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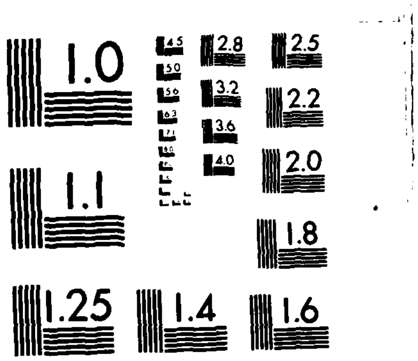

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18. SUPPLEMENTARY NOTES
   Full funding (3 yrs.) was reduced to 1 year and the amount requested reduced to half. Therefore, the proposed work and data analyses will not be completed.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

   Decomposition
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   Arctic
   Litter bags
   Fungi
   Cellulose
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
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ABSTRACT

The intent of the proposed research was to further ellucidate decomposition processes attributed by soil fungi in an Arctic terrestrial environment as those processes relate to the structure and function of decomposition in cold dominated peat soils. The approach was novel in that it was to examine the presence and abundance of total fungal hyphae by a modified Jones and Mollison (1948) technique and viable fungal hyphae by either the fluorescein diacetate (FDA) or oresein techniques of Soderstrom (1977, 1979) in relationship to: 1) the presence and activities of catabolic enzymes (i.e., chitinase, peroxidases, proteases and cellulase) present in the soil complex, and produced by the fungi. Enzyme activities were to have been measured by methods of Ander and Eriksson (1975, 76, 77); 2) the gravimetric loss of organic litter components (i.e., cellulose, hemicellulose, lignin, acid and neutral solution solubles and remaining residuals) the decomposition of which is largely attributed to soil fungi in moist but not saturated peat soils; that were measured for year one samples of a planned 3 year study. Litter components were measured in part using the techniques of Van Soest and Wine (1967, 1968); and 3) the total concentrations of nitrogen in the decomposing system in relation to the overall rate of component weight loss that was not determined because of reduction in funding amounts and duration. Litter bags constituted the experimental pool from which most measurements were taken.

Correlation and multiple regression analyses were to have been performed on the various data combinations to determine rates and function interdependence in an attempt to further define the structure and function of decomposition and associated processes at northern latitudes attributed to the fungi.

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BIOPHYSICS OF COLD ADAPTATION AND ACCLIMIZATION
MICROBIAL DECOMPOSITION

A Final Report

Submitted to

ONR Code 441MB

For

Contract Number N00014-83-K-0461

By

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99701

Report Number AES 83-10

A-1

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WORK COMPLETION SUMMARY

1983-84 Funding Cycle

The 1983-84 funding level of $52,250 was to have been in place for the start of work on 1 January 1984. Funds were not received by the University of Alaska until 1 July 1984; hence, a six month delay in the start-up of certain aspects of the study and facility establishment was experienced. Several aspects of the study were begun without funding so one complete field season (1 year) would not be lost.

Two main aspects of the study as proposed were the microcosm (*in vitro*) and litter bag (*in situ*) studies. The late funding and restrained facility development would not permit microcosm studies to be initiated during the first year of the as study initially proposed. However, substantial progress has been made with respect to the lignin-cellulose (litter bag) studies as proposed.

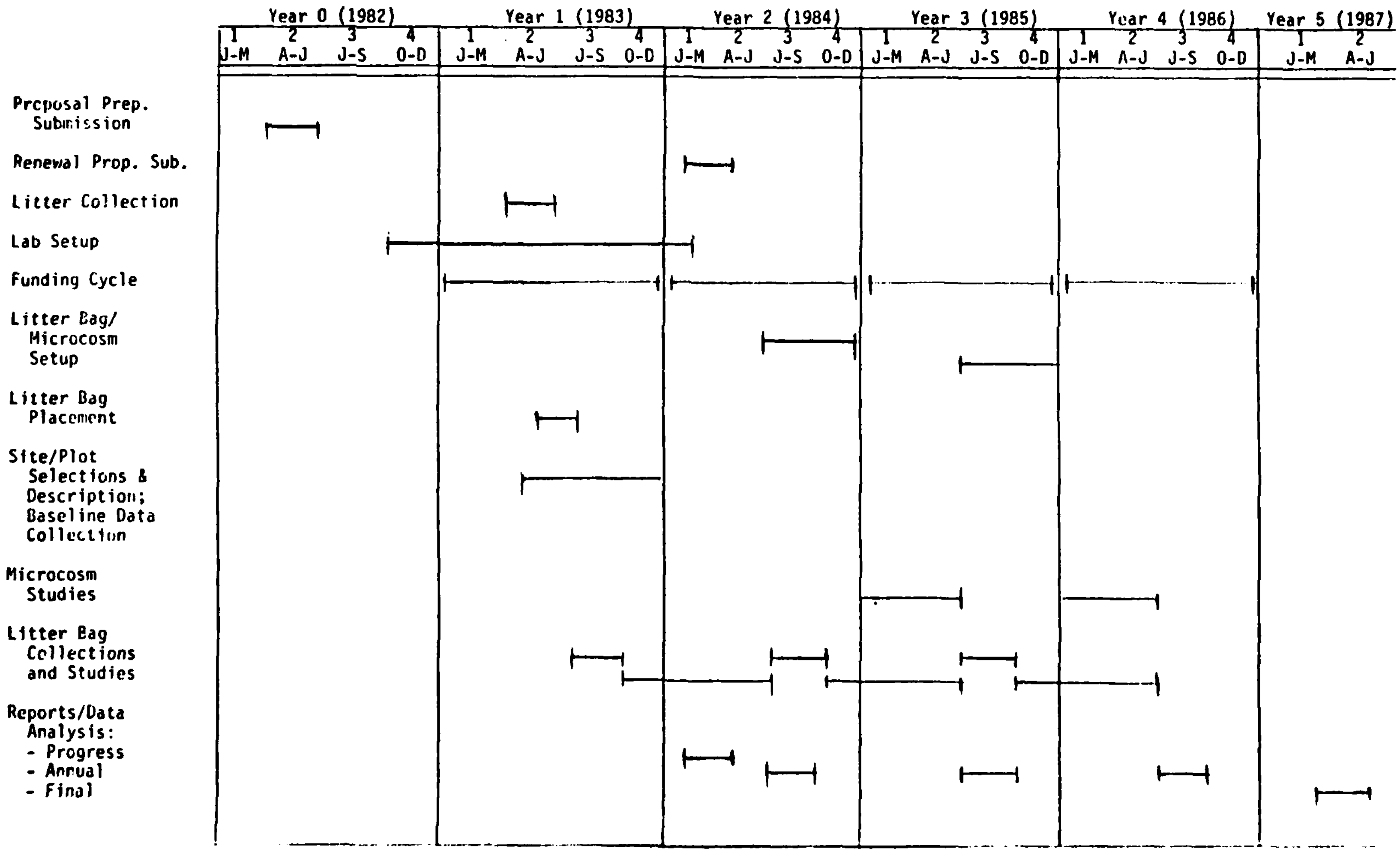
The 1983-4 (FY 83) funding of $52,250 was substantially less than was initially proposed, but it provided for the basic essentials needed to initiated the revised study plan (Table 1). Even with limited funds, the lignin-cellulose (litter bag) aspect of the study was set up to accommodate the collecting of data over a four year period as shown in the original Study Plan. This study plan has been revised (Table 1) in accordance with the 1 July 83 to 30 June 84 funding cycle.

1983-84 Fund Expenditures

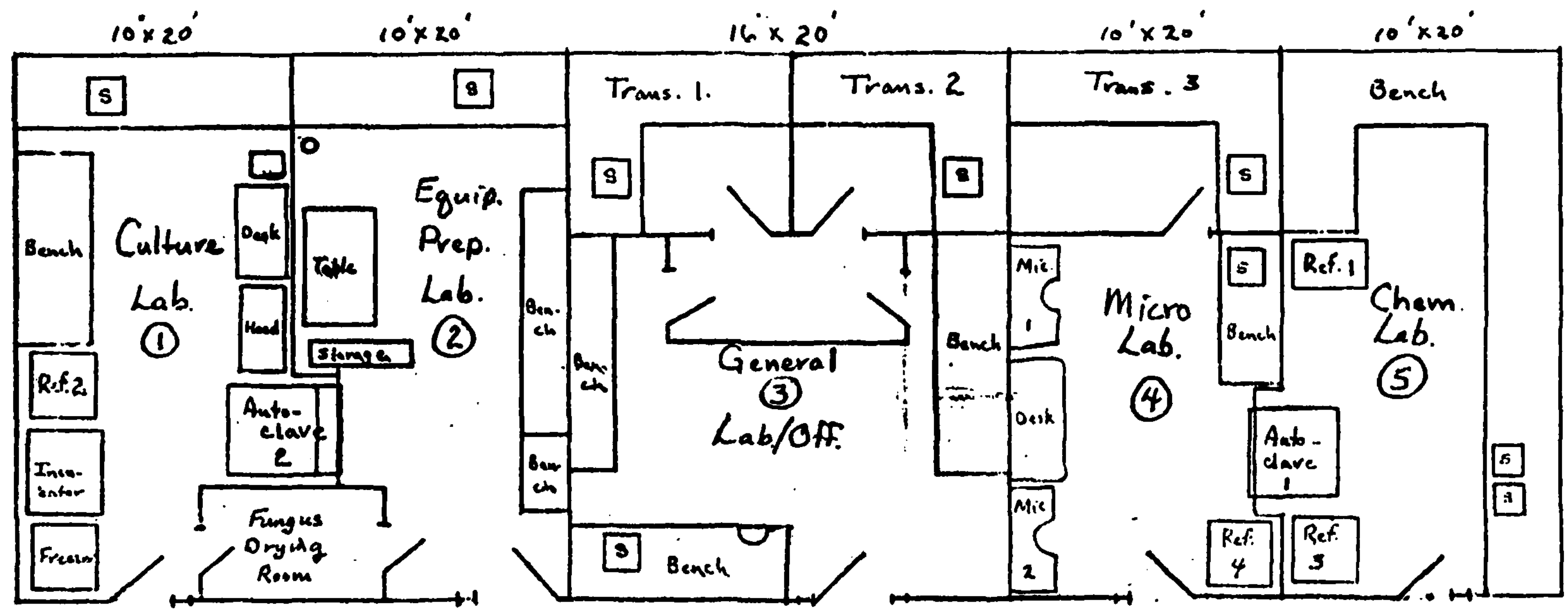
Funds awarded provided for the following:

1. four months' salary and staff benefits for the principal investigator;

Table 1. REVISED STUDY PLAN



2. the purchase of needed supplies to establish a Chemistry laboratory (Figure 1) to be used in preparing general media, stock chemicals and stain's for the determination of neutral and acid detergent soluables, hemicellulose, lignin, cellulose and ash/residue from litter bag samples;
3. the purchase of needed supplies to set up a Fungal microscopy laboratory (Figure 1) for the continuation of taxonomic and isolation work to be conducted in conjunction with microcosm studies as proposed;
4. supplies needed to establish a Culture laboratory (Figure 1) for isolating soils and decomposer fungi, for retention of a culture collection, for inoculation of seven native leaf litter types (Arctophila fulva, Betula nana, Carex aquatilis, Dupontia fisherii, Ledum palustre ss. decumbens, Salix alaxensis and S. pulchra) which are used in the lignin-cellulose studies, for special preparation/media filtration, double distilled water preparation, and epiluminescence (fluorescent) and field counting microscopy;
5. the set up of an Office (Figure 1) and computer terminal accessibility;
6. the securing of scientific equipment from the Naval Arctic Research Laboratory (December 1982 and September 1983) for conducting all phases of the proposed research and the set up test and make fully operational all equipment to be used throughout the course of study. All aspects of laboratory set up are now completed except for the General purpose laboratory/office for technical and/or graduate student use.



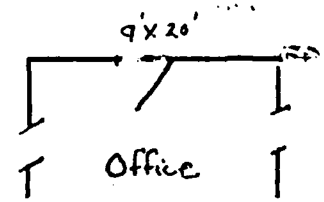


Figure 1. UAF Mycology Laboratories

5 fully equiped labs
1 Lab.-office
1 Office
3 Transfer rooms

Space

4 - 10'x20' labs
1 - 16 x 20 lab/off.
1 - 9 x 20 off.
= 1300 sq. ft.

1983 Field Work

Fall (pre abscission) leaf litter of seven vascular plant species native to Alaskan Arctic north slope tundra habitats was collected, air dried and prepared for inclusion into 10 cm^{-2} nylon monofilament screen (Nitex HC 3-500, ca. 500 μm mesh) decomposition litter bags.

Five hundred prepared litter bags were placed in the field at three sites near Barrow, Atquasuk and Driftwood, all within arctic tundra habitats. One hundred and twenty bags holding four different litter types were placed on three sites of a polygon system that included a high (dry) polygon center, mesic dwarf willow dominated meadow and a wet sedge dominated meadow near Barrow. One hundred and eighty litter bags containing six species (four overlapping with those placed at Barrow sites) of different litter types were placed near Atquasuk. Bags were placed again on high dry polygon tops, mesic and wet meadow tundra sites for valid comparisons to be made between Barrow and Atquasuk sites. The Barrow and Atquasuk (Meade River) sites are located near Eskimo populations within the Coastal Plains Province of Alaska's north slope. Barrow, however, is truly oceanic (coastal) in its climatic regime; whereas, Meade River, being 60 miles south of Barrow, is truly continental. Two hundred bags were placed at four different sites near Driftwood. The same high dry polygon top, mesic and wet meadow tundra sites were complements to Barrow and Atquasuk sites with a riverbed (disturbed) site added. A detailed site description is given in the Site Description under METHODS from observations and data collected.

1983-84 Laboratory Efforts

Two hundred and eighty-eight litter bag replicates of 144 tests and seven control samples, also in replicate, were brought into the field/sample preparation laboratory and ground using a Wiley mill (#40 mesh screen) as per the proposed methods. Chemical solutions were prepared to initiated the lignin-cellulose determinations as proposed. Six of the seven control samples have been run in addition to 186 replicates of the total 288 brought in for study.

It is important to note here that it takes one week (five working days) to run ten samples; hence, 19 weeks of effort have already been dedicated to this effort. There are 104 samples yet to run for the lignin-cellulose determinations. Until all samples are run and raw data entered into the computer system for reduction, little can be said from experimental results. Likewise, the samples have yet to be run for total nitrogen so that correlations can be computed. Microcosm studies for fungal biomass will not be initiated until next fall, pending the funding of this renewal proposal.

SITE DESCRIPTIONS

North American (Alaskan) Arctic

In North America, the Alaskan high latitudes reveal a vast and northerly dipping coastal plateau marked with an expanse of obligotrophic lakes, ponds and aquatic habitats, which cover 50% to 85% of the land's surface area and polygonally patterned ground covering 20%-40%. The land surface is covered with a select acid peat soil called tundra. Concern here is for tundra which encompasses the vast treeless and grass-sedge plain north of the 10°C July isotherm. This grass-sedge plain is sectioned into Arctic low and middle tundra.

The Alaskan North Slope is densely clothed, unlike the Antarctic, with poikilohydric (bacteria, algae, fungi and lichens) and homiohydric plants, which resist dehydration under normal climatic changes for that area. This group of organisms was placed by Walter (1973) into his 9th vegetational zone, the "Arctic tundra zone".

The Arctic flora, its distribution and the adaptations of Arctic plants to the environment, have been intensively studied by several botanists (Britton 1966; Eyre 1968; Hultén 1941-50; Polunin 1960; Porsild 1957; Savile 1972; Wiggins 1951; and Wiggins and Thomas 1962). The U.S. Arctic tundra, which extends from west to east across some 900 km and 180 km north to south, has been described vegetatively by Hultén (1968) and Wiggins and Thomas (1962). Tundra relief is subdued, with elevations along the coast at or near sea level. Relief increases ever so slightly southwardly for 200 km where tundra contacts the Foothills Province of the Brooks Mountain Range. Permafrost, first discovered by Middendorf (1864) in USSR tundra, underlies the entire US north slope region 20 to 100 cm below the grounds surface and to varying depths. Permafrost extends downward 300 m in many areas and to 450 m near Barrow, Alaska. Exceptions to the presence and depth of permafrost exist under deep lakes; e.g., Peter's Lake, and the major river channels of Meade River (Atquasuk) and the Colville River where no permafrost is found in the upper soil layers at all (Brown and West, 1970). Because of the hydrologic freeze-thaw cycle, activity resulting in the formation of polygonal surfaces is common in all study areas and they come in a variety of shapes and sizes. Drainage from tundra surfaces is poor and, for the most part, is lateral due to the impervious permafrost layer. Soils are often water saturated for most of the season and the permafrost acts as an impenetrable barrier for deep water percolation. Small streams meander and many become incised. Others develop vast floodplains where they often become heavily braided before emptying into the Arctic Ocean. Streams wander as do the characteristic footprint-like lakes, which have northwest-southeast longitudinal orientations. As lakes and ponds migrate they flow into one another. Lakes often become completely drained after which the old lake bottoms undergo morphological changes that result in characteristic patterned ground. Summertime climate is coolest along the coast and weather conditions vary considerably along the Arctic coastal plain. Atquasuk, 80 km south of Barrow, is much colder in the winter and much warmer in the summer than temperatures recorded at Barrow. Interior Driftwood, 250 km south of Barrow, which is under the influence of an oceanic climate and has mild winters, may have even colder winter and hotter summer temperatures. Both Meade River and Driftwood have climates that are vastly different from coastal Barrow. However, tundra near Barrow, Alaska is somewhat atypical for most other Arctic tundras. The Arctic Ocean surrounds the Barrow peninsula on the north, east and west.

North Slope *tundra* is almost flat with minor undulations. It extends some 300 km to the south through two upraised plateau provinces, the Arctic Coastal Plain Province and the Foothills Province. Temperatures here have been found to be greatly influenced by the prevailing northeast winds. There are no natural wind barriers on the tundra near Barrow to interrupt the prevailing NE winds. Thus, convection or radiation currents are quickly dispelled. There is never a pocketing of air down slopes into valleys or canyons as they simply do not exist at the macrorelief levels. Consequently, temperature inversions in the lower atmosphere are not as detectable on the North Slope, if at all, as they are in the interior of Alaska. Winter ice fogs are examples of these inversions in Fairbanks.

Morphogeologically, the coastal plains are young and presently in a state of dramatic change. Prevailing winds come from the NE and direct the movements of whole pond and lake systems in a unidirectional erosion pattern.

These ponds and lakes are characteristically elongated with the major axes aligned 10 to 15° west of true north. Lewellen (1972) has shown from aerial photographs that differential erosion of only the north and south ends of the ponds resulted in their migration at a rate of 1 m per year. These moving aquatic systems act as "leveling" forces on the topography. But once the "moving" system is drained away by anastomosing with another, multiple geologic forces, such as abrading winter winds, ice wedge formation and frost heaving and boiling, constantly churn up and expose tundra surface and soils. Where peat soils have accumulated, relative ages at depth have been estimated to range from approximately 2,000 to 8,000 years. Accumulated peat that becomes exposed is soon after mechanically decomposed by ice crystal formation and freeze-thaw cycles.

According to Flint and Gersper (1974), Arctic tundra soils on the North Slope, and particularly those in the vicinity of Barrow, are conveniently placed into two soil orders as defined by the U.S. Soil Classification System. The classes are inceptisols, or immature soils having weakly expressed profile characteristics and retaining close resemblances to parent materials; and histisols, which are organic soils.

Barrow

Sites for scientific investigation are delimited along the northern shore of the coastal plateau 14 km south of Point Barrow. The sites were used by the U.S. International Biological Program for its Tundra Biome intensive ecosystem study. These sites are located on coastal low wet meadow tundra 71°17' N latitude, 156°40' W longitude circa 2 km east of Barrow Village and 2 km south of the Naval Arctic Research Laboratory. The intensive study area is approximately 1400 m wide E to W and 1400 m long N to S. Sites are defined by

Footprint Creek on the north and down the middle. Gas Well Road bordered on the east, Footprint Lake on the south and an old raised beach ridge on the west.

Much of the ground's surface over these sites is polygonally patterned. An extensive interconnecting trough system has been formed. Sites slope gently to the west from Gas Well Road to Footprint Creek (Voth Slough), a verticai drop of about .78 m in a distance of 700 m. From the drainage creek the land rises westwardly in a series of four uplifted beach benches that culminate in an old beach ridge 2.82 m vertical rise above the slough. A moisture gradient is easily defined by its physiographic land surface features, peat thickness, and its characteristic plant communities. Parameters such as temperature, precipitation and relative humidity, as they are related to winds and sea ice, interact to produce the characteristic climate.

Temperatures in Barrow remain below the freezing point through most of the year. Daily maxima reach above -1.1°C, on about 109 days a year. Daily minima drop below freezing approximately 324 days a year and freezing temperatures have been observed during all months. February is generally the coldest month with a normal mean of -27.0°C. The lowest temperature ever recorded, -28.9°C, was recorded in February of 1924. In April, temperatures are steadily increasing. By mid-May winter fades and summer begins. The months of the field season are mid June, July and August to mid September. July is the warmest month; however, it rarely fails to snow on July 4.

As early as mid June the sea ice will move out and away from the beaches to expose the Arctic Ocean. Cool temperatures and onshore breezes typically bring in fog over the tundra after the ice leaves. In a predictable pattern, the occurrence of clouds, precipitation and heavy fogs build to a maximum as the number of daily sunshine hours increases. At 12:50 p.m. on November 18, the sun dips below the horizon and is not seen again until 11:51 a.m. on January 24. By approximately 9 minutes per day, the amount of daily sunshine increases until 1:06 a.m. on May 10 when the number of daylight hours has increased to 24 hours per day. On August 2, the sun finally sets for 1 hour and 25 minutes.

Climatic records kept since 1934 show low precipitation levels with a 40 year mean of 11.5 cm/yr. The range, from the low in 1935 to the high of 1963, was 4.09 to 24.82 cm of rain, fog, and snow per year. Mean snow fall was 27.2 cm for the same period with a 3 cm low in 1935 and a 60.8 cm high in 1964. Slightly over half of this precipitation, 59%, is received during the 109 day summer season. Approximately ¼ of the total rolls in off the Arctic Ocean as fog during the month of August. Most of the annual precipitation, not all of which is rain, occurs then in a short time during the fall of the year.

Mean wind speeds for the period from 1935 to the present are 11.9 mph. Relative humidity, even with a persistent wind, is still high and fluctuates between 78 and 96%. Lower humidities were detected around 2 p.m. each day and higher values were detected during the early morning and early evening hours.

Geographically, the moisture gradient extended from patterned or polygonal ground having both high centered and low recessed centered polygons of varying heights to and through a series of low profile polygons.

Peat soils of the U.S. IBP Tundra Biome wet mesic meadow sites are characteristic of cold, continental and wet coastal tundra. They are seasonally inundated during snow melt and melt water runoff. The soils are slightly to strongly acidic, with a low base status and low temperatures. They are classed as reducing soils. The soils also have moderately high carbon-nitrogen ratios and are perennially frozen beneath the 20 to 40 cm active layer. Soil scientists have distinguished three principal soil types within this somewhat stratified peat-gley composite. These were fibrists, saprists and hemic soils.

Fibrist (= fibric) peats contain rather raw and fibrous organic matter. They are often cold, water covered and found generally in polygon troughs and drainage slough depressions. They maintain an identifiable organic matter component and demonstrate rather high C:N ratios. The term given to them is cryaquepts. Fibrist cryaquepts of polygon troughs consistently had deeper mean thaw depths. Hemists showed thaw depths of 21.0-23.9 cm. Saprists ranked second with recorded depths of thaw (22.3-25.9 cm).

Saprist (= sapric) peat soils represent the other extreme by having a well disintegrated and decomposed organic matter component. These peat soils are stable, have a low C:N ratio and can be found on polygon rims and raised polygon tops, where soils tend to be less acidic and maintain low soil moistures and higher soil bulk densities. These soil types are called cryosaprists. Saprist cryosaprist soils have been examined by others (Drew 1957, Drew and Tedrow, 1957) in the vicinity of Barrow with emphasis on well drained soils of beach ridges.

Hemist (= hemic) peat soils are intermediate between the cryaquepts and cryosaprists. The organic matter is not a "humus" as found in saprist soil nor was it raw-fibrous. They tended to be dark brown, with an identifiable organic matter component and found in wet to mesic meadow tundra and in polygon low center basins. Depth of thaw in the active layer is a function of the interrelationships between soil moisture and temperature. They not only vary between these three soils types, but they also differ from year to year on individual geomorphic polygonal land forms.

By definition, permafrost is earth material whose temperature is perennially below 0°C, irrespective of the amount or state of moisture, texture, solidity or lithology. At Barrow, and on the peninsula, permafrost and its depth have been demonstrated through coring. Actual ice volume percentages decrease rapidly with depth. There is an increase to about 65% to 75% at the 1 m depth. The decline in ice percent is rapid thereafter, 60% at 2 m, 50% at 3 m, 40% at 7 m to a low of about 37% at 12 m. Investigators indicate that permafrost depth in the vicinity of Barrow is 405 m deep with a maximum measurement of 600 m near Prudhoe Bay. They make another interesting point in that ice formed in the permafrost zone is not just interstitial ice. It may take the form of nonvisible films, lenses, massive layers, wedges or crystals of varying sizes.

Geologically, the peaty coastal plain of middle Arctic tundra near Barrow, Alaska is underlain with Quaternary deposits of non consolidated clay, silt, sand or gravels that penetrate to about 45.7 m. Cretaceous sedimentary rock strata extend below this to about 731.5 m. Below this, to unknown depths, is basement rock of Paleozoic and Precambium age.

The constant shifting of surface features result in very unstable substrates which explains the existence of only one endemic grass species, *Arctagrostis latifolia* (F. Br.) Griseb. (Hultén 1968). Lists of species compiled for the Barrow area indicate that approximately 126 vascular plant, 155 bryophyte and 75 lichen species have been determined by various investigators (Murray 1977). It is suspected that approximately 100 or more species of higher fungi will ultimately be described from this same area.

Meade River (Atquasuk)

The vascular flora of the Meade River area, which is located about 100 km south of Barrow and approximately 50 km from the Arctic Ocean, has been described by Johnson (unpublished data 1966) and Hultén (1968), who incorporated the results of his and other collectors fieldwork in his Flora of Alaska and Neighboring Territories (Komarkova and Webber 1977).

The study area is found in the Arctic Slope of Alaska floral region of Hultén (1968). It belongs to Arctic Floristic zone three of Young (1971) or is transitional between his zone three and zone four; only eight species listed in his paper, having zone four as their northern limit, occur in the study area. The total vascular flora numbers about 250 species. The transition to zone four probably occurs just to the south of the study area.

Two hundred and forty-six vascular species have been reported from the Meade River area by Komarkova and Webber (1977). If all species reported by map dots in Hultén (1968) and those listed by Johnson (unpublished) are included, then the number of species in the area is probably closer to 290. This is considerably more than the reported number of species for the Arctic Ocean coastal areas (125 for Barrow and 172 for Prudhoe Bay) reported by Murray (1977). These facts document the increase of species number along the north-south gradient along the Arctic Slope. The southern increase is the result of differing climates and greater habitat diversity when compared to the more severe climate and low habitat diversity in the immediate vicinity of the ameliorating Arctic Ocean (Clebsch 1957; Clebsch and Shanks 1968). According to Murray (1977), biogeographic transitions on the Arctic Slope occur within only very short distances from the coast.

The sites with the highest species diversity, the highest occurrence of rare plants, and those which extend species ranges, include those open and disturbed (relatively disturbed compared with the tundra uplands) habitats near creeks, rivers and large lakes. The site by far the the richest in species number in the whole area occurs along one of the small tributaries of Meade River in a small valley with a variety of habitats both on north-facing and south-facing slopes. This is reportedly caused by lower competition from zonal plants in these habitats (Komarkova and Webber 1977). It cannot be assumed that environmental conditions would be that different in these localities, as similar creeks not as active erosionally with regular tundra vegetation on their banks also exist in the vicinity. It is hypothesized that rivers provide migration routes for vascular species from the south to invade the northern limits of their range (cf. Murray 1977). Some rare species also occur in shallow bogs and marshes. Kotilainen (1958) points out that many of the rare alpine species are generally found in the north and only in specific habitats like eutrophic bogs and rock crevices.

Driftwood

Five rather distinct habitat sites exist and all are essentially separated on the basis of topographical features and relative elevational gradients from the bed of the Utukok River. The highest area is a steep-sloped mountainside about two miles south of Driftwood Camp dubbed "Mushroom Mountain." The second highest site consisted of river bluff uplands. The third is mesic meadow tundra, the fourth is marshy wet-meadow tundra, and the fifth consists of raised lowland and disjunct patches of peat in the braided streambed of the Utukok River.

Mushroom Mountain supports a well-drained soil and corresponding vegetation composed of grasses, sedges, and mosses overall with Dryas octapetala on the upper portions and Salix nervosa and Vaccinium vitis-idaea on the lower portions of the slope.

The river-bluff upland habitat was composed of hummock and tussock tundra. Hummocks were dominated with Betula nana; however, Ledum palustre ssp. decumbens and Vaccinium vitis-idaea are abundant at but not limited to the periphery and bases of the raised hummocks.

Mesic meadow (lowland) tundra is characteristically wet, low-lying, and with occasional geomorphic land features such as polygon low-centered rims and solifluction benches that project upward to provide "islands" of interesting and disjunct higher plants and their associated fungi. This habitat type accounts for 50 percent or more of the tundra in and about Driftwood Camp. It is typified by a number of grasses, the sedges Carex aquatilis and Eriophorum vaginatum, and moss species interspersed with occasional Ledum palustre ssp. decumbens, Salix rotundifolia, Betula nana, and Salix alaxensis.

Marsh or wet meadow tundra is composed almost solely of Carex aquatilis and Eriophorum angustifolium. Standing water is a norm and moss carpets abound.

River bottom habitat is essentially composed of isolated peat mat islands interspersed throughout a braided and seasonally washed streambed. The peat "islands" support a variety of vascular plants, but the dominant species is Salix alaxensis. Grasses, sedges, and mosses abound and occasionally, Betula nana and Vaccinium vitis-idaea will be found on more protected "islands."

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