 | 7.29 | 4.88 | 8.56 | .645 | .161 | .055 | 10.06 |
| 2 | 0-7.5 | 21.1 | 54.0 | 24.9 | 4.60 | 3.53 | .207 | 17.05 | 3.15 | 21.29 | .260 | .125 | .078 | 2.17 |
| | 7.5-15 | 14.9 | 71.8 | 13.3 | 5.16 | 1.80 | .110 | 16.36 | 3.08 | 15.40 | .229 | .049 | .043 | 2.08 |
| | 15-30 | 25.5 | 62.1 | 12.4 | 5.42 | 1.20 | .082 | 14.63 | 3.85 | 10.53 | .313 | .053 | .045 | 3.90 |
| | 30-45 | 40.4 | 49.8 | 9.9 | 5.66 | .28 | .050 | 5.60 | 18.24 | 8.24 | 1.517 | .525 | .048 | 25.36 |

**Appendix D: Significant Differences in Organic Matter Physical and Chemical Properties in Forest Communities of Caribou Creek Watershed, Interior Alaska.**

| | | Mass ash free | pH | C | N | C/N | P | K | Ca | Mg | Fe | Mn | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | - % of volatile - | | | % of oven dry weight | | | | | | |
| All stands: | 1 | bc[1] | a | a | a | c | b | ab | c | a | a | a | a |
| | 2 | c | a | a | a | c | a | a | b | c | b | b | a |
| | 3 | bc | a | a | a | c | a | ab | a | b | ab | b | a |
| | 4 | bc | bc | b | c | a | b | ab | d | de | a | c | b |
| | 5 | a | d | b | c | a | d | b | d | e | ab | c | b |
| | 6 | ab | b | b | b | b | c | b | d | de | ab | c | b |
| | 7 | abc | c | b | c | a | c | ab | d | d | a | c | b |
| Black spruce: | | | | | | | | | | | | | |
| stands | 4 | a | a | a | b | a | a | a | a | ab | a | a | a |
| | 5 | a | b | a | b | a | c | a | a | b | a | a | a |
| | 6 | a | a | a | a | b | b | a | a | ab | a | a | a |
| | 7 | a | a | a | b | a | b | a | a | a | a | a | a |
| layers | 1 | b | a | b | a | a | b | a | a | b | b | a | a |
| | 2 | a | b | a | a | a | a | a | b | a | a | b | a |
| Aspen/Birch: | | | | | | | | | | | | | |
| stands | 1 | a | c | a | a | a | b | a | c | a | a | a | a |
| | 2 | a | b | a | a | a | ab | a | b | c | b | b | a |
| | 3 | a | a | a | a | a | a | a | a | b | ab | b | a |
| layers | 1 | b | a | a | b | a | b | a | a | a | b | a | a |
| | 2 | a | b | a | a | b | a | a | b | b | a | a | b |

[1] Letter dissimilarity denotes significant difference at the 0.05 level of confidence determined by Duncan's New Multiple Range Test. A letter sequence a>b>c>d>e represents decreasing magnitude of actual values.

**Appendix E: Significant Differences in Soil Chemical Properties in Forest Communities of Caribou Creek Watershed, Interior Alaska.**

| | | | | | | | Exchangeable bases (meq/100 g) | | | | Ca+Mg+K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | C | N | C/N | P | CEC | Ca | Mg | K | (% sat.) |
| All stands: | 1 | c[1] | b | bc | a | c | ab | a | abc | b | ab |
| | 2 | b | c | c | c | b | bc | b | ab | a | bc |
| | 3 | b | c | d | abc | a | cd | ab | a | a | a |
| | 4 | a | c | d | bc | bc | d | cd | cd | de | abc |
| | 5 | d | a | a | a | b | a | d | d | bc | d |
| | 6 | c | b | b | ab c | ab | c | bcd | cd | cd | |
| | 7 | a | c | d | abc | c | cd | cd | cd | e | bcd |
| Black spruce: | | | | | | | | | | | |
| stands | 4 | a | c | c | a | b | b | a | a | b | a |
| | 5 | c | a | a | a | a | a | b | a | a | b |
| | 6 | b | b | b | a | b | a | a | a | b | b |
| | 7 | a | c | c | a | b | b | a | a | b | a |
| depths (cm) | 0-7.5 | c | a | a | a | b | a | a | a | a | c |
| | 7.5-15 | b | b | b | b | b | b | a | b | b | c |
| | 15-30 | a | c | c | c | a | b | a | b | b | b |
| | 30-45 | a | c | c | c | a | b | a | b | b | a |
| Aspen/Birch: | | | | | | | | | | | |
| stands | 1 | b | a | a | a | b | a | a | a | b | a |
| | 2 | a | b | a | b ab | ab | a | a | a | a | |
| | 3 | a b | b | b | a b | a | a | a | a | | |
| depths (cm) | 0-7.5 | d | a | a | a | a | a | a | a | a | a |
| | 7.5-15 | c | b | b | a | b | b | b | b | b | a |
| | 15-30 | b | b | c | a | b | c | b | b | c | a |
| | 30-45 | a | b | c | a | b | c | b | b | c | a |

[1] Letter dissimilarity denotes significant difference at the 0.05 level of confidence determined by Duncan's New Multiple Range Test. A letter sequence a>b>c>d>e represents decreasing magnitude of actual values.