MASTER

Progress Report on Research on Dynamics of Tundra Ecosystems and Their Potential Response to Energy Resource Development.

Submitted to the U.S. Department of Energy

Principal Investigator: Philip C. Miller
Systems Ecology Research Group
San Diego State University
San Diego, California 92182
(714) 286-6675

Co-Principal Investigators:

F.S. Chapin, III
Arctic Institute of Biology
University of Alaska

J. Kummerow
Department of Botany
San Diego State University

A.E. Linkins
Department of Biology
Virginia Polytechnic Institute

O.K. Miller
Department of Biology
Virginia Polytechnic Institute

W.C. Oechel
Systems Ecology Research Group
San Diego State University

G.R. Shaver
Systems Ecology Research Group
San Diego State University

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Overall Project Design and Organization

The central question of this research is: What are the ecological effects (costs and benefits) of impacts that can be expected from the development and utilization of energy resources in the arctic. The impacts selected for study are: (1) altered nutrient availability (nitrogen and phosphorus); (2) altered patterns of soil water drainage; and (3) vehicle tracks. As our understanding increases the impact of fire and oil spills will be evaluated. The general ecosystem characteristics chosen to provide integrative measures of the possible ecological effects include: (1) annual primary production and (2) the relative aboveground growth of the different species or growth forms comprising the vegetation. Plant growth forms are defined by height, leaf longevity, position of the perennating bud, and rooting pattern. The growth forms and species selected are: erect deciduous shrubs (Betula nana, Vaccinium uliginosum, Salix pulchra); erect evergreen shrubs (Ledum palustre); prostrate evergreen shrub (Vaccinium vitis-idaea); tussock graminoid (Eriophorum vaginatum); rhizomatous graminoid (Carex bigelowii, Carex aquatilis*, Eriophorum angustifolium*); forb (Artemisia arctica); grass (Calamagrostis or Arctagrostis); cushion moss (Dicranum sp.); Sphagnum sp.; and Polytrichum commune.

Three underlying assumptions of this research are: (1) In nature plant species and growth forms are arranged along axes of resource availability (e.g., light energy and nitrogen) and environmental conditions (e.g., temperature and concentration of toxic chemicals). (2) Man's intrusions shift the position of a geographic area along these axes. This leads to shifts in the species and growth form composition of the area and to shifts in the rates of primary production, decomposition, and mineralization. (3) Physiological properties of

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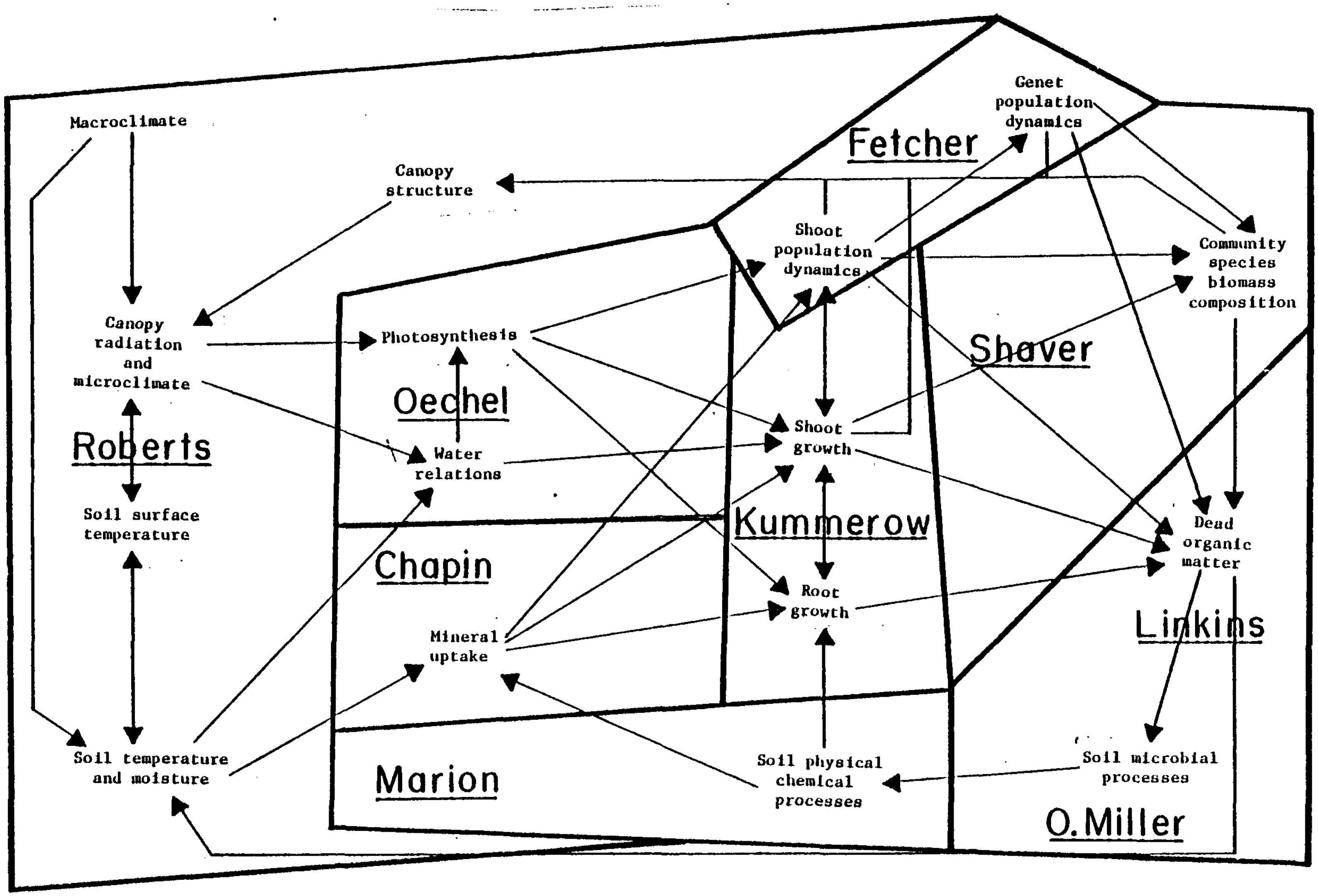
*Denotes that the species is to be characterized from the literature.

species are sufficiently similar from site to site that relationships established in one area are applicable to another.

The explicit mechanism for integrating and guiding this research and for extrapolating the existing data base to make quantitative predictions of the effects of perturbations is a simulation model of arctic tundra vegetation and soil processes called ARTUS (Artic Tundra Simulator). ARTUS is the explicit statement of the hypotheses and assumptions being tested and modified in this research. ARTUS was originally developed as a quantitative synthesis of processes measured in the IBP research in the wet meadow ecosystem at Barrow, Alaska. The set of hypotheses and assumptions encoded in ARTUS are refined according to their ability to predict three major aspects of the soil and vegetation. These are: (1) The annual primary production (net primary production from leaves) by the vegetation and/or by different plant growth forms or species. (2) Species or growth form composition as predicted by the relative production of different growth forms. And (3) the seasonal progressions of major ecosystem variables including: percent TNC (total non-structural carbohydrates), nitrogen, and phosphorus of leaves and stems by species or growth forms; exchangeable NH_4^+ and PO_4^+ in the soil below the green moss layer; soil respiration (i.e., CO_2 exchanged by plant belowground parts and decomposers); soil temperatures and thaw depth; water balance of the site and species; and the average seasonal fungal biomass in the surface soil layers. ARTUS should reproduce realistic values for these variables through a simulated period of two years.

The vegetation-soil system can be analyzed at several interconnected levels of temporal resolution, including canopy micrometeorological processes, photosynthesis, nutrient uptake, shoot and root growth, shoot population dynamics, and genet population dynamics (Fig. 1). The length of the measurement

Fig. 1. Diagram of paths of influence between processes in the production-soil system and domain of responsibility of principal investigators. Names underlined are also responsible for the larger domain enclosed in heavy lines.



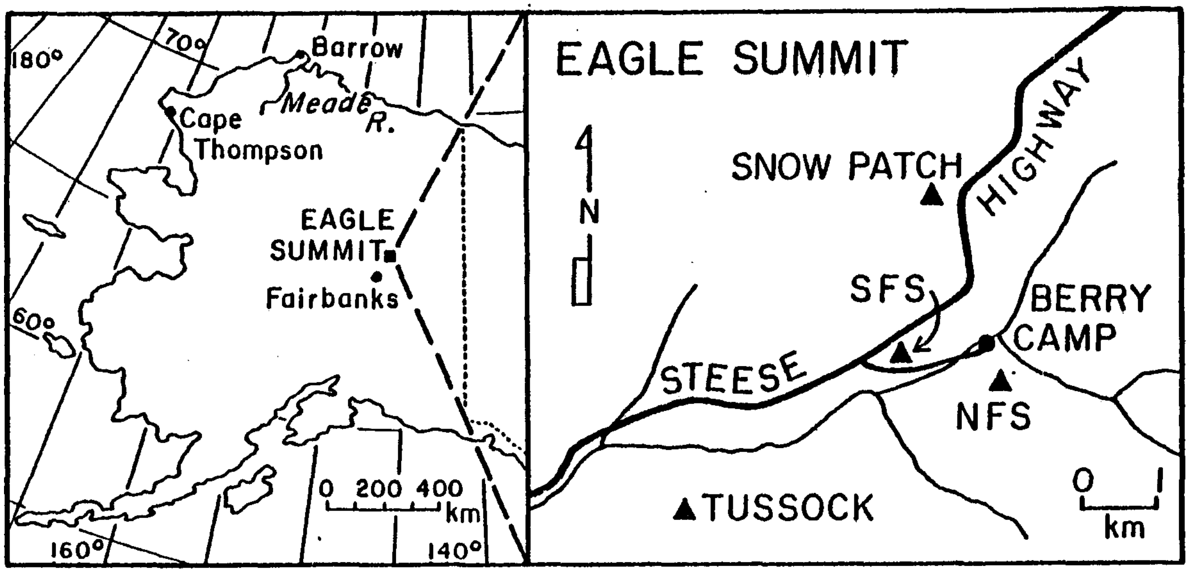
period varies with the rate of change of the parameter. Photosynthesis measurements often proceed through the course of a day, growth measurements through the course of a year, shoot population dynamics through several years, and genet population dynamics through many years. Since previous field measurements of growth involved stem and leaf area increases from a bud, it was natural to be concerned next with changes in the numbers of buds on a shrub or of meristematic regions in a tiller system. Buds and meristematic regions are termed growing points. Research in tundra during the IBP emphasized photosynthesis; growth became of interest more recently, and plant population dynamics still more recently. However, the response to nutrients has been shown to be greatest at the growing point or tiller population level and least at the photosynthetic level.

Description of Study Site

The field research to establish the necessary processes has been concencentrated at Eagle Creek and Eagle Summit, mile 101-106 on the Steese Highway, northeast of Fairbanks, Alaska. The Eagle Creek research area is located in the White Mountains about 160 km (100 miles) northeast of Fairbanks, Alaska (Fig. 2). The area is south of the Arctic Circle (66°30' N), at 65°26-27' N and 145°25-30' W, and receives almost continuous sunlight in late June. Snowmelt occurs in late May or early June.

Four sites, a snow patch, a south-facing slope, a north-facing slope, and a tussock tundra area were studied in an elevation range of 750-1050 m (Fig. 2). The aspect of the snow patch (about 1050 m elevation) is southwest. The inclination is 17° in the center and 41° near the top and bottom. In 1977 snow remained in the center until mid-July, although the upper and lower edges were snowfree by late May. Seven zones were delineated in the snow patch on the basis of the dominant plant growth forms. These zones, from above the snow

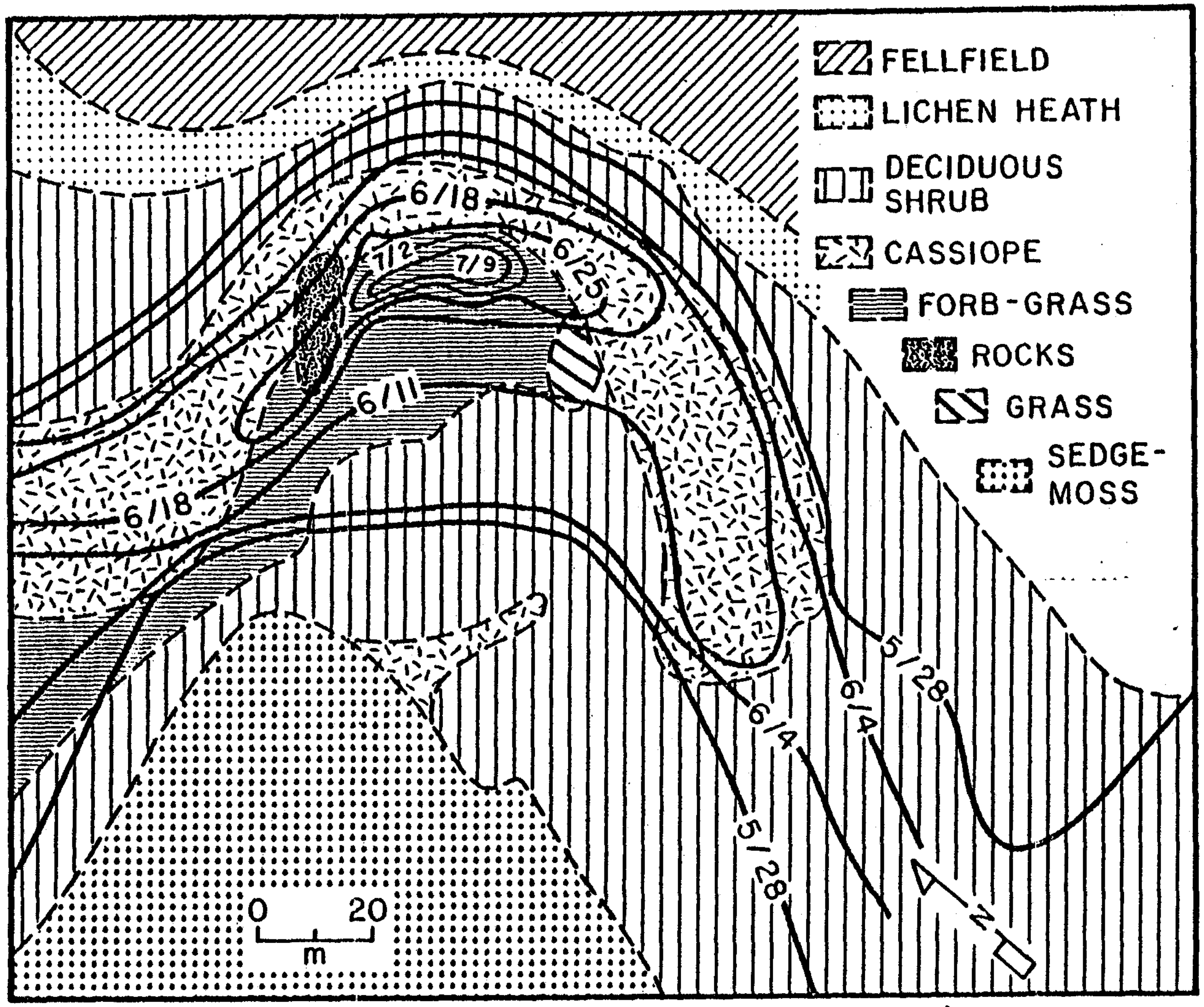
Fig. 2. Diagram showing the locations of study areas in Alaska and of sites near Eagle Summit, Alaska.



patch to below, are: fellfield, lichen-heath, upper deciduous shrub, evergreen shrub (*Cassiope*), forb-grass, lower deciduous shrub, and sedge-moss (Fig. 3). Soil properties and vegetation cover differ in the zones. In the fellfield the soil is deep with high silt-clay content and large interspersed rocks; the vegetation cover is about 25%. Soil organic matter and cover increase with distance down and across the snow patch. Below the snow patch, a thick organic mat is present and percent cover attains 100%. South- and north-facing exposures in the Eagle Summit area have species associations similar to those found in the snow patch. On the south-facing slope (900 m elevation, mile 104 Steese Highway) the vegetation is predominantly comprised of deciduous and evergreen shrubs with a moss understory. *Eriophorum vaginatum* is absent. Frostboils are common and are the only areas where the percent cover is less than 100%. Between the frostboils, an organic layer of 0.2-0.3 m is present above the silty alluvium mineral soil. On the north-facing slope (860 m elevation, mile 104.5 Steese Highway) the vegetation is more similar to that of the south-facing slope than to that of the tussock site. Although a few tussocks are present, the vegetation is mostly comprised of short evergreen and deciduous shrubs with a deep moss layer below. Moss is more dominant on the north-facing slope than on the south-facing slope.

The Eagle Creek tussock site is situated at 750 m elevation near mile 101 on the Steese Highway. The site is on a sloping ridge facing slightly north of east. The mineral soil is silt-clay loam, allowing little drainage, and is covered with a thick organic mat. Drainage is poorer than on either the south- or the north-facing slope. The vegetation, soils, and primary production of the 101 mile site have been described by Wein and Bliss (1974), Brown and Rickard (1969), and Chapin and Van Cleve (*unpubl. data*). The site is typical of moist tussock tundra dominated by the arctic cotton grass, *E. vaginatum*. In addition to the tussock graminoid, other sub-dominant life forms include: semi-erect

Fig. 3. Diagram of the vegetation zones in the snow accumulation area and the edges of the snow (heavy solid line) in weekly intervals from May 28 to July 9, 1977.



evergreen shrub (Ledum palustre), semi-erect deciduous shrub (Salix pulchra, Vaccinium uliginosum, Betula nana), creeping woody evergreen (Vaccinium vitis-idaea, Empetrum nigrum), deciduous rhizomatous creeper (Rubus chamaemorus), and rhizomatous graminoid (Carex spp.).

Progress To Date: Simulation Model

The first formulation of ARTUS combined plant growth models based on different plant growth forms in wet meadow tundra at Barrow, Alaska, and tussock and shrub tundra at Meade River, Alaska, decomposition models based on wet meadow tundra at Barrow, soil chemical models based on agricultural soils at lower latitudes, soil microbiological based on processes at Barrow and in agricultural soils, and soil thermal processes based on the wet meadow soils at Barrow. The computer program for ARTUS was debugged in spring and fall, 1978, before and after the summer field season. The work on ARTUS during the spring was mainly directed towards clarifying research for the 1978 field season needed to define parameters and relationships. The computer program for ARTUS had not run successfully by November due to its complex structure, conflicts resulting from various levels of resolution contained in the earlier models, and problems of maintaining consistent sets of variable units.

A workshop was held in San Diego in November 1978 to review the progress of all our subprojects and of projects whose objectives are related to ours but whose source of funding is outside of DOE. The progress to date on implementing ARTUS was reviewed and the basic identification of compartments and essential processes was reconsidered. The outside reviewers at the workshop (Dr. Boyd Strain, Duke University; Dr. Vern Cole, Colorado State University; and Dr. Keith Van Cleve, University of Alaska) stressed the immediate need for involving the principal investigators more closely with the modeling activities.

Following this workshop, the general structure of ARTUS was re-evaluated and re-organized in order to make the subroutines more compatible with the natural divisions of investigators' interests and ecosystem processes. The resulting subroutines were used to guide the principal investigators in developing research plans for the summer of 1979. ARTUS was simplified and re-coded to reflect this new organization and to run on a Hewlett-Packard 9845 portable computer (following the suggestions of the reviewers and Drs. D. DiMichaels and P. Sharp, Texas A & M, and Dr. P. Coyne, Lawrence Livermore Laboratory, who were consulted regarding computer hardware appropriate for this task). This implementation to date has been completed during four weekends with a borrowed Hewlett-Packard 9845. The essential differences in the new formulation of ARTUS consist of a greatly simplified overhead program, a common set of units for all sections of the model, and continuity in the logic linking the soil and plant systems. All of which have facilitated the development of a running model. Furthermore, the organization and programming language of the Hewlett-Packard 9845 makes the model more accessible to the various principal investigators. We anticipate involving the principal investigators with ARTUS in March or April, after we have our own machine. The HP-9845 will be taken to Alaska during the field season and ARTUS will be run in Fairbanks and in the field at Eagle Creek using a portable generator in order to incorporate field results as rapidly as possible, guide on-going summer research, and to directly involve the principal investigators in model development.

ARTUS will be refined and expanded during the spring of 1979, incorporating the data of this and other projects on various tundra vegetation types. A soil oxygen submodel is currently being developed to be included in ARTUS, since the effects on soil oxygen seem critical in altered water drainage and vehicle tracks. Simulations will be run to test the accuracy of ARTUS in calculating peak season biomass, nutrient contents, and seasonal rate of soil processes for the 1977 data set of the vegetation types at the snow patch site, 1977 and 1978 data sets for the Eagle Creek tussock tundra, and 1977 data sets for Cape Thompson. In addition, the experiments planned for the summer of 1979 will be simulated prior to the summer of 1979 to further clarify areas where future research is needed.

Progress to Date: Field and Laboratory Studies

Basic properties of different plant communities occurring along a gradient of snow accumulation have been characterized to indicate controls on the distribution of plant species and preliminary carbon and nutrient budgets. The communities, from above to below the center of the snow accumulation area, are: fellfield, lichen-heath, upper deciduous shrub, *Cassiope*, forb-grass, lower deciduous shrub, and sedge-moss. The biomass of evergreen shrubs was between 110 to 273 g m^{-2} in all zones except the forb-grass zone and forb-grass (Table 1). The biomass of deciduous shrubs was relatively high in the upper and lower deciduous shrub zones and in the sedge-moss zone, but was zero in the forb-grass zones. Production was higher below the center of the snow patch than above, and highest in the forb-grass and lower deciduous shrub zones. Production depends on growing point densities and growth per growing point. Growing point densities increased from the fellfield to the lower deciduous shrub. Growth per growing point also increased but not as

Table 1. Production of various growth forms in the seven vegetation zones of the snow patch site, Eagle Creek, 1978.

	FF	LH	UDS	C	GF	LDS	SM
			Biomass (g m^{-2})				
Evergreen shrub	111.0	221.0	265.3	273.0	0	111.0	178.0
Deciduous shrub	2.9	0	9.5	4.0	0	59.6	27.8
Carex	3.1	2.2	0.7	6.1	60.9	5.6	22.3
Forb	9.8	2.8	2.2	14.4	54.1	26.8	4.5
Grass	0.2	0.7	2.2	8.1	14.4	13.1	0.1
			Growing Points (m^{-2})				
Evergreen shrub	2005	5290	4555	5375	0	1703	1510
Deciduous shrub	100	0	475	200	0	1490	855
Carex	53	35	–	80	508	18	208
Forb	123	168	93	210	748	708	230
Grass	0	43	63	153	655	218	28
			Production (g m^{-2} $year^{-1}$)				
Evergreen shrub	43.1	58.1	46.1	57.7	0	94.4	51.0
Deciduous shrub	2.0	0	9.5	4.0	0	59.6	27.8
Carex	3.1	2.4	0.7	6.1	60.9	5.6	22.3
Forb	9.8	2.8	2.2	14.4	54.1	26.8	4.5
Grass	0.2	0.7	2.2	8.1	14.4	13.1	0.1
			Nitrogen Uptake (g m^{-2} $year^{-1}$)				
Evergreen shrub	0.53	0.63	0.50	0.70	0	1.02	0.55
Deciduous shrub	0.02	0	0.10	0.04	0	0.54	0.20
Carex	0.04	0.03	0.01	0.09	0.88	0.08	0.32
Forb	0.13	0.028	0.035	0.20	0.89	0.28	0.05
Grass	0.002	0.006	0.017	0.068	0.117	0.106	0.001

consistently. Plant nitrogen and phosphorus contents were highest in the forbs and lowest in the evergreen shrubs. Within a species, plant nitrogen and phosphorus contents increased towards the center of the snow patch. Leaf longevity within a species of evergreen increased towards the center of the snow patch. The uptake of nitrogen and phosphorus increased with production.

The length of the growing season was shorter towards the center of the snow patch, but temperature during the growing season was higher. The forb-grass zone has a shorter growing season than the *Cassiope* zone, in contrast to common statements that *Cassiope* indicates late lying snow and that evergreen species occur with short growing seasons so that leaf production costs can be regained over several seasons. The daily production rate was highest in the forb-grass and lower deciduous shrub zones. The higher temperatures in the center of the snow patch did not compensate for the shorter growing season. Heating degree days were highest in the fellfield and lowest in the center of the snow patch, because the longer season in the fellfield more than compensated for its cooler temperatures. Production per degree day was highest in the forb-grass and lower deciduous shrub zones. The indications are that the length of growing season does not determine the distribution of evergreen and deciduous growth forms. Since growth rates are higher at the same temperatures in the forb-grass and lower deciduous shrub zones, some additional factors must be limiting production.

Nitrogen and phosphorus in the soil solution and in exchangeable form were generally higher in the forb-grass and lower deciduous shrub zones. Carbon/nitrogen ratios indicate more favorable conditions for mineralization in the forb-grass zone. Nitrogen and phosphorus uptake per year was also highest in these zones. However, nitrogen and phosphorus uptake per meter of fine root was lower in forb-grass and lower deciduous shrub zones than in the fellfield, although not as low as in the sedge-moss zone. The turnover of exchangeable nitrogen and phosphorus in the soil must be greater in order to supply the uptake rates in the lower snow patch zones. Therefore, nutrient limitation may be more common in the zones below the snow patch.

The mycorrhizal associates increase below the snow patch. The mycorrhizal associates may compensate for the lower nutrient availability, a conclusion consistent with F.S. Chapin's laboratory results (this Progress Report). The lack of mycorrhizal associates in the forb-grass zone may be compensated for by the input of nitrogen from litter deposited during the winter. Thus, nutrients and mycorrhizal associates, factors which have generally been overlooked, seem to play a major role in the distribution of species along this snow patch gradient (P.C. Miller, ms. this Progress Report).

Phenological observations on the major species were made through two years in a diversity of habitats and vegetation types to indicate possible controls on plant growth and to document seasonal patterns of changes in plant vegetative and reproductive structures in the Eagle Creek area. Even though the timing of growth initiation varied among the deciduous species, onset of senescence occurred simultaneously. The delay in leaf production in deciduous shrubs was greater in erect shrubs than in prostrate shrubs and was correlated with numerical decline of erect deciduous shrubs towards the center of the snow patch. Erect deciduous shrubs were absent from the center of the snow patch possibly because the growing season was too short to allow full development. Forbs were the only plants which initiated growth under the snow. The observations indicate that although initiation of growth was dependent on temperature and the emergence of the site from under the snow, phenological events at the end of the growing season are relatively independent of the environmental situation and are synchronous across a diversity of sites (Murray and Miller, ms. this Progress Report).

Roots, rhizomes, and soil organic matter were excavated in six vegetation zones at the snow patch site and at the tussock site. Roots were seperated into size classes. Root density increased from above the snow patch to below. Root length-density (m of root/cc of soil) in the tussock tundra was more similar to root length-density in the fellfield zone, even though the vascular plant species present in tussock tundra are similar to those in the lower deciduous shrub zone. The tussock tundra has more soil organic matter than any of the zones of the snow patch site (P. C. Miller, et al., ms. Progress Report).

In order to measure the influence of soil water content on the soil thermal regime, a set of three wooden dams was installed in July 1978, in the *E. vaginatum* tussock tundra on slightly sloping ground. It was anticipated that the dams would impound water on the uphill side causing saturated soils, while reducing run-on of water to the sites below the dam, causing drier soils. However, the impoundment of water did not occur because the dams were installed after the major period of runoff. The dams should impound water during the summer of 1979. Thermocouples were placed in tussock and intertussock areas in the air and in the soil at three depths at nine locations along transects above and below the dams. Soil and air temperatures, wind speed, and solar, infrared, and net radiation, were measured from mid-June to mid-August at the impoundment site. These measurements have been summarized to present basic microclimatic information about the tussock tundra and to support the measurements of evapotranspiration (see Table 2). The measurements from 1978 will also be used as control data to compare with the values to be obtained during the 1979 summer when the water is impounded.

Evapotranspiration was measured with a cuvette which was placed over the different surfaces for about 1 minute while the increase in the humidity inside the cuvette was monitored with a model 880 dewpoint hygrometer. Measurements were made continuously through the 24-hour period and summarized at 20-minute intervals throughout the day. Measurements were made on tussock and moss covered intertussock areas through the course of 10 days in order to give 10 daily actual evpotranspiration rates. Potential evaporation from the same days was calculated from the daily microclimate data. Measurements of evapotranspiration were also made for 2 days in the six vegetation zones at the snow patch site.

The temperature measurements indicate that the intertussock areas are on the average two degrees cooler than the tussock areas. The temperatures of the intertussock areas are below air temperature at night under low radiation conditions and sufficiently below air temperature that the dewpoint of the surface is lower than the dewpoint of the air. Thus, at night there is condensation of water in the intertussock moss area. The albedo of the tussock surfaces is about 0.2, similar to that of the wet meadow and other similarly vegetated surfaces. Infrared from the sky is on the order of 0.3-0.4 cal cm^{-2} min^{-1}. Potential evapotranspiration is about 1 mm day^{-1}, close to the actual evaporation rates. Evapotranspiration from the tussock is about 60% of that from the moss covered intertussock areas. Actual

Table 2. Microclimate Summary 1978

	Air temperature (°C)		Solar irradiance			Sky infrared irradiance			Net radiation			Wind (mph)		Tussock temperatures (°C)						Intertussock temperatures (°C)					
			$cal\ cm^{-2}\ min^{-1}$		$cal\ cm^{-2}\ d^{-1}$	$cal\ cm^{-2}\ min^{-1}$		$cal\ cm^{-2}\ d^{-1}$	$cal\ cm^{-2}\ min^{-1}$		$cal\ cm^{-2}\ d^{-1}$			2 cm		10 cm		30 cm		2 cm		10 cm		30 cm	
	Max.	Min.	Max.	Min.	Daily total	Max.	Min.	Daily total	Max.	Min.	Daily total	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
June 27	15.25	5.91	1.00	0.01	419	-	-	- [a]	-	-	-	-	-	11.31	6.43	8.01	5.13	1.55	0.00	5.60	1.68	1.95	-0.01	0.74	-1.46
28	14.52	5.85	1.32	0.00	441	1.31	-0.02	534	-	-	-	-	-	10.65	5.97	7.87	5.09	1.55	0.38	4.81	.84	2.95	-1.21	2.24	-1.73
29	18.23	4.20	0.57	0.00	319	0.52	-0.02	288	-	-	-	-	-	11.19	5.59	7.83	4.34	1.53	0.58	5.20	2.06	2.25	0.12	1.25	-0.78
30	20.00	1.94	1.04	0.00	344	0.52	-0.05	291	-	-	-	-	-	13.92	5.91	9.17	4.76	1.51	-1.89	5.83	-0.74	3.32	-3.14	2.56	-4.07
July 1	26.05	2.43	1.29	0.00	425	1.17	-0.05	346	-	-	-	6.53	0.00	13.40	7.40	10.16	5.36	2.72	0.55	7.55	1.40	3.69	0.08	2.22	-1.16
2	18.76	3.59	0.62	0.00	322	0.57	-0.04	294	-	-	-	5.22	0.04	16.05	8.09	9.64	6.64	2.10	0.86	7.23	2.65	2.92	0.35	1.38	-0.81
3	22.85	3.40	1.00	0.01	460	0.79	-0.08	368	-	-	-	8.12	0.03	13.72	6.50	11.27	5.77	2.42	0.14	8.90	2.08	4.17	-0.76	2.35	-1.34
4	25.91	8.64	0.45	0.00	180	0.34	-0.15	89	-	-	-	5.12	0.00	17.06	10.02	12.59	8.30	3.53	1.51	8.64	3.51	4.54	0.55	2.70	-0.74
5	-	-	0.96	0.00	438	0.92	-0.10	325	-	-	-	7.09	0.00	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	1.29	0.00	259	1.19	-0.08	199	0.06	0.00	17	4.35	0.07	-	-	-	-	-	-	-	-	-	-	-	-
7	26.11	12.28	1.05	0.00	265	1.16	-0.02	247	0.02	-0.01	5	5.67	0.00	17.34	10.25	13.34	8.09	3.49	0.76	9.69	2.22	5.15	-1.04	2.20	-2.80
8	21.60	8.46	0.36	0.00	145	0.17	-0.06	43	0.04	-0.06	3	4.72	0.00	18.81	10.61	12.85	9.48	3.78	1.77	10.14	3.95	4.41	0.87	2.75	-1.44
9	33.12	8.05	1.04	0.00	458	0.14	0.00	21	0.64	-0.05	253	9.75	0.00	18.83	10.47	12.93	9.52	3.63	2.08	11.78	3.62	6.09	1.69	3.01	-0.87
10	33.18	9.40	1.07	0.00	453	0.56	0.00	101	0.58	-0.04	219	4.72	0.00	18.87	11.20	13.72	9.25	3.77	1.14	11.87	4.70	6.55	1.80	3.22	-0.93
11	28.85	7.45	1.04	0.00	488	0.16	0.00	22	0.92	-0.07	274	9.30	0.00	18.47	9.33	13.01	8.27	3.89	1.96	11.92	5.05	5.60	2.96	3.23	0.52
12	27.16	11.99	1.13	0.01	568	0.23	0.00	62	0.83	-0.07	364	7.66	0.00	-	-	-	-	-	-	13.49	6.37	8.29	3.02	4.29	-0.63
13	28.99	10.83	1.05	0.00	372	0.79	-0.03	122	0.79	-0.03	232	5.32	0.00	17.83	11.05	13.05	8.86	3.98	2.14	12.04	7.25	7.07	4.06	3.38	0.50
[b] 14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	22.68	5.68	1.19	0.00	537	-	-	-	0.96	-0.10	726	9.34	0.81	16.16	7.36	12.27	7.56	3.68	1.97	-	-	-	-	-	-
[c] 16	23.26	13.48	1.15	0.05	208	-	-	-	0.83	0.02	-	6.51	2.19	14.90	11.52	11.31	7.90	3.65	2.30	9.55	7.24	4.88	3.09	1.75	-0.35
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	21.74	5.79	1.30	0.00	410	-	-	-	0.96	-0.10	726	10.26	0.56	12.89	9.96	12.41	8.87	4.42	2.35	10.37	5.14	5.40	2.04	1.89	-0.64
21	25.43	1.07	1.13	0.00	358	-	-	-	0.53	-0.06	177	5.74	0.02	14.86	5.48	11.27	6.07	4.32	1.41	9.98	1.44	5.27	0.97	2.18	-1.01
22	23.82	6.21	1.14	0.00	350	-	-	-	0.45	-0.05	150	4.88	0.10	14.92	7.66	12.55	7.23	6.29	0.87	10.10	2.02	4.65	-0.18	1.55	-2.37
23	26.58	2.59	1.15	0.00	518	0.47	-0.12	215	1.01	-0.07	319	7.54	0.04	14.12	6.74	11.31	6.01	2.49	-0.67	12.07	3.97	5.88	0.64	2.00	-1.86
24	24.72	0.20	1.12	0.00	356	0.63	-0.18	111	0.53	-0.06	99	5.21	0.03	14.17	4.29	9.16	3.59	2.95	-1.17	11.24	0.77	4.54	0.08	2.38	-2.59
25	19.99	5.19	0.45	0.00	238	0.33	-0.11	78	0.21	-0.06	55	7.87	0.02	14.24	6.22	11.24	6.03	3.44	0.18	11.12	4.16	6.00	0.63	2.83	-2.37
26	19.92	6.19	0.72	0.00	216	0.32	-0.07	130	0.41	-0.05	158	5.68	0.04	13.90	6.53	12.27	6.51	4.00	1.31	9.27	2.65	5.48	0.85	2.76	-1.00
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	25.64	4.13	1.04	0.00	340	0.64	-0.14	150	0.62	-0.07	138	8.25	0.04	15.42	6.39	11.72	7.32	2.74	0.84	10.92	2.53	4.50	1.32	2.14	-0.09
29	25.06	0.49	1.02	0.00	463	0.88	-0.11	42	0.50	-0.07	175	10.37	0.01	14.91	4.88	11.45	5.36	2.80	0.14	10.85	1.89	4.88	0.81	1.55	-0.92
30	27.05	2.76	1.27	0.00	400	0.91	-0.07	217	0.83	-0.07	170	7.80	0.05	15.58	6.52	11.46	6.17	3.18	1.46	12.29	2.91	4.97	1.32	1.77	-0.53
31	31.15	2.92	0.96	0.00	537	0.61	-0.11	274	0.58	-0.11	205	4.15	0.06	20.43	7.33	15.00	6.53	3.67	1.27	13.10	2.86	5.86	1.66	2.70	-0.41
August 1	29.27	4.48	1.20	0.00	363	0.82	-0.06	156	0.51	-1.04	98	9.36	0.06	17.20	7.50	12.77	7.92	3.64	1.67	12.00	3.81	5.77	1.88	1.92	-1.21
2	25.74	0.43	1.23	0.00	445	0.85	-0.37	231	0.32	-0.13	109	7.10	0.08	17.48	-0.34	16.45	1.24	7.35	-3.43	12.78	-5.12	7.68	-6.41	4.47	-6.92
3	27.51	5.40	0.93	0.00	674	0.66	-0.07	328	0.64	-0.09	204	5.23	0.04	17.64	7.37	12.28	6.14	3.55	1.68	12.09	2.17	5.76	1.57	2.37	0.04
4	27.85	4.01	0.93	0.00	516	0.62	-0.13	277	0.67	-0.09	300	9.66	0.04	16.63	6.12	12.84	6.06	3.71	2.20	12.45	2.63	5.95	1.90	2.62	0.00
5	-	-	0.87	0.00	355	1.12	-0.06	183	0.65	-0.06	236	9.41	1.14	14.10	10.15	11.49	7.48	3.83	2.28	10.93	3.08	5.49	-2.33	2.39	-5.66
6	17.71	7.79	0.52	0.00	190	0.43	-0.04	96	0.46	-0.05	124	8.27	0.06	12.78	9.64	11.27	8.09	4.49	2.64	10.06	5.14	5.50	2.14	2.39	-0.13
7	23.25	5.46	0.88	0.00	329	0.64	-0.07	112	0.69	-0.05	209	8.97	0.07	12.62	5.74	9.92	6.07	3.89	2.04	9.60	3.71	5.01	1.91	2.30	0.10
8	22.87	8.23	0.77	0.00	368	0.51	-0.07	213	0.56	-0.08	208	6.18	0.07	16.43	7.89	11.48	7.63	3.57	2.30	12.17	5.10	6.04	2.52	2.83	0.04
[b] 9	-	-	0.99	0.00	459	0.89	-0.11	327	0.73	-0.08	278	10.45	0.75	-	-	-	-	-	-	-	-	-	-	-	-
10	21.12	4.92	0.88	0.00	489	0.78	-0.11	300	0.69	-0.10	278	9.38	3.04	14.16	7.02	10.63	6.66	4.62	1.87	12.01	5.36	6.15	2.83	3.58	1.30
11	23.28	-0.92	0.91	0.00	493	0.76	-0.12	248	0.68	-0.11	254	9.26	0.65	14.20	4.60	10.82	5.39	3.65	2.19	11.79	3.87	6.32	2.91	3.29	0.91
12	24.30	-1.16	0.99	0.00	230	1.11	-0.07	217	0.73	-0.06	113	8.04	0.03	15.14	4.81	11.87	7.13	3.75	1.12	12.64	2.86	6.88	2.90	3.79	0.56
13	23.38	4.69	0.94	0.00	388	0.68	-0.07	270	0.73	-0.05	215	8.77	0.04	15.51	7.39	11.99	5.78	4.55	0.79	11.44	3.68	7.31	1.97	2.67	0.06
14	22.41	6.98	1.09	0.00	273	1.05	-0.05	230	0.85	-0.04	172	10.04	0.04	14.17	8.02	11.76	7.27	4.56	2.39	11.69	5.02	7.32	3.36	3.77	0.55
15	15.59	6.98	0.73	0.00	194	0.53	-0.03	134	0.46	-0.05	108	6.53	0.04	12.53	8.28	9.90	6.77	4.26	2.65	8.68	5.09	5.50	2.32	2.82	0.26
16	21.03	1.46	0.52	0.00	218	1.06	-0.07	163	0.85	-0.09	113	5.82	0.03	13.00	5.79	9.44	6.06	3.86	-1.03	10.45	3.15	4.94	-1.66	2.72	-3.42
17	20.05	-1.74	0.95	0.00	494	0.70	-0.14	351	0.60	-0.14	263	6.77	0.04	11.96	1.95	9.96	3.37	3.81	1.70	8.42	0.22	4.49	0.26	2.62	-0.38

[a] Partial day.
[b] Voltmeter problem
[c] 9a.m.-midnight

evapotranspiration from the tussocks is less than the potential evapotranspiration while actual evapotranspiration from the intertussock areas is greater than the potential evapotranspiration.

Measured evapotranspiration from the different vegetation types at all sites was lowest in the fellfield and highest in the intertussock areas in the Eriophorum vaginatum tussock tundra. Expressed as a fraction of absorbed solar irradiance, the measured evapotranspiration from the fell-field accounted for only about 4% of the absorbed solar irradiation, while in the moss covered intertussock areas it accounted for about 25%. The partitioning of absorbed solar radiation measured in this study was similar to the partitioning which can be calculated from Addison (1977) on Devon Island in raised beach ridge and tussocky sedge-moss tundra. The evapotranspiration and potential evapotranspiration measurements are further discussed in the paper to be submitted to Holarctic Ecology by Oberbauer et al. (ms. this Progress Report).

Leaf conductances were measured on intact plants in the field in the summer of 1978. A null balance diffusion porometer was constructed in San Diego by Dr. Steve Roberts following a design by Dr. Paul Jarvis and modified by Dr. Patrick Coyne at Lawrence Livermore Laboratory. Leaf conductances of about 15 different vascular plant species were measured through the daylight period on 6 days. The maximum leaf conductances of the different species of the different growth forms followed an expected pattern. The forb had the highest leaf conductances, followed closely by grasses and sedges. The lowest conductances were measured in evergreen shrubs. The leaf conductance measurements and additional measurements on the water relations of tundra plants are summarized in the manuscripts by Oberbauer and P.C. Miller (this Progress Report).

Macroclimatic data were collected at Berry Camp in 1976, 1977, and 1978 (Table 3). The data were collated by all the subprojects. Additional data were summarized from Weather Bureau records for nearby towns (Central, Gilman Creek, and Circle City) and for Fairbanks (College Observatory and University Experiment Station). Correlations will be made between the Weather Bureau records, long term records, and the Berry Camp records to search for ways of broadening the climatic record at Eagle Creek. Temperatures collected at Cape Thompson in 1977 will be correlated with temperature data from Katzebue to ascertain how closely the Kotzebue conditions can be applied to the Cape Thompson area. The ability to describe the seasonal progression of temperatures, precipitation, and irradiance is critical in order to simulate seasonal progressions of plant and soil processes in locations other than Eagle Creek. Unfortunately, one of the major sources of error in the simulations of plant and soil processes for remote locations on the north slope will probably be the lack of climatic data.

The integration and quantification of belowground processes in arctic ecosystems is very recent. The current simulation model, based on general concepts from other areas requires parameters to be measured in the water-logged, organic tundra soils. Some of these basic soil properties have been measured on this project and are summarized in the following tables. (Barkley and Kellog, ms. this Progress Report). The data are available as background for the development of the simulation models and for other projects. Nitrogen has been shown to affect aboveground plant growth in tussock tundra, and to vary in different montane tundra types. The ammonium electrode appeared to be a reasonable, fast method for measuring nitrogen in tussock tundra since it had been used

Table 3.

Berry Camp Macroclimate 1976

Dates		Temperature (°C) Max	Min	Relative humidity (%) Max	Min	Solar absolute max (cal cm^{-2}min^{-1})	Daily solar total (cal cm^{-2}day^{-1})	Precipitation (mm)
June	27	-	-	-	50	-	-	-
	28	14.5	9	100	61	-	-	0
	29	11	8.5	100	66	-	-	0
	30	13.5	6.5	94	48	-	-	0
July	1	11.5	6.5	100	70	-	-	0
	2	14	8	91	60	-	-	0
	3	-	8	100	-	-	-	0
	4	9.5	8	96	64	-	-	0
	5	8	7.5	91	73	-	-	0
	6	17	6	98	48	-	-	0
	7	20.5	7.5	93	42	-	-	0
	8	16	9.5	98	60	-	-	0
	9	13	8	92	76	-	-	0
	10	15	6	98	58	-	-	0.7
	11	16.5	11	80	48	-	-	0
	12	14.5	8	91	51	-	-	0
	13	18.5	8	94	42	-	-	0
	14	16	6.5	100	65	0.85	320	5.6
	15	15.5	10.5	100	53	1.0	430	0
	16	14	6.5	100	59	1.4	480	0
	17	15.5	6	100	58	0.7	400	0
	18	18	8	100	50	1.0	340	0
	19	18.5	5	98	39	0.9	350	0
	20	23.5	9.5	82	30	1.05	260	0
	21	21.5	8.5	74	36	1.15	380	0
	22	22	9.5	95	43	1.05	350	0.01
	23	22.5	9	100	40	1.0	490	0.8
	24	20	9.5	100	56	1.05	400	6.9
	25	16	9.5	100	72	1.16	200	2.0
	26	12	9.5	100	60	0.68	210	0.9
	27	19	10	100	49	1.25	290	0
	28	21	9	98	42	1.08	420	0
	29	26	9.5	96	41	1.0	450	0
	30	16.5	9.5	100	63	1.42	350	0
	31	17	5.5	100	51	1.05	390	0
Aug	1	22	11	89	54	1.0	410	0
	2	24.5	15.5	100	58	0.9	280	0
	3	22	14.5	100	62	1.0	380	0
	4	17.5	12.5	100	68	0.75	190	0
	5	-	-	100	-	1.08	260	0
	6	-	-	-	-	1.0	380	8.8
	7	-	-	-	-	0.45	220	8.8
	8	-	-	-	-	0.55	200	8.8
	9	15.5	8.5	98	61	0.80	230	0.9
	10	16.5	8.5	100	58	1.05	290	0
	11	16	8.5	100	61	0.95	270	0
	12	-	-	100	-	0.35	130	0
	13	-	-	-	-	0.78	210	0
	14	-	-	-	-	0.90	290	0
	15	-	-	100	-	0.52	-	0.8
	16	-	-	-	-	-	-	4.0
	17	-	-	-	-	-	-	0.2
	18	-	-	-	-	-	-	6.2

Table 3.

Berry Camp Macroclimate Summer 1977

Dates		Temperature (°C) Max	Min	Relative humidity (%) Max	Min	Solar absolute max ($cal\ cm^{-2} min^{-1}$)	Daily solar total ($cal\ cm^{-2} day^{-1}$)	Precipitation (mm)
May	25	-	-	-	-	-	-	-
	26	9	2.5	100	55	0.92	140	t
	27	9.5	2.5	100	64	0.82	200	2.9
	28	16	1	100	28	1.22	400	t
	29	18	1	64	26	1.24	330	t
	30	16	5	100	42	1.2	330	0
	31	10.5	1.5	100	56	0.6	250	6.5
June	1	13.5	3	100	46	-	-	t
	2	13.3	5.5	100	41	1.1	280	t
	3	15	4.5	100	40	1.35	430	1.4
	4	17.5	5	100	40.5	1.25	310	3.0
	5	16.6	4	100	26	1.32	450	5.2
	6	15.5	4	100	31	1.22	400	5.2
	7	16	2	100	41	1.3	390	1.4
	8	17.5	3	100	37	1.28	500	0.6
	9	19.5	6.5	100	33	1.5	490	t
	10	19	5	100	36	1.4	410	1.9
	11	17.4	7.5	100	42	0.95	280	7.3
	12	14.5	5.5	100	70	1.0	260	5
	13	17	4.8	100	46	1.35	390	4.7
	14	19	8.8	100	42	1.25	380	3.7
	15	16	6.5	100	57	-	-	10.0
	16	16.5	5	100	53	1.2	390	11.0
	17	19.5	5	100	36	1.15	270	1.2
	18	13	5	100	74	0.6	140	5.6
	19	14.5	5	100	37	1.25	380	t
	20	15.0	6.5	100	48	1.25	330	2.0
	21	13.5	6	100	53	0.7	-	1.5
	22	14.5	4	100	66	0.9	320	2.8
	23	17.2	7.5	100	31	1.2	370	0.3
	24	10	7	100	91	0.55	160	3.4
	25	12	6.5	100	76	0.9	260	11.5
	26	13	4	100	41	1.3	400	0.2
	27	15	3.5	100	44	0.9	230	t
	28	10	1.5	100	40	1.25	370	2.8
	29	12	-1	94	32	1.2	500	0
	30	17	9	72	34	1.2	440	0
July	1	12	2.5	100	47	1.0	310	1.6
	2	7	-2	100	40	0.8	280	t
	3	11.2	-1.8	100	38	1.0	300	t
	4	14	0.8	100	38	1.25	340	2.0
	5	15.8	3	100	38	1.3	400	3.0
	6	20	3	100	31	1.25	360	3.0
	7	20.2	7.2	70	32	1.15	370	t
	8	21	6.5	100	30	1.14	460	0
	9	18	9.5	64	38	1.2	380	0
	10	19	4	75	37	1.12	470	0
	11	19.5	4	96	37	1.16	550	0
	12	17	5	81	36	1.14	540	0
	13	14.5	2	96	39	-	550	0
	14	18	7	80	38	1.12	470	0
	15	17.2	5	100	41	1.2	440	t
	16	18	4	100	31	1.2	350	t

Table 3.

Berry Camp - Summer 1977

Dates		Temperature (°C) Max	Min	Relative humidity (%) Max	Min	Solar absolute max (cal $cm^{-2}min^{-1}$)	Daily solar total (cal $cm^{-2}day^{-1}$)	Precipitatio (mm)
July	17	18	4	100	48	1.1	310	5.3
	18	13.5	4.5	100	84	1.0	120	2.3
	19	12	5	100	76	-	-	5.1
	20	15	7	100	44	1.3	400	t
	21	16	8.5	100	52	1.1	310	t
	22	14.5	7.5	100	67	0.9	160	9.2
	23	14	7	100	77	1.1	250	1.15
	24	17.5	4	100	50	1.0	320	3.7
	25	18	5.5	100	52	1.1	310	3.7
	26	23.5	5.5	100	32	1.15	380	0
	27	-	8	100	33	1.15	370	0
	28	19	7	100	26	1.0	410	0
	29	26.1	12.2	73	31	1.1	430	0
	30	25.6	11.7	100	34	1.0	430	0
	31	23.9	11.7	81	38	1.02	410	0
Aug	1	22.8	7.8	100	37	1.02	420	0
	2	22.8	8.3	100	38	1.2	320	0
	3	26.7	6.1	100	26	1.0	340	0
	4	30	10.6	98	26	1.0	380	0
	5	-	10.6	91	35	-	-	t
	6	16.5	2.5	100	57	-	-	1.2
	7	18.5	3.5	100	62	0.9	-	0
	8	23	13	86	40	1.1	380	0
	9	23.5	12	100	44	1.1	350	0
	10	23.5	11	100	42	1.0	340	4.7
	11	16.5	8.6	100	66	0.8	180	18.3
	12	18	5	100	43	0.88	330	0
	13	-	-	96	46	0.9	250	0
	14	17.2	6.1	100	38	0.8	240	0
	15	17.8	6.1	100	43	1.1	300	0
	16	20	6.7	100	36	0.8	200	0
	17	20.6	6.7	100	37	1.1	300	1.2
	18	22.2	7.8	100	35	-	-	t
	19	-	-	-	-	1.1	340	0
	20	-	11	100	52	-	-	0
	21	22	11	92	46	-	-	0
	22	18	11	100	38	0.9	390	0
	23	16	3	100	44			0
	24	13	3.5	100	63			0
	25	11.2	2.5	100	79			3.2
	26	9.5	1	100				1.0
	27							t
	28							0
	29							1.8
	30							0
	31							0

Table 3.

Berry Camp Macroclimate Summer 1978

Dates		Temperature (°C)		Relative humidity (%)		Solar absolute max	Daily solar total	Precipitation
		Max	Min	Max	Min	(cal $cm^{-2}min^{-1}$)	(cal $cm^{-2}day^{-1}$)	(mm)
May	30	-	-	-	-	-	-	19.2
	31	-	-	-	-	-	-	0
June	1	-	-	-	-	-	-	2.6
	2	-	4	-	-	-	-	0.6
	3	13	3.5	100	54	1.32	550	2.5
	4	16	4	100	44	1.44	500	3.1
	5	15	5	98	40	1.12	480	0
	6	-	-	100	-	0.15	40	0.6
	7	7	5	100	59	0.45	100	0.2
	8	12.5	4	100	46	1.45	400	0.4
	9	15	5	92	43	1.40	420	0
	10	17	9	100	48	1.3	290	0.7
	11	17	7.5	100	48	1.35	500	0
	12	14.5	7.5	100	67	1.0	280	2.4
	13	14	5.5	100	70	1.42	330	5.6
	14	17	5.5	100	48	1.32	470	0
	15	14.5	5	100	51	1.4	520	2.0
	16	13.5	10	100	78	0.65	190	2.9
	17	15	8	100	54	0.6	270	1.3
	18	13.5	8	100	55	1.3	370	0
	19	12	8	100	68	1.25	400	0
	20	10.5	6	100	79	1.0	140	0
	21	15.5	6	100	48	1.3	340	0
	22	14.5	10.5	100	78	0.3	-	4.8
	23	9.5	8.5	100	83	0.7	160	2.0
	24	11.5	7	100	69	1.4	320	5.5
	25	15	8.5	100	63	-	-	5.5
	26	12	9.5	100	71	0.6	270	3.6
	27	14.5	9.5	100	83	1.45	200	15.0
	28	14.5	10	100	60	1.5	430	0
	29	17.5	10	100	62	1.0	300	0
	30	14.5	11	100	76	1.3	260	0
July	1	15.5	8.5	100	62	1.4	400	4.0
	2	15.5	10	100	69	1.05	330	4.2
	3	19.5	10.5	100	52	1.35	460	0
	4	22	14.5	100	51	1.4	350	0
	5	25.5	14.5	100	48	1.42	460	0
	6	20	16	100	68	1.3	230	1.2
	7	17.5	15	100	82	1.4	270	6.0
	8	22	13	100	66	1.3	450	1.8
	9	24	13.5	100	48	1.3	500	0
	10	22.5	14	100	53	1.45	350	0
	11	22	13.5	100	53	1.25	540	0
	12	20.5	15	100	62	1.22	460	0
	13	20	11	100	53	1.3	390	0
	14	17	10	100	54	1.25	420	0
	15	15.5	7.5	100	56	1.3	-	0
	16	17.5	7.5	100	54	1.3	400	0
	17	19	8.5	100	51	1.4	360	1.8
	18	20.5	10.5	100	58	1.25	460	2.2
	19	21.5	11	100	57	1.2	280	0
	20	17	7	100	62	-	-	0

Table 3.

Berry Camp - Summer 1978

Dates		Temperature (°C)		Relative humidity (%)		Solar absolute max	Daily solar total	Precipitation
		Max	Min	Max	Min	(cal $cm^{-2} min^{-1}$)	(cal $cm^{-2} day^{-1}$)	(mm)
July	21	17.5	7	100	54	-	-	3.8
	22	16.5	11	100	67	-	-	3.8
	23	20.5	9	100	57	-	-	4.9
	24	20	8.5	100	53	-	-	0
	25	18	11.5	100	67	1.42	-	2.1
	26	18.5	11.5	100	60	1.35	400	3.0
	27	21	12	100	57	1.25	430	1.6
	28	23	9.5	100	50	1.05	500	0
	29	23	14	100	48	1.05	400	0
	30	23	11	100	48	1.45	270	0
	31	28	11.5	100	46	1.05	470	0
Aug	1	24.5	14.5	100	41	1.3	340	0
	2	20	9.5	100	62	1.32	350	~~8.6~~
	3	24.5	9.5	100	49	1.05	490	8.6
	4	-	13	100	41	1.1	450	~~8.6~~
	5	17.5	13	100	82	1.25	270	3.2
	6	15	9.5	100	100	0.85	200	6.6
	7	15.5	14.5	100	66	1.05	200	0
	8	18	13.5	100	74	1.08	280	4.0
	9	18	11	100	68	1.12	440	0
	10	15	10.5	98	68	1.05	480	0
	11	16	9.5	100	55	1.05	450	0
	12	21	8	100	50	1.1	370	0
	13	-	-	-	-	-	-	11.5
	14	-	-	-	-	-	-	11.0
	15	12.5	10.5	100	96	0.7	150	6.8
	16	14.5	7.5	100	72	1.08	280	0
	17	16	6.5	100	46	1.0	400	0
	18	20.5	6	100	41	1.0	400	0
	19	23	7.5	100	46	1.0	410	0
	20					0.6	130	3.2
	21							4.3
	22							~~4.3~~
	23							2.4
	24							0
	25							0
	26							0
	27							0
	28							0
	29							0
	30							0
	31							0
Sept	1							0
	2							0
	3							0
	4							0
	5							0
	6							0
	7							5.8
	8							0
	9							0
	10							0
	11							2.3
	12							0

Kotzabue
Lat. 66°52'
Long. 162°38'
Elev. 10 m

Table 3.

Macroclimate

1978

Date		Temperature (C°) max	min	Precipitation (mm)
June	1	12.8	-1.1	t
	2	4.4	-1.9	0
	3	15.5	0	t
	4	11.1	5.6	t
	5	8.9	4.4	0
	6	6.1	2.8	.25
	7	8.3	2.8	0
	8	9.4	4.4	0
	9	11.6	5.6	0
	10	8.3	5	0
	11	10	4.4	0
	12	11.1	7.8	0
	13	11.6	7.8	t
	14	24.4	10.5	1.02
	15	14.4	7.2	.76
	16	11.6	5.6	0
	17	12.8	8.3	t
	18	11.1	7.2	1.52
	19	9.4	5.6	0
	20	10	4.4	0
	21	13.9	7.8	1.27
	22	12.2	7.2	12.7
	23	13.3	5.6	.51
	24	11.1	4.4	0
	25	11.1	7.2	0
	26	12.2	5.6	0
	27	11.6	2.2	0
	28	10.5	6.7	1.52
	29	10.5	6.7	.76
	30	10.5	6.7	.51
Total		11.4	5.2	20.83
July	1	12.2	6.7	.76
	2	16.1	10	0
	3	16.1	11.1	0
	4	14.4	12.2	t
	5	18.9	13.3	t
	6	19.4	12.2	t
	7	17.2	12.2	.76
	8	18.9	12.8	0
	9	16.7	13.9	t
	10	20	13.3	t
	11	18.9	13.3	0
	12	15.5	12.2	0
	13	17.2	11.6	0
	14	20	14.4	0
	15	22.2	14.4	0
	16	18.3	12.8	0
	17	22.2	13.3	0
	18	21.7	16.1	0
	19	18.9	14.4	14.22
	20	17.8	13.9	1.52

Date		Temperature (C°) max	min	Precipitation (mm)
July	22	13.3	12.2	t
	23	15	11.6	0
	24	15	12.2	0
	25	15	11.6	0
	26	16.1	10.5	0
	27	12.8	11.1	t
	28	16.1	10.5	t
	29	15.5	11.1	1.52
	30	16.1	13.9	6.10
	31	15	11.6	5.33
Total		17	12.4	36.32
Aug.	1	13.9	11.1	.25
	2	15.5	11.1	0
	3	18.9	10.5	0
	4	16.1	12.8	.25
	5	13.9	10.5	0
	6	11.1	8.3	0
	7	12.2	8.3	t
	8	13.9	10.5	4.83
	9	20	12.2	0
	10	21.1	12.2	0
	11	22.2	12.8	0
	12	22.2	13.3	0
	13	18.3	12.2	t
	14	15.5	10.5	0
	15	12.2	9.4	0
	16	15.5	11.1	0
	17	18.9	10	0
	18	16.7	11.6	0
	19	17.2	11.1	6.86
	20	14.4	11.1	1.52
	21	12.8	9.4	t
	22	14.4	8.9	0
	23	13.9	8.9	0
	24	17.8	8.3	0
	25	15	12.2	.25
	26	17.2	11.6	t
	27	15.5	11.1	.25
	28	13.3	11.6	.51
	29	15	10.5	t
	30	17.8	10	0
	31	17.2	10	0
Total		16.2	10.8	14.99

Kotzabue

Lat. 66°52'
Long. 162°38'
Elev. 10 m

Table 3. 1977

Macroclimate

Date		Temperature (C°) max	min	Precipitation (mm)
June	1	3.3	-0.6	0
	2	3.9	-2.7	0
	3	12.2	-2.7	t
	4	10	1.7	0
	5	7.8	1.7	t
	6	10	2.2	t
	7	8.9	3.3	t
	8	17.2	4.4	t
	9	14.4	7.2	t
	10	8.9	3.3	0
	11	9.4	1.1	0
	12	15.5	3.3	t
	13	6.7	3.9	t
	14	8.9	5	t
	15	6.7	2.8	0
	16	10.5	2.8	0
	17	12.2	4.4	0
	18	11.1	7.2	0
	19	15.5	7.2	0
	20	10.5	3.3	0
	21	8.9	3.9	.51
	22	7.2	1.7	t
	23	4.4	0.6	0
	24	4.4	0.6	0
	25	9.4	1.1	0
	26	12.2	5.6	0
	27	12.8	7.2	0
	28	12.8	7.2	0
	29	12.8	5.6	0
	30	8.9	3.3	0
Total		9.9	3.2	.51
July	1			
	2	13.3	1.1	0
	3	15.5	4.4	0
	4	11.6	6.7	0
	5	13.3	6.1	t
	6	16.7	5	t
	7	24.4	11.1	0
	8	21.1	11.6	.25
	9	21.7	13.3	0
	10	19.4	13.3	0
	11	23.3	15.5	0
	12	28.8	17.8	0
	13	19.4	10.5	0
	14	22.8	9.4	t
	15	20.6	13.9	t
	16	18.9	10.5	0
	17	10.5	7.2	0
	18	7.8	5	0
	19	13.3	5.6	0
	20	17.2	8.9	0
	21	21.7	12.8	0

Date		Temperature (C°) max	min	Precipitation (mm)
July	22	21.1	15.5	0
	23	20.6	14.4	0
	24	23.9	12.8	0
	25	22.8	14.4	0
	26	25	13.9	t
	27	20.6	16.1	t
	28	17.8	13.9	t
	29	20.6	13.3	0
	30	22.2	14.4	0
	31	22.8	17.8	0
Total		18.8	10.9	.25
Aug.	1	17.8	15	0
	2	18.9	13.9	t
	3	23.3	13.9	0
	4	18.9	15	.25
	5	18.3	12.8	.25
	6	16.7	12.2	0
	7	20.6	11.6	0
	8	22.2	13.9	.25
	9	19.4	12.2	t
	10	17.2	14.4	1.02
	11	16.1	12.8	2.29
	12	21.1	12.8	t
	13	18.9	12.2	5.59
	14	19.4	12.2	6.35
	15	17.8	11.6	t
	16	16.7	12.8	.25
	17	19.4	12.2	0
	18	18.9	14.4	t
	19	18.9	12.2	t
	20	22.2	11.1	0
	21	21.1	15	0
	22	21.1	15	0
	23	18.9	12.2	0
	24	17.2	11.6	0
	25	15.5	10.5	0
	26	12.2	6.1	0
	27	11.6	5	t
	28	12.8	8.9	.51
	29	11.6	9.4	1.27
	30	12.8	10	t
	31	14.4	8.3	0
Total		17.8	12	18.03

Kotzabue
Lat. 66°52'
Long. 162°38'
Elev. 10 m

Table 3. 1976

Macroclimate

Date	Temperature (C°) max	min	Precipitation (mm)
June 1	13.3	2.8	1.02
2	8.9	2.2	2.29
3	4.4	-1.1	t
4	12.2	-1.1	0
5	14.4	1.1	1.02
6	3.9	0.6	t
7	6.1	-1.1	0
8	4.4	-1.1	0
9	1.1	-1.1	0
10	3.3	-0.6	0
11	4.4	1.1	0
12	8.3	0.6	0
13	10	0.6	0
14	5.6	1.1	0
15	5.6	0.6	0
16	5	0.6	t
17	4.4	1.1	t
18	3.9	0.6	t
19	2.2	0.6	t
20	10	1.7	.25
21	3.9	1.1	5.08
22	8.3	3.9	1.52
23	11.6	5	-
24	8.3	0.6	2.79
25	18.3	0	t
26	15	3.9	0
27	5	0.6	0
28	4.4	0.6	0
29	5.6	1.1	2.54
30	4.4	0.6	.76
Total	7.4	0.8	17.27
July 1	2.8	0	t
2	7.2	-1.1	.51
3	6.7	2.2	18.54
4	3.9	1.1	1.78
5	2.8	1.1	-
6	12.2	5.6	t
7	6.7	1.7	0
8	8.9	2.2	0
9	12.8	6.7	0
10	15.5	8.9	0
11	16.1	10	0
12	20.6	12.8	0
13	15	3.9	0
14	10	3.9	0
15	19.4	8.9	0
16	14.4	10	0
17	16.1	8.3	0
18	13.3	7.2	0
19	19.4	7.8	0
20	18.9	10.5	0
21	20	11.6	0

Date	Temperature (C°) max	min	Precipitation (mm)
July 22	17.2	10.5	0
23	19.4	8.3	0
24	21.1	13.9	0
25	16.7	11.6	0
26	13.9	10	0
27	12.8	3.9	0
28	16.7	11.1	2.54
29	13.3	8.9	1.78
30	14.4	8.9	0
31	17.2	8.3	0
Total	13.9	7.1	29.46
Aug. 1	15.5	10	0
2	18.3	10	0
3	12.2	10	0
4	15	10.5	0
5	17.8	12.8	0
6	20	12.2	0
7	17.2	10.5	0
8	16.1	7.8	0
9	16.1	11.1	0
10	13.3	10.5	.76
11	16.7	11.1	0
12	17.8	11.6	.51
13	14.4	11.6	2.29
14	16.1	11.6	6.86
15	13.3	7.8	1.78
16	14.4	8.3	0
17	15	8.3	0
18	15.5	6.1	0
19	13.3	8.3	0
20	13.3	10	0
21	13.3	10	0
22	17.8	8.9	t
23	18.3	10	0
24	16.7	9.4	0
25	18.3	11.1	t
26	16.7	11.1	0
27	15.5	10	0
28	13.9	11.1	0
29	14.4	11.6	0
30	14.4	8.9	0
31	18.9	7.8	0
Total	15.8	10	12.19

Univ. Expt. Station
Lat. 64°51'
Long. 147°52'
Elev. 475 m

Table 3.

Macroclimate

1978

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June	1	25	3.3	-	5.84
	2	18.3	4.4	2.54	0.51
	3	20	3.3	2.54	0
	4	24.4	3.3	5.59	0
	5	18.9	8.3	3.56	0.76
	6	15.5	3.3	2.79	0
	7	18.3	2.8	2.03	0
	8	20.6	1.7	3.30	0
	9	23.9	3.9	8.13	0
	10	21.1	4.4	1.52	5.33
	11	23.9	9.4	4.83	0
	12	20.6	10	1.02	0
	13	21.1	8.9	4.57	8.38
	14	21.1	5	-	0
	15	21.1	9.4	8.38	2.54
	16	16.1	3.9	0.76	4.83
	17	17.2	5	2.79	0
	18	18.3	3.3	2.79	0
	19	17.2	3.9	1.78	0
	20	18.3	-2.2	1.78	0
	21	19.4	-5	3.30	0
	22	21.1	9.4	1.27	0
	23	15.5	7.2	-	0
	24	17.2	6.1	-	2.79
	25	17.8	4.4	-	0
	26	15.5	7.8	-	2.29
	27	16.7	2.8	0.51	2.54
	28	16.7	5.6	4.32	0.51
	29	18.3	8.3	1.78	t
	30	17.8	8.9	1.27	1.27
Total		19.2	5.1	87.88	37.85
July	1	19.4	6.7	-	0
	2	20	5.6	4.57	1.27
	3	25.6	9.4	6.10	1.27
	4	25.6	8.9	9.40	0
	5	27.8	10.5	3.81	0
	6	24.4	12.8	4.32	2.79
	7	15.6	12.2	2.03	0
	8	26.1	10	5.84	4.83
	9	26.1	11.1	6.35	0
	10	27.2	10.5	5.59	0
	11	30	9.4	5.84	0.51
	12	23.9	15	4.06	3.05
	13	21.7	12.2	2.79	10.67
	14	23.9	8.9	4.57	2.03
	15	22.8	8.9	5.08	0.51
	16	22.3	6.1	5.08	0
	17	26.7	7.2	3.30	0
	18	24.4	5.6	5.33	0
	19	26.1	7.8	5.33	0
	20	21.1	10.5	-	0

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
July	21	23.9	7.8	-	0
	22	19.4	9.4	-	5.84
	23	23.9	7.8	8.38	0
	24	25	6.7	-	15.49
	25	20.6	6.1	-	0
	26	24.4	7.2	2.54	0
	27	23.9	5.6	3.56	4.57
	28	25.6	7.8	4.38	0
	29	28.3	7.8	-	0
	30	30	10	-	0
	31	28.3	7.8	4.83	0
Total		24.7	8.8	-	52.83
Aug.	1	26.1	10.5	3.81	2.29
	2	22.8	10.5	5.33	2.54
	3	25.6	10	6.60	0
	4	27.8	7.2	3.81	0
	5	23.9	12.2	3.05	8.64
	6	21.1	13.3	3.05	0
	7	22.2	6.7	3.05	0
	8	27.2	10	5.08	0
	9	25.6	8.3	2.29	6.60
	10	23.9	6.1	4.32	0
	11	26.1	7.8	3.30	0
	12	23.9	8.3	3.81	0
	13	25.6	7.2	5.33	3.56
	14	21.1	8.3	-	1.27
	15	20.6	9.4	3.05	0
	16	22.2	7.2	3.30	0
	17	23.3	6.2	2.79	0
	18	22.3	2.8	6.35	0.76
	19	25	2.2	2.79	0
	20	15	5	3.56	1.52
	21	11.1	5.6	0.51	11.18
	22	13.3	5.6	1.27	0.51
	23	13.3	7.8	2.54	1.78
	24	-	-	-	0
	25	-	-	-	0
	26	21.1	4.4	4.83	0
	27	22.8	0.6	3.56	0
	28	23.3	4.4	1.02	0
	29	22.2	5	5.08	0
	30	22.8	3.9	2.29	t
	31	22.2	6.1	2.29	0
Total		22.2	7	101.35	40.64

Table 3.

Univ. Expt. Station
Lat. 64°51'
Long. 147°52'
Elev. 475 m

1977

Macroclimate

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June	1	-	-	-	0
	2	21.1	8.3	7.39	0
	3	24.4	7.8	5.59	0
	4	22.8	8.3	3.30	0
	5	16.7	7.2	2.54	0
	6	22.2	6.1	4.57	0
	7	21.7	4.4	5.33	0
	8	25.6	5.6	3.81	0
	9	23.9	8.3	7.62	0
	10	25	8.9	7.62	2.03
	11	26.1	8.3	6.35	0
	12	16.1	10.5	12.7	12.45
	13	16.1	10	-	20.02
	14	22.8	11.6	4.57	2.03
	15	21.7	10	1.02	16.0
	16	23.9	12.2	5.59	0
	17	24.4	10	2.79	0
	18	22.2	9.4	5.08	15.24
	19	20	7.2	3.05	0
	20	23.3	6.7	4.06	1.02
	21	21.1	7.2	6.35	0
	22	22.8	8.9	4.57	2.29
	23	23.3	9.4	10.67	6.86
	24	22.2	10	4.57	t
	25	22.2	9.4	3.30	3.05
	26	23.9	9.4	4.57	0
	27	21.1	7.8	-	0
	28	20.6	7.8	6.35	2.29
	29	21.1	-1.1	5.08	1.27
	30	21.1	4.4	5.84	0
Total		22.1	8.2	160.27	84.58
July	1	21.1	9.4	-	0.25
	2	18.3	7.2	3.56	0
	3	17.8	3.9	4.32	0
	4	20	4.4	2.03	0
	5	22.2	6.1	5.08	1.52
	6	24.4	6.1	5.59	0
	7	28.8	8.9	4.57	0
	8	28.8	9.4	6.60	0
	9	27.2	7.8	5.59	0
	10	27.2	10	7.62	5.08
	11	28.8	10	5.33	0
	12	28.8	10	9.40	0
	13	27.2	9.4	7.37	0
	14	25.6	8.9	4.32	0
	15	22.2	10	3.56	5.08
	16	21.1	6.1	-	0
	17	26.1	6.1	2.79	0
	18	22.8	7.2	2.79	0
	19	22.2	6.1	2.79	1.27
	20	22.2	7.2	6.35	0.76

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
July	21	22.2	6.7	3.30	t
	22	17.8	11.6	-	8.38
	23	23.3	11.1	5.59	2.79
	24	25.6	7.2	3.81	0
	25	26.7	7.2	3.81	t
	26	28.3	8.9	6.35	0
	27	27.2	7.2	5.84	0
	28	27.8	8.3	5.33	0
	29	30.6	8.9	3.81	0
	30	32.8	11.6	6.60	0
	31	30	12.8	6.60	1.52
Total		25	8.3	150.37	26.67
Aug.	1	30	11.6	4.06	0
	2	25.6	12.8	4.06	0
	3	28.8	9.4	3.30	0
	4	26.7	11.1	6.35	0
	5	25.6	12.8	-	t
	6	21.1	11.6	0.25	4.32
	7	23.9	9.4	3.30	0
	8	28.8	6.7	2.54	0
	9	23.9	9.4	11.18	0
	10	29.4	12.2	3.30	1.02
	11	28.8	12.8	1.78	0
	12	27.2	13.8	4.83	0
	13	28.2	11.1	3.56	0
	14	30	6.7	3.81	0
	15	25.6	10	2.79	0
	16	24.4	10.5	3.56	0
	17	25	7.2	2.29	0
	18	27.8	12.8	2.79	0
	19	27.2	13.3	0.76	0
	20	28.3	8.3	7.11	0
	21	31.7	19.2	-	0
	22	27.2	13.3	3.05	0
	23	26.1	10.5	1.27	0
	24	22.8	4.4	1.78	0
	25	21.7	6.1	2.54	0
	26	18.9	7.8	-	6.10
	27	17.2	1.1	7.62	0
	28	16.1	1.7	3.56	0
	29	15.5	-2.2	2.79	0.76
	30	16.1	-2.2	2.54	0
	31	20.6	2.2	2.54	0
Total		24.9	9.2	106.17	12.19

Univ. Expt. Station
Lat. 64° 51'
Long. 147°52'
Elev. 475 m

Table 3.

1976

Macroclimate

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June	1	22.2	3.9	2.29	0
	2	23.3	7.8	0.51	0
	3	23.3	6.1	-	0
	4	23.3	9.4	0.51	0
	5	25	7.2	11.18	0
	6	21.7	3.9	3.05	0
	7	24.4	6.1	2.79	0
	8	18.3	5	1.02	0
	9	20	8.9	3.81	0
	10	25	8.9	6.10	0
	11	22.8	6.1	8.89	0
	12	23.9	7.2	8.31	0
	13	26.7	9.4	2.54	0
	14	28.3	7.2	5.59	0
	15	28.3	7.2	-	0
	16	24.8	8.3	2.54	0
	17	18.9	10	3.81	11.83
	18	17.8	7.8	3.56	0
	19	18.9	8.9	0.25	0
	20	21.1	4.4	2.79	0
	21	5	6.1	10.16	0
	22	21.1	7.8	3.81	0
	23	15	8.9	0.25	0
	24	20	10	2.79	0
	25	21.1	10.5	0.76	0
	26	23.9	4.4	8.13	10.67
	27	26.7	11.1	9.14	0
	28	20.6	12.8	2.03	0
	29	17.2	8.9	3.56	6.60
	30	19.4	11.1	3.30	0
Total		22.3	7.8	125.48	28.7
July	1	20.6	10.5	1.78	0
	2	18.3	10	1.02	0
	3	20	9.4	1.52	0
	4	17.8	8.3	0.76	0
	5	12.2	6.7	9.91	10.16
	6	24.4	6.1	5.08	1.78
	7	25.6	10	4.57	0
	8	24.4	11.6	4.06	0
	9	21.7	8.3	-	0
	10	24.4	7.8	5.59	0
	11	27.2	10	6.60	0
	12	26.1	10	3.05	0
	13	24.4	8.3	7.87	0
	14	23.3	7.2	9.14	0
	15	21.7	10	2.79	2.03
	16	21.7	10.5	3.81	3.05
	17	19.4	6.7	1.78	1.27
	18	21.7	8.3	18.29	0.51
	19	24.4	7.2	5.08	0
	20	27.2	9.4	7.39	t

Date		Temperature (C°) max	min	Evap. (mm)	PPT (mm)
July	21	30.6	7.2	2.79	0
	22	29.4	10.5	7.87	0
	23	27.2	11.1	4.32	0
	24	25.6	10.5	3.81	0
	25	21.1	12.8	2.29	13.21
	26	21.7	10	-	11.43
	27	23.9	11.1	12.7	0
	28	25	10	9.40	0
	29	30.6	10.5	6.86	0
	30	27.8	12.8	5.59	0
	31	26.7	4.4	4.06	0
Total		23.7	9.3	170.69	43.43
Aug.	1	31.7	11.1	5.33	0
	2	29.4	13.3	6.60	0
	3	25.6	11.6	3.56	0
	4	21.7	16.1	2.03	0
	5	27.2	7.8	3.30	0
	6	29.4	8.3	3.05	4.83
	7	23.9	9.4	4.57	0
	8	22.2	9.4	2.29	0
	9	23.9	8.3	2.29	3.05
	10	25.6	8.3	5.84	0
	11	25.6	7.8	2.79	0
	12	24.4	11.6	1.78	13.21
	13	23.3	6.7	4.32	6.60
	14	25.6	8.9	3.56	0
	15	21.1	10	3.81	0
	16	18.9	8.9	2.54	0
	17	18.3	6.7	-	17.27
	18	20	8.3	5.08	5.08
	19	18.3	8.3	-	0
	20	19.4	5	5.84	0
	21	18.9	0.6	4.06	0
	22	20	5.6	1.52	0
	23	19.4	8.9	5.84	0
	24	22.8	11.1	1.78	0
	25	25.6	5	3.30	0
	26	23.9	2.8	0.51	0
	27	23.9	2.8	-	0
	28	24.4	3.3	6.35	0
	29	20.6	7.8	2.29	0
	30	17.2	3.9	2.54	0
	31	20	2.8	2.54	0
Total		23.1	7.8	106.17	50.04

Table 3.

College Observatory
Lat. 64° 52'
Long. 147° 50'
Elev. 621 m

1978

Macroclimate

Date	Temperature (C°) max	min	Precipitation (mm)
June 1	22.2	7.8	3.05
2	12.2	3.3	3.81
3	16.1	3.3	0.51
4	19.4	3.3	0.25
5	21.7	6.7	0
6	18.9	8.3	0.51
7	14.4	4.4	0.51
8	15.5	2.8	0
9	21.7	8.3	0
10	23.3	10.5	0
11	23.9	9.4	5.08
12	23.9	10.5	3.05
13	20.6	9.4	4.06
14	16.7	5.6	1.52
15	21.7	7.8	4.32
16	18.3	4.4	0
17	11.6	5	3.05
18	17.8	3.3	0.51
19	18.9	7.2	0
20	13.9	6.1	2.29
21	17.8	2.8	2.54
22	20	8.9	1.52
23	21.7	7.8	0
24	13.3	5.6	1.02
25	16.1	5.6	1.52
26	17.2	8.3	2.03
27	16.1	8.3	0.25
28	16.7	7.8	0.51
29	17.8	8.9	0
30	17.8	10	0
Total	18.4	6.6	
July 1	15	6.7	2.29
2	19.4	5.6	0.25
3	22.2	9.4	0.51
4	26.1	11.1	0
5	25.6	11.6	0
6	28.3	12.8	2.79
7	25	12.8	0.51
8	19.4	10	1.52
9	26.1	11.6	0
10	26.7	12.8	0
11	27.2	10.5	0.51
12	30	15	5.08
13	19.4	12.8	8.89
14	22.2	11.1	0.76
15	24.4	8.9	t
16	22.8	7.2	t
17	23.3	10	0.25
18	23.9	11.1	0
19	26.7	9.4	t
20	24.4	11.1	1.27

Date	Temperature (C°) max	min	Precipitation (mm)
July 21	19.4	8.3	0.25
22	20	9.4	2.54
23	19.4	7.8	0
24	23.9	8.3	0
25	25.6	9.4	11.94
26	22.8	10	1.52
27	21.1	11.1	0
28	25	7.2	0
29	26.1	7.8	0
30	28.3	10	0
31	28.3	10	0
Total	23.8	10.1	40.89
Aug. 1	30.6	12.2	0
2	25	11.1	3.05
3	23.9	7.2	0
4	27.2	8.3	0
5	28.3	12.2	0.76
6	23.9	13.9	4.32
7	21.1	7.2	0
8	22.8	10	0
9	26.7	12.8	0
10	27.8	11.1	5.08
11	26.1	8.9	t
12	25.6	8.3	0
13	25.6	11.1	4.32
14	21.1	10.5	0
15	20	11.1	1.78
16	20.6	8.9	t
17	21.7	6.7	0
18	22.8	2.8	0
19	22.8	3.3	0
20	25	10.5	1.02
21	14.4	8.3	8.38
22	11.1	8.9	1.27
23	12.8	8.3	t
24	12.8	2.8	0.51
25	18.9	0	t
26	19.4	4.4	0
27	19.4	5.6	0
28	23.3	5	0
29	23.9	3.9	0
30	22.8	6.1	0
31	22.2	6.7	0
Total	22.2	8	30.48

Macroclimate

Date	Temperature (C°) max	min	Precipitation (mm)
June 1	16.7	3.3	0.76
2	21.1	8.3	0
3	21.1	7.8	0
4	25	9.4	t
5	22.2	7.2	4.32
6	20	5.6	0
7	22.2	4.4	0
8	21.7	5.6	0
9	25.6	6.1	0
10	23.9	8.9	0
11	26.1	8.3	0
12	23.9	11.1	t
13	16.1	11.1	20.57
14	16.1	11.1	4.32
15	22.8	11.6	13.72
16	21.1	10.5	6.35
17	24.4	11.1	0.25
18	23.9	11.1	3.56
19	13.9	7.2	12.95
20	20	7.8	t
21	23.9	8.3	1.27
22	21.1	10.5	0.76
23	22.2	8.9	6.86
24	22.8	10.5	0
25	16.7	9.4	0
26	22.2	9.4	0
27	21.1	7.8	2.79
28	21.7	8.3	1.78
29	19.4	3.9	1.02
30	22.2	5.6	0
Total	21.4	8.3	84.07
July 1	22.8	8.3	0
2	18.9	7.2	0
3	16.7	3.3	0
4	18.3	7.2	1.27
5	16.7	6.1	0.51
6	22.2	6.7	0
7	25.6	10	0
8	27.2	16.7	0
9	28.8	8.3	0.25
10	26.1	10	0
11	27.2	12.2	0
12	29.4	11.6	0
13	27.8	9.4	0
14	24.4	8.9	0
15	23.9	10	0.51
16	22.2	6.7	4.57
17	20.6	7.2	1.78
18	25	9.4	0.51
19	22.8	6.1	0
20	20	7.8	0.25

Date	Temperature (C°) max	min	Precipitation (mm)
July 21	21.7	7.2	0
22	22.8	11.6	9.40
23	17.8	11.1	t
24	23.3	7.8	1.78
25	25	8.3	0
26	25.6	8.3	0
27	26.7	13.3	t
28	27.8	8.3	0
29	27.8	10	0
30	31.7	12.2	0
31	32.2	13.9	0.51
Total	24.2	9.3	21.34
Aug. 1	30.6	12.8	1.02
2	25	13.9	0
3	26.1	8.9	0
4	30	11.6	0
5	32.2	13.3	0
6	22.2	11.6	4.32
7	21.1	7.2	t
8	26.7	14.4	0
9	28.8	16.7	t
10	25	12.8	0
11	29.4	13.3	2.54
12	22.2	7.2	0
13	25.6	13.3	0
14	28.3	13.3	0
15	30	15.5	0.25
16	22.2	7.2	t
17	23.9	10	0
18	21.7	12.8	0
19	27.8	9.4	0
20	25.6	10.5	0
21	28.3	12.2	0
22	31.7	15	0
23	30	10.5	0
24	25	6.7	0
25	23.9	6.7	t
26	19.4	7.2	1.02
27	16.1	2.2	4.32
28	17.2	-1.7	t
29	14.4	4.4	0.25
30	12.8	7.8	1.02
31	18.9	2.8	t
Total	24.6	10.1	14.73

Table 3.

College Observatory
Lat. 64°52'
Long. 147°50'
Elev. 621 m

1976

Macroclimate

Date		Temperature (C°) max	min	Precipitation (mm)
June	1	20	3.9	0
	2	23.3	6.3	0
	3	23.3	10	0
	4	21.7	7.8	2.54
	5	23.9	5.6	0
	6	25	8.3	0.25
	7	16.7	3.3	1.52
	8	16.7	3.3	0
	9	18.3	8.9	0.76
	10	18.9	8.9	0
	11	24.4	8.3	0
	12	23.3	7.2	0
	13	25	7.2	0
	14	26.7	6.7	0
	15	28.3	7.2	0
	16	28.3	10	0
	17	25.6	11.6	0
	18	20.6	8.3	11.68
	19	16.1	8.3	t
	20	20.6	5	t
	21	21.7	8.9	0
	22	22.2	8.9	0
	23	18.9	9.4	t
	24	14.4	8.9	t
	25	18.9	9.4	4.83
	26	17.8	7.8	0
	27	25	11.1	0
	28	26.7	13.9	0
	29	21.1	10	8.38
	30	19.4	8.9	3.56
Total		21.8	8	33.53
July	1	20	7.8	t
	2	17.8	8.9	6.35
	3	19.4	9.4	t
	4	21.1	8.3	2.03
	5	14.4	7.2	1.27
	6	15	6.1	t
	7	25	11.1	0
	8	26.1	12.2	0.25
	9	22.8	8.9	0.25
	10	22.2	7.2	0
	11	25.6	10.5	0
	12	27.8	11.6	0
	13	26.1	9.4	0
	14	26.1	9.4	0
	15	23.9	10	0
	16	23.3	11.1	0.51
	17	22.8	6.7	1.02
	18	20.6	9.4	3.05
	19	22.8	7.2	0
	20	25	10.5	0

Date		Temperature (C°) max	min	Precipitation (mm)
July	21	28.3	7.2	0
	22	30.6	11.6	0
	23	30	11.1	0
	24	28.8	11.1	0
	25	23.3	12.8	9.91
	26	18.9	11.1	t
	27	20.6	10.5	4.83
	28	23.9	8.9	0
	29	25	10.5	0
	30	31.1	13.9	0
	31	20	3.9	0
Total		23.6	9.6	29.46
Aug.	1	31.1	14.4	0
	2	32.2	13.9	0
	3	23.9	11.6	0
	4	23.3	14.4	0
	5	25	8.3	0
	6	27.2	9.4	0
	7	29.4	13.9	0
	8	17.8	10.5	7.11
	9	21.7	8.9	0
	10	21.7	8.9	0
	11	25	7.8	0
	12	23.9	12.8	1.27
	13	21.1	7.2	7.37
	14	23.3	11.6	0
	15	25	11.6	0
	16	19.4	9.4	0
	17	18.3	6.7	2.03
	18	18.3	7.2	0
	19	18.9	8.9	0.25
	20	18.3	4.4	0
	21	18.9	1.7	0
	22	18.9	3.9	0
	23	24.4	5.6	0
	24	24.4	8.9	0
	25	26.7	7.8	0
	26	25	3.9	0
	27	25	3.3	0
	28	23.9	3.9	0
	29	21.1	8.3	0
	30	20	4.4	0
	31	20	3.9	0
Total		22.9	8.3	18.03

Circle City

Table 3.

Macroclimate

1978

Date	Temperature (°C) max	min	Precipitation (mm)
June 1	-	-	0
2	-	-	0
3	-	-	0
4	-	-	0
5	-	-	0
6	-	-	0
7	16.1	8.9	0
8	15	4.4	0
9	18.9	1.7	0
10	22.8	2.8	0
11	23.9	11.1	0
12	22.8	8.9	0
13	18.9	8.9	0
14	-	-	0
15	24.4	8.3	1.27
16	20	5.6	0
17	-	-	0
18	-	-	0
19	-	-	6.10
20	17.8	5.0	t
21	-	-	0
22	20	8.9	6.10
23	21.1	9.4	5.59
24	15	6.1	3.30
25	-	-	0
26	17.8	9.4	1.02
27	13.9	8.9	3.81
28	12.8	2.2	13.21
29	17.2	9.4	.51
Total 30	17.2	8.3	.51 → 41.4
July 1	20.6	9.4	9.14
2	21.7	9.4	2.03
3	20.6	8.9	0
4	22.2	10.5	0
5	26.1	10.5	0
6	27.2	15.5	0
7	23.9	13.9	4.83
8	22.8	10.5	.76
9	28.3	11.1	.51
10	28.9	7.8	0
11	27.8	13.9	0
12	28.3	10.5	0
13	26.7	13.9	0
14	26.7	10	0
15	22.2	8.3	0
16	19.4	5	.25
17	26.7	4.4	0
18	27.2	9.4	0
19	26.7	6.7	0
20	23.9	12.2	.51
21	21.1	10	0
22	22.2	11.1	1.78
23	19.4	6.7	0
July 24	22.8	5.6	0
25	26.7	8.3	0
26	22.2	11.1	0
27	23.3	7.8	0
28	26.1	8.9	0
29	27.8	9.4	0
30	28.3	12.8	0
31	26.7	7.8	
Total	24.7	9.7	19.8
Aug 1	31.1	11.1	5.59
2	26.7	11.6	0
3	21.7	7.8	0
4	26.7	7.8	0
5	28.8		0
6		12.8	7.11
7	20.6	8.3	4.83
8	16.1	8.3	5.84
9	21.7	4.4	0
10	24.4	2.8	0
11	20.6	1.1	0
12	21.7	0.6	0
13	26.1	10.5	0
14	22.2	10	5.59
15	16.1	2.2	9.40
16	-	-	0
17	-	-	0
18	-	-	0
19	-	-	0
20	-	-	0
21	17.2	8.3	5.08
22	16.7	8.3	1.27
23	16.7	8.9	0
24	14.4	-0.6	0
25	10.5	-1.7	0
26	20.6	6.9	0
27	-	-	0
28	-	-	0
29	22.8	1.1	0
30	-	-	0
31	23.9	2.8	.51
Total	21.4	6.1	45.21

Gilmore Creek
Lat. 64°59'
Long. 147°31'
Elev. 959 m

Table 3.

1978

Macroclimate

Date	Temperature (C°) max	min	Precipitation (mm)
June 1	21.1	6.1	.51
2	12.8	6.7	5.33
3	16.1	0.6	0
4	18.3	1.1	0
5	19.4	1.1	.76
6	17.2	6.7	1.02
7	12.8	1.1	t
8	13.9	0.6	0
9	20	1.1	0
10	22.2	7.8	0
11	22.8	7.2	0
12	22.2	8.9	.25
13	20.6	6.7	.76
14	18.9	3.9	0
15	21.1	6.7	0
16	16.7	0	0
17	10.5	5	7.62
18	16.7	0	0
19	17.2	3.3	4.06
20	12.8	0	1.02
21	16.1	0	0
22	18.9	6.1	1.78
23	18.3	3.9	8.89
24	11.6	4.4	3.30
25	14.4	3.3	0
26	16.1	7.2	1.52
27	14.4	7.2	5.84
28	13.9	3.9	5.84
29	15.5	6.1	.76
30	16.1	7.2	0
Total	16.9	4	50.8
July 1	15	2.8	0
2	17.8	3.3	0
3	20.6	6.1	t
4	23.9	6.7	0
5	24.4	8.3	0
6	27.8	12.2	0
7	27.8	12.2	t
8	20.6	6.7	0
9	23.9	8.3	0
10	21.7	8.3	0
11	25	7.2	0
12	28.3	11.6	1.52
13	20.6	14.4	t
14	21.1	6.7	23.62
15	23.3	5.6	8.38
16	21.7	2.8	0
17	22.2	6.1	t
18	21.7	6.1	0
19	24.4	6.1	0
20	23.9	10	0
21	17.2	2.8	1.78
July 22	19.4	7.8	0
23	18.9	3.9	2.03
24	22.2	3.9	0
25	23.9	5.6	1.02
26	22.2	7.2	4.06
27	20.6	5.6	0
28	22.2	5	4.32
29	21.7	4.4	0
30	26.1	6.7	0
31	26.1	7.2	0
Total	22.4	6.8	46.74
Aug. 1	28.8	8.3	0
2	23.3	8.9	2.29
3	21.7	3.9	0
4	25	4.4	0
5	25.6	6.7	.25
6	23.3	9.4	1.52
7	22.8	2.2	0
8	21.1	5.6	0
9	27.2	7.8	0
10	25	9.4	0
11	23.9	3.3	0
12	25	4.4	0
13	25.6	8.9	0
14	22.2	7.2	0
15	18.3	8.3	5.08
16	17.8	5.6	1.27
17	20.6	1.1	0
18	21.1	-0.6	0
19	23.3	0.6	0
20	23.9	7.8	2.54
21	12.8	4.4	16.0
22	10	6.7	4.83
23	11.6	5.6	.25
24	11.6	0.6	1.02
25	17.8	-2.7	0
26	17.8	1.7	0
27	17.2	1.1	0
28	21.7	1.1	0
29	22.8	1.1	0
30	23.3	2.8	0
31	20.6	2.8	0
Total	21.1	4.4	35.05

Gilmore Creek
Lat. 64°59'
Long. 147°31'
Elev. 959 m

Table 3.

1977

Macroclimate

Date	Temperature (C°) max	min	Precipitation (mm)
June 1	15	-1.1	1.27
2	17.2	5.6	0
3	18.9	5.6	0
4	20	4.4	0
5	18.9	5.6	10.16
6	20.6	0	0
7	20.6	0	t
8	20.6	0	0
9	23.9	1.1	0
10	22.8	3.3	0
11	21.1	3.3	0
12	22.2	5	20.83
13	15	5.6	21.59
14	16.1	5.6	.76
15	22.2	8.3	1.27
16	20	7.2	1.27
17	22.8	4.4	0
18	20.6	5	5.08
19	10	3.9	17.02
20	17.2	1.7	0
21	21.7	5	0
22	21.1	7.2	.76
23	20	2.2	3.05
24	21.1	2.8	0
25	12.2	5	t
26	15.5	3.9	2.54
27	19.4	2.8	.51
28	19.4	5	2.54
29	17.2	-2.2	t
30	20	-0.6	0
Total	19.1	3.6	88.65
July 1	21.1	2.8	0
2	16.1	3.9	0
3	12.2	2.2	0
4	16.1	3.9	12.7
5	17.8	1.7	10.16
6	20.6	1.1	0
7	23.9	5.6	0
8	25.6	4.4	0
9	27.8	3.9	0
10	27.2	3.3	0
11	27.2	-	0
12	26.7	2.2	0
13	24.4	3.3	0
14	22.2	1.1	0
15	22.8	3.9	t
16	20.6	1.7	3.30
17	20.6	1.7	0
18	22.8	2.8	1.27
19	20.6	0.6	3.30
20	20.6	0.6	3.30
21	20	3.9	2.79

Date	Temperature (C°) max	min	Precipitation (mm)
July 22	21.7	11.1	t
23	21.7	7.8	2.54
24	21.7	5.6	13.72
25	22.8	5.6	1.27
26	25.6	5.6	t
27	26.1	7.8	0
28	26.1	5.6	0
29	26.1	7.2	0
30	30	10.5	0
31	30	10	5.08
Total	22.8	1.1	59.44
Aug. 1	31.7	9.4	0
2	31.7	8.3	0
3	24.4	5.6	0
4	27.2	8.9	0
5	31.1	9.4	0
6	19.4	10.5	16.51
7	19.4	3.9	0
8	26.1	11.6	4.57
9	27.8	12.8	t
10	27.8	12.8	t
11	27.8	10.5	.76
12	21.7	5.6	0
13	23.9	4.4	0
14	27.2	8.3	0
15	27.8	12.8	1.78
16	20	5.0	.51
17	22.8	-	0
18	24.4	11.6	0
19	24.4	6.7	0
20	24.4	7.2	0
21	28.3	8.3	0
22	31.7	8.9	0
23	27.2	3.3	0
24	21.7	1.1	0
25	21.1	5.6	t
26	18.3	5	1.27
27	15	-1.7	0
28	15.5	-4.4	0
29	15.5	3.3	.51
30	16.7	1.7	3.81
31	17.8	1.7	t
Total	23.9	6.6	29.72

Gilmore Creek
Lat. 64° 59'
Long. 47° 31'
Elev. 959m

Table 3.

Macroclimate

1976

Date	Temperature (°C) max	min	Precipitation (mm)
June 1	17.2	0	0
2	20.6	3.9	0
3	21.1	4.4	0
4	20	2.8	0
5	22.2	1.7	0
6	24.4	6.7	.78
7	12.2	0	1.27
8	13.9	2.2	0
9	15.5	3.3	0
10	15.5	3.3	0
11	21.1	4.4	0
12	21.1	-0.6	1.52
13	23.3	1.7	0
14	24.4	2.8	0
15	25.6	3.3	0
16	25.6	6.7	0
17	25	6.7	0
18	16.1	4.4	1.52
19	15	5.6	.25
20	18.3	-0.6	0
21	18.9	4.4	0
22	19.4	1.7	0
23	16.1	4.4	0
24	11.6	5.6	0
25	15.5	5	5.08
26	20	2.2	0
27	16.7	6.7	0
28	23.9	10	0
29	18.3	6.7	11.43
30	17.2	6.1	5.08
Total	19.2	3.8	26.92
July 1	17.2	4.4	t
2	14.4	6.7	7.37
3	20	8.9	.51
4	20	5.6	1.52
5	11.1	5.6	2.79
6	13.9	2.8	.25
7	23.3	5	t
8	23.9	5.6	0
9	20.6	3.9	0
10	16.7	2.8	0
11	23.9	5.6	0
12	23.9	8.3	0
13	22.8	3.9	0
14	22.8	3.9	0
15	20.6	7.2	19.81
16	18.3	7.8	4.32
17	20.6	3.3	16.5
18	20	4.4	3.30
19	19.4	3.9	12.19
20	22.8	5.6	0
21	25.6	3.3	0
22	27.8	6.7	0

Date	Temperature (°C) max	min	Precipitation (mm)
July 23	28.3	5.6	0
24	26.7	6.1	7.11
25	21.7	10.5	9.91
26	16.7	6.1	t
27	17.2	8.3	4.83
28	21.7	5	0
29	22.8	6.7	0
30	28.3	11.6	0
31	20	0.6	0
Total	21.1	5.6	90.17
Aug 1	25	6.1	0
2	29.4	8.3	0
3	22.8	7.8	12.96
4	20	11.6	1.27
5	21.7	3.9	0
6	23.9	5.6	0
7	27.8	8.3	0
8	17.8	9.4	12.45
9	19.4	4.4	0
10	19.4	5.6	0
11	22.2	3.9	0
12	20	8.9	7.37
13	20	3.9	0
14	22.2	4.4	0
15	23.9	7.2	t
16	17.2	5.6	0
17	16.7	5	6.10
18	15	4.4	0
19	17.2	4.4	1.27
20	15	-0.6	t
21	17.2	0	0
22	18.3	0	0
23	17.8	2.2	0
24	21.1	3.3	0
25	23.9	2.2	0
26	22.2	-0.6	0
27	22.8	-1.1	0
28	22.8	-1.1	0
29	20	3.3	t
30	17.8	-0.6	t
31	16.7	2.2	0
Total	20.6	4.2	41.4

Central 2
Lat. 65°34'
Long. 144°49'
Elev. 960 m

Table 3.

Macroclimate

1978

Date	Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June 1	18.9	3.9	-	t
2	15.5	5	-	0
3	18.3	3.3	-	0
4	20.6	3.9	1.27	0
5	21.7	6.7	3.81	0
6	21.7	6.7	4.83	0
7	16.7	5.6	2.79	0
8	14.4	5	2.54	0
9	22.2	5	3.56	0
10	22.2	1.7	3.81	0
11	22.8	11.1	4.57	0
12	21.7	6.7	2.54	0.76
13	21.1	9.4	2.79	13.46
14	20	4.4	1.02	2.29
15	22.2	9.4	-	0
16	21.1	3.3	5.08	0
17	14.4	7.2	0.76	4.83
18	18.3	7.2	1.78	0.51
19	16.1	7.2	3.81	0
20	17.2	6.7	6.10	0
21	18.3	4.4	1.52	0
22	20	9.4	5.84	4.06
23	20	8.9	1.52	1.78
24	14.4	6.1	1.52	0.51
25	16.7	5	1.52	2.79
26	15	4.4	0.25	3.81
27	15	4.4	1.02	7.11
28	16.7	5	2.54	2.54
29	16.7	6.1	3.56	0.76
30	18.3	7.2	0.76	0
Total	18.6	6	82.04	45.21
July 1	18.9	8.3	2.03	2.79
2	20	8.3	1.02	4.57
3	21.1	6.1	3.30	0.25
4	23.9	10	0.76	0
5	27.2	11.1	0.76	0
6	29.9	16.1	5.08	0
7	21.7	12.8	0.25	2.03
8	26.1	11.1	3.05	0
9	26.7	11.1	1.52	1.52
10	27.2	12.8	3.81	0
11	26.7	12.2	4.06	0
12	26.7	10.5	5.08	0
13	23.9	13.9	6.10	0
14	23.9	13.3	1.78	0.25
15	22.2	7.2	5.33	0
16	20	5.6	2.54	0.76
17	23.9	6.7	3.56	0
18	22.2	9.4	3.81	0.25
19	24.4	6.7	1.52	0
20	21.1	12.2	2.54	0.25
July 21	19.4	5.6	2.54	0
22	20	9.4	3.30	1.78
23	21.7	9.4	2.79	1.02
24	22.2	3.9	2.03	0
25	25	10	3.56	0
26	21.7	6.1	0.76	0
27	22.8	12.2	3.81	0
28	25.6	9.4	3.81	0.51
29	26.7	6.1	5.33	0
30	26.7	6.1	3.30	0
31	27.8	8.3	3.81	0
Total	23.8	9.4	92.96	16.0
Aug. 1	29.4	13.3	5.84	0
2	26.1	11.1	2.54	9.40
3	24.4	7.2	3.56	0
4	26.1	8.9	2.54	0
5	27.2	12.8	4.83	1.02
6	21.7	10.5	3.81	20.32
7	18.9	8.3	1.02	7.62
8	16.7	7.2	2.03	2.03
9	20.6	7.2	0	0
10	21.7	4.4	3.56	0
11	18.9	3.9	3.56	0
12	18.3	0.6	4.06	0
13	23.9	11.1	2.03	0.76
14	21.1	8.3	-	8.13
15	15	6.1	2.79	20.07
16	15.5	6.1	2.79	0
17	17.2	5	3.81	0
18	18.3	-1.1	1.52	0
19	22.2	0	2.29	0
20	21.1	6.1	2.03	0
21	19.4	8.3	3.05	5.59
22	16.7	7.8	3.56	0
23	17.2	8.3	3.30	1.02
24	17.2	3.3	2.54	0
25	16.1	-2.2	5.59	0
26	20	3.9	1.02	0
27	21.7	3.3	2.79	0
28	22.2	-4.4	1.52	0
29	22.2	1.7	0.25	0
30	23.9	3.9	1.78	0
31	21.7	5	1.27	0
Total	20.7	5.6	83.57	75.95

Central 2
Lat. 65°34'
Long. 144°49'
Elev. 960 m

Table 3.

Macroclimate

1977

Date	Temperature (C°) max	min	Evap. (mm)	PPT (mm)	Date	Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June 1	19.4	2.8	6.35	2.03	July 21	21.7	9.4	4.83	2.29
2	18.9	3.9	0.51	0	22	21.7	10	2.29	0.25
3	20	7.8	1.78	0.76	23	20	8.9	1.78	0.25
4	21.1	8.3	3.81	1.27	24	21.7	7.8	2.29	3.56
5	22.8	6.7	4.32	1.27	25	22.8	6.7	1.27	0
6	21.1	6.7	3.81	0	26	22.8	5.6	3.81	0
7	22.2	5.6	4.32	0.51	27	25.6	8.9	5.33	0
8	20	6.1	3.81	0	28	28.3	13.9	5.59	0
9	23.3	6.1	4.57	3.30	29	28.3	8.9	3.81	0
10	23.9	10	3.30	0	30	30.6	12.2	6.10	0
11	23.9	8.3	3.30	0	31	30	13.3	5.08	0
12	22.8	11.1	3.81	3.81	Total	22.6	7.6	112.52	43.43
13	20	3.9	1.27	0	Aug. 1	28.8	12.8	-	0
14	21.1	9.4	3.81	3.81	2	27.2	7.8	4.32	0
15	22.8	11.1	5.08	20.83	3	27.2	8.3	4.57	0
16	21.8	10	2.54	1.27	4	28.8	9.4	2.54	0
17	24.4	7.8	2.03	1.02	5	31.1	11.6	7.11	0
18	23.3	9.4	1.78	0.51	6	29.4	10	2.29	0
19	19.4	6.1	3.81	1.52	7	21.7	6.7	3.81	0
20	20.6	7.8	2.79	0	8	23.9	10	3.05	0
21	22.2	6.7	2.29	0.25	9	26.1	14.4	3.81	0
22	20	6.1	2.29	5.08	10	28.3	11.1	2.03	0
23	20.6	11.6	3.81	4.57	11	28.8	13.3	1.27	9.65
24	22.2	8.9	1.52	4.06	12	19.4	7.8	0.25	3.81
25	15.5	8.9	2.29	10.16	13	21.7	6.1	2.79	0
26	17.8	8.9	5.08	0.51	14	25.6	8.3	1.27	0
27	19.4	6.1	2.79	3.30	15	27.8	8.9	3.30	1.02
28	19.4	6.7	3.30	0	16	22.2	7.2	3.81	0
29	16.1	0	3.05	0	17	23.3	7.8	3.81	0
30	18.9	3.3	2.03	0	18	24.4	11.6	0.51	0.51
Total	20.8	7.2	95.50	67.82	19	25.6	8.9	2.29	0
July 1	20	8.9	3.30	3.05	20	22.2	9.4	3.56	0
2	13.3	1.1	-	3.30	21	24.4	8.9	0.51	0
3	12.8	1.7	3.30	0	22	26.1	8.9	3.81	0
4	16.1	1.7	3.81	1.02	23	23.3	11.1	0.51	0
5	21.1	3.3	1.27	2.54	24	19.4	6.1	4.57	0
6	23.9	3.3	2.29	0.25	25	18.3	1.1	2.79	0
7	25	10.5	3.81	0	26	15.5	6.1	0	5.84
8	26.1	-	3.81	0	27	10.5	1.7	0.25	3.81
9	26.7	10	3.81	0	28	13.3	-5.5	-	0
10	22.8	8.3	7.62	0	29	15.5	0.6	1.27	0
11	23.9	10	5.84	0	30	13.9	7.2	2.29	2.29
12	24.4	7.2	5.08	0	31	21.7	-1.1	2.29	0
13	22.2	3.3	5.84	0	Total	23.1	7.6	77.22	26.92
14	20	4.4	5.08	0					
15	23.3	7.2	3.81	0					
16	22.2	9.4	1.78	1.78					
17	23.9	5.6	3.81	0					
18	22.8	10	3.56	14.73					
19	16.7	6.1	-	10.41					
20	18.3	8.9	2.54	0					

Table 3.

Central 2
Lat. 65°34'
Long. 144°49'
Elev. 960 m

1976

Macroclimate

Date	Temperature (C°) max	min	Evap. (mm)	PPT (mm)
June 1	20	2.8	3.81	0
2	19.4	4.4	3.56	3.56
3	20	5.6	4.57	0.25
4	18.9	2.2	3.30	0
5	23.3	2.2	4.06	0
6	25	6.1	5.33	0.76
7	16.7	0.6	3.30	0
8	17.2	7.2	3.56	0
9	16.7	6.7	1.27	2.03
10	17.8	0.6	2.03	0
11	21.1	1.1	7.11	0
12	19.4	2.8	3.81	0
13	21.7	1.7	3.56	0
14	25.6	5	6.35	0
15	26.7	6.7	4.57	0
16	25.6	10	3.81	1.27
17	23.3	4.4	2.54	2.54
18	19.4	7.8	4.57	0.51
19	17.2	9.4	0.76	0
20	21.1	5	3.56	0
21	22.2	5	8.38	3.81
22	21.7	4.4	7.11	0
23	17.8	3.9	3.56	0
24	18.9	1.1	2.79	0
25	17.8	10	5.08	0
26	22.2	8.9	3.81	0
27	24.4	10	4.06	0
28	25	8.9	6.10	0
29	20.6	5.6	-	2.79
30	16.1	7.8	4.06	5.33
Total	20.8	5.3	124.66	22.86
July 1	19.4	6.1	3.81	0.25
2	18.2	9.4	1.52	0
3	18.9	6.7	2.03	2.03
4	19.4	6.7	2.03	1.52
5	15.5	3.3	1.52	0
6	18.3	3.9	2.83	0
7	24.4	3.9	3.56	0
8	25	9.4	2.79	0.76
9	22.2	8.3	3.05	2.79
10	19.4	3.9	6.86	6.10
11	21.7	6.1	2.03	2.03
12	22.8	3.9	3.56	0
13	23.3	8.3	6.60	0
14	22.8	6.1	3.30	0
15	21.7	11.6	3.05	1.27
16	-	11.1	3.05	0.51
17	20.6	6.7	1.27	0.51
18	20	11.1	4.57	0
19	23.9	7.2	3.56	4.06
20	23.9	5.6	4.06	0

Date	Temperature (C°) max	min	Evap. (mm)	PPT (mm)
July 21	28.3	8.9	4.83	0
22	28.8	11.1	3.81	1.52
23	28.3	6.7	5.08	0.76
24	28.3	7.2	3.81	0
25	27.8	11.1	7.37	4.06
26	21.1	10	1.78	1.78
27	22.2	9.4	2.54	0.51
28	24.4	6.1	2.54	0
29	27.8	7.2	4.83	0
30	29.4	16.7	3.30	0
31	22.2	7.2	4.83	0
Total	23.0	7.8	108.97	55.88
Aug. 1	23.3	5.6	3.05	0
2	26.7	14.4	4.32	0
3	27.8	13.3	1.78	2.54
4	27.8	15	2.79	7.11
5	27.8	9.4	1.78	2.79
6	27.8	8.9	1.52	0
7	27.2	8.3	3.56	2.79
8	22.8	11.6	0.51	1.27
9	19.4	7.2	2.29	3.56
10	20	7.8	0	0
11	21.1	7.2	2.79	5.59
12	21.7	11.6	0.76	3.30
13	16.1	8.9	4.06	0
14	20.6	4.4	0.25	0
15	21.7	5	1.52	1.78
16	18.9	6.7	2.03	11.94
17	18.9	8.3	1.78	0
18	18.3	5.6	1.27	15.24
19	18.3	7.2	0.76	0
20	10	5	0.76	0
21	17.2	0	1.78	0
22	18.9	3.9	1.02	0
23	20.6	6.1	0	0
24	22.8	7.8	1.27	0
25	23.9	3.3	2.54	0
26	23.9	1.7	3.81	0
27	22.8	1.1	3.05	0
28	21.1	1.7	2.03	0
29	21.7	2.2	-	0
30	15.5	6.7	10.67	0
31	21.1	5	0.51	0
Total	21.4	7	64.26	56.64

Table 3.

CAPE THOMPSON, AK. 1977
TEMPERATURES °C

DATE	MAX	MIN	Remarks
9 JULY	25	13	
10	26	-	
11	27	-	
12	28	7	
13	27	22	
14	19	11	
15	15	8	
16	11	5	
17	11	4	
18	20	4	
19	20	7	
20	-	6	
21	22	-	
22	26	15	
23	22	14	
24	24	8	
25	27	12	
26		14	
27	17	10	
28	16	14	
29	22	10	
30	22	14	
31 JULY	27	12	
1 AUGUST	20	13	
2	15	11	
3	19	12	
4	20	15	
5	20	11	
6	17	~~12~~ 8	
7	17	9	Strong N winds
8	13	-	Strong N winds
9	21	9	foggy
10		9	foggy
11	21		foggy
12	18	8	
13	22	11	
14	18	13	
15	-	12	
16	15	-	

Table 3.

	Max	Min	
17 August	18	13	strong S winds
18	–	15	strong S winds
19	17	16	
20	20	16	
21	20	17	
22	16	13	
23	17	11	
24	13	9	
25	11	7	
26 August	–	1	

[1] quite incomplete.

successfully in other soils. However, several problems were encountered. In extracting the nearly saturated soils, the extraction solution becomes diluted. This dilution changes the water potential of the extracted solution, making it different from that of the reference solution. The difference in water potential changes the calibration of the ammonium electrode. Once the problems in calibration had been isolated and clarified, measurements of soil ammonium continued. The measurements in 1978, completed on samples which were extracted within 24 hours, indicated considerably lower soil ammonium than previous measurements (Barkley and Kellogg ms. this Progress Report). Immediate extraction, rather than storage by drying or freezing, seems critical.

Measurements were completed to indicate the vertical and horizontal variability of soil nitrogen in tussocks, which occurs with different degrees of invasion by other species, and the variation in different montane tundra types. The results indicate considerable variability, therefore, sample size must be carefully considered in interpreting soils data.

Litter bags to estimate rates of decomposition were set out in the tussock site, at the snow patch site in the upper deciduous shrub, lower deciduous shrub, and sedge-moss zones, and on the north-facing slope near Berry Camp in hummocky tundra. The hemicellulose, cellulose and lignin content of the green litter was analyzed for the initial conditions (Table 4a & b) and in late August after being in place for 6 weeks (Table 5). The litter changed little during this period except that the lignin content of E. vaginatum litter increased from 6.75% for green, undecomposed material to 9-13% after 6 weeks. It is assumed that its increase resulted from the initial loss of leachable cell contents. It is anticipated that decomposition

Table 4a.

Hemicellulose, cellulose and lignin content of fresh material from Eagle Summit, Alaska

Species	Sample No.	Hemicellulose (%)	Lignin (%)	Cellulose (%)
Betula nana (leaves)	1	9.15	4.95	14.86
	3	8.62	4.60	15.23
		*8.89 (0.19)	*4.78 (0.18)	*15.05 (0.19)
Betula nana (twigs)	5	13.69	25.49	27.69
	6	13.44	24.18	30.43
	7	15.77	23.53	28.34
	8	13.40	23.95	28.79
		*14.06 (0.57)	*24.25 (0.42)	*28.81 (0.59)
Cassiope tetragona (leaves)	9	9.04	10.49	18.07
	10	8.78	10.15	18.01
	11	11.78	8.49	16.79
	12	9.35	10.38	16.98
		*9.74 (0.69)	*9.88 (0.47)	*17.46 (0.34)
Carex biglowii (leaves)	13	36.44	4.99	23.64
	14	38.68	3.93	23.97
	15	36.05	5.12	23.39
	16	37.39	4.54	23.32
		*37.14 (0.59)	*3.65 (0.092)	*23.58 (0.15)
Eriophorum vaginatum (leaves)	17	42.94	6.36	24.61
	18	40.19	7.10	25.47
	19	41.77	6.78	24.90
	20			
		*41.63 (0.69)	*6.75 (0.19)	*24.99 (0.22)
Eriophorum vaginatum (dead) leaves)	21	31.72	8.37	33.02
	22	32.01	7.86	34.58
	23	33.24	7.62	34.62
		*32.32 (0.40)	*7.95 (0.19)	*34.07 (0.46)

*Mean:
()Standard error of the mean.

Table 4b.

Litter BAg Study at Eagle Summit (1978 bags)

	# of Bags	Harvest Schedule Aug 78	June 79	Aug 79	June 80
Tussock site	32* green	8**	8	8	8
Tussock site	32 standing dead	8	8	8	8
NPK 25 Tussock site	8	2	2	2	2
(E. vaginatum-willow)					
Moss-Carex, site	24	6	6	6	6
(Carex biglowii)					
Campsite site	24 green	6	6	6	6
(E. vaginatum)					
Upper Deciduous Shrub (Cassiope tetragona)	24 green	6	6	6	6
Lower Decid. Shrub	16 leaves	4	4	4	4
(Betula nana)	16 twigs	4	4	4	4
Vehicle Track (Center and Side) (E. vaginatum)	24	8	8	8	-

(Lee Stuart) Left her #177 thru #200 for her litter bags)

* 16 below and 16 above ground
** 4 below and 4 above ground

TOTAL	200	52	52	52	44

Table 5.

Hemicellulose, lignin and Cellulose Content of Fresh Material From Eagle Summit, Alaska

Species	Litter bag No.	Plot & Depth	% Hemicellulose	Lignin	Cellulose
E. vaginatum	#4 green litter	Class 3 Tussock-0cm	43.83	3.78	27.55
"	"	"	44.60	3.07	27.57
E. vaginatum	#7 green litter	Class 4 Tussock-0cm	39.72	8.48	28.37
"	"	"	38.45	9.36	28.77
E. vaginatum	#8 green litter	Class 4 Tussock-4cm	32.41	10.80	23.73
"	"	"	32.18	10.14	25.03
E. vaginatum	#9 green litter	Class 3 Tussock-0cm	35.88	11.38	28.65
"	"	"	37.91	11.09	28.83
E. vaginatum	#21 green litter	Class 3 Tussock-0cm	44.08	3.47	23.44
"	"	"	43.49	3.01	26.26
E. vaginatum	#22 green litter	Class 3 Tussock-4cm	30.18	13.36	28.17
"	"	"	30.21	13.56	28.55
E. vaginatum	#30 green litter	Class 3 Tussock-0cm	33.95	11.18	27.12
"	"	"	31.62	13.60	27.96
E. vaginatum	#33 green litter	Fertilizer Plot 0cm	42.40	4.84	26.97
"	"	"	41.94	5.16	27.31
E. vaginatum	#41 stand. dead	Class 4 Tussock-4cm	33.51	9.94	23.69
"	"	"	26.78	5.99	31.88
E. vaginatum	#42 stand. dead	Class 4 Tussock-0cm	30.95	5.69	32.67
"	"	"	30.59	6.01	32.47
E. vaginatum	#45 stand. dead	Class 4 Tussock-4cm	30.11	5.31	30.79
"	"	"	30.17	5.76	30.48
E. vaginatum	#46 stand. dead	Class 4 Tussock-0cm	33.90	4.62	30.49
"	"	"	33.43	4.82	31.40
E. vaginatum	#50 stand. dead	Class 3 Tussock-0cm	33.44	5.58	31.03
"	"	"	33.27	4.46	32.00
E. vaginatum	#74 Campsite	Tussock 0cm	29.41	12.28	24.19
"	"	"	30.17	10.24	24.29
E. vaginatum	#85 Campsite	Intertussock-4cm	36.56	10.29	26.21
"	"	"	36.36	12.23	26.35
E. vaginatum	#86 Campsite	Intertussock-0cm	37.65	8.13	27.35
"	"	"	39.83	4.05	26.15
E. vaginatum	#89 Campsite	Tussock 4cm	24.46	17.86	24.63
"	"	"	25.87	16.76	23.29
E. vaginatum	#90 Campsite	Tussock 0cm	39.75	3.96	27.73
		"	38.90	4.40	27.26
E. vaginatum	Tracksamples		38.25	2.77	24.32
"	"		38.32	3.00	25.37
"	"		37.11	3.91	26.2

will be more pronounced at the second sample period in June 1979.

Fungal length in meters per gram dry weight of soil was greatest in the tussocks in June (Table 6). Fungal weight in grams mycelium per meter square in the tussocks was less than that in the sedge-moss plot because of the less dense, highly organic 022 soil profile (Zone 3 in Table 7) in the tussocks. Intertussock soils were the third highest in fungal length in June (Table 6). The surface intertussock temperature remains fairly high in midseason (6.7–8.9°C diurnal mean, Table 8) and even reaches highs of 9–15°C in the early afternoon (Table 9). Unlike the raised tussock, the moisture content remains very high. By the August sample extremely high fungal biomass readings were obtained in the intertussock sample (Table 6). The tussock plot still had the highest fungal biomass but elevated temperatures were accompanied by drying conditions which reduced the fungal biomass slightly. The tussock Zone 4 (Table 6) soil sample was predominantly mineral soil and contains a low fungal biomass or length. Samples in the forb-grass community had the lowest fungal biomass. There are few mycorrhizal fungi in this zone. Complete interpretation of these results depends on the results of the soil analyses carried out by the University of Alaska Soil Analysis Laboratory at Palmer, Alaska, coordinated by Dr. J. McKendrick.

Analysis of the total carbon and nitrogen in soil cores sampled for fungal biomass also indicated trends among the plant communities. The fellfield had little nitrogen and low organic matter content (Tables 10–11). The nitrogen content was highest in the forb-grass, with carbon:nitrogen ratios of 21/1 and 29/1 (Table 10). The forb-grass community contrasts greatly with the tussock site (Table 10) which has high mycelial counts (Table 6) and organic matter levels of 70% or more (Table 10).

Table 6a.

1978 Eagle Summit Fungal Biomass in meters per g. dry wt. soil

	Julian Day 186							Julian Day 238						
Habitat	Subsample A		Subsample B		X̄		m	Subsample A		Subsample B		X̄		m
Fell-Field (Dryas)	426	589	562	583	540	76.9	38.4	540	672	480	596	572	81.8	40.9
Fell-Field (Loiseleuria)														
Upper Dec. Shrub (Cassiope)	1111	738	1688	1308	1211	396.1	198.1	604	405	395	449	463	96.7	48.4
Dec. Forb	343	148	397	210	275	115.3	57.6	222	301	385	320	307	67.1	33.6
Lower Dec. Shrub (Betulanana)	1234	1669	1360	1383	1411	183.7	91.9	2453	2022	1945	2139	2139	223.6	111.8
Moss-Carex (+ Salix)	5640	5658	7639	6626	6391	951.1	475.5	1784	1600	1820	2101	1826	206.9	103.4
Tussock	7513	7583	7421	7229	7437	153.4	76.7	4060	3440	4019	3725	3811	288.9	144.4
Tussock (zone 4)*	94.3	127.1	117.4	165	126	29.5	14.7	90.8	87.3	50.2	46.8	68.8	23.5	11.7
Intertussock	4143	3519	4215	4030	3977	314.5	157.3	11912	9700	10910	9482	10501	1131	565.6

*Largely mineral soil.

Table 6a.

1978 Eagle Summit Fungal Biomass in g/m^2

	Julian Day 186							Julian Day 238						
Habitat	Subsample A		Subsample B		$\bar{X}$		m	Subsample A		Subsample B		$\bar{X}$		m
Fell-Field (Dryas)	6.07	8.38	7.99	8.29	7.68	1.09	0.55	4.60	5.72	4.08	5.07	4.87	0.70	0.35
Fell-Field (Loiseleuria)														
Upper Dec. Shrub (Cassiope)	4.87	3.24	7.40	5.74	5.31	1.74	0.87	7.47	5.01	4.88	5.55	5.73	1.20	0.60
Dec. Forb	3.59	1.54	4.14	2.20	2.87	1.20	0.60	2.14	2.90	3.71	3.08	2.96	0.65	0.32
Lower Dec. Shrub (Betulanana)	5.85	7.91	6.44	6.55	6.69	0.87	0.44	13.78	11.36	10.93	12.02	12.02	1.25	0.63
Moss-Carex (+ Salix)	9.07	9.10	12.29	10.66	10.28	1.53	0.77	6.06	5.44	6.19	7.14	6.21	0.70	0.35
Tussock	10.03	10.12	9.90	9.65	9.93	0.20	0.10	8.75	7.41	8.66	8.02	8.21	0.62	0.31
Tussock (zone 4)	2.16	2.91	2.69	3.77	2.38	1.55	0.78	2.09	2.00	1.15	1.07	1.58	0.54	0.23
Intertussock	9.38	7.97	9.55	9.13	9.01	0.71	0.36	43.54	35.46	39.88	34.66	38.38	4.13	2.07

Table 6b.

Chemical Analyses of Soils From Eagle Summit Alpine Tundra

Site	Sample No.	pH	PPM Ca.	Mg.	Phosphate	K
Class 2 Tussock	2A	4.4	1074	159	2	[illegible]
Class 2 Tussock	4A	4.7	835	155	6	[illegible]
Class 2 Tussock	4B	5.0	537	127	2	[illegible]
Class 4 Tussock	2A	4.6	604	115	4	[illegible]
Class 4 Tussock	4A	4.7	537	96	4	[illegible]
Class 4 Tussock	4B	5.0	470	119	2	24
Class 5 Tussock	2A	4.7	604	135	2	[illegible]
Class 5 Tussock	4A	4.7	571	127	6	[illegible]
South Slope	S_1-R_1 (2)A	4.8	1511	195	11	142
South Slope	S_1-R_2 (2)A	5.1	2283	239	7	[illegible]
South Slope	S_2-R_1 (2)A	4.7	1410	179	11	[illegible]
South Slope	S_2-R_1 (2)A		*			
Moss-Carex	S_1-R_1 (2)A	5.6	2619	247	6	67
Moss-Carex	S_1-R_2 (2)A	5.0	2653	215	13	158
Moss-Carex	S_2-R_1 (2)A	5.0	2418	219	6	101
Moss-Carex	S_2-R_2 (2)A	4.9	2015	191	6	86
Campsite	S_1-R_1	5.2	1477	235	11	52
Campsite	S_1-R_2(2)A	5.3	1528	219	4	93
Campsite	S_2-R_1	5.6	1545	247	7	112
Campsite	S_2-R_2	5.3	1612	247	9	78
Dec. Forbes	S_1-R_1 (2)A	5.0	2585	231	22	235
Dec. Forbes	S_1-R_2 (2)A	5.2	2518	267	62	270
Dec. Forbes	S_2-R_1 (2)A	5.3	2115	109	111	52
Dec. Forbes	S_2-R_2 (2)A	5.2	2283	131	15	93
LDS	S_1-R_1 (3)A	4.8	2149	339	33	[illegible]
LDS	S_1-R_2 (2)A	4.8	2854	354	28	[illegible]
LDS	S_2-R_1 (3)A	5.5	3358	231	20	120
LDS	S_2-R_2 (2)A	5.4	2653	183	33	139

* Insufficient soil to do soil analysis

Table 6b.

Total Carbon, and Nitrogen of Soils From Eagle Summit Alpine Tundra

Site	Sample No.	% Carbon	% Nitrogen	C/N Ratio
Class 2 Tussock	1A	42.15	1.21	39/1
Class 2 Tussock	3A	43.39	2.35	18/1
Class 4 Tussock	1A	43.42	1.82	24/1
Class 4 Tussock	3A	29.78	1.27	24/1
Class 5 Tussock	1A	40.11	1.10	36/1
Class 5 Tussock	3A	39.16	1.46	27/1
South Slope	S_1-$R_1$0	44.17	1.47	30/1
South Slope	S_1 - R_2 (#1)A	37.26	1.48	25/1
South Slope	S_1 - R_2 (#1)B	9.21	0.51	18/1
South Slope	S_2 - R_1 (#1)A	24.67	1.37	18/1
South Slope	S_2 - R_2 (#1)A	19.35	0.90	22/1
Moss-Carex	S_1 - R_1(#1)A	41.10	2.89	14/1
Moss-Carex	S_1 - R_2(#1)A	45.46	1.21	38/1
Moss-Carex	S_2 - R_1(#1)A	40.03	1.87	21/1
Moss-Carex	S_2 - R_2(#1)A	43.12	1.40	31/1

Table

Campsite	S_1 - R_1(#1)A	41.18	1.29	32/1
Campsite	S_1 - R_2(#1)A	39.93	1.47	27/1
Campsite	S_2 - R_1(#1)A	36.69	1.50	25/1
Campsite	S_2 - R_2(#1)A	34.66	1.74	20/1
Dec. Forb	S_1 - R_1(#1)A	19.67	1.24	16/1
Dec. Forb	S_1 - R_2(#1)A	23.14	1.52	15/1
Dec. Forb	S_2 - R_1(#1)A	17.72	1.09	16/1
Dec. Forb	S_2 - R_2(#5)A	20.98	1.34	16/1
LDS	S_1 - R_1(#2)A	23.32	1.27	18/1
LDS	S_1 - R_2(#1)A	24.52	1.30	19/1
LDS	S_2 - R_1(#1)A	27.82	1.51	18/1
LDS	S_2 - R_2(#1)A	31.21	1.64	19/1

Table 6b.

Percent Carbon and Organic Matter of Soils from Eagle Summit Alpine Tundra

Site		% Carbon	% Total Organic Matter[1]	$\bar{X}$	SD	S
Class 2 Tussock	1A	42.15	72.67			
Class 2 Tussock	3A	43.39	74.80			
Class 4 Tussock	1A	43.42	74.86			
Class 4 Tussock	3A	29.78	51.34			
Class 5 Tussock	1A	40.11	69.15			
Class 5 Tussock	3A	39.16	67.51	68.39	8.87	3.62
South Slope	S1	44.17	76.15			
South Slope	S1	37.26	64.24			
South Slope	S1	9.21	15.88			
South Slope	S2	24.67	42.53			
South Slope	S2	19.35	33.36	46.42	24.11	10.78
Moss-Carex	S1	41.10	70.86			
Moss-Carex	S1	45.46	78.37			
Moss-Carex	S2	40.03	69.01			
Moss-Carex	S2	43.12	74.34	73.15	4.13	2.06
Campsite	S1	41.18	70.99			
Campsite	S1	39.93	68.84			
Campsite	S2	36.69	63.25			
Campsite	S2	34.66	59.75	65.71	5.14	2.57
Dec. Forb	S1	19.67	33.91			
Dec. Forb	S1	23.14	39.89			
Dec. Forb	S2	17.72	30.55			
Dec. Forb	S2	20.98	36.17	35.13	3.92	1.96
LDS	S1	23.32	40.20			
LDS	S1	24.52	42.27			
LDS	S2	27.82	47.96			
LDS	S2	31.21	53.81	46.06	6.12	3.06

[1]Derived by assuming that average carbon content of soil organic matter is 5.8%. Therefore 100:58 = 1.724. Jacob S. Joffe 1949 The ABC of Soils p. 283.

Table 6b.

Chemical Analysis from Eagle Summit
Alpine Tundra

Plot	Zone	pH	PPM Ca	Mg	P	K
Class 4 Tussock	2	4.4	269	80	6	105
Inter-Tussock	2	4.5	604	123	6	71
Class 4 Tussock	2	4.6	772	131	6	56
Moss-Carex-Salix	2	5.7	3358	398	11	63
Lower Dec. Shrub	2	5.4	2720	211	18	90
Dec. Forb	2	4.8	1209	88	9	67
Upper Dec. Forbes	2	4.7	1746	175	6	90
Fell Field 1)	2	4.9	2015	251	15	135
Fell Field 2)	2	4.8	336	52	7	78
<u>Aug. 1978 Field Cores</u>						
Class 4 Tussock	2	4.9	403	104	2	37
Inter-Tussock	2	4.9	403	111	4	34
Class 4 Tussock	2	4.8	504	127	6	56
Class 4 Tussock	3 → 4	5.0	369	135	4	30
Campsite (hummock)	2	5.3	2787	374	7	78
Campsite (depression)	2	5.7	2518	358	9	97
Moss-Carex-Salix	2	5.7	3358	398	9	48
Moss-Carex-Salix	3 → 4	5.6	3358	398	24	34
Lower Dec. Shrub	2	5.2	3358	314	29	223
Dec. Forb	2	4.9	940	123	9	90
Upper Dec. Shrub	2	4.5	1377	159	6	116
Upper Dec. Shrub	3 → 4	4.6	269	52	7	75
Fell Field 1)	2	4.8	1545	306	11	123
Fell Field 2)	2	4.8	2015	314	11	146

Table 7.

PROFILE DESIGNATIONS FOR SOIL CORE ANALYSES

Eagle Summit, Alaska

Orson K. Miller, Jr.

These soil profile designations called zones are designated for use primarily in the Tussock Tundra and intended to be used to achieve sampling uniformity. The depth of the sample should be recorded, however. (It is anticipated that some profiles will be missing in some, especially the 022 or A1.) One will encounter frozen soil or an A2 profile composed of parent material in some cases.

Zone 1: (Profile 01) Clearly recognizable plant parts both dead and alive but not containing current year living aerial plant parts. This zone in tussocks has a light brown to distinctive rusty brown color but intertussock and other areas may be brownish black to dull brown.

Zone 2: (Profile 021) A fibric character with some visible and recognizable plant parts intermixed with plant roots and to a lesser extent some blackish brown to deep blackish brown OM which is somewhat humic, greasy when rolled between the fingers and not containing visible plant parts. Also having a higher density than Zone 1.

Zone 3: (Profile 022) Characterized by blackish brown to deep blackish brown OM, humic, greasy when rolled between the fingers, mostly without visible plant parts except for living plant roots.

Zone 4: (Profile A1) OM as in Zone 3 intermixed with parent material (PM), dense but lighter brown or gray brown colors are seen.

a. Largely OM, some PM

b. Largely PM with minor admixture of OM in a mosaic pattern.

c. Almost 100% PM of clay, gravel or rocks and gravel.

Table 8.

Eagle Summit Temperature Data

Daily Means 1978

Plot	Tussock 3A		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)	10	30	10	0	10	0	10	20	30	30	30	10	0
Probe (#)	2	3	4	5	6	8	10	12	19	23	25	26	28
7/17/78	10.0	2.7	12.5	8.9	4.0	10.8	13.5	10.0	2.8	3.8	2.2	11.6	11.3
7/18/78	9.5	2.7	11.5	7.5	3.6	11.6	12.7	9.1	2.7	3.9	2.3	9.1	11.7
7/19/78	9.9	2.9	11.7	7.9	4.0	11.8	12.4	9.5	3.1	4.3	2.6	10.2	13.0
7/20/78	9.6	3.1	11.0	8.8	4.4	12.3	11.9	9.3	3.4	4.3	3.4	10.9	13.6
7/21/78	8.0	2.6	9.6	6.5	3.7	10.2	10.7	7.6	2.9	3.7	3.7	9.6	1.1
7/22/78	9.2	2.9	11.2	7.9	4.1	11.6	12.5	9.0	3.2	4.0	4.0	11.6	12.6
7/23/78	9.6	3.0	11.5	8.2	4.3	11.7	12.4	9.3	3.4	4.3	3.9	11.2	14.8
7/24/78	9.1	3.0	10.4	6.7	3.8	12.9	11.0	8.8	3.1	4.2	3.8	10.8	13.4
7/25/78	9.6	3.2	11.4	7.9	4.2	12.4	12.6	9.6	3.3	3.9	2.8	12.1	14.1
7/26/78	9.7	3.2	11.5	7.5	4.2	11.6	12.5	9.4	3.4	3.4	2.8	11.4	13.9
7/27/78	9.9	3.3	12.1	8.4	4.5	12.5	13.2	9.6	3.6	4.3	2.9	12.1	14.2
7/28/78	10.1	3.2	12.0	8.6	4.6	12.9	13.1	9.8	3.7	4.8	3.0	12.2	14.8
7/29/78	9.7	3.1	11.5	8.9	4.7	14.2	12.7	9.4	3.7	4.9	3.1	12.4	14.1
7/30/78	7.5	2.8	9.9	6.7	4.2	12.5	10.4	9.1	3.4	4.5	2.9	9.3	11.6
7/31/78	5.4	3.4	7.5	5.1	5.0	16.9	14.8	9.7	2.7	3.5	2.4	11.4	11.5
8/1/78	10.6	2.7	12.8	8.9	4.2	14.6	14.1	10.4	3.0	4.4	2.3	13.6	15.6
8/2/78	10.2	2.9	12.2	9.3	4.4	12.2	13.4	10.0	3.4	4.5	2.9	13.0	15.1
8/3/78	8.4	2.6	11.6	7.8	3.8	13.0	13.8	8.7	3.0	3.8	2.3	12.8	16.9
8/4/78	9.1	2.6	11.3	7.6	4.0	14.3	12.7	7.8	2.9	3.9	2.3	11.9	15.0
8/5/78	9.3	2.6	11.0	8.3	4.3	11.2	11.8	9.2	3.2	4.1	2.7	11.0	12.1
8/6/78	8.8	2.6	11.1	8.7	5.5	11.1	11.2	9.2	4.7	5.2	4.3	9.6	10.4
8/7/78	6.0	4.3	8.2	7.1	4.3	10.0	10.1	8.2	4.1	4.2	3.4	9.2	11.5
8/8/78	7.5	4.6	10.1	8.6	4.4	14.3	13.5	9.6	4.3	5.0	3.9	13.6	16.7
8/9/78	8.8	4.5	10.6	8.4	5.3	14.8	12.6	10.0	3.6	5.0	3.4	11.6	14.6
8/10/78	7.0	5.5	9.4	7.1	4.5	13.7	12.4	8.4	4.6	4.9	4.2	11.7	14.4
8/11/78	5.6	3.4	8.5	6.2	3.6	11.0	10.0	7.3	3.2	3.8	2.9	10.6	12.1
8/12/78	6.2	3.7	8.2	5.7	2.8	13.8	10.4	7.2	2.7	3.3	2.5	10.0	11.4
8/13/78	7.0	3.0	9.0	7.6	4.2	11.5	12.5	8.8	2.8	4.1	2.8	10.4	12.1

Table 8.

Eagle Summit Temperature Data

1978

Tussock Plot Mile 101

Depth (cm)	10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)	2	3	4	5	6	8	10	12	19	23	25	26	28
6/30/78		-3.0	-4.0	5.0		8.7	0.7	6.0	-2.0	-0.3	-3.0	4.7	7.0
7/1/78		4.5	-3.4	-4.0		9.4	0.7	5.3	-2.4	-0.6	-3.2	2.9	9.5
7/2/78		4.7	-2.5	-3.8		9.1	1.6	5.1	-2.4	0.0	-3.1	2.7	9.0
7/3/78	8.6	2.3	-1.1	3.1	2.6	14.9	3.6	7.6	0.1	2.4	-0.7	4.8	12.1
7/4/78	9.1	1.2	0.7	7.6	2.8	14.7	5.2	9.8	1.8	4.1	1.1	7.3	13.7
7/5/78	9.4	1.4	6.6	7.7	2.8	23.1	10.6	10.2	1.8	4.1	1.1	7.4	16.6
7/6/78	10.6	1.8	12.5	8.0	3.3	14.5	13.4	11.2	2.5	4.8	1.6	8.2	13.3

Table 9.

Eagle Summit Temperature Data
1978
Tussock Plot Mile 101

Date	Depth (cm)	10	30	10	0	10	0	0	10	20	30	30	10	0
	Probe (#)	2	3	4	5	6	8	10	12	19	23	25	26	28
6/30	3:40 PM		-3	-4	4		8	1	6	-2	-1	-3.0	5	8
	6:40 PM		-3	-4	6		12	2	6	-2	0	-3.0	5	8
	9:40 PM		-3	-4			6	-1	6	-2	0	-3.0	4	5
7/1	Mid PM		5	-4	-4		2	-1	5	-2	-1	-3.0	2.5	2
	3:40 AM		3.5	-4	-4		8	-2	3.5	-3	-1	-3.0	1.0	4
	6:40 AM		3.0	-4	-4		15.5	1	3.5	-3	-1	-3.5	1.0	18
	9:40 AM		3.0	-4	-4		16	2	4.0	-3	-1	-4.0	2	16
	Noon PM		4.0	-3	-4		14	3	6.5	-2	-1	-3.0	3	14
	3:40 PM		6.0	-3	-4		11	2	7.0	-2	0	-3.0	5	11.5
	6:40 PM		6.0	-3	-4		7.5	1.5	7.0	-2	0	-3.0	5	7.5
	9:40 PM		5.5	-2	-4		1.5	-1	6.0	-2	0	-3.0	4	3
7/2	Mid PM		5.0	-2	-4		2	-1.5	5.0	-2.5	0	-3.0	2.5	1.5
	3:40 AM		4.0	-2.5	-4		5	-1	4.0	-2.5	0	-3.0	1.5	4.5
	6:40 AM		3.5	-3	-4		8.5	0	3.5	-2.5	0	-4.0	1.5	7.5
	9:40 AM		4.0	-2	-4		11.5	2	4.0	-2.5	-0.5	-3.0	2.0	13.0
	Noon PM		4.0	-3	-4		14	4.5	5.0	-2.5	-0.5	-3.0	2.5	15.5
	3:40 PM		5.0	-3	-3.5		16	5.0	6.0	-2.5	-0.5	-3.0	3.5	15.0
	6:40 PM		6.0	-2.5	-3.5		11.0	3.5	7.0	-2.0	2.0	-3.0	4.0	10.0
	9:40 PM		6.0	-2	-3.0		4.5	0.5	6.5	-2.0	-0.5	-3.0	4.0	5.0
7/3	Mid PM		5.0	-3	-3.5		1.5	1.5	5.5	-2.0	1.0	-3.0	2.5	-0.5
	3:40 AM		4.0	-3.0	-3.5	2	8	0	4.0	-2.0	0.5	-3.0	1.5	6.0
	6:40 AM		4.0	-3.0	-4.0	4.5	15.5	0.5	4.0	-2.0	0	-3.0	2.0	13.5
	9:00 AM	7.0	1.0	0.0	8.0	2.0	28.0	5.0	8.0	1.0	3.0	0.0	7.0	22.0
	Noon	8.0	1.0	0.0	8.0	2.0	23.0	6.0	9.5	1.0	3.0	0.5	7.5	17.0
	3:00 PM	9.0	1.0	0.0	8.0	2.5	20.0	6.0	10.0	1.5	3.5	1.0	8.0	17.5
	6:00 PM	9.5	1.0	0.0	7.0	2.5	16.5	6.5	10.0	1.5	4.0	1.0	8.0	14.0
	9.00 PM	9.5	1.0	0.5	4.5	2.5	6.5	3.5	10.0	1.5	4.0	1.0	1.5	7.0
7/4	Mid	8.5	1.0	0.5	5.0	2.5	8.0	3.0	9.0	1.5	4.0	1.0	6.0	7.5
	3:00 AM	8.0	1.0	0.5	5.5	2.5	12.5	4.0	8.0	1.5	4.0	1.0	5.5	11.0
	6:00 AM	8.0	1.0	0.5	8.0	2.5	16.5	5.5	8.5	1.5	4.0	1.0	6.0	16.0
	9:00 Am	8.5	1.0	0.5	9.5	2.5	19.0	6.5	9.5	1.5	4.0	1.0	7.0	17.5
	Noon	9.5	1.0	0.5	11.5	3.0	21.0	7.5	10.5	2.0	4.0	1.0	8.0	19.0
	3:00	10.0	1.5	1.0	9.0	3.0	18.5	6.0	11.0	2.0	4.0	1.0	9.0	16.0

Table 9.

7/4	6:00	10.5	1.5	1.0	7.0	3.0	14.0	5.0	11.0	2.0	4.0	1.5	9.0	13.5
	9:00	10.0	1.5	1.0	5.5	3.0	8.0	4.0	11.0	2.0	4.5	1.5	8.0	9.0
7/5	Mid	9.5	1.0	0.5	4.5	3.0	6.5	3.5	10.0	2.0	4.0	1.0	7.0	6.5
	3:00	8.5	1.0	0.5	5.0	2.5	13.0	3.5	8.5	1.5	4.0	1.0	6.0	11.0
	6:00	8.0	1.0	0.5	6.0	2.0	30.0	7.0	9.0	1.5	4.0	1.0	6.0	18.0
	9:00	8.5	1.5	*1.0	6.5	3.0	28.0	*7.0	9.5	2.0	4.0	1.5	7.5	18.0
	Noon	9.5	1.5	13.5	8.5	2.5	33.5	17.5	10.5	1.5	4.0	1.0	7.0	22.5
	3:00	10.5	2.0	15.0	11.0	3.0	27.0	19.0	11.5	2.0	4.0	1.0	8.5	22.0
	6:00	11.5	2.0	15.0	12.5	3.5	24.0	17.0	12.5	2.0	4.5	1.0	9.5	18.0
7/6	9:00	11.5	2.0	14.0	9.5	3.5	17.0	15.0	12.5	2.5	5.0	1.5	9.5	15.0
	Mid	11.5	2.0	13.0	7.0	3.5	12.0	13.0	12.0	2.5	5.0	1.5	9.0	11.5
	3:00	11.0	2.0	12.0	6.0	3.5	10.0	11.5	11.0	2.5	5.0	1.5	8.0	9.5
	6:00	10.0	1.5	11.5	6.0	3.0	11.5	11.0	10.0	2.0	5.0	2.0	7.5	10.5
	9:00	9.5	1.5	11.5	9.0	3.0	13.5	13.0	10.0	2.0	4.5	1.5	7.0	13.5
	Noon	10.0	1.5	13.0	10.5	3.5	23.0	17.0	11.5	3.5	4.5	1.5	8.0	20.0

*9:00 AM 7/5/78 prob #4 placed at 5 cm in same intertussock.

*9:00 AM 7/5/78 prob #10 placed at 0 cm (surface) in tussock 3A.

Table 9.

Eagle Summit Temperature Data

Plot		Tussock 3A		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
7/17/78	6:00 pm	9.9	2.5	12.9	10.2	4.0	11.0	14.5	9.9	2.7	3.7	2.2	12.2	11.5
	9:00 pm	10.0	2.9	12.0	7.5	4.0	10.5	12.5	10.0	2.9	3.9	2.2	11.0	11.1
7/18/78	Midnight	9.9	2.9	10.3	4.5	3.5	4.9	9.0	9.4	3.0	4.0	2.4	8.0	4.0
	3:00 am	8.8	3.0	8.9	3.7	3.4	3.2	7.2	8.1	2.9	4.0	2.5	6.4	2.5
	6:00 am	7.9	2.8	7.8	3.1	3.0	9.3	6.6	7.0	2.5	3.9	2.4	5.0	6.5
	9:00 am	7.3	2.3	9.4	5.0	2.7	15.0	13.2	6.8	2.0	3.4	2.0	7.0	17.9
	Noon	9.0	2.4	13.5	9.4	3.2	17.0	17.0	9.0	2.0	3.3	2.0	12.1	15.9
	3:00 pm	10.0	2.5	14.2	16.2	3.9	19.0	18.9	10.2	2.9	3.9	2.2	15.0	17.5
	6:00 pm	11.4	3.0	14.4	10.6	4.4	15.0	16.0	11.3	3.0	4.0	2.4	14.9	19.9
	9:00 pm	11.5	3.0	13.5	7.4	4.3	9.0	13.3	11.1	3.1	4.3	2.5	11.9	9.5
7/19/78	Midnight	11.0	3.0	11.3	4.3	3.9	3.6	9.5	10.1	3.1	4.5	2.5	8.2	3.6
	3:00 am	9.9	3.0	9.8	3.3	3.5	3.1	7.5	8.9	3.0	4.5	2.7	6.0	1.6
	6:00 am	8.9	2.9	9.8	5.0	3.3	14.5	10.7	7.9	2.9	4.2	2.6	7.2	13.5
	9:00 am	8.9	2.7	11.0	8.9	3.3	13.0	14.0	8.3	2.6	4.0	2.4	10.2	18.3
	Noon	9.2	2.5	12.2	10.6	3.7	15.9	15.0	9.0	2.7	3.9	2.2	12.5	20.2
	3:00 pm	10.0	2.7	13.2	11.0	4.1	16.0	15.0	10.2	3.0	4.0	2.4	13.2	18.0
	6:00 pm	10.8	3.0	13.3	11.0	4.9	15.8	14.4	11.0	3.7	4.5	2.9	12.9	16.9
	9:00 pm	10.8	3.3	12.6	9.0	4.9	12.5	12.7	10.8	3.8	4.8	3.0	11.4	11.5
7/20/78	Midnight	10.2	3.1	11.0	7.7	4.4	10.2	10.6	10.0	3.5	4.5	3.0	9.5	9.0
	3:00 am	9.5	3.0	10.1	7.0	4.0	8.2	9.7	9.0	3.2	4.3	2.8	8.0	7.9
	6:00 am	9.0	3.0	9.9	7.7	4.0	11.0	10.5	8.5	3.2	4.2	2.8	9.0	12.7
	9:00 am	8.9	3.0	10.2	8.8	4.2	12.1	11.5	8.5	3.4	4.3	3.0	10.0	14.0
	Noon	9.4	3.0	11.9	10.9	4.4	18.0	15.5	9.0	3.3	4.2	2.8	12.6	18.5
	3:00 pm	9.8	3.0	12.2	12.4	4.5	17.5	14.9	9.8	3.3	4.0	4.0	17.6	25.7
	6:00 pm	10.0	3.0	11.7	9.3	4.7	13.3	12.7	9.9	3.5	4.2	4.2	12.5	14.3
	9:00 pm	9.7	3.4	10.7	6.9	4.6	8.3	10.1	9.5	3.7	4.5	4.5	7.7	6.7

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
7/21/78	Midnight	8.9	3.2	8.6	3.5	4.2	1.0	6.5	8.5	3.5	4.5	4.5	3.5	0.5
	3:00 am	7.7	3.0	7.0	2.5	3.6	-1.9	5.0	7.0	3.0	4.0	4.0	-2.3	-1.0
	6:00 am	6.5	2.5	6.3	3.5	3.0	7.3	6.1	5.9	2.7	3.6	3.6	4.9	6.5
	9:00 am	6.5	2.2	8.5	7.0	3.0	12.5	12.0	6.0	2.5	3.3	3.3	11.9	17.4
	Noon	7.5	2.5	10.7	9.1	3.5	17.1	15.5	7.1	2.7	3.4	3.4	15.1	17.5
	3:00 pm	8.5	2.5	12.0	10.0	3.9	16.6	14.5	8.4	3.0	3.5	3.5	15.4	20.0
	6:00 pm	9.0	2.5	12.0	9.0	4.0	16.9	14.0	9.0	3.0	3.5	3.5	16.3	18.7
	9:00 pm	9.5	2.6	11.5	7.3	4.0	11.8	11.9	9.3	3.1	3.8	3.7	11.6	11.3
7/22/78	Midnight	9.3	3.0	10.3	6.0	4.0	8.0	9.9	8.0	3.3	4.0	4.0	8.3	7.7
	3:00 am	8.9	3.0	9.5	5.4	4.0	7.5	8.8	8.4	3.3	4.0	4.0	7.3	6.9
	6:00 am	8.2	3.0	9.1	6.1	3.7	11.5	10.0	7.8	3.0	3.9	3.9	9.7	12.4
	9:00 am	8.0	2.8	10.4	8.4	3.6	13.5	13.4	8.0	2.9	3.7	3.7	12.5	16.2
	Noon	8.9	2.5	11.9	9.4	4.0	16.7	15.3	8.8	3.0	3.8	3.8	15.0	17.0
	3:00 pm	9.9	3.0	12.8	9.8	4.3	12.5	15.0	10.0	3.3	4.0	4.0	13.3	15.9
	6:00 pm	10.2	3.0	13.3	10.8	4.5	12.9	15.6	10.4	3.5	4.0	4.0	16.5	17.0
	9:00 pm	10.5	3.0	12.1	7.5	4.8	10.0	12.0	10.2	3.6	4.3	4.3	10.3	8.0
7/23/78	Midnight	9.9	3.0	10.5	5.3	4.1	5.9	9.1	9.5	3.5	4.5	4.5	7.0	5.4
	3:00 am	9.0	3.0	9.3	5.0	3.9	6.5	8.3	8.5	3.3	4.4	4.4	6.5	5.4
	6:00 am	8.5	3.0	9.0	5.9	3.9	11.3	9.5	7.8	3.2	4.3	4.3	9.0	11.6
	9:00 am	8.5	2.9	10.6	8.8	3.9	13.3	14.0	8.0	3.0	4.0	4.1	12.9	18.9
	Noon	9.0	2.8	12.3	8.9	4.0	19.6	15.0	9.0	3.0	4.0	2.5	16.3	30.1
	3:00 pm	10.0	2.9	13.8	13.0	4.2	17.8	16.6	10.0	3.2	4.0	2.5	13.9	27.0
	6:00 pm	11.0	3.2	14.0	11.6	5.0	13.0	15.5	10.8	3.8	4.5	4.5	14.9	13.0
	9:00 pm	11.0	3.5	12.2	7.2	5.0	6.5	11.5	10.5	3.9	4.7	4.7	9.1	7.0

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
7/24/78	Midnight	10.0	3.5	10.0	3.9	4.5	1.4	7.8	9.4	3.6	4.8	4.8	4.5	1.1
	3:00 am	8.6	3.3	8.0	2.9	3.7	1.5	5.6	7.7	3.3	4.5	4.5	3.1	0.1
	6:00 am	7.5	3.0	7.5	3.2	3.5	12.2	8.0	6.7	3.0	4.1	4.1	4.6	9.0
	9:00 am	7.5	2.5	6.3	5.9	3.1	23.0	7.0	6.8	2.8	3.9	3.9	13.1	23.9
	Noon	8.5	2.6	12.0	10.0	3.3	19.0	16.0	8.4	2.5	3.7	3.7	16.9	25.9
	3:00 pm	9.9	2.8	13.9	10.5	3.9	18.5	16.5	10.0	2.9	3.9	3.9	17.8	18.9
	6:00 pm	10.5	3.0	13.2	9.0	4.1	16.5	14.8	10.5	3.1	4.1	2.6	15.6	17.9
	9:00 pm	10.6	3.3	12.3	7.9	4.4	11.3	12.0	10.5	3.5	4.8	3.0	10.8	10.7
7/25/78	Midnight	10.0	3.2	11.0	6.3	4.3	9.0	10.5	10.0	3.5	4.8	3.0	9.0	8.5
	3:00 am	9.3	3.2	9.8	5.0	4.0	5.5	8.8	9.0	3.2	4.8	3.0	6.4	4.6
	6:00 am	8.5	3.0	9.2	5.8	3.6	11.6	9.7	8.0	3.0	4.3	2.8	9.2	11.5
	9:00 am	8.5	2.9	11.3	9.9	3.7	17.2	15.2	8.4	3.0	3.0	2.6	16.0	24.0
	Noon	9.5	3.0	13.0	9.9	4.2	14.9	16.2	9.9	3.1	3.1	2.5	15.0	16.5
	3:00 pm	10.0	3.4	12.0	8.6	4.5	15.9	12.9	10.1	3.5	3.5	2.6	13.6	18.1
	6:00 pm	10.4	3.4	12.6	10.0	4.5	15.0	14.7	10.5	3.6	3.6	2.9	16.5	18.5
	9:00 pm	10.6	3.4	12.2	7.7	4.8	10.3	12.4	10.5	3.6	3.8	3.0	11.2	11.0
7/26/78	Midnight	10.2	3.5	11.0	5.7	4.5	6.8	10.1	10.0	3.9	3.9	3.0	7.4	5.1
	3:00 am	9.4	3.3	9.8	5.0	4.0	6.3	8.5	8.9	3.4	3.4	3.0	6.5	5.5
	6:00 am	8.6	3.0	9.0	4.9	3.7	12.5	9.5	8.0	3.1	3.1	2.9	7.0	10.5
	9:00 am	8.5	2.9	11.0	7.4	3.7	16.0	14.9	8.0	3.0	3.0	2.6	13.6	18.3
	Noon	9.2	3.3	12.0	9.0	4.0	19.2	15.0	9.3	3.1	3.1	2.7	16.7	28.4
	3:00 pm	10.0	3.0	13.2	10.8	4.2	13.0	15.3	10.2	3.2	3.2	2.5	14.8	20.0
	6:00 pm	10.7	3.3	13.5	10.3	4.7	12.3	15.0	10.5	3.5	3.5	2.6	16.1	15.9
	9:00 pm	10.8	3.5	12.1	6.5	4.8	6.9	11.5	10.5	3.8	3.8	3.0	9.0	7.2

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
7/27/78	Midnight	10.2	3.5	10.7	5.3	4.5	5.7	6.8	9.5	3.8	3.8	3.0	6.8	4.8
	3:00 am	9.4	3.5	9.8	5.3	4.1	6.9	8.8	8.7	3.5	3.8	3.0	6.8	6.9
	6:00 am	8.6	3.0	9.5	6.4	4.0	11.9	10.1	7.9	3.3	3.3	2.9	9.9	12.5
	9:00 am	8.5	2.9	11.0	9.0	3.9	16.1	15.0	8.1	3.1	4.2	2.5	15.0	23.5
	Noon	9.5	3.0	13.0	11.0	4.2	16.0	18.2	9.5	3.5	4.5	2.6	15.0	19.0
	3:00 pm	10.5	3.2	14.7	12.8	4.9	20.1	18.5	10.5	3.7	4.5	2.8	18.1	22.5
	6:00 pm	11.3	3.5	14.0	10.1	5.0	13.6	15.7	11.2	4.0	4.9	3.0	14.1	14.3
	9:00 pm	11.3	3.6	13.9	7.6	5.0	10.0	12.5	11.2	4.0	5.0	3.0	11.3	10.2
7/28/78	Midnight	10.7	3.6	11.3	5.0	4.8	4.9	10.0	10.5	4.0	5.0	3.1	6.7	4.0
	3:00 am	9.9	3.4	9.9	4.2	4.4	4.5	8.0	9.2	3.8	5.0	3.1	5.0	3.0
	6:00 am	8.6	3.1	8.9	4.9	4.0	10.2	8.6	8.0	3.4	4.9	3.0	6.6	9.0
	9:00 am	8.4	2.9	10.9	8.5	3.7	15.1	15.0	8.0	3.0	3.4	2.6	14.3	22.0
	Noon	9.5	3.0	13.1	11.5	4.1	21.5	17.9	9.4	3.2	5.0	2.7	19.0	30.0
	3:00 pm	10.9	3.1	14.5	14.7	5.0	20.5	17.7	10.7	3.9	4.8	3.0	18.5	23.5
	6:00 pm	11.5	3.3	14.5	12.2	5.2	19.2	15.8	11.1	4.0	5.0	3.1	18.1	20.5
	9:00 pm	11.5	3.5	12.9	7.5	5.4	7.2	12.0	11.1	4.3	5.0	3.3	9.2	6.7
7/29/78	Midnight	10.6	3.5	10.7	4.7	5.0	3.1	8.8	10.1	4.1	5.1	3.5	5.0	2.0
	3:00 am	9.4	3.2	8.9	3.5	4.5	2.1	6.8	8.6	3.9	5.0	3.2	0.5	-8.0
	6:00 am	8.1	3.0	8.5	4.6	4.0	12.9	9.5	7.5	3.5	4.9	3.0	7.5	11.1
	9:00 am	8.0	2.7	10.8	10.0	4.0	19.9	14.9	7.9	3.0	4.2	2.8	16.6	23.9
	Noon	8.9	2.7	12.0	11.3	4.2	20.0	15.8	8.8	3.2	4.2	2.5	17.5	23.5
	3:00 pm	10.0	3.0	13.5	13.0	4.9	20.0	16.5	10.0	3.5	4.5	2.9	19.0	25.0
	6:00 pm	11.1	3.2	14.1	13.0	5.6	19.5	15.5	11.0	4.1	5.9	3.2	18.0	20.0
	9:00 pm	11.3	3.5	13.5	11.2	5.7	16.0	14.0	11.0	4.5	5.0	3.5	14.7	15.2

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
7/30/78	Midnight	10.6	3.6	11.0	6.0	5.2	6.0	9.4	10.5	4.5	5.3	3.6	6.7	4.0
	3:00 am	10.0	3.5	9.9	4.5	5.0	3.8	7.8	9.8	4.2	5.1	3.5	4.8	1.9
	6:00 am	8.9	3.3	10.0	5.0	4.5	11.8	8.8	8.3	3.9	5.0	3.5	6.8	8.9
	9:00 am	8.5	3.1	10.6	10.3	4.5	16.0	12.9	8.1	3.5	4.8	3.0	15.0	19.4
	Noon	9.0	3.0	11.5	11.4	4.9	18.0	13.8	9.0	3.8	4.8	3.0	16.8	20.5
	3:00 pm	8.5	2.2	8.0	2.5	3.5	1.5	6.0	13.0	3.0	3.9	3.0	3.4	17.5
	6:00 pm	7.3	2.0	7.5	3.2	3.0	12.0	7.8	6.7	2.4	3.5	2.0	5.0	8.9
	9:00 pm	7.2	1.9	10.5	6.5	2.8	20.7	16.5	7.0	2.1	3.2	1.7	15.8	-
7/31/78	Midnight	9.8	2.4	10.1	4.5	4.0	3.5	8.5	9.6	3.3	4.0	2.5	5.0	2.9
	3:00 am	8.4	2.2	8.0	2.5	3.5	1.5	5.9	8.0	3.0	3.9	2.0	2.5	0.0
	6:00 am	7.3	2.0	7.5	3.3	3.0	12.0	7.8	6.7	2.5	3.5	1.9	5.0	8.9
	9:00 am	7.2	1.9	10.5	6.5	2.6	20.6	16.5	7.0	2.1	3.3	1.7	15.7	25.0
	Noon	2.8	3.5	4.3	3.0	9.4	37.5	23.0	9.1	2.3	3.3	2.7	20.0	28.1
	3:00 pm	3.0	5.0	9.0	9.9	10.0	26.7	22.3	11.5	2.5	3.0	3.5	27.3	12.5
	6:00 pm	1.5	3.0	3.3	4.0	10.2	21.1	19.3	12.7	2.5	2.5	2.6	3.0	3.9
	9:00 pm	3.1	7.0	7.0	7.0	4.9	12.2	14.9	12.6	3.2	4.5	2.3	12.6	10.8
8/1/78	Midnight	12.1	2.9	12.7	5.5	4.4	6.5	10.5	11.5	3.3	4.9	2.5	7.2	5.2
	3:00 am	10.5	2.7	10.5	4.0	3.9	4.9	8.5	9.9	3.0	4.5	2.5	4.5	2.5
	6:00 am	9.1	2.4	10.0	5.0	3.3	16.3	10.7	8.2	2.6	4.1	2.1	10.0	15.9
	9:00 am	9.1	2.5	12.1	9.1	3.5	19.0	16.5	8.9	2.6	4.1	2.1	18.3	25.6
	Noon	10.0	2.5	14.3	12.3	3.9	18.3	17.5	10.0	2.8	4.1	2.1	17.7	19.4
	3:00 pm	11.0	2.5	15.0	14.9	4.4	21.7	20.3	11.0	3.0	4.2	2.2	22.5	26.5
	6:00 pm	11.6	2.8	15.0	12.5	5.0	18.5	16.7	11.8	3.4	4.4	2.4	17.9	19.9
	9:00 pm	11.6	2.9	13.0	8.2	5.0	11.5	12.3	11.6	3.6	4.6	2.5	10.5	9.9

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
8/2/78	Midnight	10.8	3.0	11.6	7.3	4.6	9.3	10.7	10.7	3.5	4.8	2.5	9.0	3.6
	3:00 am	10.0	3.0	10.7	6.9	4.4	9.3	10.2	9.9	3.5	4.8	2.6	8.9	8.8
	6:00 am	9.5	3.0	10.0	6.6	4.1	9.1	9.8	9.1	3.5	4.9	2.8	9.0	9.5
	9:00 am	9.1	3.0	10.6	8.6	4.0	13.6	14.0	8.9	3.2	4.5	2.5	13.3	17.9
	Noon	9.7	2.7	12.5	9.1	4.1	12.5	15.1	9.8	3.1	4.5	2.5	14.1	23.6
	3:00 pm	10.2	2.8	14.1	13.6	4.3	18.5	18.4	10.1	3.2	4.3	2.5	19.9	26.7
	6:00 pm	11.2	3.0	15.1	15.3	4.9	18.8	17.3	10.9	3.4	3.4	5.0	22.1	24.5
	9:00 pm	11.2	3.0	13.0	7.0	5.0	6.1	11.8	10.8	3.6	4.6	2.6	8.0	6.5
8/3/78	Midnight	10.1	3.1	10.0	3.6	4.5	1.5	7.7	9.5	3.9	4.8	2.8	3.1	1.2
	3:00 am	-	2.8	7.9	2.0	3.8	-1.9	5.2	7.9	3.5	3.0	2.1	0.9	1.0
	6:00 am	7.3	2.5	6.8	2.3	3.0	2.9	9.6	6.3	2.9	4.0	2.3	3.0	5.2
	9:00 am	7.0	2.3	9.1	6.1	3.0	16.0	13.9	6.2	2.5	3.8	2.1	13.9	21.5
	Noon	2.1	2.2	13.1	9.5	3.1	27.5	21.0	7.9	2.5	3.5	1.9	22.5	37.5
	3:00 pm	10.0	2.5	15.9	14.9	3.7	24.0	21.1	9.9	2.6	3.6	2.0	26.3	33.5
	6:00 pm	11.3	2.6	16.0	15.1	4.5	20.9	18.1	10.7	2.9	3.5	2.7	20.0	23.4
	9:00 pm	11.3	2.5	14.0	9.0	4.8	13.0	13.5	10.9	3.1	4.0	2.5	12.5	11.8
8/4/78	Midnight	10.6	2.9	11.0	4.5	3.2	8.8	10.0	3.5	3.5	4.3	2.6	4.9	2.5
	3:00 am	9.0	2.5	8.8	3.2	3.8	2.4	6.5	8.5	3.0	4.5	2.5	3.1	0.9
	6:00 am	6.1	2.1	6.9	3.1	4.5	4.9	5.8	6.6	2.8	4.0	2.2	3.0	1.2
	9:00 am	7.1	2.3	9.0	6.1	3.0	14.9	12.1	6.5	2.5	3.6	2.1	2.1	17.8
	Noon	8.0	2.1	11.5	10.5	3.3	21.1	16.6	7.6	2.4	3.5	2.0	19.6	28.9
	3:00 pm	11.5	2.3	13.9	12.6	4.0	23.5	18.6	9.0	2.8	3.6	2.0	24.3	31.6
	6:00 pm	-	3.8	15.7	11.1	4.9	25.0	17.9	10.1	3.0	3.8	2.2	25.0	25.5
	9:00 pm	11.1	2.5	13.9	9.9	4.9	13.8	14.0	10.6	3.2	4.0	2.5	13.0	12.0

Table 9.

Eagle Summit Temperature Data

Date	Plot	Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
	Depth (cm)	10	30	10	0	10	0	0	10	20	30	30	10	0
	Probe (#)	2	3	4	5	6	8	10	12	19	23	25	26	28
8/8/78	Midnight	6.5	6.9	7.0	6.1	4.2	7.5	9.5	8.9	3.5	4.3	3.0	8.2	8.0
	3:00 am	6.4	8.2	8.9	5.4	4.0	7.2	8.5	8.1	9.8	9.0	9.0	9.0	8.8
	6:00 am	4.8	4.5	5.0	5.0	3.9	12.2	10.2	7.9	3.2	4.3	2.8	10.9	13.5
	9:00 am	8.2	4.3	4.5	9.2	4.0	20.5	15.9	8.3	3.1	4.2	2.8	16.5	26.0
	Noon	9.6	2.9	13.9	11.5	4.5	22.3	19.9	10.0	3.3	4.1	2.5	21.9	30.8
	3:00 pm	10.9	3.0	15.0	14.4	4.9	21.3	17.6	11.1	3.5	4.5	2.9	22.1	25.6
	6:00 pm	10.0	3.3	14.2	9.9	5.0	14.6	14.6	11.5	3.9	4.9	3.0	14.6	14.2
	9:00 pm	3.6	3.5	12.2	7.1	4.5	8.7	11.5	11.1	3.9	5.0	5.3	5.5	6.5
8/9/78	Midnight	-	7.0	7.1	6.0	5.9	7.0	8.5	10.1	3.9	5.1	5.9	3.1	5.3
	3:00 am	7.1	5.5	9.5	6.0	4.0	8.5	8.9	8.8	3.5	4.0	3.1	7.0	7.5
	6:00 am	8.8	4.5	9.5	6.6	4.0	12.1	10.0	8.5	3.3	4.9	3.0	8.1	10.0
	9:00 am	9.5	3.7	12.5	8.9	9.2	26.7	16.9	9.5	3.5	5.0	3.0	15.5	24.6
	Noon	10.0	3.6	14.0	10.0	4.4	22.0	17.8	10.3	3.3	5.0	2.9	19.6	26.8
	3:00 pm	10.9	3.7	14.0	14.5	4.9	18.2	15.0	11.0	3.5	5.2	3.0	18.2	21.1
	6:00 pm	11.2	4.1	13.4	9.9	5.2	14.9	13.5	11.2	3.9	5.5	3.2	12.8	13.7
	9:00 pm	4.0	4.0	4.5	4.9	4.9	9.0	10.2	10.5	3.6	5.5	3.2	8.1	7.6
8/10/78	Midnight	4.0	9.8	6.5	6.5	6.8	8.0	8.4	9.0	9.9	9.9	9.9	9.9	10.0
	3:00 am	3.9	8.4	4.9	4.1	4.1	6.5	7.1	8.0	3.5	5.0	4.5	5.0	5.0
	6:00 am	3.3	8.1	4.9	5.0	3.9	15.0	14.0	7.0	7.2	4.9	4.5	4.6	3.7
	9:00 am	8.0	3.5	10.9	7.1	3.9	25.0	14.9	7.5	3.1	4.6	2.8	13.5	23.0
	Noon	8.3	3.5	11.9	7.6	3.9	25.9	16.5	7.9	3.0	4.6	2.7	16.2	27.4
	3:00 pm	9.2	3.5	13.2	9.8	4.0	17.9	15.6	9.0	3.2	3.2	2.9	20.9	25.2
	6:00 pm	9.9	3.6	12.5	10.3	5.0	5.3	12.9	9.5	3.3	3.3	2.9	16.6	15.9
	9:00 pm	9.6	3.6	10.5	6.5	4.5	6.1	9.5	9.1	3.5	3.5	3.5	6.9	5.1

Table 9.

Eagle Summit Temperature Data

Plot		Tussock-3		Intertussock			Tussock-3	Inter-tussock	Tussock-3	Inter-tussock	Tussock-3	Tussock-4		
Depth (cm)		10	30	10	0	10	0	0	10	20	30	30	10	0
Probe (#)		2	3	4	5	6	8	10	12	19	23	25	26	28
8/11/78	Midnight	4.5	5.0	8.0	3.4	4.1	0.4	5.8	8.0	3.4	4.0	2.0	2.0	3.5
	3:00 am	-0.2	3.5	2.0	3.6	3.6	0.3	3.6	6.4	3.2	3.1	0.5	0.5	-2.0
	6:00 am	-0.2	3.6	3.6	3.2	3.6	6.8	6.9	5.1	5.9	6.5	6.9	7.0	6.9
	9:00 am	6.5	3.0	9.0	5.7	3.1	24.5	13.5	5.9	2.6	2.5	2.5	12.1	19.6
	Noon	7.6	3.0	12.5	7.4	3.1	24.1	18.0	7.5	2.5	2.5	2.5	23.0	30.5
	3:00 pm	8.5	3.0	13.1	14.9	3.5	17.2	15.1	8.5	2.6	4.0	2.5	24.9	24.5
	6:00 pm	9.2	3.0	11.3	7.4	4.0	11.5	10.9	8.7	2.7	4.0	2.5	11.5	11.0
	9:00 pm	8.8	3.2	8.6	3.9	3.8	3.4	6.5	8.0	3.0	4.0	3.5	3.5	2.9
8/12/78	Midnight	5.5	3.7	3.6	3.5	1.5	4.2	3.5	6.9	3.8	4.0	2.0	0.9	-2.0
	3:00 am	-	2.0	2.3	2.1	2.1	-2.1	1.9	4.4	3.0	3.5	3.9	0.0	0.3
	6:00 am	5.0	2.4	5.5	2.2	2.4	15.0	8.2	4.0	3.5	2.5	2.9	3.0	3.5
	9:00 am	2.3	9.9	5.6	2.3	2.3	34.0	16.3	5.0	1.9	3.0	1.9	18.5	30.5
	Noon	7.8	2.5	13.0	8.8	2.9	21.0	16.3	8.0	2.0	3.1	2.1	18.2	20.5
	3:00 pm	9.0	2.6	13.2	12.8	3.4	18.6	15.2	9.5	2.2	3.5	2.1	19.9	18.5
	6:00 pm	9.9	3.0	11.5	7.9	3.6	10.9	11.3	9.9	2.5	3.8	2.1	10.8	10.7
	9:00 pm	9.9	3.1	10.5	6.2	3.9	9.0	10.1	9.9	2.8	3.0	3.0	8.5	9.2
8/13/78	Midnight	3.5	3.1	7.5	5.3	4.7	3.6	7.5	9.0	2.9	4.5	2.5	4.0	1.9
	3:00 am	3.0	3.0	4.2	3.1	6.0	7.2	8.0	8.1	2.6	4.5	2.6	5.9	5.9
	6:00 am	7.9	3.1	8.8	6.9	3.2	12.3	11.2	7.3	2.5	2.9	3.0	3.2	3.5
	9:00 am	8.1	2.9	11.1	9.0	3.3	17.0	16.2	8.1	2.5	4.0	2.5	16.5	24.9
	Noon	9.1	3.0	8.9	10.5	3.9	13.1	16.0	9.8	2.9	4.1	3.6	16.5	18.1
	3:00 pm	10.1	3.0	13.3	10.5	4.3	16.0	16.0	10.2	3.1	4.5	2.8	16.0	18.3

Table 10.

Percent Carbon, Hydrogen, Nitrogen and Organic Matter of
Soils from Eagle Summit Alpine Tundra

Plot	Zone	Core No.	% Carbon	% Hydrogen	% Nitrogen	C/N	% OM	Remarks
Fell Field 1)	2	74	20.20	2.47	0.73	28/1	34.83	
Fell Field 1)	2	74	22.06	2.68			33.03	
Fell Field 2)	2	76	28.01	3.99	0.37	76/1	48.29	
Fell Field 2)	2	76	29.50	4.13	0.23	128/1	50.86	
Upper Dec. Shrub	2	64	35.16	4.39	0.60	59/1	60.62	
Upper Dec. Shrub	2	64	27.54	3.04	0.16	172/1	47.48	
Dec. Forb	2	59	19.19	2.33	0.90	21/1	33.09	
Dec. Forb	2	59	19.42	2.29	0.67	29/1	33.48	
Lower Dec. Shrub	2	52	40.94	4.14	0.96	43/1	70.59	
Lower Dec. Shrub	2	52	38.07	3.89	1.01	38/1	65.64	
Moss-Carex-Salix	2	45	23.30	3.11	0.67	35/1	40.17	
Moss-Carex-Salix	2	45	23.68	2.79	0.95	25/1	40.83	
Tussock	2	7	42.27	5.13	0.58	73/1	72.88	
Tussock	2	7	42.43	4.60	0.05		73.15	
Inter-tussock	2	12	41.37	4.50	0.86	48/1	71.33	
Inter-tussock	2	12	41.43	4.64	0.83	50/1	71.43	

Fell Field 1) = Dryas
Fell Field 2) = Loiseleuria

Table 11.

Percent Carbon, Hydrogen, Nitrogen and Organic Matter of Soils From Eagle Summit Alpine Tundra

Plot	Zone	Core No.	% Carbon	% Hydrogen	% Nitrogen	C/N	% OM	Remarks
Fell Field 1)	2	63	8.09	2.05			13.95	
Fell Field 1)	2	63	11.39	1.84	0.09	126/1	19.64	
Fell Field 2)	2	71	24.35	3.16	0.38	64/1	41.98	
Fell Field 2)	2	71	18.79	3.01			32.40	
Upper Dec. Shrub	2	54	12.99	1.50			22.40	
Upper Dec. Shrub	2	54	7.59	1.05			13.09	
Dec. Forb	2	49	17.85	1.87			30.78	
Dec. Forb	2	49	18.81	2.21	0.42	45/1	32.43	
Lower Dec. Shrub	2	40	28.14	3.40	1.28	22/1	48.52	
Lower Dec. Shrub	2	40	25.08	2.73	0.65	39/1	43.24	
Moss-Carex-Salix	2	36	44.52	4.95	1.79	25/1	76.76	
Moss-carex-Salix	2	36	44.23	4.53	1.31	34/1	76.26	
Tussock	2	6	42.88	4.90	0.83	52/1	73.93	
Tussock	2	6	40.90	4.96	0.71	58/1		
Tussock	3-4	6	7.72	1.03			13.31	
Tussock	3-4	6	8.62	1.13			14.86	
Inter-Tussock	2	12						
Inter-Tussock	2	12						

Fell Field 1) = Dryas
Fell Field 2) = Loiseleuria

Thus, based on results from the first season of this subproject the plant communities in the snow patch site and the tussock tundra site differ in the fungal biomass, presence of mycorrhizal fungi (Table 12), and levels of soil nitrogen, soil carbon, and total soil organic matter. Daily surface and soil temperatures in the tussock site were higher than was anticipated. Initial decompositon is progressing strongly in some cases but it is too early to compare plant communities.

The cover and distribution of mosses, by species, and the cover of lichens and vascular plants along the snow patch gradient was determined (Figs. 4-7). Species of *Polytrichum* and *Pogonatum* were predominantly found in the driest areas of the snow patch gradient (fellfield, lichen-heath, upper deciduous shrub, and *Cassiope*). *Dicranum* spp. were found predominantly in the *Cassiope* zone, an area of moderate moisture. *Sphagnum* species were found in the wet sedge-moss zone where the feather mosses were also found in great abundance. These data indicate physiological differences in the moss species which account for spatial separation along a moisture gradient.

The cover and distribution of mosses, by species, in tussock and inter-tussock areas was determined (Fig. 8). Distribution was measured by tussock class (Fetcher and Shaver, Progress Report Part II) and by slope and aspect within the tussock. In the area of *Eriophorum* tussocks, tussock classes (Fetcher and Shaver *in press*) varied greatly in percent cover of mosses. The ranking of tussock classes according to moss cover was 6 > 4 > 5 > 3 > 7 > 2. The most abundant species were *Sphagnum balticum*, *S.* lenensea, *Dicranum elongatum*, and *Polytrichum commune*. *Sphagnum* spp. were more common in tussocks of assumed older age. *Dicranum* and *Polytrichum* were the most common species in the youngest tussock class.

Table 12.

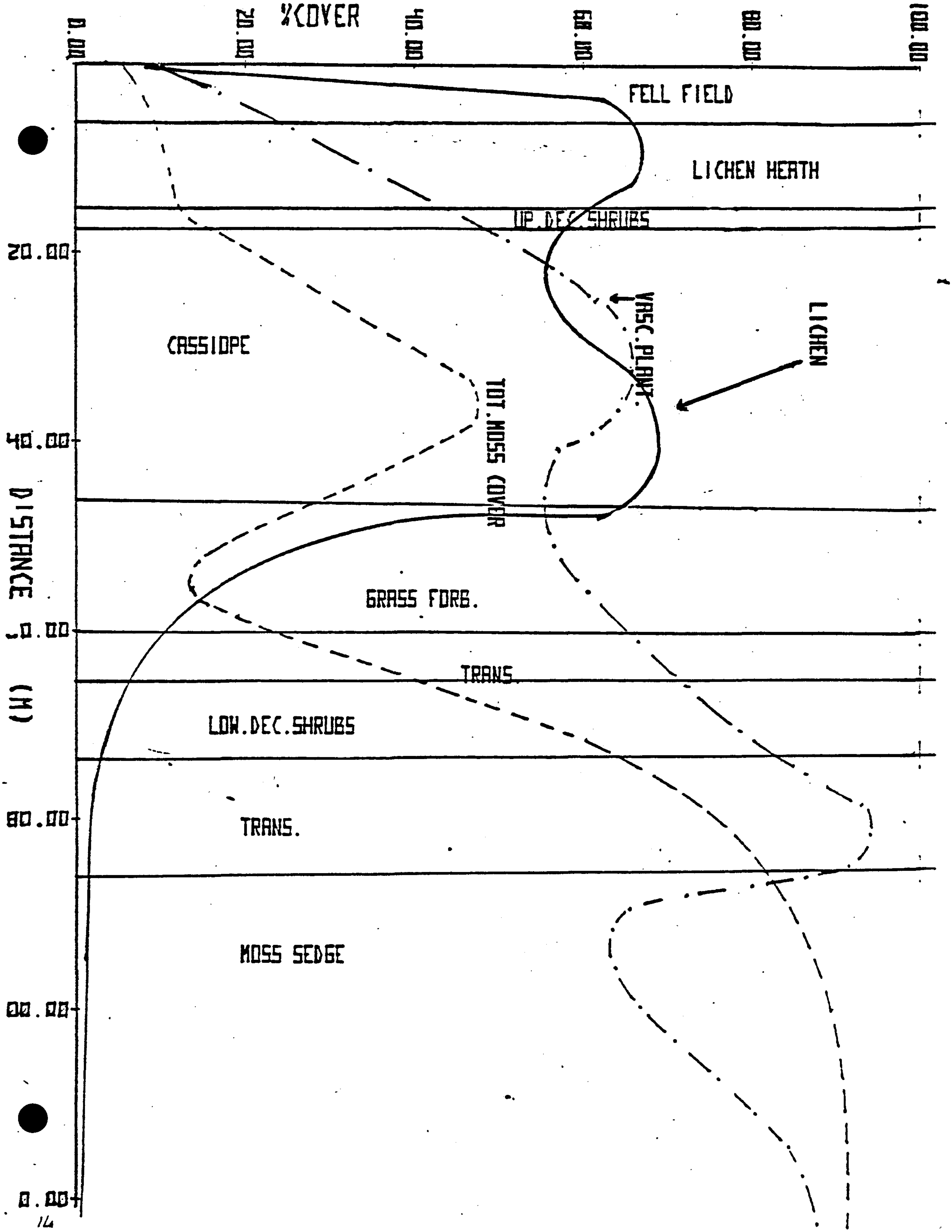
Initial Results

Plant Root Analyses for Mycorrhizae

O. K. Miller

Plant Species Examined as of Jan. 11, 1979	Observations
Anemone sp.	endomycorrhizae present and an unusual ect-endomycorrhizal infection on several roots.
Arctostaphylos alpina	two types of mycorrhizae: a. yellowish ectomycorrhizal fungus with clamp connections. b. typical black ectomycorrhizae of *Cenococcum grandiforme*.
Betula nana	abundant white ectomycorrhizae with clamp connections.
Carex biglowii	no sign of mycorrhizae
Ledum decumbens	possibly an endomycorrhizal fungus, mostly withered young roots.
Loiseleuria procumbens	very unusual roots and root associated fungi with areas of endomycorrhizal infections.
Petasites frigidus	scattered infections of a dematiaceous endomycorrhizal fungus.
Oxytropis nigrescens	no sign of any mycorrhizal fungi.
Vaccinium uliginosum	abundant dematiaceous endomycorrhizae.
Vaccinium vitis-idaea	scattered "weak" endomycorrhizae (recently released from snow).

Figure 4. Idealized distribution of lichen, vascular plant, and moss cover in the snow patch, 1978.



%COVER
DISTANCE (M)
FELL FIELD
LICHEN HEATH
UP.DEC.SHRUBS
CASSIOPE
VASC.PLANT.
LICHEN
TOT.MOSS COVER
GRASS FORB.
TRANS.
LOW.DEC.SHRUBS
TRANS.
MOSS SEDGE

14

Figure 5. Idealized distribution of *Polytrichum* spp., *Pogonatum* spp., *Dicranum* spp., *Sphagnum* spp., and total moss on the snow patch, 1978.

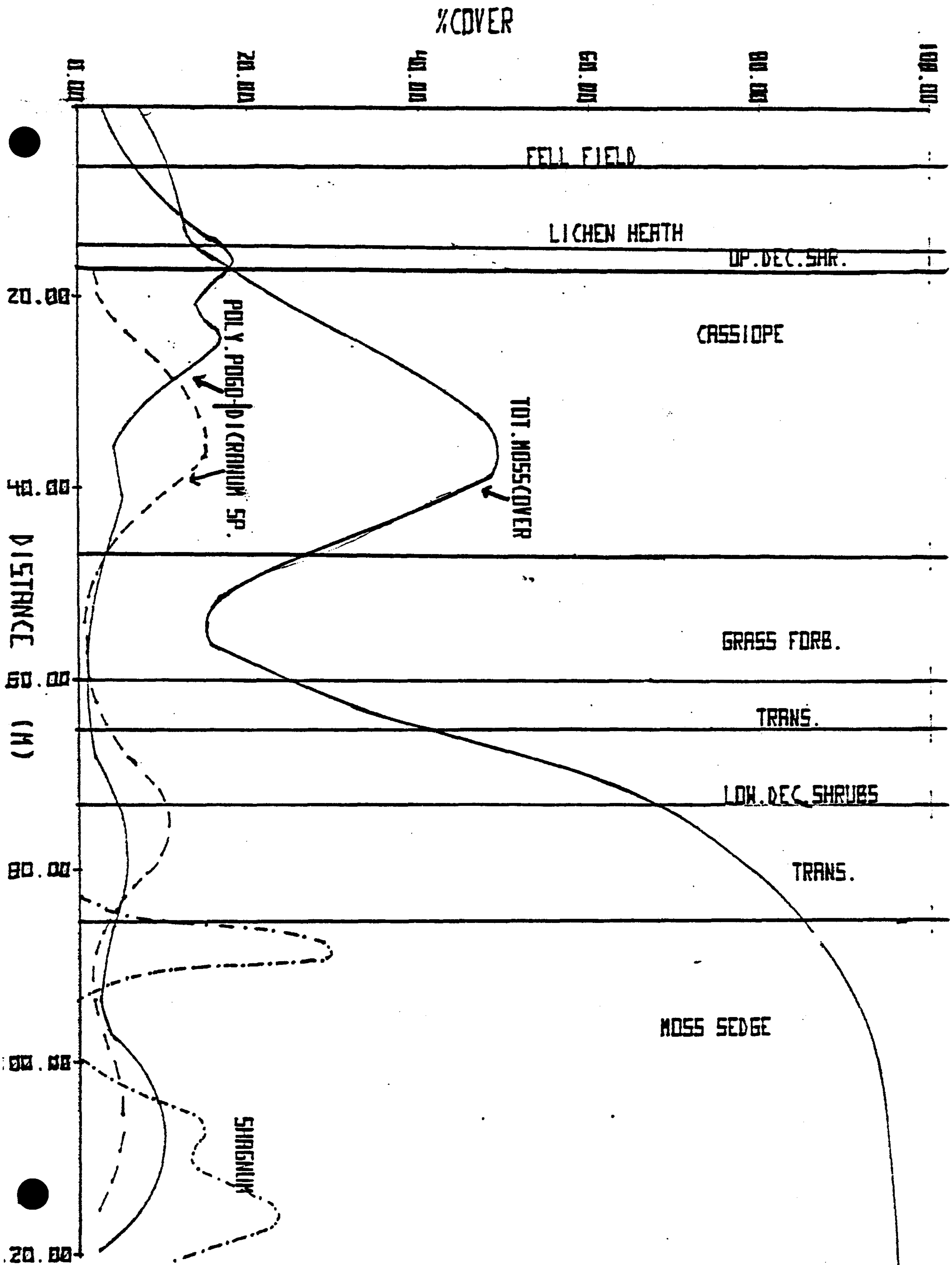
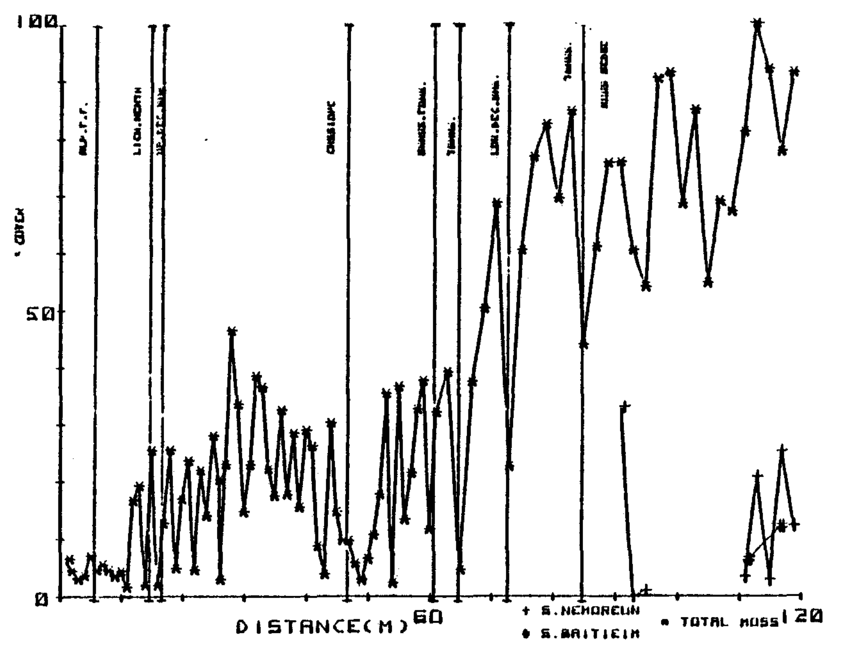
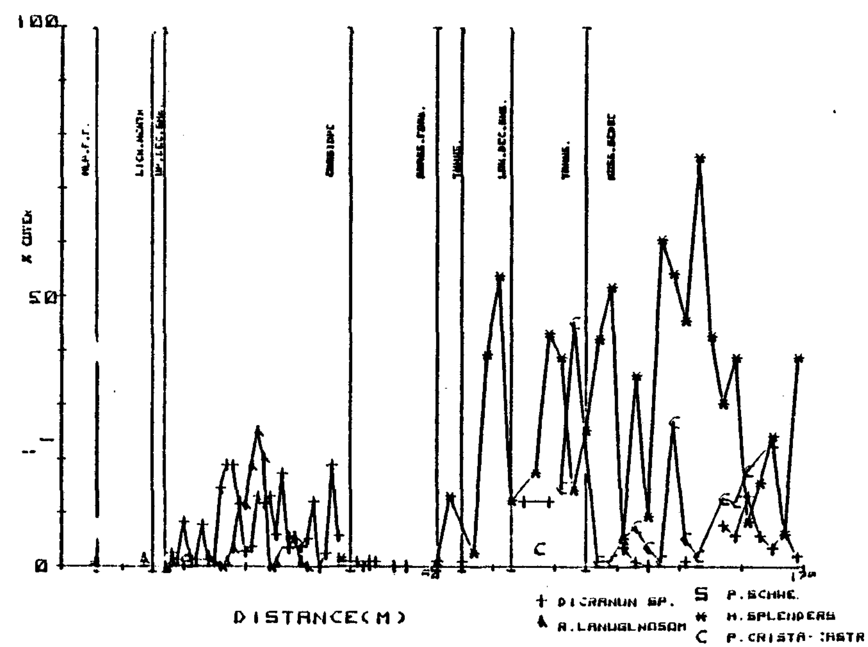
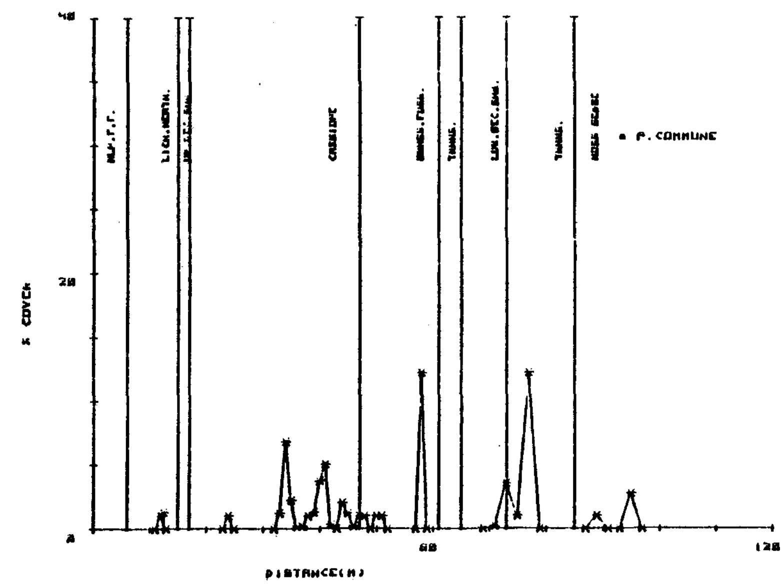
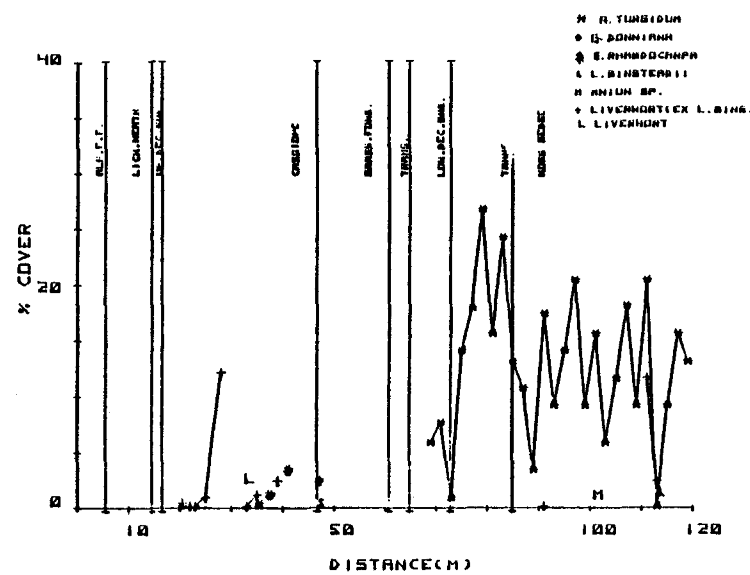

%COVER
0.00
20.00
40.00
60.00
80.00
100.00
FELL FIELD
LICHEN HEATH
DP.DEC.SHR.
CASSIOPE
POLY.POGO
DICRANUM SP.
TOT.MOSSCOVER
GRASS FORB.
TRANS.
LOW.DEC.SHRUBS
TRANS.
MOSS SEDGE
SPHAGNUM
DISTANCE (M)
20.00
40.00
60.00
80.00
00.00
20.00

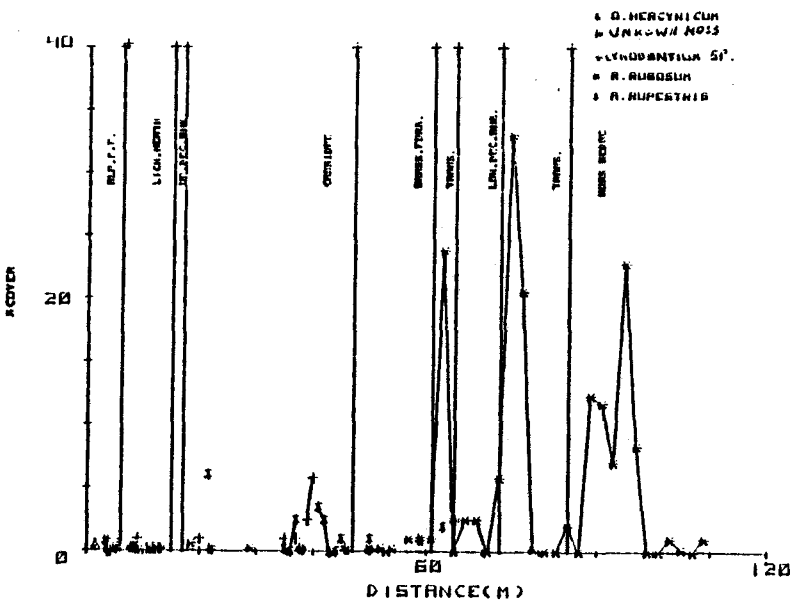
Figure 6a, b. Distribution of moss species and total moss cover on the snow patch, 1978.

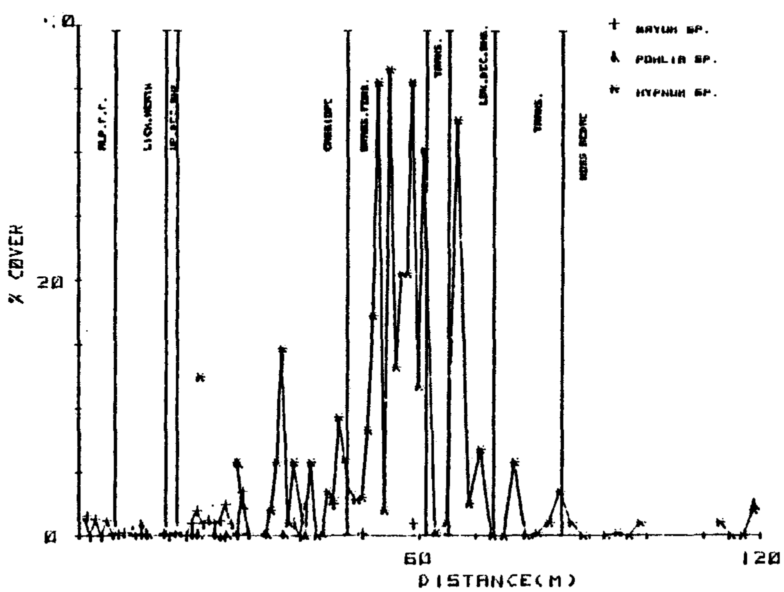

DISTANCE(M)
TOTAL MOSS


DISTANCE(M)


% COVER
DISTANCE(M)


% COVER
DISTANCE(M)


% COVER
DISTANCE(M)
UNKNOWN MOSS


BRYUM SP.
POHLIA SP.
HYPNUM SP.
% COVER
DISTANCE(M)

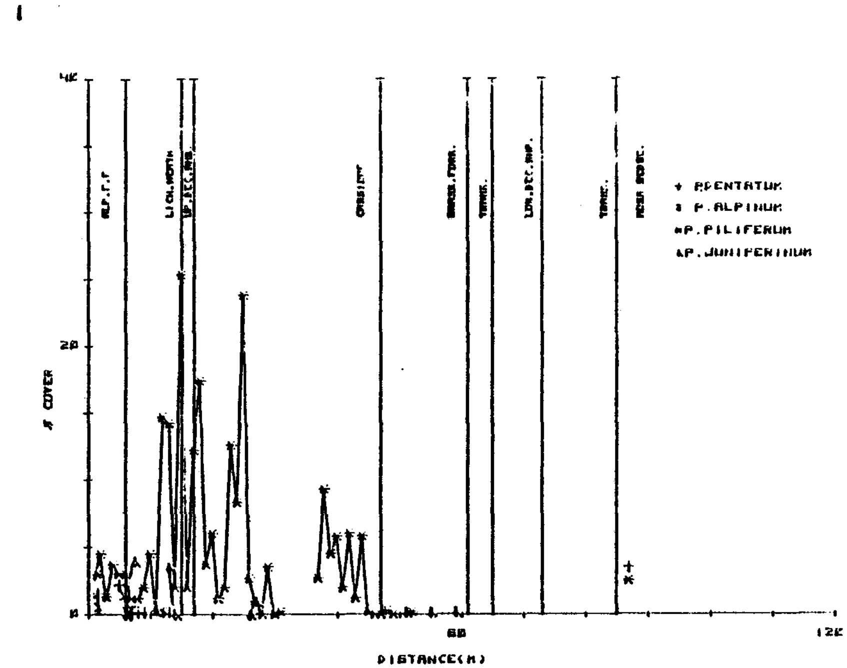
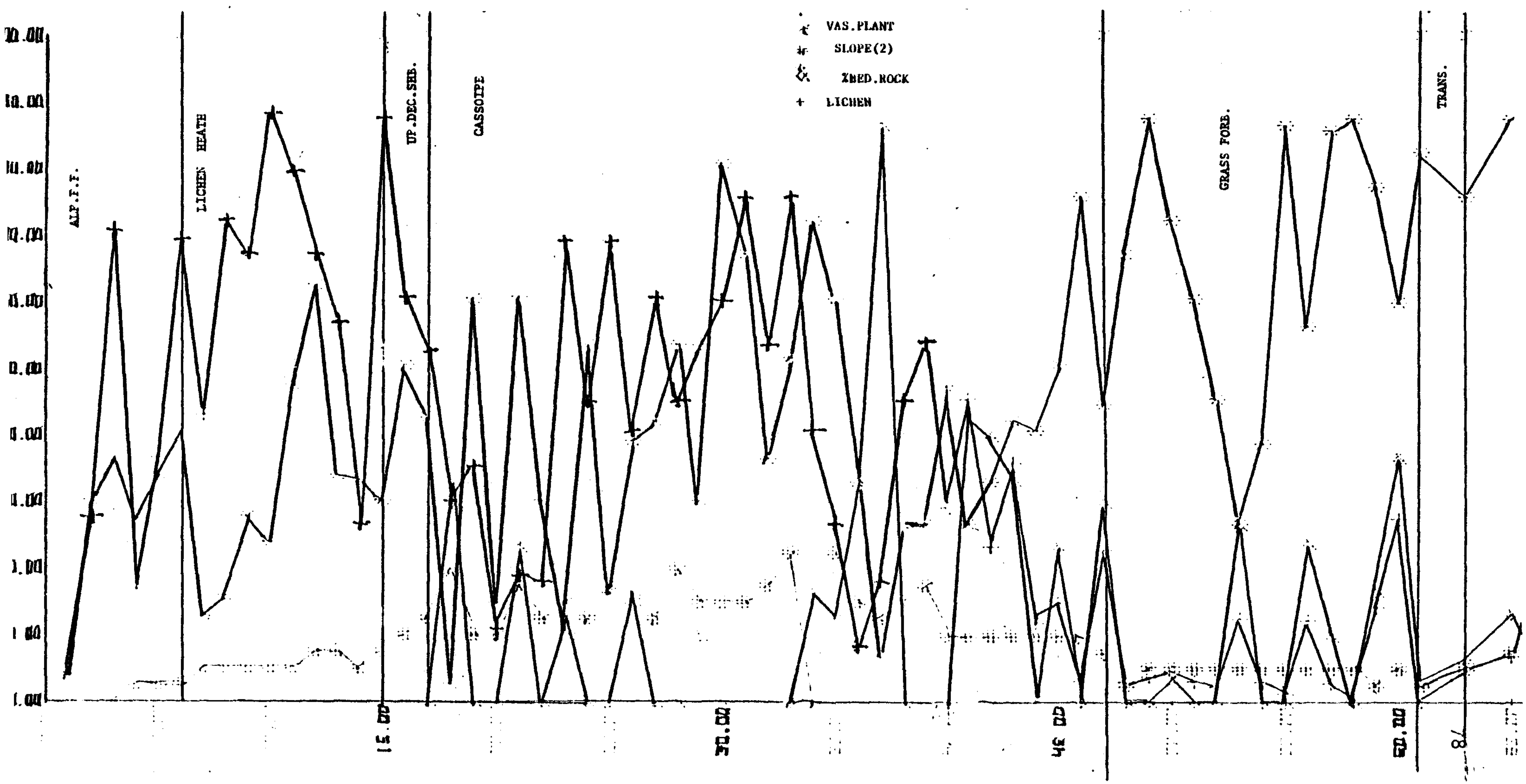

P. ALPINUM
P. PILIFERUM
P. JUNIPERINUM
% COVER
DISTANCE(M)

Figure 7a, b. Percent bedrock, vascular plant cover, lichen cover, and slope at the snow patch, 1978.



VAS.PLANT
SLOPE(2)
%BED.ROCK
LICHEN
ALP.F.F.
LICHEN HEATH
UP.DEC.SHB.
CASSOIPE
GRASS FORE.
TRANS.

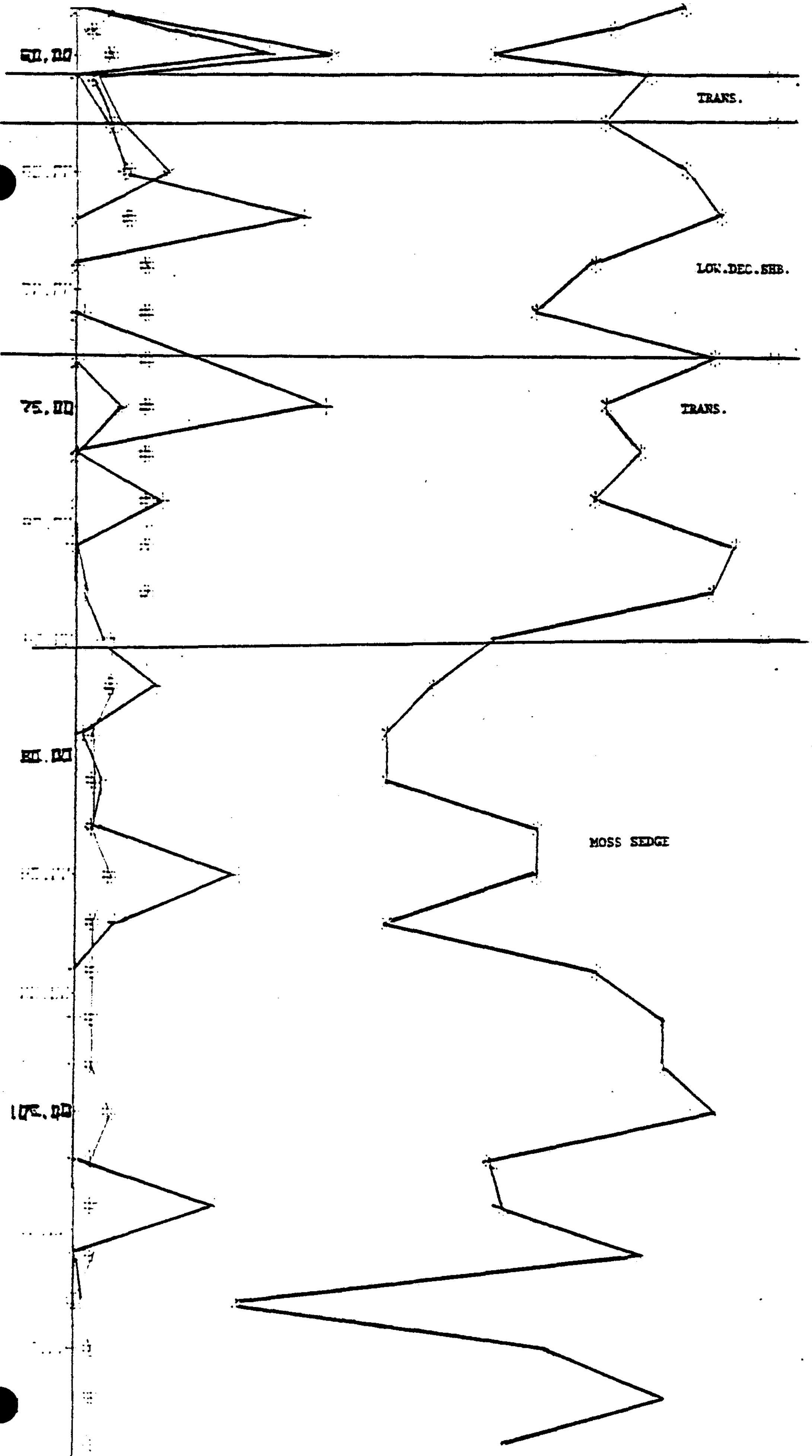

TRANS.
LOW.DEC.SHB.
TRANS.
75.00
MOSS SEDGE

Figure 8. Distribution of mosses and bare ground on *Eriophorum* tussocks classes 2b through 7. Numbers and letters represent the surface type classification:

1. *Eriophorum vaginatum* tussock > 20 cm diameter, > 15 cm height, > 5% relative cover of moss, shrubs, and *Carex*.
    a. Organic soil surrounding tussock
    b. Mineral soil surrounding tussock
2. *E. vaginatum* tussock > 15 cm diameter, > 15 cm height, > 10% relative cover of moss, shrubs, and *Carex*.
    a. Invading species mostly moss
    b. Invading species mostly shrubs
    c. Invading species mostly *Carex*
3. *E. vaginatum* tussock with 10-50% cover of moss, shrubs, and *Carex*.
    a. Moss + shrub cover > *Carex* cover
        1. Moss > shrub
        2. Shrub > moss
    b. *Carex* > moss + shrub
4. *E. vaginatum* tussock with 50-97% relative cover of moss, shrubs, and *Carex*.
    a. Moss + shrub > *Carex*
        1. Moss > shrub
        2. Shrub > moss
    b. *Carex* > moss + shrub
5. *E. vaginatum* tussock with > 97% relative cover of moss, shrub, and *Carex*; > 3% *E. vaginatum*; elevation above surrounding surface > 5 cm.
    a. Moss + shrub > *Carex*
        1. Moss > shrub
        2. Shrub > moss

b. *Carex* > moss + shrub

6. No tussock recognizable; surface not entirely surrounded by higher surfaces, or, if so, > 95% covered by vegetation and with maximum depth < 10 cm.

a. Underlain by old tussock

b. Not underlain by tussock, partly surrounded by lower surfaces

c. Surrounded by higher surfaces, moss 50%

d. Surrounded by higher surfaces, *Carex* 50%

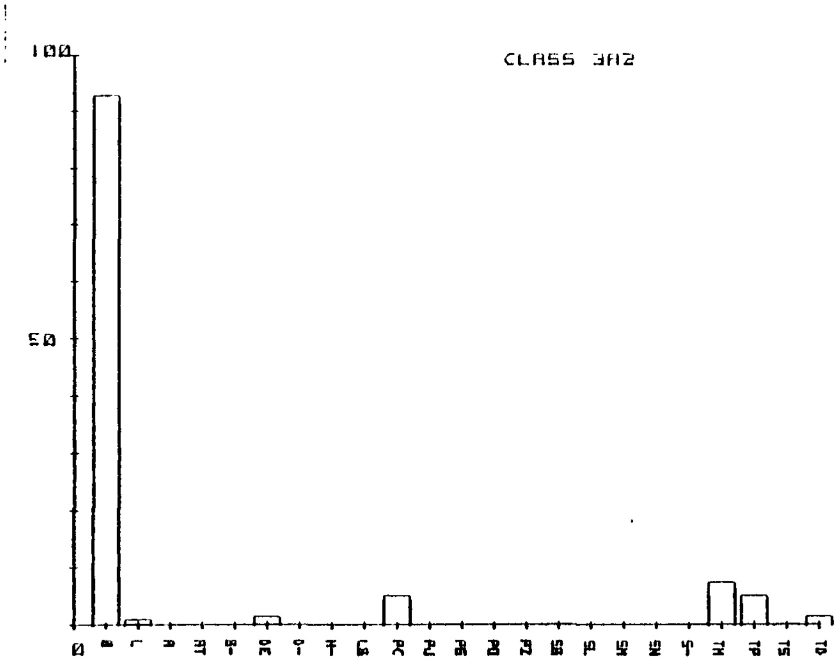
7. Intertussock space, entirely surrounded by higher surfaces, vegetative cover 95%.

The vertical axis represents the percent cover of each species or bare ground. The horizontal axis represents the species as follows:

0	no bryophytes	Sb	*Sphagnum balticum*
l	liverwort (in script)	Sl	*Sphagnum lenense*
a	unknown acrocarpous moss (in script)	Sm	*Sphagnum magellanicum*
At	*Aulacomnium turgidum*	Sn	*Sphagnum nemoreum*
B–	*Bryum* sp.	S–	*Sphagnum* sp., other than the above
De	*Dicranum elongatum*	H–	*Hypnum*
Lb	*Lophozia binsteadii* (a liverwort)	Pc	*Polytrichum commune*
Pj	*Polytrichum juniperinum*	PG	*Plagiothecium laetum*
PO	*Pohlia* sp.	PZ	*Pleurozium schreberi*

(*Hypnum* was probably most *H. callichroum*. *Pohlia* is at least partly *P. nutans*.)

(Other species found on the tussock site: *Hylocomium splendens*)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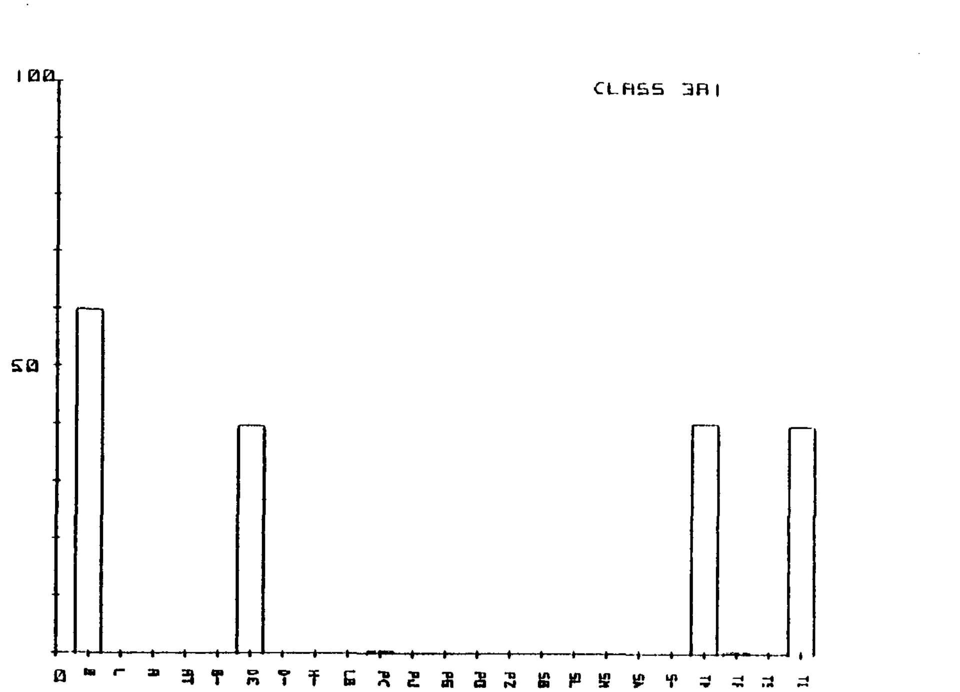
50
0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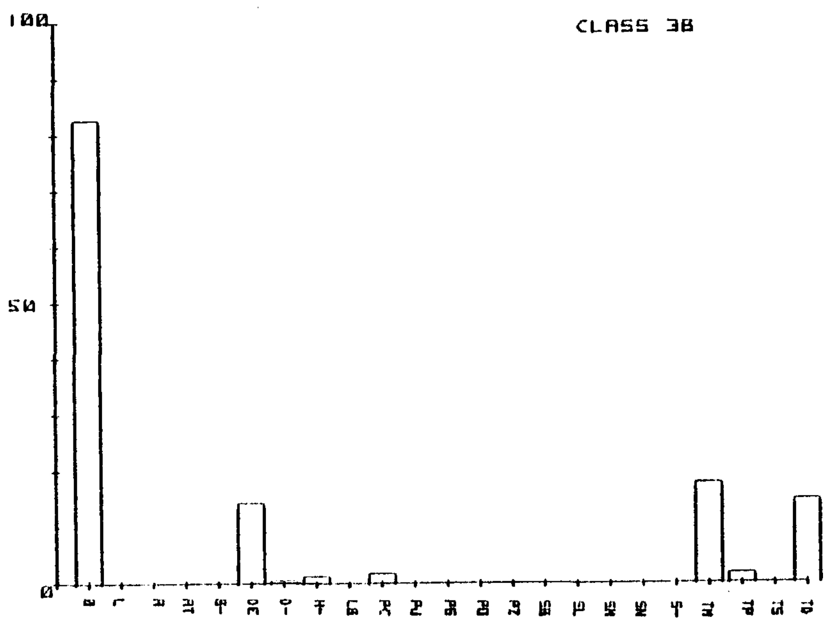
CLASS 3B
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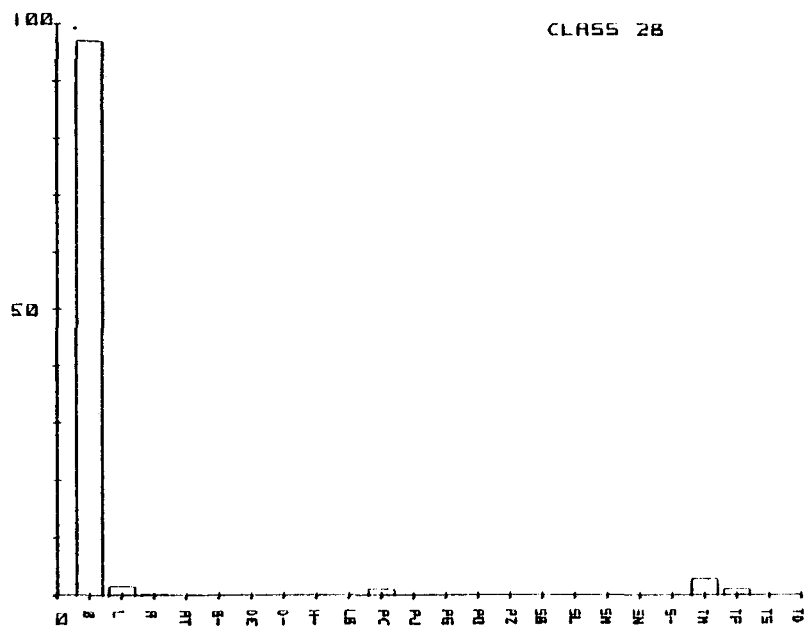
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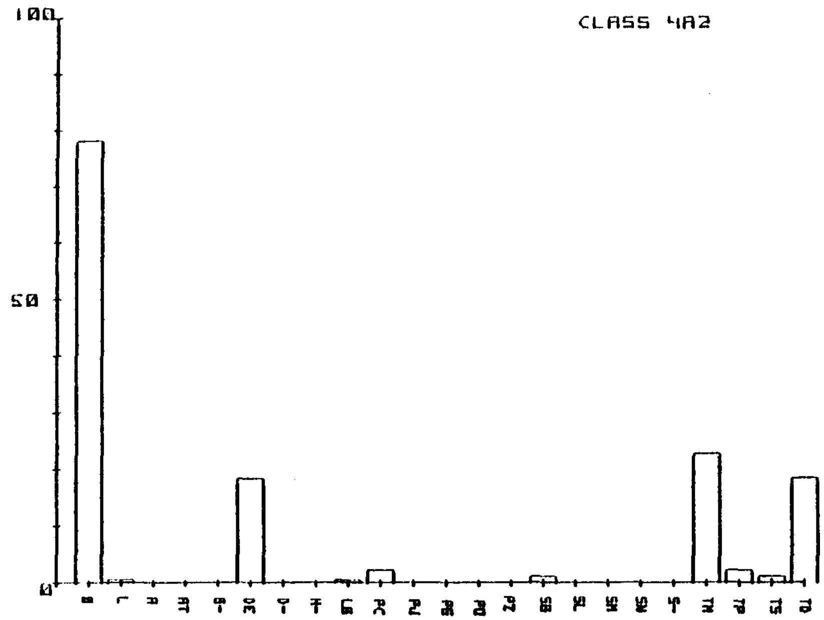
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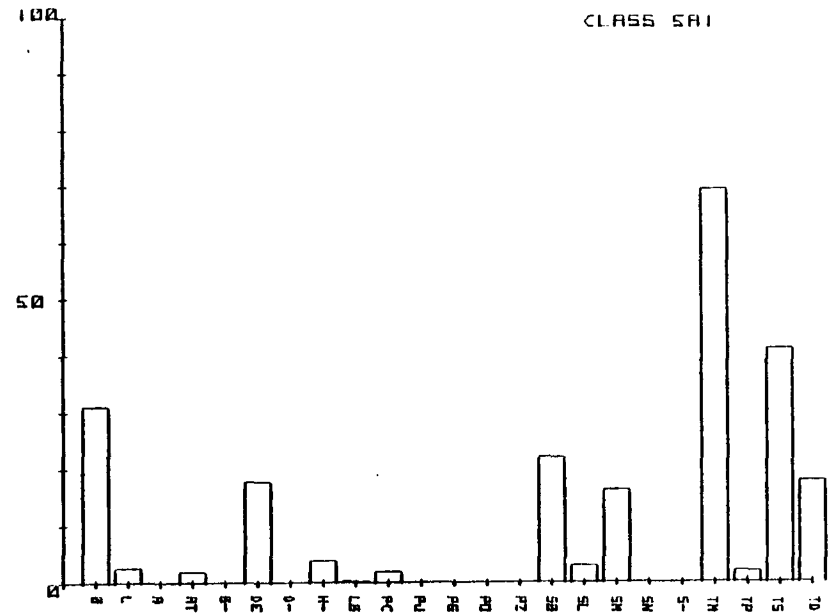
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50
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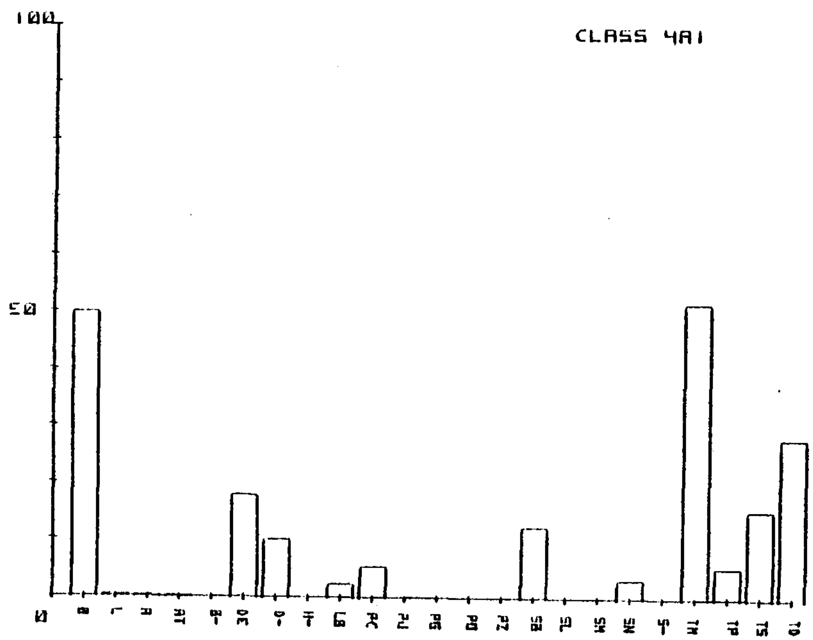
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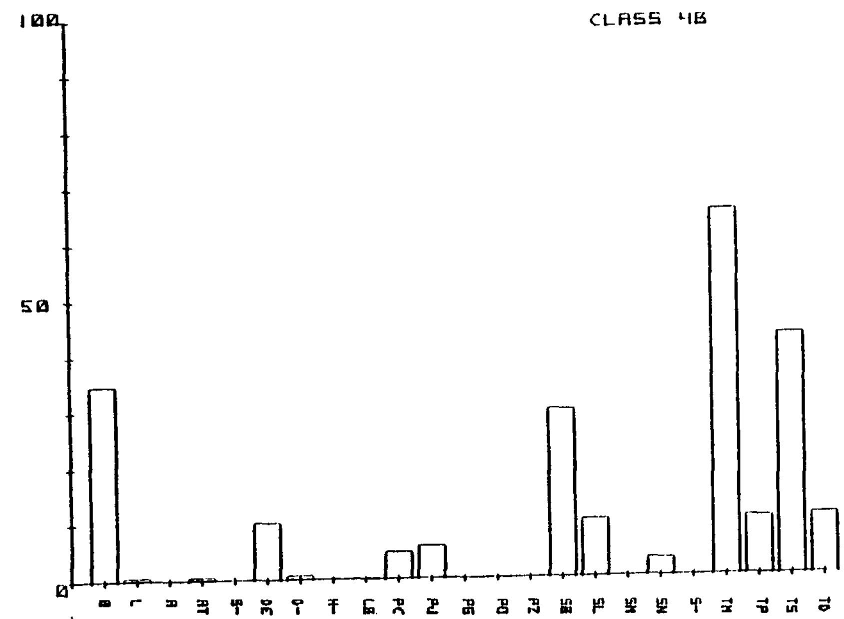
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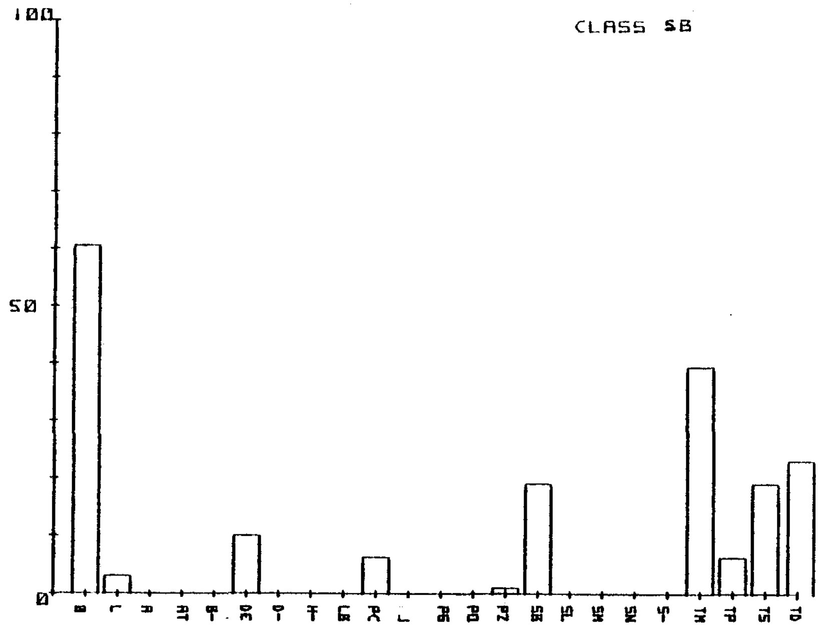
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100
50
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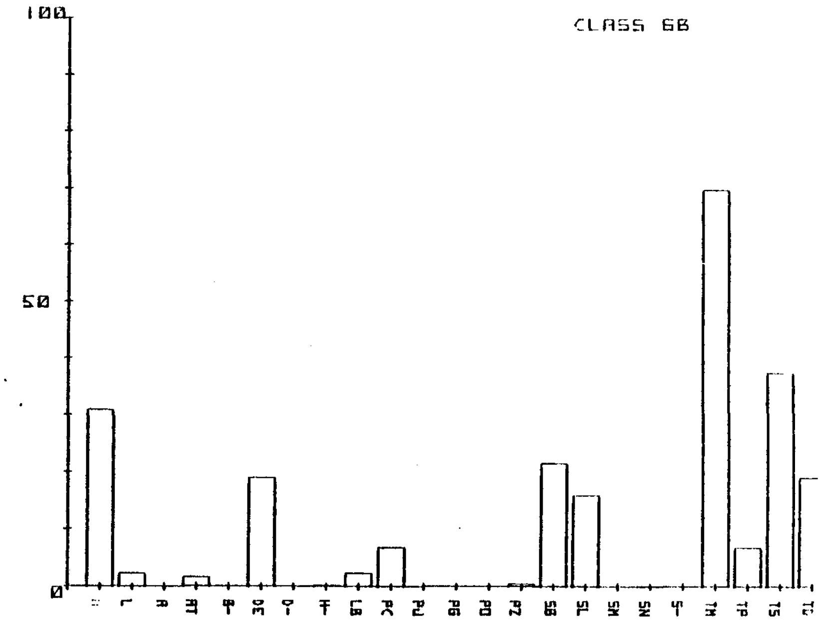
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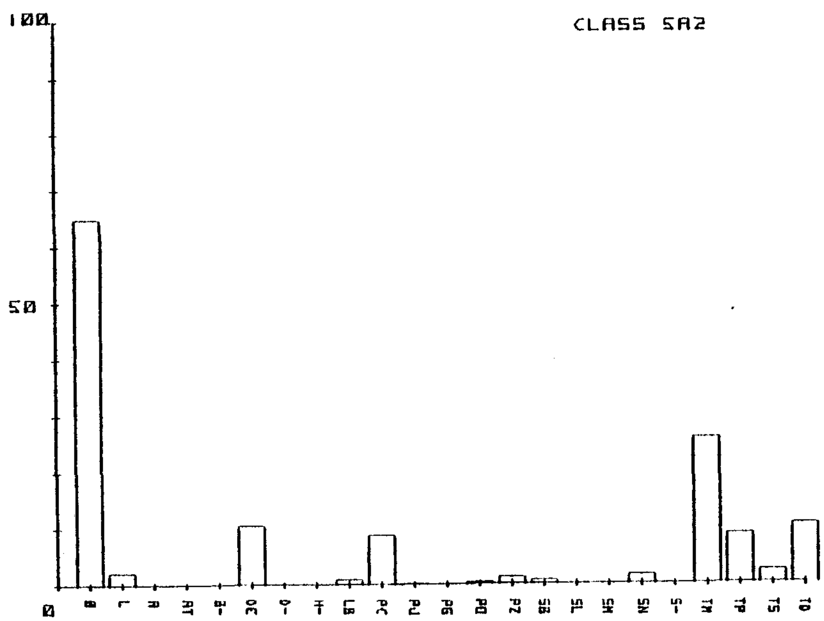
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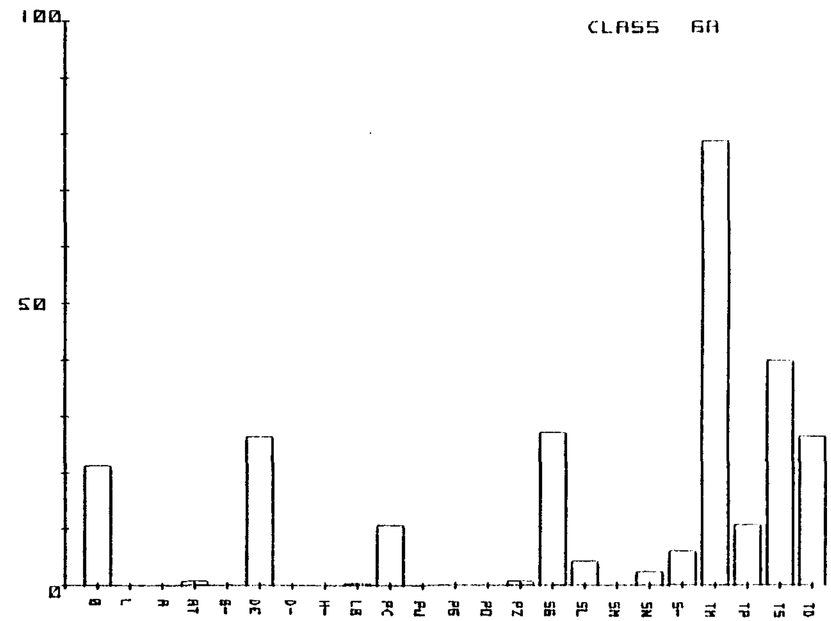
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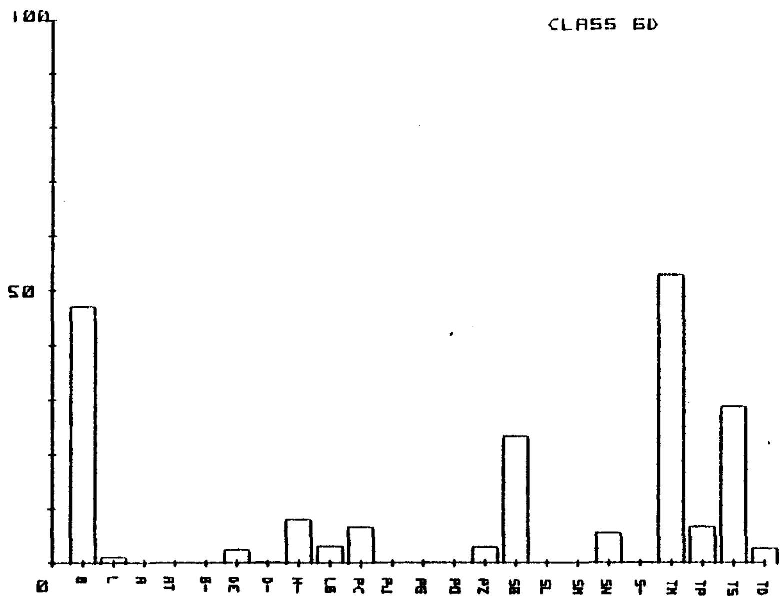
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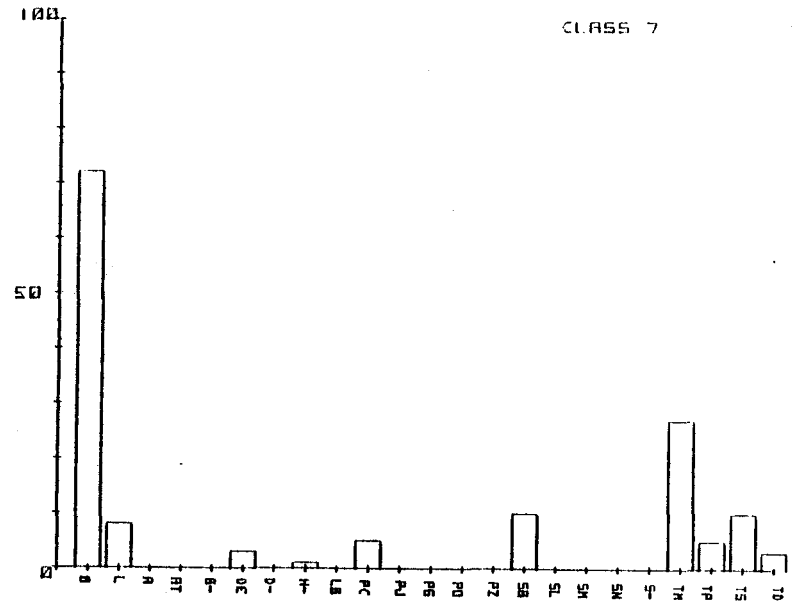
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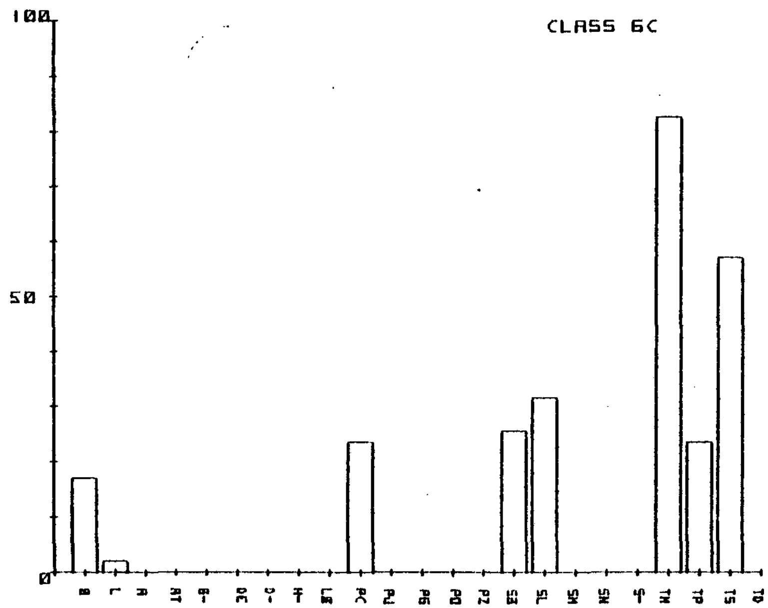
CLASS 6C
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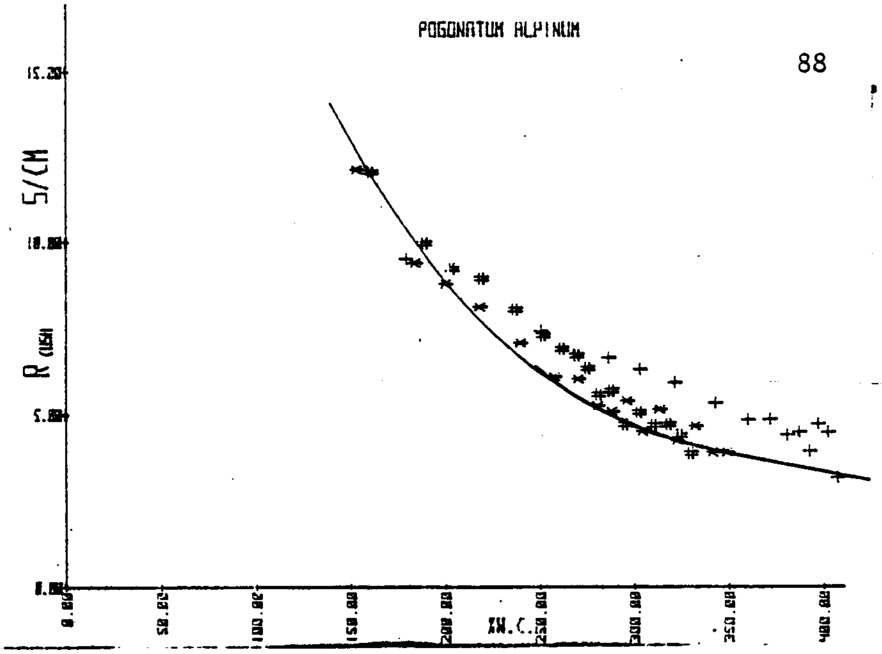
50
0

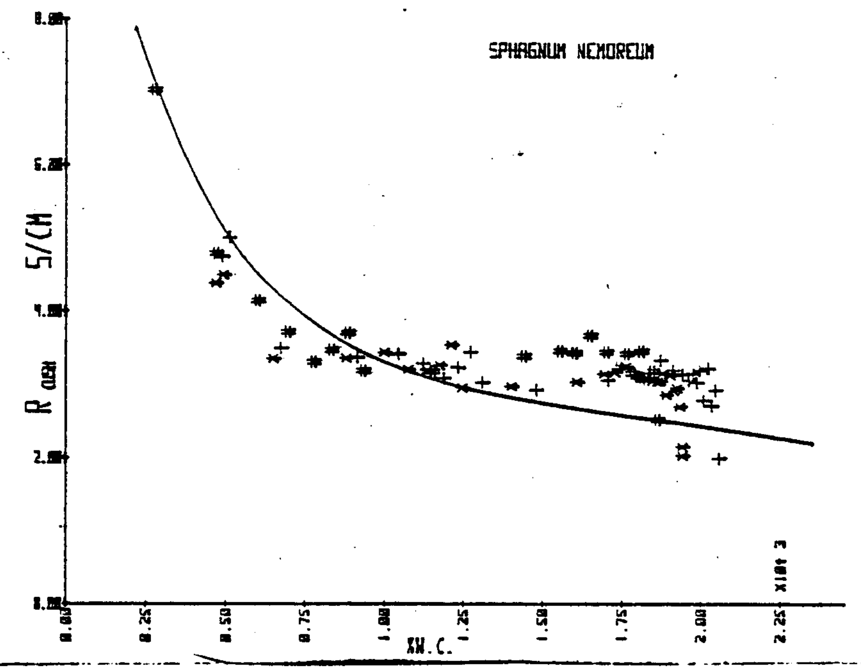
Resistance to water loss of three moss species was determined and correlated to the aridity of the habitat where they occur (Fig. 9). Cushion (leaf) and boundary layer resistances were measured in: Pogonatum alpinum, Dicranum elongatum, and Sphagnum nemoreum, in relation to tissue water content and wind speed, respectively. Saturated water contents were measured. It was found that the moss species which are dominant at the drier end of the snow patch gradient require less water to reach saturation than those at the wetter end of the gradient (S. nemoreum > D. elongatum > P. alpinum). At 50% of saturation, resistances to water loss were low (< 0.4 s cm^{-1}). Species from drier habitats (P. alpinum > D. elongatum > S. nemoreum) had higher resistances to water loss under these conditions.

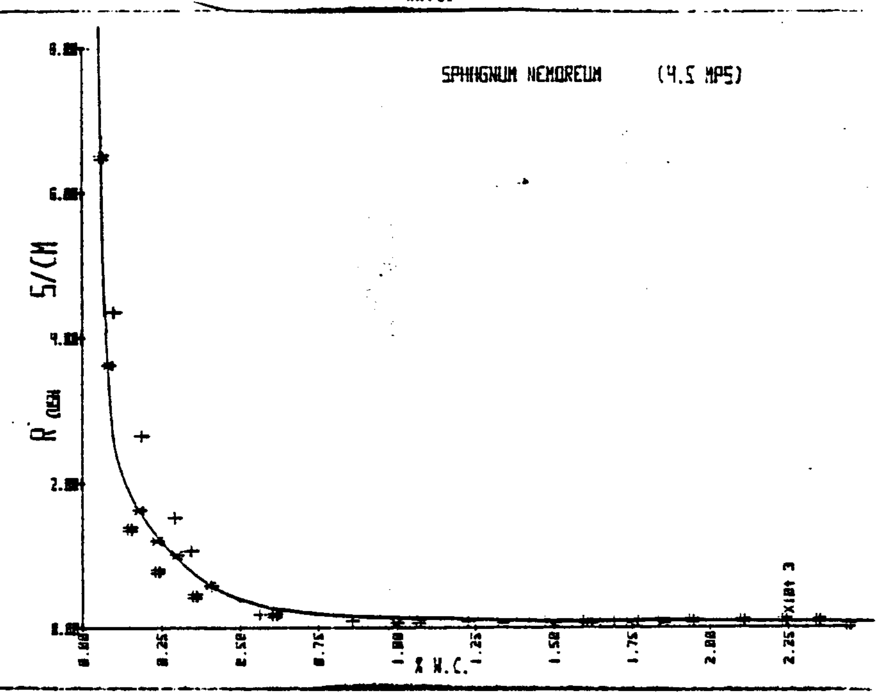
The photosynthetic response to fertilization of major vascular and non-vascular species was determined (Figs. 10-12). Included were the photosynthetic responses of eight vascular and three non-vascular species to nitrogen, phosphorus, and two levels of nitrogen-phosphorus-potassium (NPK) fertilizer applied 2 years previously during the summer of 1976. Moss species responded positively to all fertilizer treatments. Generally, the greatest enhancement was found with the high NPK treatment followed by high phosphorus, high nitrogen, and low NPK. In general, fertilizer treatments depressed vascular plant photosynthesis. In about half of the cases, high phosphorus fertilization resulted in the greatest suppression. In only 3 of 32 treatment-species combinations was photosynthesis unaffected (two treatments) or enhanced (one treatment) by fertilization. Any increase in vascular plant productivity which occurs as a result of fertilization must, therefore, do so by changes in the pattern of carbon allocation rather than increases in photosynthesis.

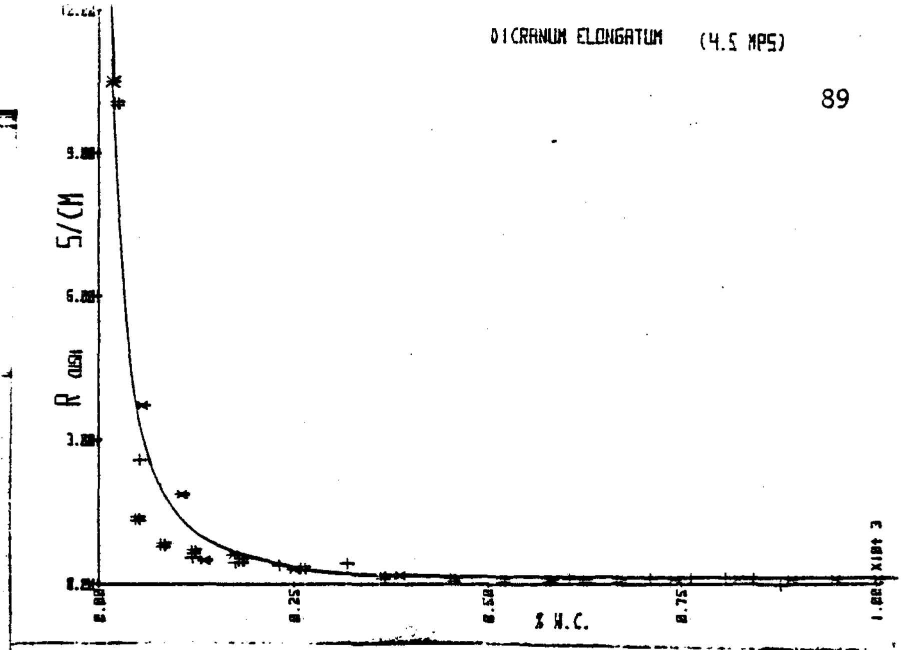
Figure 9a, b. Leaf plus air resistance in three moss species as a function of wind speed and water content.

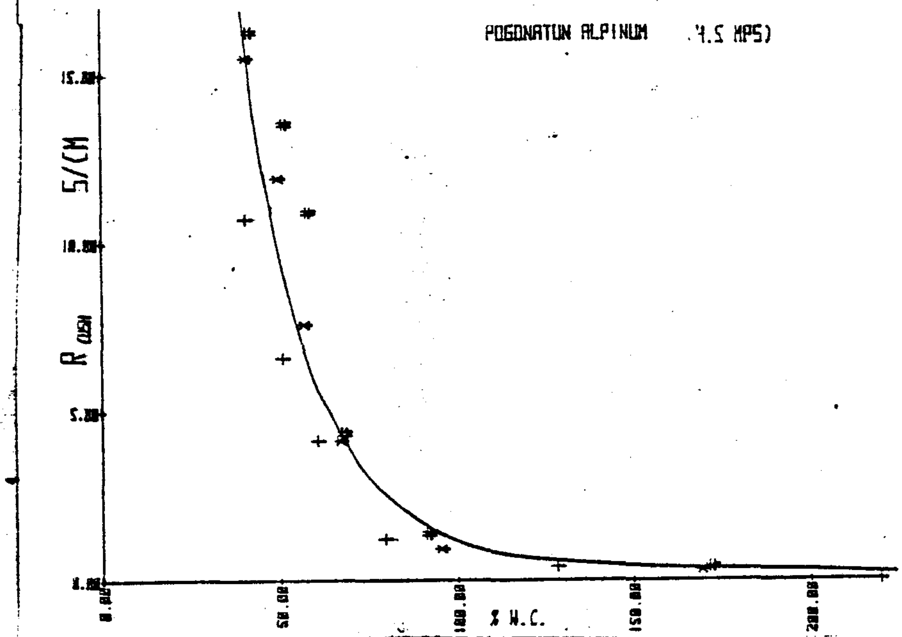
Note: Resistances near saturation are approximately equal to air (boundary layer) resistance at the respective wind speed.


POGONATUM ALPINUM
R S/CM
%W.C.
0.00
5.00
10.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00


SPHAGNUM NEMOREUM
R S/CM
%W.C.
0.00
2.00
4.00
6.00
8.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
X10+ 3


SPHAGNUM NEMOREUM (4.5 MPS)
R S/CM
% W.C.
0.00
2.00
4.00
6.00
8.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
X10+ 3


DICRANUM ELONGATUM (4.5 MPS)
S/CM
9.00
6.00
3.00
0.00
0.25
0.50
0.75
1.00
% W.C.


POGONATUM ALPINUM (4.5 MPS)
S/CM
15.00
10.00
5.00
0.00
50.00
100.00
150.00
200.00
% W.C.

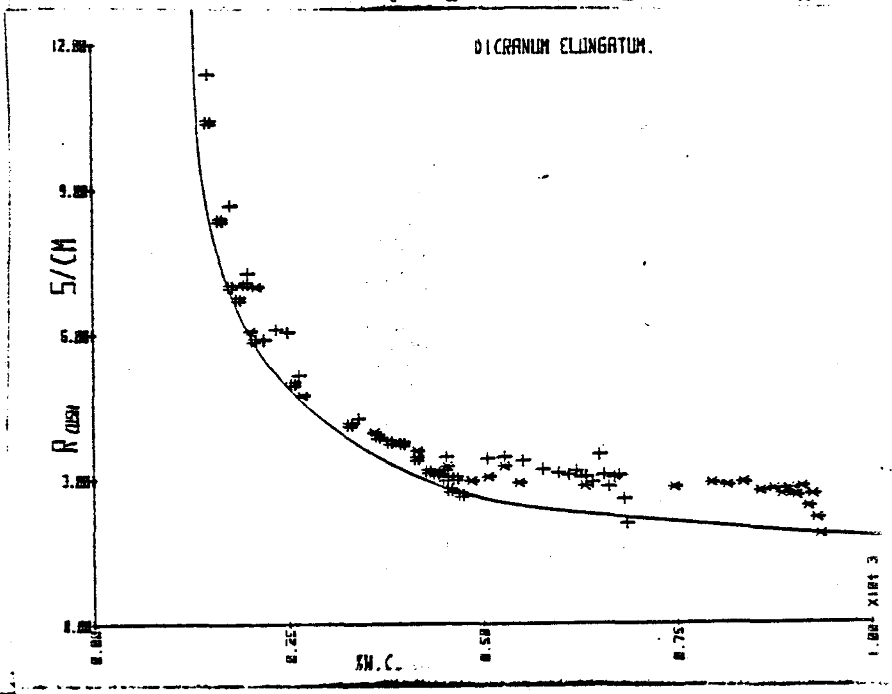
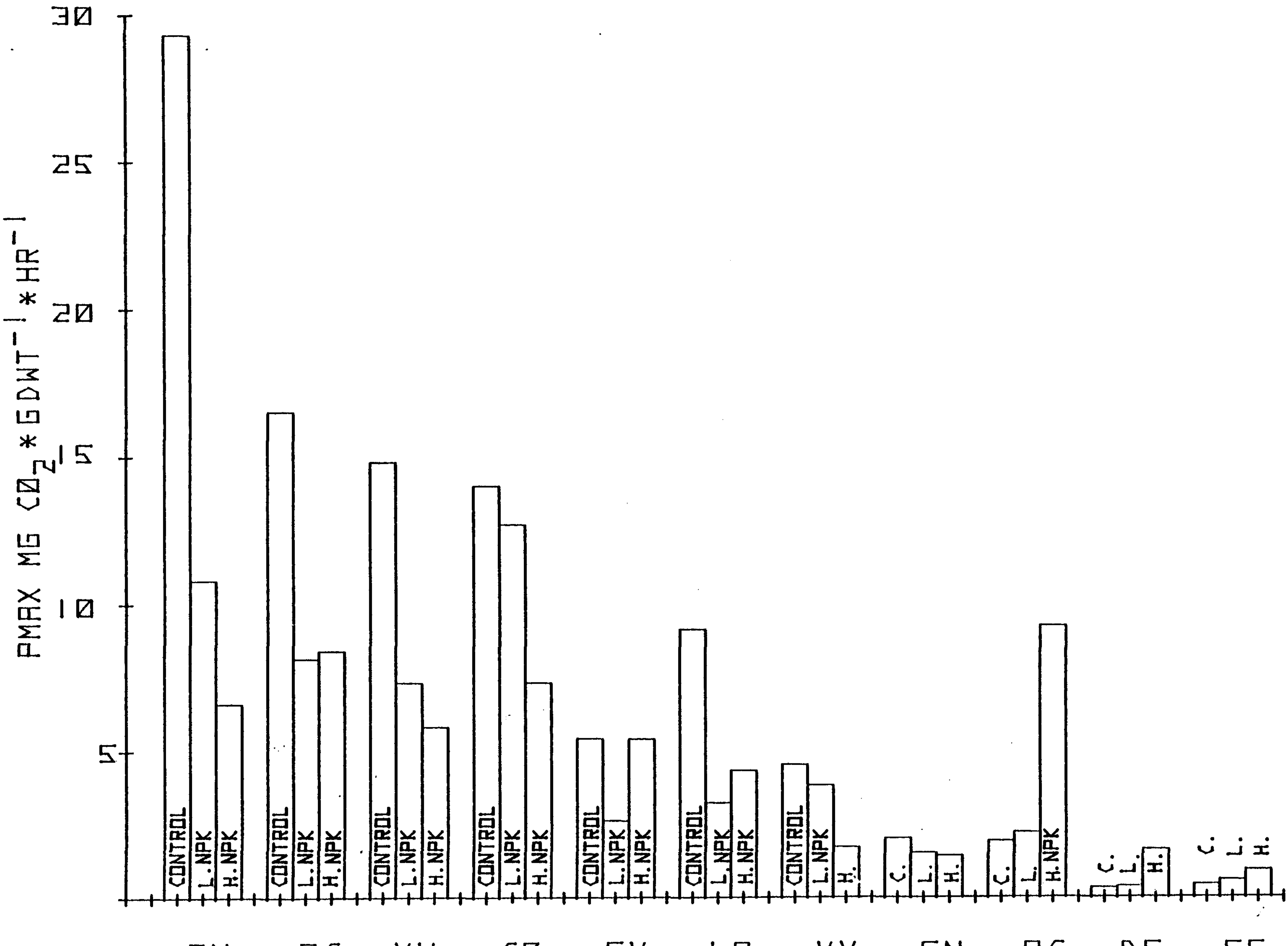

DICRANUM ELONGATUM.
12.00
9.00
6.00
3.00
0.00
S/CM
0.25
0.50
0.75
1.00
%W.C.

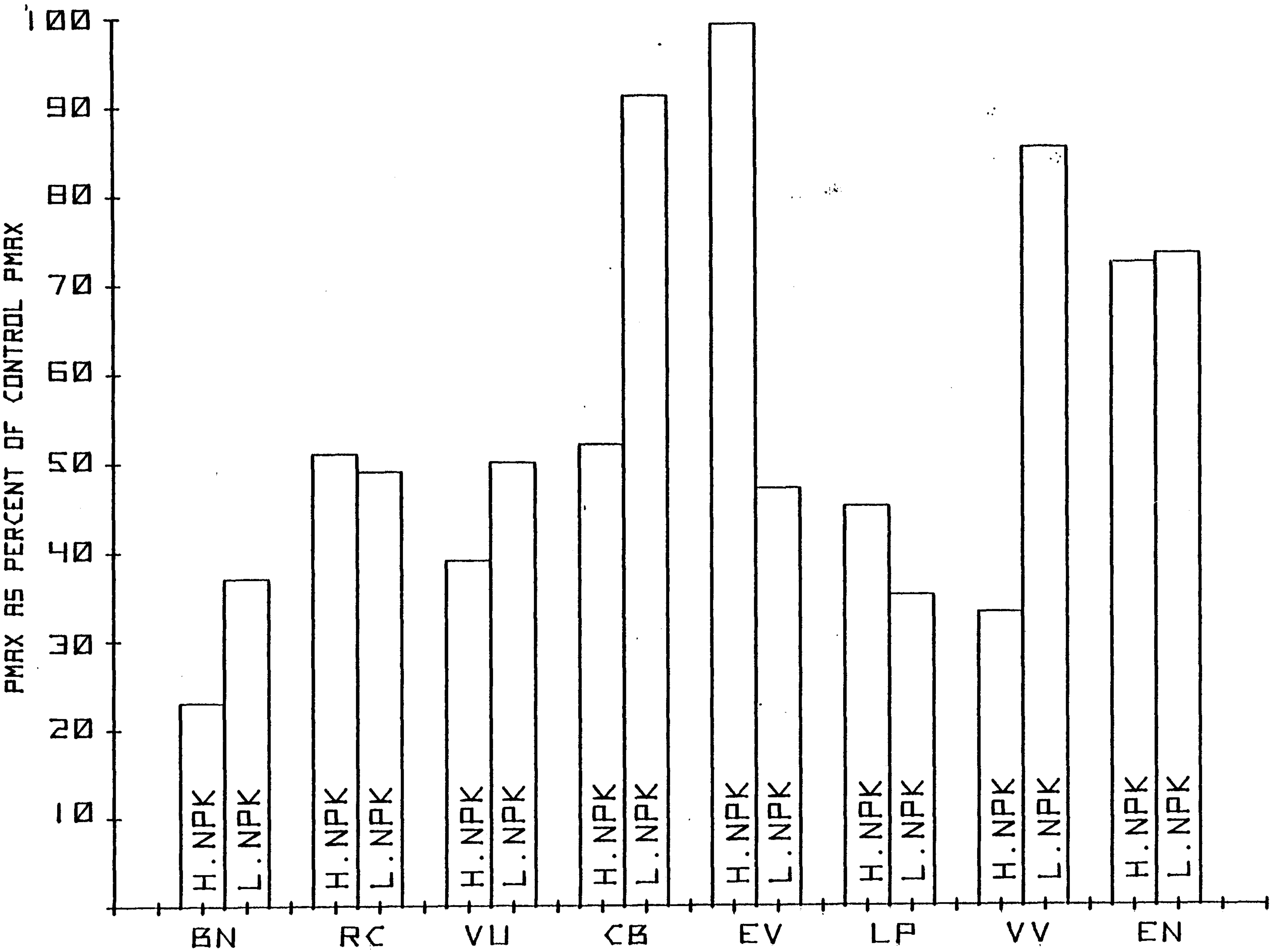
Figure 10. Maximum photosynthetic rate as a function of four nutrient treatments for 11 vascular and non-vascular plants. The species are: BN = Betula nana, RC = Rubus chamaemorus, VU = Vaccinium uliginosum, CB = Carex bigelowii, EV = Eriophorum vaginatum, LP = Ledum palustre, VV = Vaccinium vitis-idaea, EN = Empetrum nigrum, PC = Polytrichum commune, DE = Dicranum elongatum, SS = Sphagnum subsecundum.



PMAX MG CO2 * G DWT-1 * HR-1
30
25
20
15
10
5
CONTROL
L.NPK
H.NPK
C.
L.
H.
BN
RC
VU
CB
EV
LP
VV
EN
PC
DE
SS

91

Figure 11a, b. Effect of fertilization on maximum photosynthetic rates for vascular (a) and non-vascular (b) plants as a percent of control. (See Fig. 10 for abbreviations of species names.)


PMAX AS PERCENT OF CONTROL PMAX
100
90
80
70
60
50
40
30
20
10
H.NPK
L.NPK
BN
RC
VU
CB
EV
LP
VV
EN

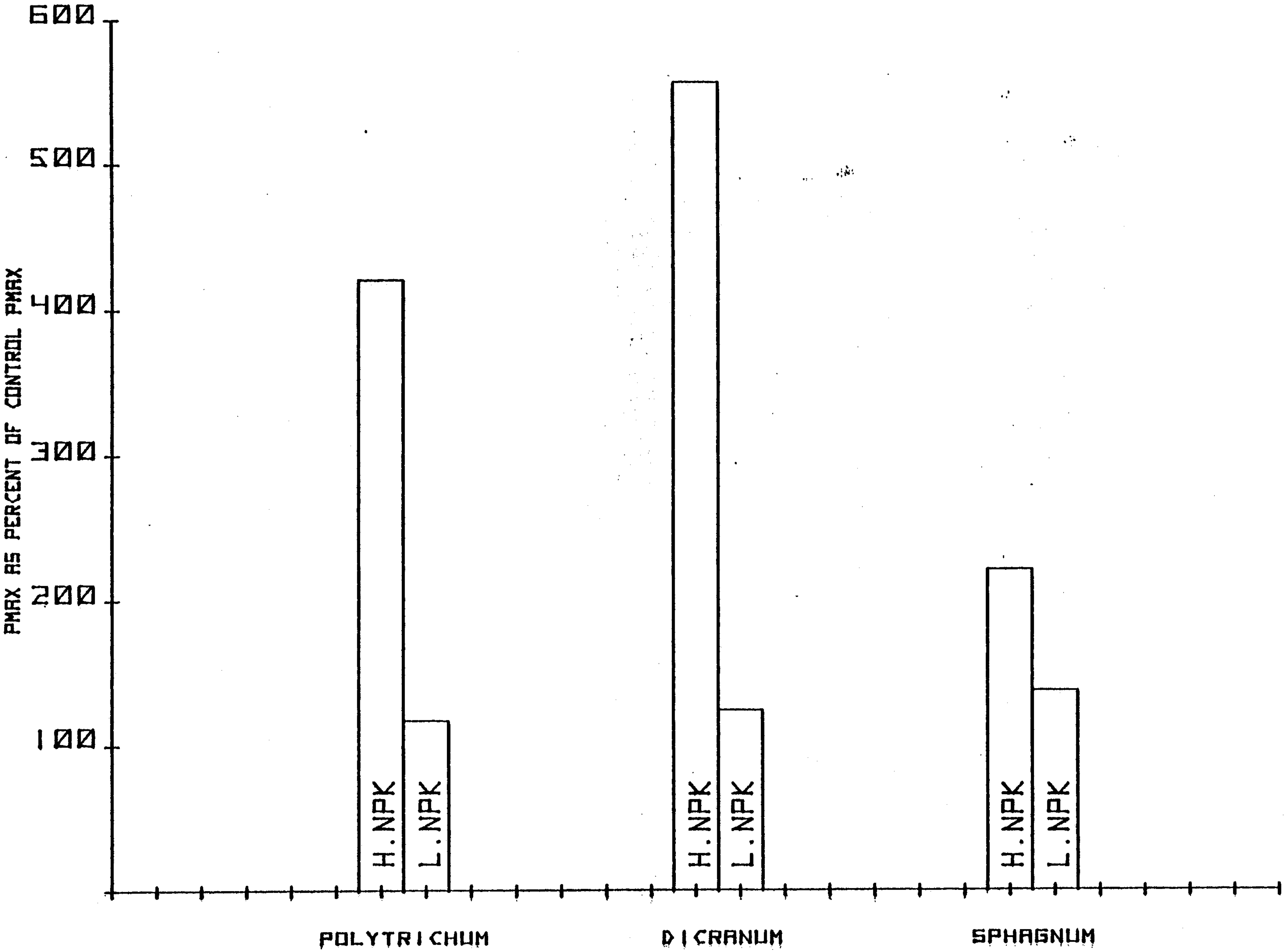
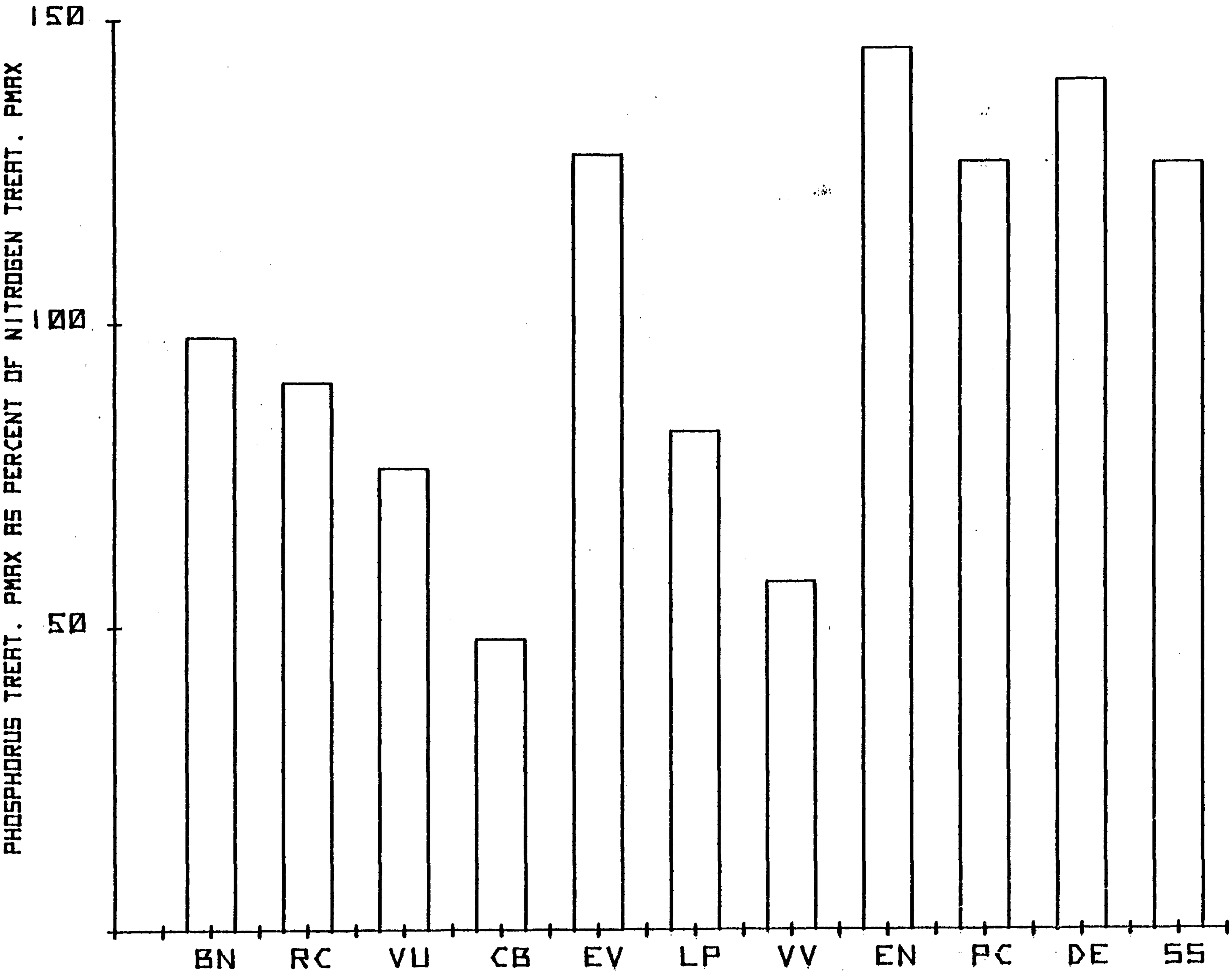

PMAX AS PERCENT OF CONTROL PMAX
600
500
400
300
200
100
H.NPK
L.NPK
H.NPK
L.NPK
H.NPK
L.NPK
POLYTRICHUM
DICRANUM
SPHAGNUM

Figure 12. The percent effect on maximal photosynthetic rates of phosphorus fertilization relative to nitrogen fertilization. Fertilizer was applied in 1976 and photosynthesis was measured in 1978. (See Fig. 10 for abbreviations of species names.)


PHOSPHORUS TREAT. PMAX AS PERCENT OF NITROGEN TREAT. PMAX
150
100
50
BN
RC
VU
CB
EV
LP
VV
EN
PC
DE
SS

The light and/or temperature dependence of photosynthesis, leaf respiration, and root respiration were determined for four vascular plant species (Figs. 13-16, Tables 13-15). These response surfaces will be refined this spring through additional experimentation, and measurements on other important species will be added. The species completed to date (*E. vaginatum*, *V. vitis-idaea*, *B. nana*, and *C. aquatilis*) indicate fairly low light compensation points (5-50 $\mu E\ m^{-2}\ s^{-1}$). High rates of photosynthesis occur at 5°C (56-97% of maximum) and at 30°C (53-84%). Temperature optima for photosynthesis range from 8.5 to 22°C. It is noteworthy that photosynthetic maxima, especially for *E. vaginatum* and *V. vitis-idaea* are considerably below values reported by Johnson and Tieszen (1976) for Meade River, Alaska but are in good agreement with values reported in the Russian literature (Svetsova 1970) (Table 13). Photosynthetic productivity at Eagle Creek may, therefore, be less than previously thought.

There is a tenfold range in rate of phosphate uptake by excised roots of the seven tundra species examined (Table 16). These differences in phosphate uptake rate were clearly associated with growth form. The shrub roots, all of which were highly mycorrhizal, had lower phosphate uptake rates than the two graminoids (*Eriophorum* and *Carex*), which in other tundra sites lack mycorrhizae or are infected only in the litter layer. Thus, it appears that much of phosphate uptake by shrubs may be largely done by mycorrhizae rather than directly by roots, as shown in many laboratory studies (e.g., Rovira 1974), but the graminoids, which expend less energy supporting mycorrhizae, must support a higher phosphate uptake rate. *Carex* with its fine secondary roots had a much higher phosphate uptake rate than did *Eriophorum*.

Table 13. Maximum photosynthetic rates of selected Eagle Creek vascular plants compared to published values.

A COMPARISON OF PHOTOSYNTHETIC RATES

($MG\ CO_2 * G^{-1} * H^{-1}$)

	PRESENT STUDY	SHVETSOVA (1970)	TIESZEN (1976)
BETULA NANA	10.63	11	37
ERIOPHORUM VAGINATUM	6.79		27
E. ANGUSTIFOLIUM		14	
VACCINIUM VITIS-IDAEA	2.02	3	5-7
CAREX AQUATILIS	21.01		35
C. ENSIFOLIA		9	

Table 14. Characteristics of the light response of vascular plant photosynthesis.

	$\mu E \cdot m^{-2} \cdot s^{-1}$		
	50% P_{MAX}	100% P_{MAX}	COMPENSATION POINT
ERIOPHORUM VAGINATUM	300	980	10
VACCINIUM VITIS-IDAEA	260	600	50
BETULA NANA	230	900	5

Table 15. Characteristics of the temperature response of vascular plant photosynthesis.

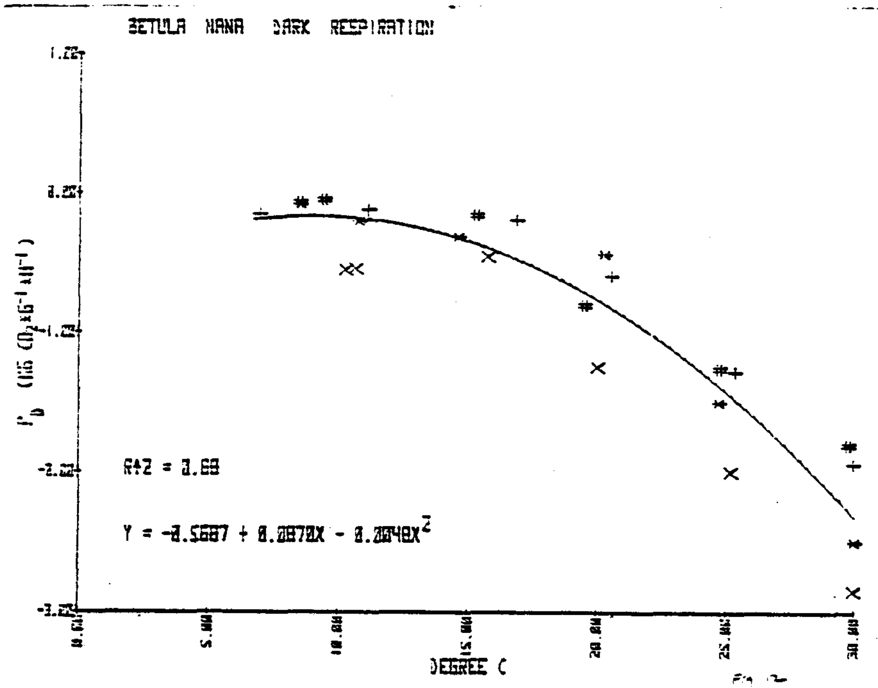
SPECIES	P_{MAX} (MG CO_2*G^{-1}*H^{-1})	T_{OPT} (°C)	% P_{MAX} 5°C	% P_{MAX} 30°C	80% P_{MAX} (°C)	R^2	IRRADIANCE μE*M^{-2}*H^{-1}
ERIOPHORUM VAGINATUM	6.79	12	92	54	1—24	0.11	150
CAREX AQUATILIS	21.01	22	56	79	11—33	0.78	300
VACCINIUM VITIS-IDAEA	2.02	8.5	97	84*	-1*—17.5	0.71	300
BETULA NANA	18.63	18	50	53*	9.5—26	0.59	300

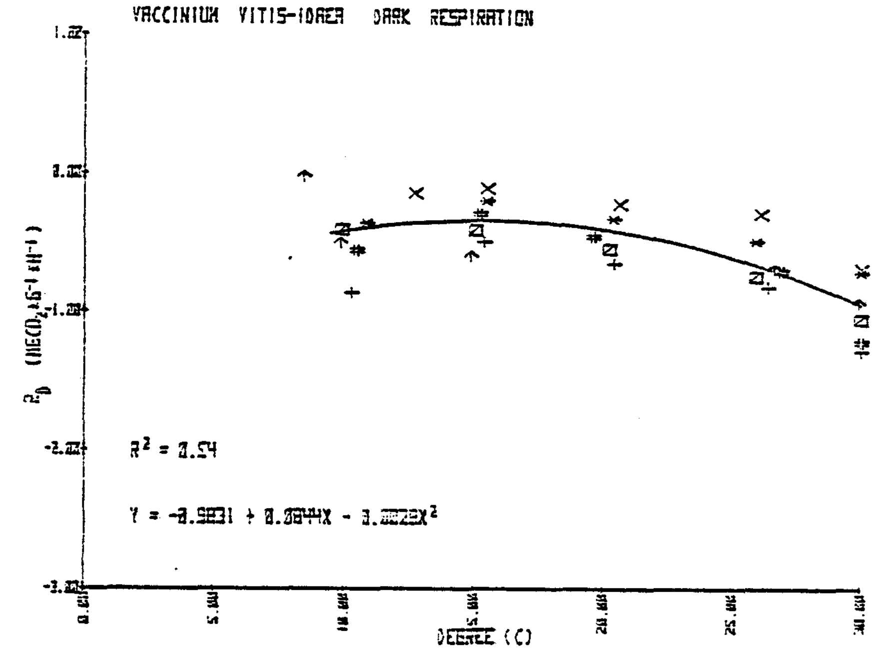
*EXTRAPOLATED FROM 2° POLYNOMIAL FIT

Table 16. Rate of phosphate absorption by excised unsuberized roots of tundra shrubs representing different growth forms measured at low (0.5μM) and high (10μM) phosphate concentrations and at 10° or 20°C. Mean ± standard error, n=4.

Species	Rate of phosphate absorption ($n\ M\ hr^{-1}\ g^{-1}$ dry wt) 10°C .5μM	10°C 10μM	20°C .5μM	20°C 10μM
Graminoid				
Eriophorum vaginatum	489 ± 37	600 ± 46	144 ± 4	694 ± 126
Carex aquatilis	312 ± 30	2141 ± 114	267 ± 13	3155 ± 170
Deciduous Shrub				
Salix pulchra	119 ± 14	615 ± 16	-	-
Betula glandulosa	168 ± 14	454 ± 40	-	-
Vaccinium uliginosum	48 ± 4	259 ± 25	142 ± 31	325 ± 27
Evergreen Shrub				
V. vitis-idaea	103 ± 10	494 ± 28	126 ± 19	755 ± 22
Ledum palustre	25 ± 3	84 ± 4	59 ± 13	178 ± 10

Figure 13a. Temperature dependence of leaf dark respiration of *B. nana*, *V. vitis-idaea*, and *C. aquatilis*.


BETULA NANA DARK RESPIRATION
R↑2 = 0.88
Y = -0.5687 + 0.0870X - 0.0048X²
DEGREE C


VACCINIUM VITIS-IDAEA DARK RESPIRATION
R² = 0.54
Y = -0.5831 + 0.0644X - 0.0025X²
DEGREE (C)

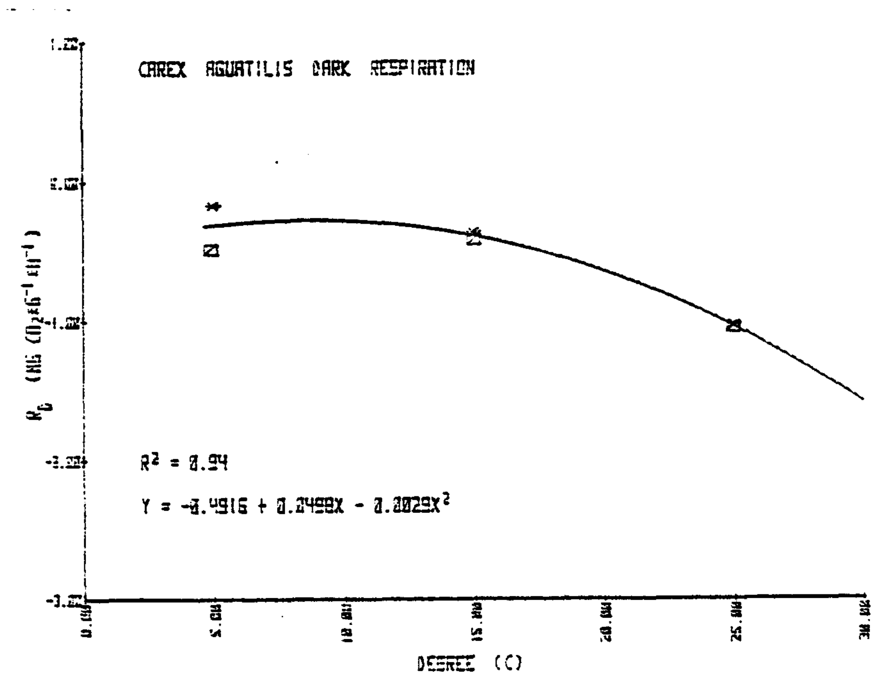
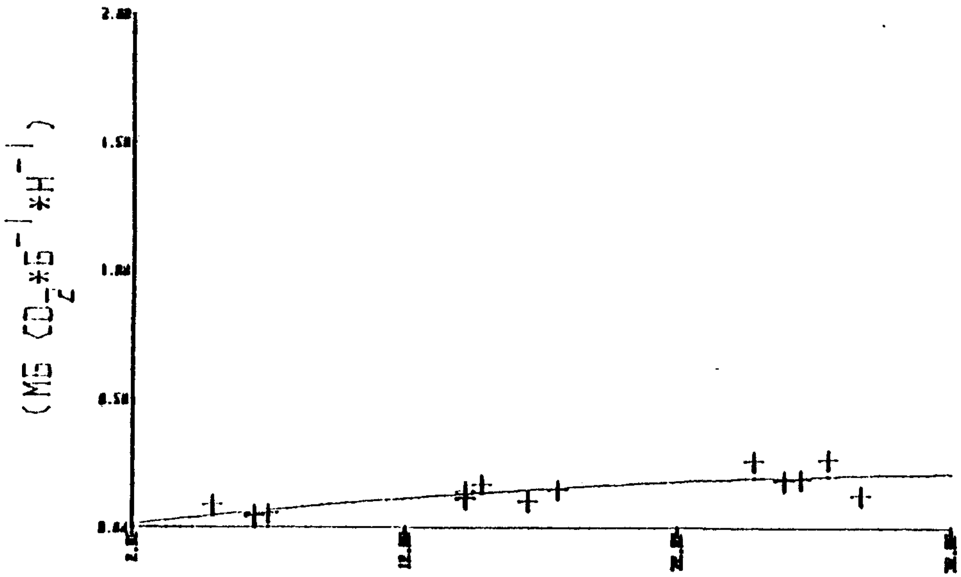
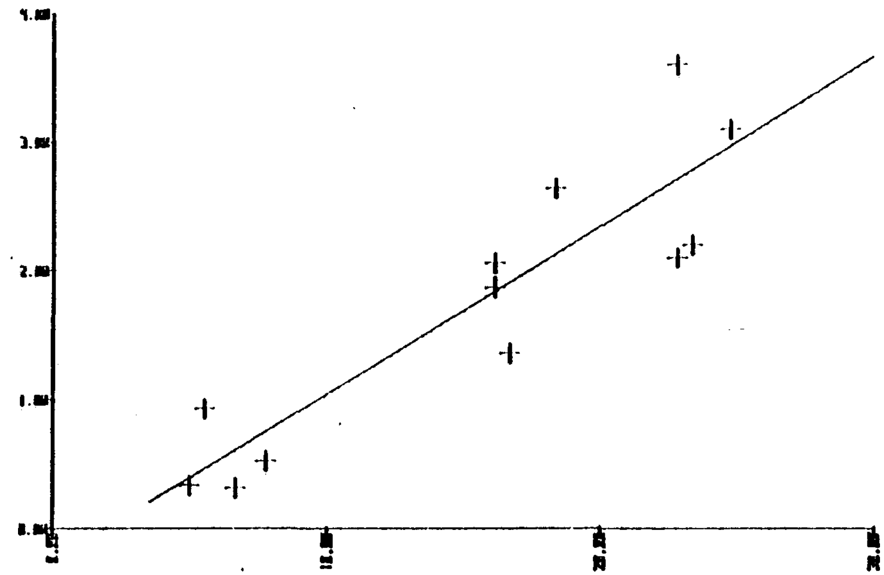

CAREX AQUATILIS DARK RESPIRATION
R² = 0.94
Y = -0.4916 + 0.0498X - 0.0029X²
DEGREE (C)

Figure 13b. Root temperature dependence of respiration in four vascular plant species.

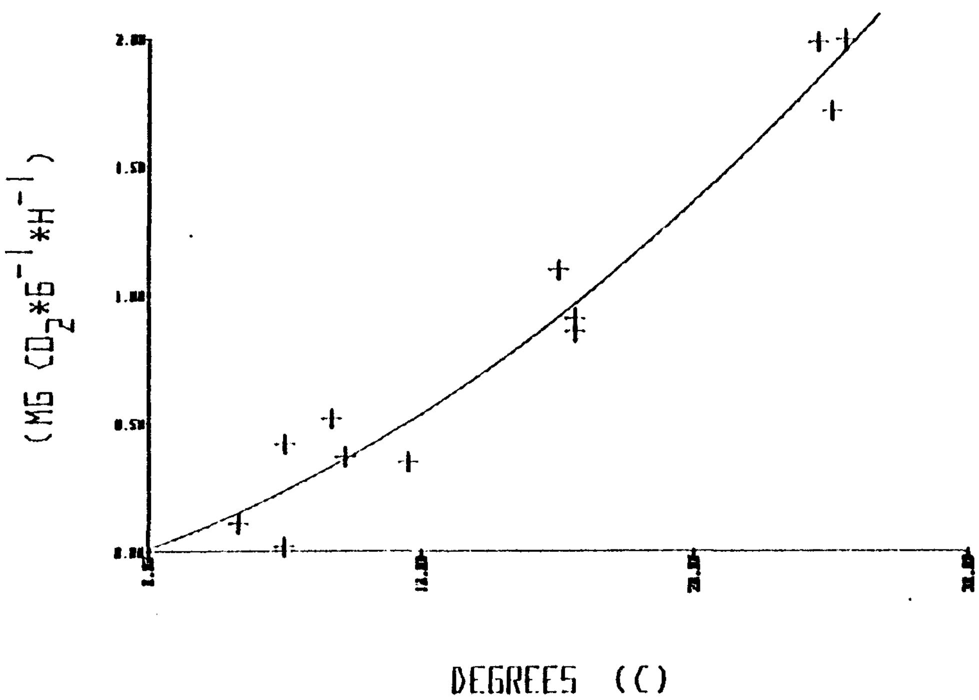
BETULA NANA ROOT RESPIRATION



VACCINIUM VITIS-IDAEA ROOT RESPIRATION



ERIOPHORUM VAGINATUM ROOT RESPIRATION



CAREX AQUATILIS ROOT RESPIRATION

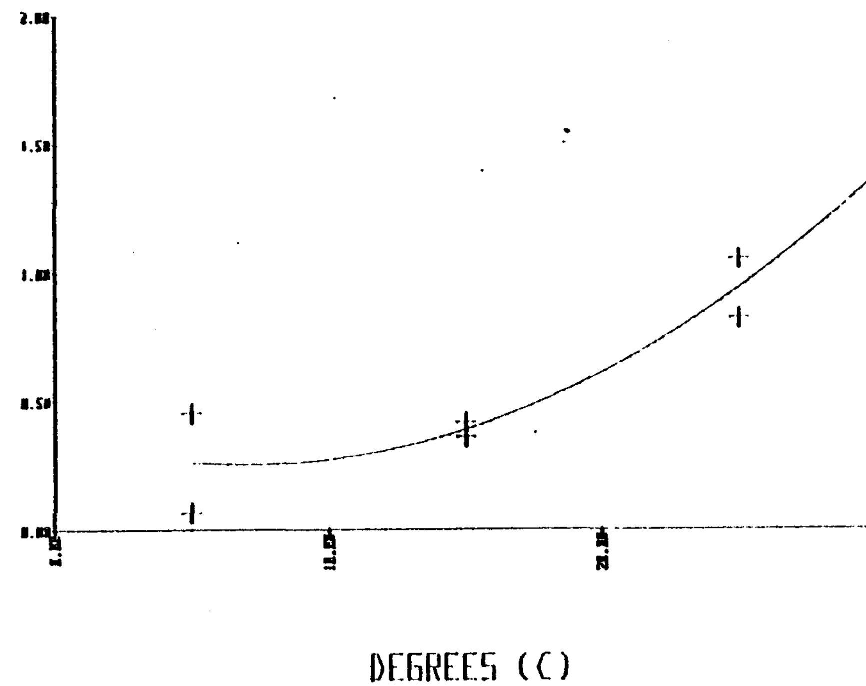
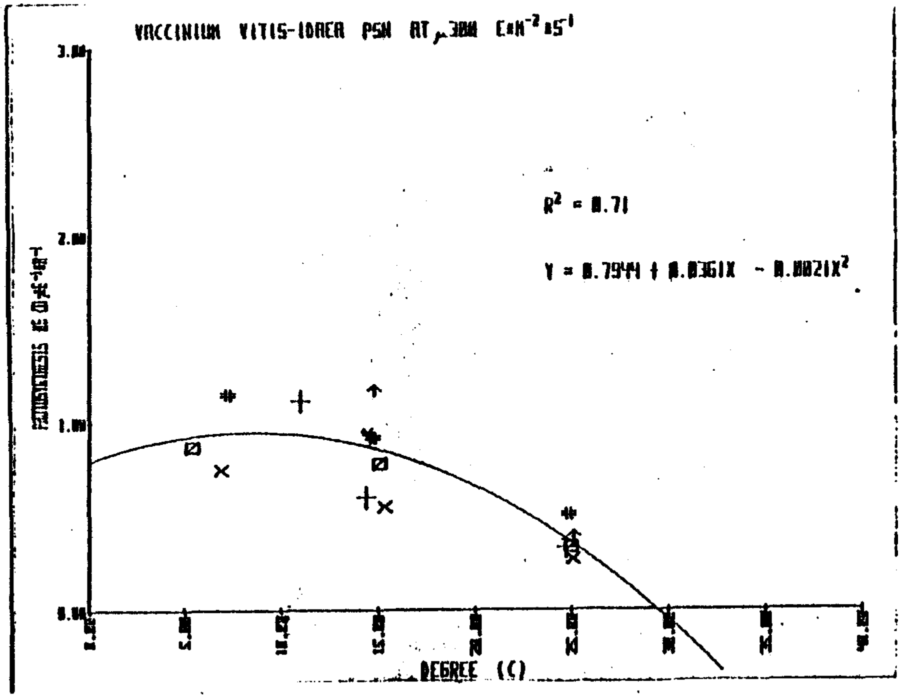
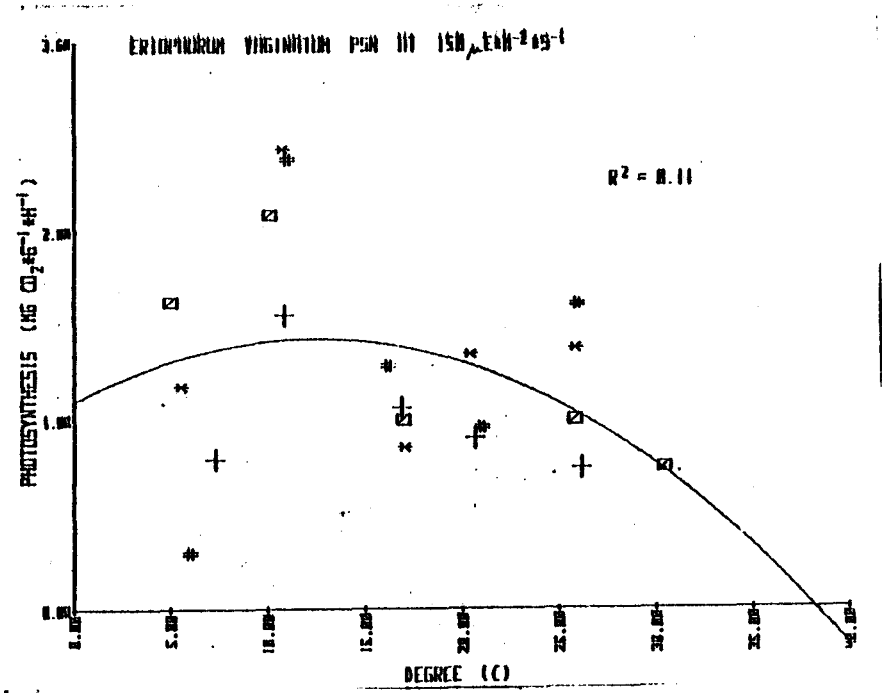
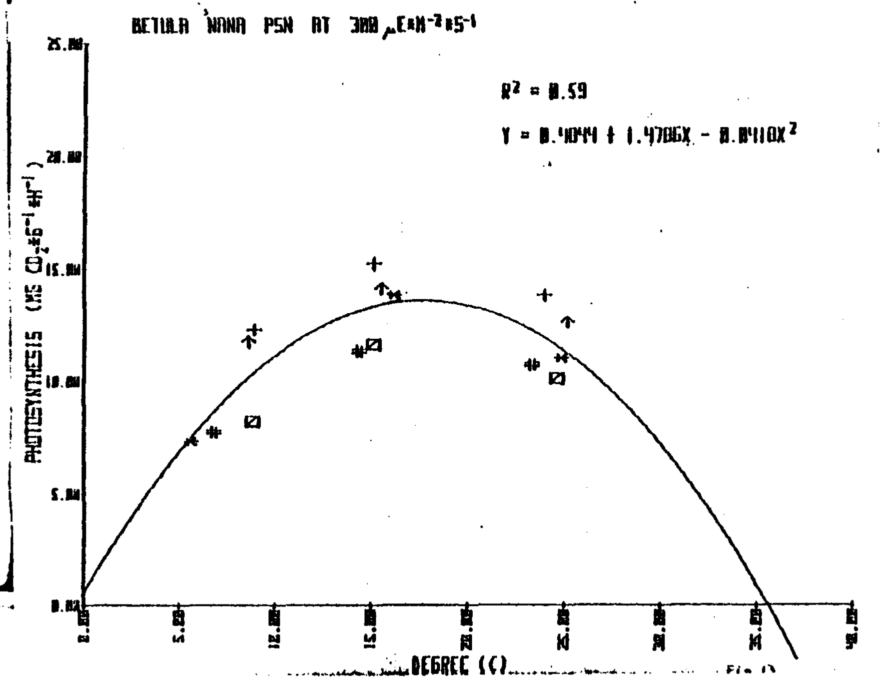


Figure 14. Temperature dependence of photosynthesis of _B. nana_, _E. vaginatum_, _V. vitis-idaea_, and _C. aquatilis_.


VACCINIUM VITIS-IDAEA PSN AT 300 μE*M-2*S-1
R² = 0.71
Y = 0.7944 + 0.0361X - 0.0021X²
PHOTOSYNTHESIS (MG CO2*G-1*H-1)
DEGREE (C)


ERIOPHORUM VAGINATUM PSN AT 150 μE*M-2*S-1
R² = 0.11
PHOTOSYNTHESIS (MG CO2*G-1*H-1)
DEGREE (C)


BETULA NANA PSN AT 300 μE*M-2*S-1
R² = 0.59
Y = 0.4044 + 1.4706X - 0.0410X²
PHOTOSYNTHESIS (MG CO2*G-1*H-1)
DEGREE (C)

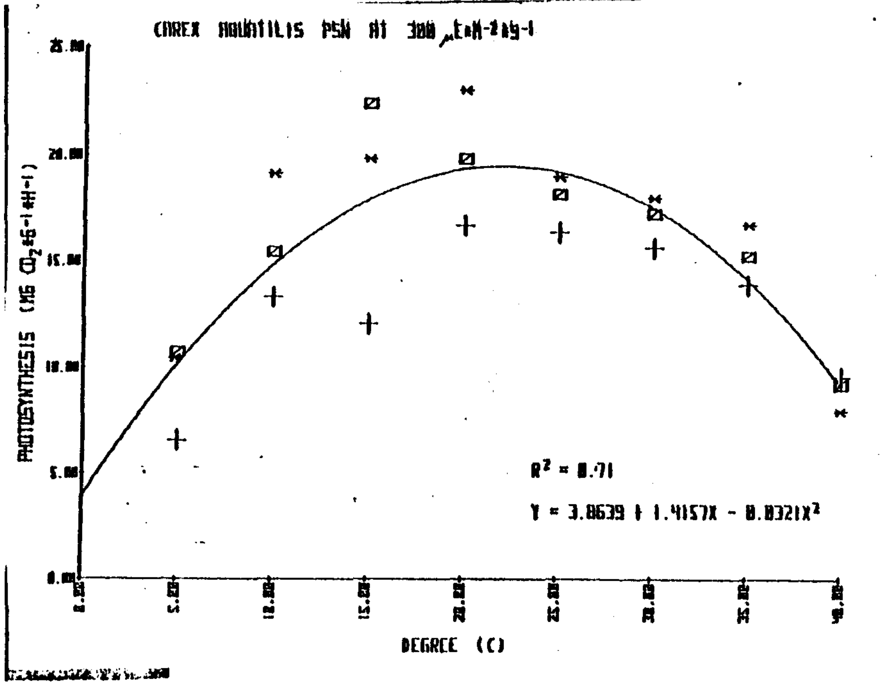

CAREX AQUATILIS PSN AT 300 μE*M-2*S-1
R² = 0.71
Y = 3.8639 + 1.4157X - 0.0321X²
PHOTOSYNTHESIS (MG CO2*G-1*H-1)
DEGREE (C)

Figure 15. The temperature sensitivity of photosynthesis in plant species as a percent of the maximal rate observed in 1978.

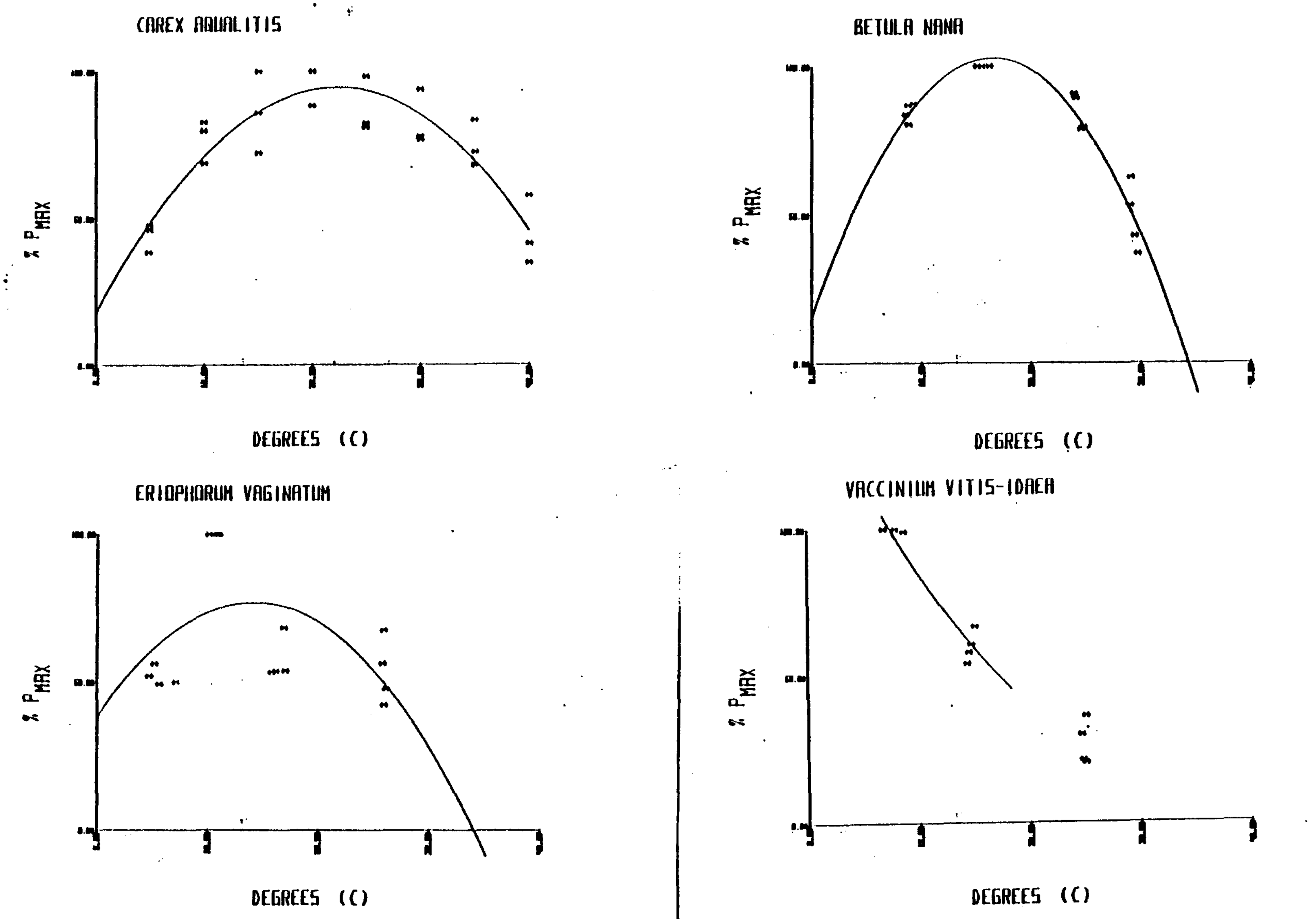
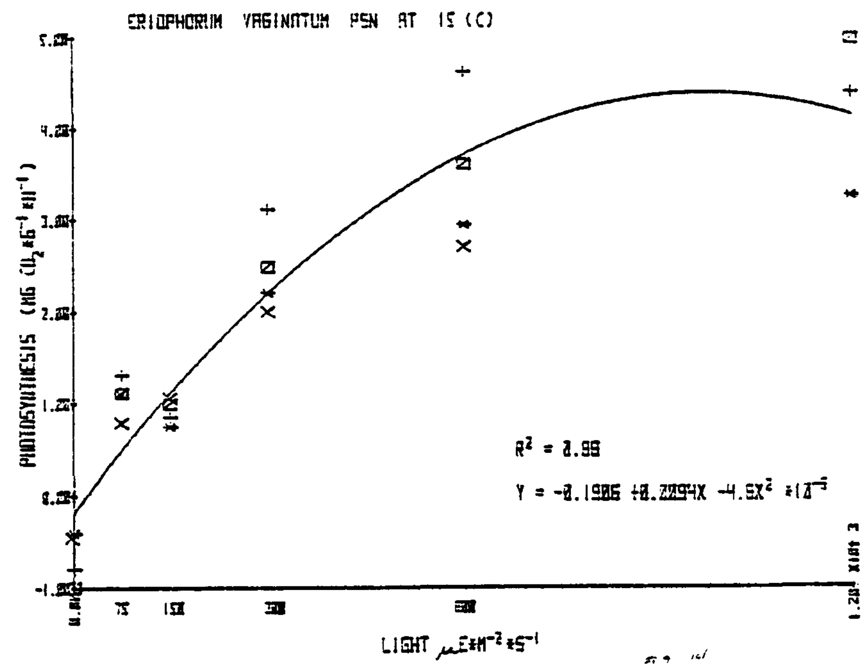
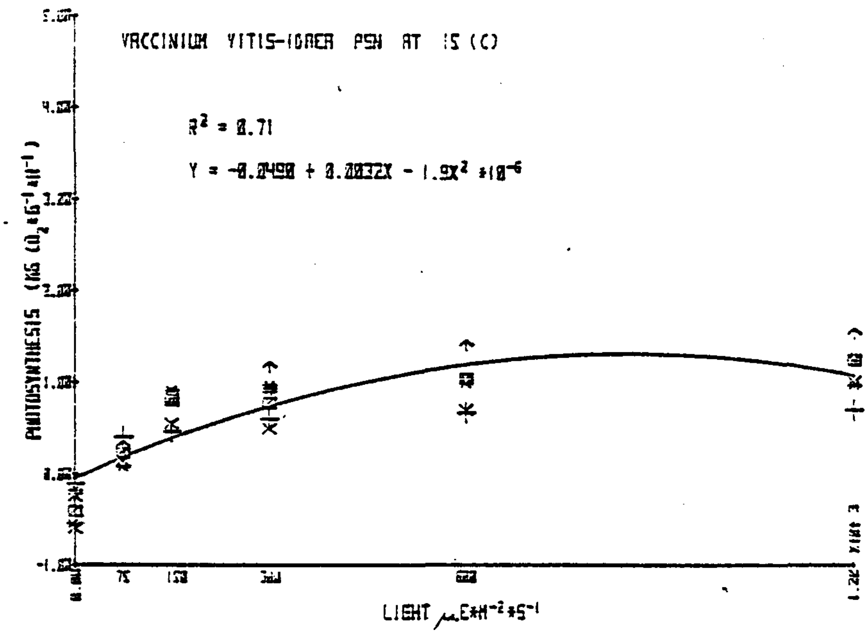
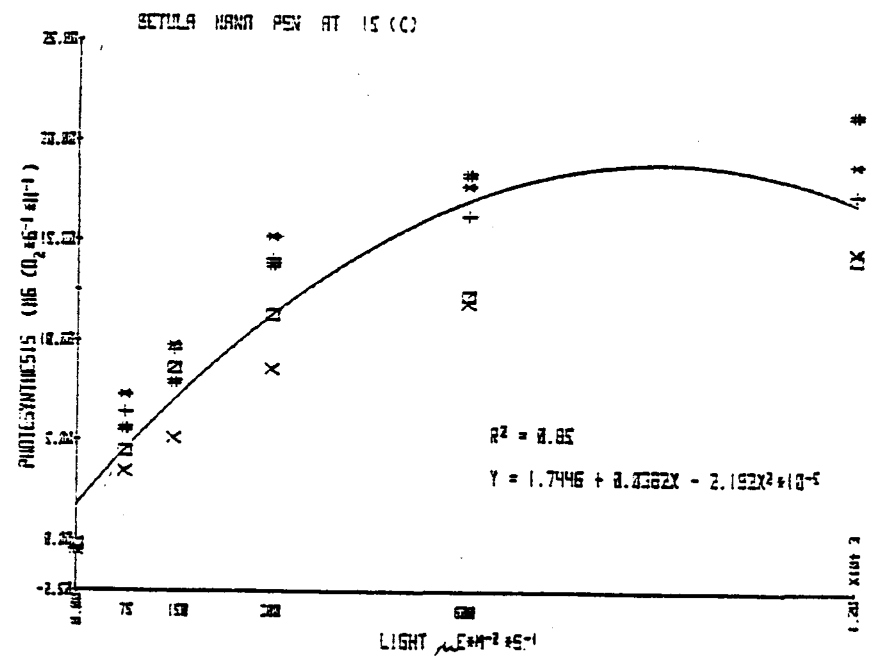
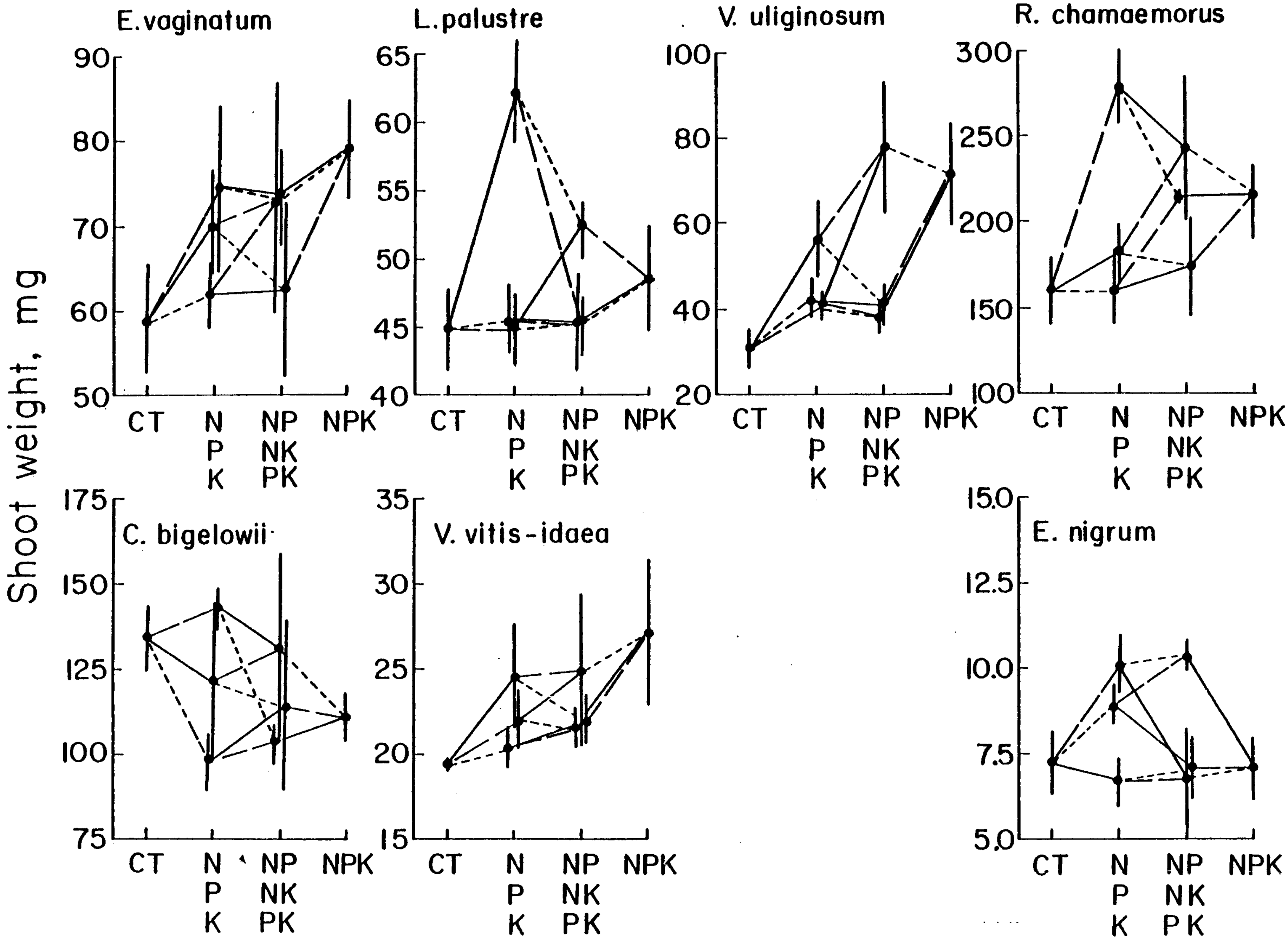

CAREX AQUALITIS
% P_MAX
DEGREES (C)
BETULA NANA
% P_MAX
DEGREES (C)
ERIOPHORUM VAGINATUM
% P_MAX
DEGREES (C)
VACCINIUM VITIS-IDAEA
% P_MAX
DEGREES (C)

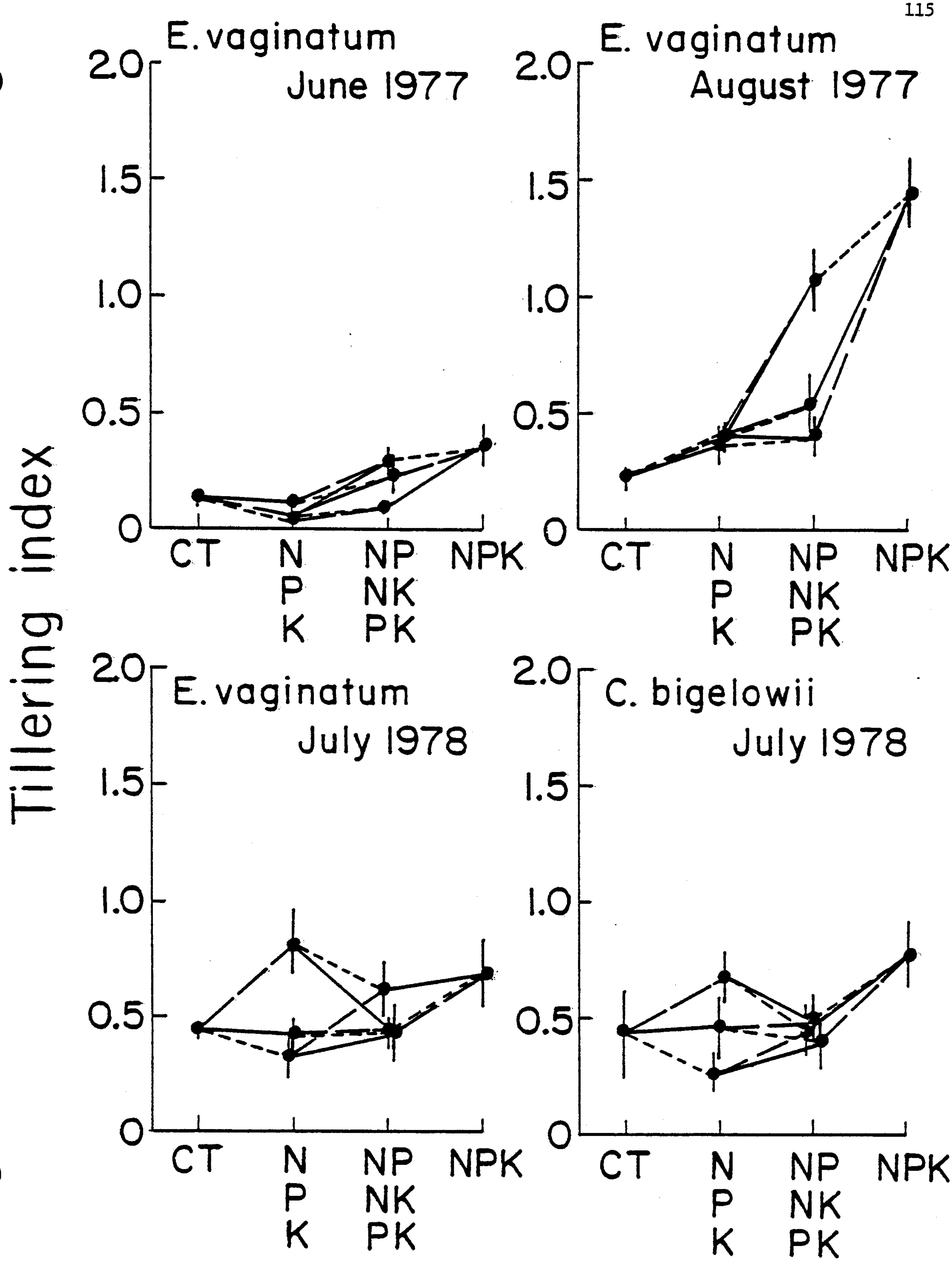
Figure 16. Light dependence of photosynthesis in *E. vaginatum*, *V. vitis-idaea*, and *B. nana*. The curves were drawn with first or second order polynomial regressions fit to the data.


ERIOPHORUM VAGINATUM PSN AT 15 (C)
PHOTOSYNTHESIS (MG CO_2*G^{-1}*H^{-1})
R^2 = 0.99
Y = -0.1986 +0.0294X -4.5X^2 *10^{-5}
LIGHT μE*M^{-2}*S^{-1}

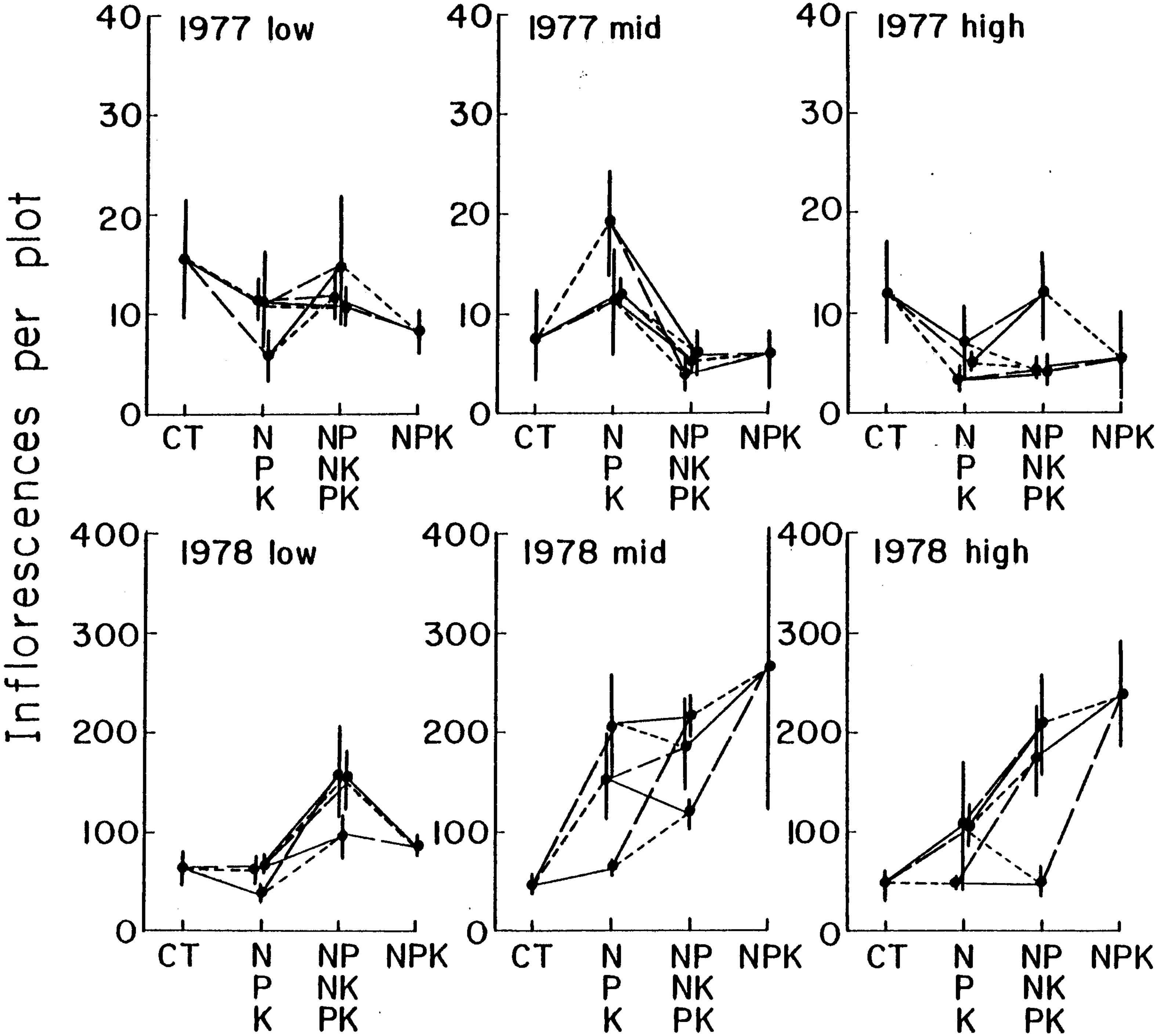

VACCINIUM VITIS-IDAEA PSN AT 15 (C)
R^2 = 0.71
Y = -0.0498 + 0.0032X - 1.9X^2 *10^{-6}
PHOTOSYNTHESIS (MG CO_2*G^{-1}*H^{-1})
LIGHT μE*M^{-2}*S^{-1}


BETULA NANA PSN AT 15 (C)
PHOTOSYNTHESIS (MG CO_2*G^{-1}*H^{-1})
R^2 = 0.85
Y = 1.7446 + 0.0362X - 2.192X^2*10^{-5}
LIGHT μE*M^{-2}*S^{-1}


Shoot weight, mg
E. vaginatum
90
80
70
60
50
L. palustre
65
60
55
50
45
40
V. uliginosum
100
80
60
40
20
R. chamaemorus
300
250
200
150
100
CT
N
P
K
NP
NK
PK
NPK
C. bigelowii
175
150
125
100
75
V. vitis-idaea
35
30
25
20
15
E. nigrum
15.0
12.5
10.0
7.5
5.0



E. vaginatum
June 1977
E. vaginatum
August 1977
E. vaginatum
July 1978
C. bigelowii
July 1978
Tillering index
2.0
1.5
1.0
0.5
0
CT
N
P
K
NP
NK
PK
NPK


Inflorescences per plot
1977 low
1977 mid
1977 high
1978 low
1978 mid
1978 high
0
10
20
30
40
0
100
200
300
400
CT
N
P
K
NP
NK
PK
NPK

Among the shrubs, phosphate uptake was closely related to growth rate and the nutrient status of sites characteristically occupied by the species. Thus, S. pulchra and B. glandulosa, which tend to grow rapidly and occupy relatively high-nutrient sites, had higher phosphate uptake rates than the species characteristic of low-nutrient sites (Table 15). Among the low-nutrient site species, L. palustre, which tends to grow slowly and occupy nutrient poor sites had the lowest rate of phosphate uptake. Although the evergreen V. vitis-idaea is slow growing, it had a substantial rate of phosphate absorption. Thus, among the shrubs (with exception of V. vitis-idaea) rate of phosphate absorption was highest in the more rapidly growing species that occupy the more nutrient-rich sites. This suggests that growth rate (and, hence, nutrient requirement) is associated with high phosphate uptake rate and that plants growing in the most nutrient-poor sites do not have the highest rates of phosphate uptake under standard conditions, as originally presumed.

Rate of phosphate absorption was less temperature-sensitive in the graminoids, both of which are deep-rooted than in the shrubs, all of which are shallow-rooted (Table 15). Thus, the deep-rooted species that are normally exposed to low soil temperatures maintain relatively high rates at low temperature, compared to shallow-rooted species.

Differences in rates of phosphate absorption between primary and lateral roots of any one species differed as much as any one root type among all species examined (Table 17). In C. aquatilis secondary roots have five- to tenfold higher rates than primary roots of the same age, whereas, in the shrubs lateral roots have about fourfold higher phosphate uptake rates than primary roots. In V. vitis-idaea belowground stems had very low phosphate uptake rates.

Table 17. Rate of phosphate absorption by different root types of various tundra species measured at 10°C at low (0.5μM) and high (10μM) phosphate concentrations. Mean ± standard error, n=4.

Species	Primary Root .5μM	Primary Root 10μM	Lateral Root .5μM	Lateral Root 10μM
Eriophorum vaginatum				
unsuberized	489 ± 37	600 ± 46	na[a]	na
suberized	122 ± 14	282 ± 16	na	na
Carex aquatilis				
unsuberized	31 ± 4	374 ± 37	312 ± 30	2141 ± 114
suberized	40 ± 5	250 ± 37	na	na
Betula glandulosa	-	118 ± 7	168 ± 14	454 ± 40
Vaccinium uliginosum	-	-	48 ± 4	259 ± 25
V. vitis-idaea	5 ± 1[b]	32 ± 8[b]	103 ± 10	494 ± 28
Ledum palustre	-	20 ± 3	25 ± 3	84 ± 4

[a]na: not applicable - such root types do not occur

[b]belowground stem rather than primary root

Clearly the fine lateral root system characteristic of most tundra plants is the most important site of absorption of phosphate and presumably of other nutrients. Primary roots and underground stems in the case of *V. vitis-idaea* probably serve basically to explore new areas of soil rather than to absorb nutrients. Because of the high degree and fine-grained nature of environmental heterogeneity in the tundra this exploratory function may be quite important.

The suberization of primary roots that occurs with age in *Eriophorum* and *Carex* reduces phosphate uptake, particularly in *Eriophorum*. Qualitative observations suggest that a larger proportion of the primary root system is suberized in *Carex* than in *Eriophorum*.

The roots used in the above experiments were carefully selected to be representative of roots that were unquestionably alive and functional. In the case of the shrubs many other roots appeared to be alive but were much darker and were excluded in the measurements described above. On live roots that were randomly sampled without regard for color, as might be done in root biomass separations, phosphate uptake rates did not differ significantly from rates measured on carefully selected roots according to normal procedure. Thus, it appears valid to consider that the uptake rates presented in Tables 15-16 represent the entire fine root system and that the uptake rate of fine roots does not change substantially with root age.

Root respiration rate of excised roots differed less among species than did phosphate uptake rate, respiration varying about threefold among species (Table 18). while phosphate uptake rate and root respiration were not clearly related. *Eriophorum*, which produces an entirely new root system each year, had the highest root respiration rate of all species examined.

Table 18. Rate of respiration of excised primary and secondary roots of various tundra species measured at 10°C. Mean ± standard error, n=5.

Species	Respiration rate (μg C hr^{-1} g^{-1} dry wt) Primary root	Lateral root
Eriophorum vaginatum		
unsuberized	7557 ± 176	na[a]
suberized	2884 ± 214	na
Carex aquatilis		
unsuberized	6078 ± 853	4187 ± 444
suberized	2457 ± 232	na
Salix pulchra	-	3270 ± 487
Betula glandulosa	-	4093 ± 275
Vaccinium uliginosum	-	2271 ± 278
V. vitis-idaea	1499 ± 159[b]	4337 ± 183
Ledum palustre	2388 ± 141	6022 ± 333

[a]na: not applicable - such roots do not exist

[b]underground stem rather than primary root

Respiration rates of excised roots corresponded to the maintenance respiration, as contrasted with growth respiration rate measured by Oechel on laboratory grown seedlings (subproject 6) and thus provide a measure of the carbon expended in maintenance and normal functioning of the root. The phosphate uptake rate compared to the respiration rate gives an index of the amount of phosphorus acquired per carbon respired. Although respiration provides energy for a wide variety of functions, including phosphate uptake, this ratio still provides a useful index of the amount of phosphorus that can be acquired per carbon respired and, therefore, some indication of phosphorus-absorbing efficiency of different root types. The unsuberized roots of Eriophorum and lateral roots of Carex absorb more phosphorus per carbon respired than any shrub (Table 19). The evergreen Ledum has lowest uptake respiration ratio of any species examined. The role of secondary roots of Carex in phosphate uptake is clear from their high ratio of phosphate absorbed to carbon respired. This contrasts with unsuberized primary roots which have a low ratio of phosphate absorbed to carbon respired.

The nitrogen and phosphorus concentrations of the fine roots sampled were generally quite high but showed no clear relationship to either phosphate uptake rate or respiration rate when the various species were compared (Table 19). The suberized portions of Eriophorum roots were low in nutrient concentration, respiration, and phosphate uptake and appeared to play a role of nutrient and water transport from less suberized root portions rather than a direct role in nutrient uptake. In contrast, the suberized roots of Carex retain substantial nutrient concentrations and phosphate uptake rate, suggesting that they retain a more active role than in Eriophorum.

Table 19a. Ratio of phosphorus absorbed to carbon respired (g g^{-1}) per unit root and time for excised primary and lateral roots of various tundra species at 10°C. Phosphate uptake was measured at a low ecologically realistic concentration (0.5μM).

Species	Phosphorus absorbed/carbon respired ($\times 10^{-3}$) (g g^{-1}) Primary root	Lateral root
Eriophorum vaginatum		
unsuberized	2.01	na[a]
suberized	1.31	na
Carex aquatilis		
unsuberized	0.16	2.31
suberized	0.50	--
Betula glandulosa	--	1.27
Vaccinium uliginosum	--	0.66
V. vitis-idaea	0.10[b]	0.74
Ledum palustre	--	0.13

[a]na: not applicable

[b]underground stem rather than primary root

Table 19b. Nitrogen and phosphorus content (% dry weight) of roots of various tundra species. Roots sampled are the active roots comparable to those used in phosphate uptake and respiration measurements. Mean ± standard error, n=4.

Species	Nitrogen (% dry wt)		Phosphorus (% dry wt)	
	Primary	Lateral	Primary	Lateral
<u>Eriophorum vaginatum</u>				
unsuberized	1.13 ± 0.01	na[a]	0.180 ± 0.002	na
suberized	0.27 ± 0.01	na	0.029 ± 0.002	na
<u>Carex aquatilis</u>				
unsuberized	1.47 ± 0.10	1.41 ± 0.00	0.380 ± 0.033	0.24 ± 0.002
suberized	0.97 ± 0.05	na	0.184 ± 0.011	na
<u>Salix pulchra</u>	-	1.48 ± 0.02	-	0.139 ± 0.003
<u>Betula glandulosa</u>	-	1.19 ± 0.01	-	0.123 ± 0.002
<u>Vaccinium uliginosum</u>	-	1.25 ± 0.01	-	0.119 ± 0.001
<u>V. vitis-idaea</u>	0.57 ± 0.01[b]	1.08 ± 0.01	0.059 ± 0.002[b]	0.109 ± 0.001
<u>Ledum palustre</u>	0.75 ± 0.03	1.21 ± 0.04	0.061 ± 0.003	0.111 ± 0.003

[a]na: not applicable - such roots are not produced

[b]belowground stem rather than primary root

The rate of absorption of phosphate is easier to measure than that of many other key elements. Differences in phosphate uptake rate observed among species or root types are presumed to be representative of differences for the absorption of other elements. Samples have been collected to test this assumption. The rate of uptake by four species at two temperatures was measured for phosphate, ammonium, nitrate, potassium, and chloride (a non-limiting nutrient). These samples are currently being analyzed.

Rates of nutrient absorption by excised roots provide only an index of nutrient uptake by intact plants, because the rate of nutrient absorption also depends upon its rate of removal from the root and other interactions between roots and shoots. In order to obtain more ecologically realistic measurements of nutrient uptake rates, a system that flows nutrients past roots of intact plants has been built, and the rate of nutrient removal from the solution will be measured.

An experiment has been completed which analyzed the effect of variable nitrogen, phosphorus, and temperature on _E. vaginatum_ tillers grown in nutrient solutions under controlled environmental conditions. The results showed that doses of 21 mg liter^{-1} of nitrate nitrogen, 1/10 of the strength of a conventional nutrient solution, in combination with 3.10 mg liter^{-1} of phosphorus produced a twofold biomass increase after 18 weeks growth whereas neither N nor P alone significantly influenced biomass production. The temperature treatments of 10° and 15°C showed no differences in biomass production. Root:shoot biomass ratios averaged 0.36 and were apparently not affected by the treatments. Functional leaf areas were significantly increased by fertilizer addition. They rose from 3.9 cm^2 with only traces of N and P to 20.3 cm^2 with the full treatment. Root surface areas ranged from 129 to 294 cm^2 fron the low to high fertilizer treatments; however, these figures were not significantly different. Nitrogen and phosphorus concentration in the plant tissue was greatly enhanced with both nitrogen and phosphorus addition. Nitrogen and phosphorus incorporation rates were found to be 0.18 and 1.27 mg g^{-1} wk^{-1} for the low and high N fertilization and 0 and 0.51 mg g^{-1} wk^{-1} for the low and high P treatments, respectively.

Growth chamber facilities to handle the complete range of temperatures have been installed to be used during experimentation. An extensive experiment has been initiated to test the temperature effect on nutrient uptake of V. vitis-idaea and E. vaginatum at five temperatures ranging from 2° to 20°C and test the competitive effects of uptake between these two species.

The characterization of several morphological features of V. vitis-idaea has been accomplished. Root area:leaf area ratios ranged from 2.4 to 8.0 and the total root length per centimeter of rhizome varied from 20.2 to 47.9. This type of information should eventually permit predictions such as root surface areas from the measurement of leaf areas only.

Uniform cuttings of C. tetragona have been successfully rooted in vermiculite. This success will enable uniform material to be obtained from field-collected plants, which are usually too large and heterogeneous to adequately handle in limited growth chamber space. With these cuttings, nutrient uptake and growth rate studies can be performed on a considerable number of individuals, thus reducing variability of the data as well as conserving growth chamber space.

Research on the comparative descriptions of the growth, branching patterns, and carbon and biomass allocation of E. vaginatum, L. palustre,

V. uliginosum, and V. vitis-idaea, which represent different growth forms present in tussock tundra is now almost complete. The research was separated into two parts in the field. One set of observations was devoted to a descriptive comparison of growth/size/turnover relationships in the three dominant shrub species at Eagle Creek, V. uliginosum, V. vitis-idaea, and L. palustre. The second set of observations consisted of both experimental and descriptive studies of the same relationships in E. vaginatum.

Results of the shrub comparison indicate large differences between the three species studied, with V. uliginosum, the deciduous species, being unique. The rate of cambial growth and the rate of addition of new growing points in V. uliginosum are two to three times higher than in L. palustre, which has a rate of new growing point production 50% higher than V. vitis-idaea. Cambial growth in V. vitis-idaea is essentially zero. Rates of stem death are highest in V. uliginosum and lowest in L. palustre, resulting in different rates of stem turnover. The higher rate of stem turnover in V. uliginosum presumably is accompanied by a higher rate of nutrient and carbon losses in dead stems, compounding the losses in its deciduous leaves. Vaccinium uliginosum thus appears to be far less conservative of its nutrient capital than L. palustre or V. vitis-idaea.

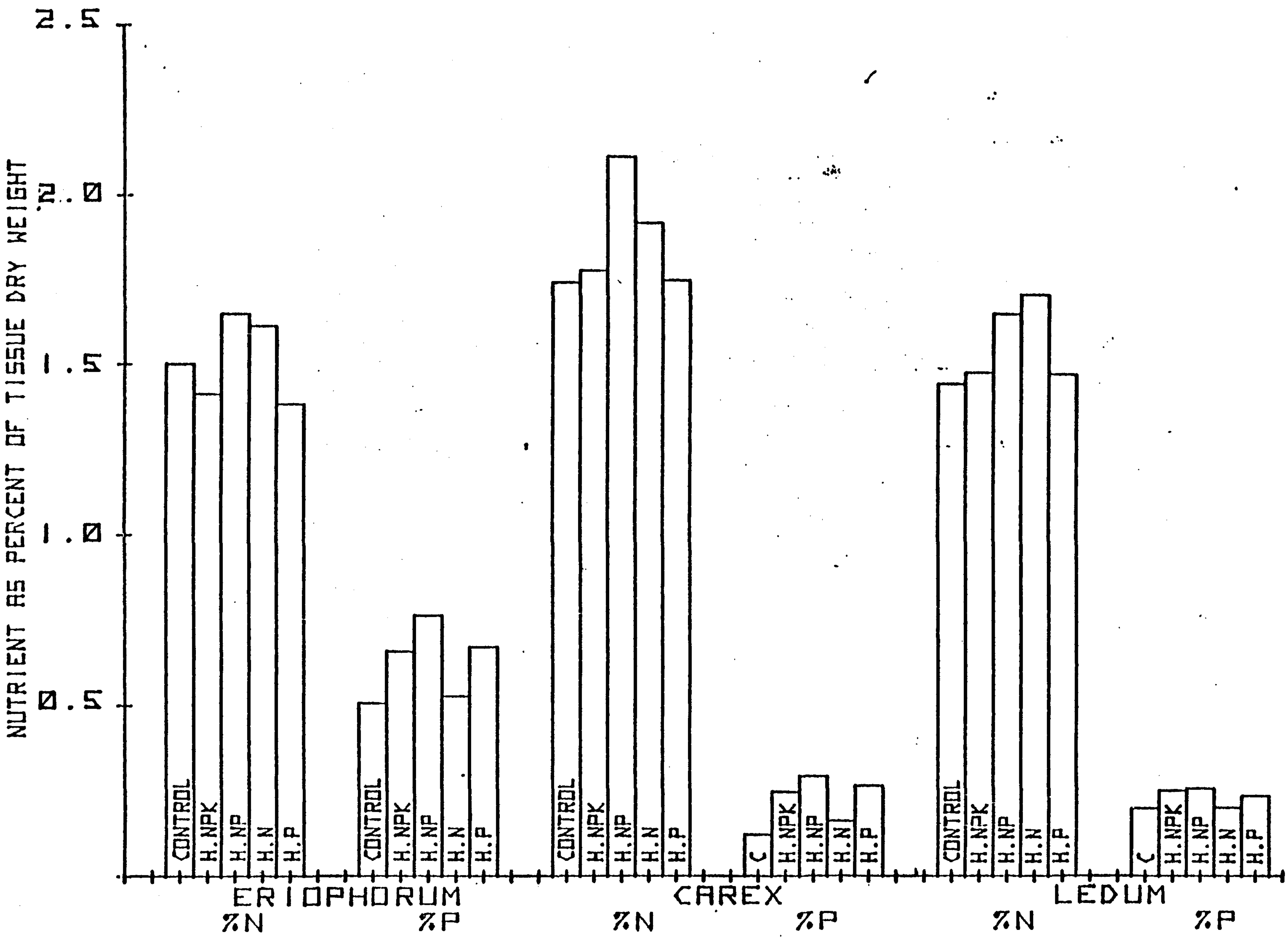
Both evergreen species undergo the greatest leaf loss in midsummer, as new leaves are produced. It is hypothesized that this is the result of senescence due to reallocation of nutrient from old to new tissue.

The principal conclusion of the work on E. vaginatum is that it is successful over a wide range of sites partly because its growth, allocation patterns, and demographic patterns are highly plastic. Mean leaf number at flowering varies from about 20 leaves in undisturbed tundra to less than 10 leaves in disturbed or fertilized tundra. Age at tillering decreases with disturbance from a mean of 6-8 years in undisturbed tundra to a mean of 2-3 years after disturbance. Tiller turnover and minimum tiller age at flowering decrease with disturbance, resulting in faster population growth. The lower mean age of the tiller populations in disturbed sites suggests that the large, positive net growth observed on disturbances is accompanied by a much higher rate of leaf and tiller turnover.

Whole-tussock characteristics of E. vaginatum also vary with age, size, and degree of disturbance. Tillering rate increases as tussock size and tussock density decrease. The number of tillers per tussock is a linear function of tussock diameter, rather than tussock area. Minimum tussock size at flowering is lower on disturbances than on undisturbed sites.

Our experiments to determine the effects of a change in available nutrients on growth and turnover rates of selected species by continued monitoring of a field fertilization experiment was to determine whether species within a similar plant growth form would respond to a controlled perturbation in a manner which was distinctive from the responses of species of different growth forms (Fig. 17). The controlled perturbation was a factorial NPK fertilization experiment in the tussock tundra. The growth forms compared were functionally deciduous graminoids, deciduous shrubs, and evergreens. Two common species of each growth form were sampled and concentrations of nitrogen, phosphorus, potassium, calcium, magnesium, and total nonstructural carbohydrate determined as well as yearly production per stem or per tiller. The species were E. vaginatum, C. bigelowii, L. palustre, V. vitis-idaea, V. uliginosum, and B. nana.

Figure 17. Effect of nutrient treatment on tissue nutrient content. H = high treatment (see text); C = control.


NUTRIENT AS PERCENT OF TISSUE DRY WEIGHT
2.5
2.0
1.5
1.0
0.5
CONTROL
H.NPK
H.NP
H.N
H.P
C
ERIOPHORUM
CAREX
LEDUM
%N
%P
%N
%P
%N
%P

The results indicate significant differences in magnitude of the responses of nutrient and total nonstructural carbohydrate concentrations among species, with the responses usually but not always in the same direction for all species. Growth forms were not consistently different from each other in the responses of nutrient and total nonstructural carbohydrate concentration and frequently the two species from the same growth form responded differently. Growth per stem or per tiller was stimulated most strongly by nitrogen or nitrogen plus phosphorus fertilization in five of six species, with small and usually insignificant differences in magnitude but not direction of the response (species *N and species *N*P interactions).

Nutrient concentrations responded principally without interaction between fertilization treatments but the growth response consistently was characterized by the nitrogen*phosphorus interaction, indicating that individual nutrient concentrations may vary widely and independently but that growth at Eagle Creek requires a balanced plant nutrition with first nitrogen and then phosphorus as the principal limiting factors. Carex bigelowii growth was decreased by potassium fertilization. These results contrast with results from similar communities in Sweden where phosphorus was most limiting, and in Britain where potassium was most limiting. Decreases in total nonstructural carbohydrate with fertilization suggested that carbon supply was not limiting to plant growth.

The main conclusion of the research is that species respond individually in terms of nutrient and total nonstructural carbohydrate accumulation to fertilization, and that the growth forms studied are not distinctive from each other on the basis of plant nutrition or growth. Predictions of the responses of different growth forms occurring in the same community on the basis of observations of geographical and interhabitat trends may not be valid. Resampling in July 1978 indicated different nutrient effects on plant growth than in 1977, with phosphorus fertilization frequently stimulating growth with or without nitrogen. However, nutrient analyses of 1978 samples are still incomplete. Also in 1978, there was a significant fertilization effect on flowering of E. vaginatum, due mainly to the phosphorus*potassium interaction.

Responses of Rubus chamaemorus and Empetrum nigrum to fertilization were characterized in 1978. The eight species for which nutrient responses were characterized account for 99% of the biomass and production at Eagle Creek. All species respond about equally in terms of growth, tentatively refuting the hypothesis that the deciduous growth form should be most responsive. However, evidence from other sites suggests that the most responsive species are high-turnover species that are not found in undisturbed vegetation but invade later. Nutrient concentrations usually respond to fertilization without interaction between fertilizers, and the concentration response varies in both magnitude and directions among species of the same as well as different growth forms.

Reproductive allocation of the vascular species at Eagle Creek was remarkably consistent at 3%-4% of total annual production. Vaccinium vitis-idaea was an exception, with almost 22% of total production allocated to sexual structures in 1978. Of the production allocated to sexual reproduction, he proportion allocated to viable seeds varied widely, from 0.001% in B. nana to 27.6% in R. chamaemorus. Abortion of reproduction in berry-forming species takes place early, while species producing loose seed abort later in the progression from flower bud to mature seed.

An original hypothesis of the work on reproductive allocation was that E. vaginatum might be so successful on disturbances because it has a high reproductive effort. Results from 1978 invalidate that hypothesis and suggest that seed dispersal mechanisms and seedling growth characteristics are more important. Observations of seed revegetation of small disturbances indicate that most seedlings are E. vaginatum seedlings, and that both survivorship and rate of invasion of other species is low. A distinct seasonal peak in seedling establishment occurs in late June–early July, with some variation related to rainfall. The seedlings established at that time have the highest survivorship.

Contrary to suggestions in much of the tundra literature, seedlings are present in large numbers in undisturbed tundra, particularly L. palustre, E. vaginatum, and E. nigrum. Based on analysis of age structures, at least L. palustre and probably also E. nigrum seedlings survive to become adults in undistrubed tundra. Seed germination in undisturbed sites is higher but varies depending upon substrate. Mortality rates of most species are high. Seedling distribution on substrates of different types is non-random, with highest densities in dead leaves attached to old E. vaginatum tussocks, and in Sphagnum or Dicranum moss mats.

Root growth observation boxes were constructed and placed in the field in late July 1978, after soil thaw had proceeded to a sufficient depth to allow their installation. A total of 17 boxes are in place at Eagle Creek, and 4 at Toolik Lake. These will be observed for root distribution patterns and elongation rates in 1979.

Agenda for 1978 DOE-Tundra Workshop on:
Availability, Uptake, and Use of Environmental Resources in Tundra
San Diego Country Estates
17-22 November 1978

Friday, 17 November

AM : Introduction to ARTUS (Stuart, P.C. Miller)
Introduction to the workshop (Shaver)

PM : Everett (Structure and Parent Materials)
Stuart (Soil Oxygen)

PPM : Modeling session (Heat and Oxygen Movement in Soils)

Saturday, 18 November

AM : Miller (Models of Decomposition and Mineralization)
O.K. Miller (Microbiology)

PM : Linkins & Neal (Enzymology)
Mangan (Root Excavation STudies)

PPM : Modeling session (Microbial Processes, Decomposition, Mineralization, Denitrification, Nitrification, Precipitation, Exchange Reactions)

Sunday, 19 November

AM : Miller (Models of Nutrient and Water Uptake)
Kellogg (Soil Nutrient)
Chapin (Nutrients)

PM : P.C. Miller (Heat Balance and Evapotranspiration)
Roberts (Plant Water Relations, Theory)
Oberbauer (Tundra Plant Water Relations)

PPM : Modeling session (Water and Nutrient Uptake, Movement to Roots)

Monday, 20 November

AM : Miller (Models of Photosynthesis, Respiration, Biosynthesis)
Oechel (Carbon)

PM : Shaver (Growth)
Prudhomme (Allocation)

PPM : Modeling session (Photosynthesis, Respiration, Biosynthesis)

Tuesday, 20 November

AM : Miller (Allocation, Expansion, Completion)
Kummerow (Growth)
Murray (Phenology)
Chester (Reproduction)

Tuesday, 20 November (cont.)

PM : Fetcher (Populations)
McGraw (Seedlings)

PPM : Modeling session (Allocation, Expansion, Competition)

Wednesday, 22 November

AM : Stuart (ARTUS)
Critique by Reviewers
P.C. Miller (1979 Proposal)
Shaver (Publication Strategy)

PM : Departure

Reviewers: Dr. Boyd Strain, Duke University, Botany Dept.
Dr. C. Vern Cole, USDA, ARS, Colorado State University
Dr. Keith VanCleve, Univeristy of Alaska, Forest Soils Laboratory