ssp. *monticola, S. tricuspidata, Oxytropis Jordalii, Cassiope tetragona, Androsace Chamaejasme* ssp. *Lehmanniana, Phlox alaskensis, Eritrichium aretioides, Pinguicula vulgaris* and *Chrysanthemum integrifolium.*

Much less common were: *Woodsia glabella, Elymus innovatus, Carex petricosa, Salix arctica, Polygonum viviparum, Anemone parviflora, Lesquerella Calderi, Smelowskia borealis, Draba barbata* (new to the flora of North America), *Parnassia Kotzebuei, Saxifraga oppositifolia, Potentilla fruticosa, P. nivea, Dryas alaskensis, Hedysarum Mackenzii, Oxytropis Maydelliana, Rhododendron lapponicum, Castilleja hyperborea, Pedicularis lanata, Valeriana capitata, Campanula aurita, Antennaria densifolia, Arnica alpina* ssp. *attennuata, Crepis nana, Erigeron purpuratus, Senecio resedifolius* and *Taraxacum alaskanum.*

STONY FLOOD PLAIN

Stony flood plain valley bottom is oriented southeast-northwest between low limestone hills. Starting at the head of the valley, the following more or less distinct plant habitats were examined in some detail: 1) Well-drained gravelly or sandy stream banks, the down-stream parts subject to spring flooding; 2) Dry, stony ridges usually with some soil around or between the stones; 3) Moist flood-plain meadows; 4) Moist, peaty bogs well above present flooding; 5) Low willow thickets, mostly on boulder flats between former stream beds but no longer subject to flooding; the space between boulders now well filled by sediments topped by a humus layer; the older and mature willow thickets are now being invaded by white spruce (see Fig. 2).

1) Gravelly or sandy stream banks: *Equisetum arvense, E. palustre, E. variegatum, Poa alpina, Carex capillaris, C. scirpoidea, Juncus albescens, J. castaneus, Tofieldia pusilla, Arenaria Rossii, A. obtusiloba, Anemone parviflora, Papaver Keelei, Braya glabella, B. Richardsonii, Cardamine purpurea, Draba longipes, Saxifraga aizoides, Parnassia Kotzebuei, Crepis nana* and *Senecio resedifolius.*

2) Dry, stony ridges: *Carex petricosa, Salix reticulata, Arenaria arctica, Silene acaulis, Papaver Walpolei, Lesquerella Calderi, Saxifraga oppositifolia, Dryas alaskensis, D. sylvatica, Hedysarum Mackenzii, Arctostaphylos Uva-Ursi, Campanula uniflora, Arnica alpina* ssp. *attennuata, Artemisia arctica, Chrysanthemum integrifolium* and *Solidago multiradiata.*

3) Moist flood-plain meadows: *Elymus innovatus, Deschampsia brevifolia, Carex atrofusca, Polygonum viviparum, Melandrium apetalum, Thalictrum alpinum, Parrya nudicaulis, Oxytropis Jordalii, Hedysarum alpinum, Castilleja hyperborea, Lagotis glauca, Pedicularis capitata, P. sudetica, P. verticillata, Pinguicula vulgaris, Arnica Lessingii and Aster sibiricus.*

4) Moist peaty bogs: *Equisetum scirpoides, Lycopodium Selago, Festuca altaica, Hierochloe alpina, Eriophorum callitrix, E. vaginatum, Kobresia simpliciuscula, Carex atrofusca, C. consimilis, C. misandra, C. lugens, C. membranacea, C. vaginata, Luzula groenlandica, Salix arctica, Polygonum Bistorta, Rumex arcticus, Saxifraga Hirculus, S. hieracifolia, Potentilla fruticosa, Vaccinium Vitis-Idaea, Arctostaphylos rubra, Ledum decumbens, Rhododendron lapponicum, Pedicularis arctica, P. labradorica, P. sudetica, Pinguicula villosa* and *Saussurea angustifolia.*

5) Low Willow thickets: *Picea glauca, Calamagrostis canadensis* var. *Langsdorffii, Salix alaxensis, S. Barrattiana, S. Bebbiana, S. glauca, Betula glandulosa, Delphinium glaucum, Valeriana capitata* and *Petasites frigida.*

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The Role of Spring Thaw In String Bog Genesis

Much has been written in several languages on the problems of distribution and genesis of string bogs. With the exception of certain botanical studies of string bog flora[1,2], there have been little more than cursory attempts to develop an understanding of the physical and biological forces involved in the formation of string bogs. In three recent textbooks on cold region geomorphology[3,4,5], little attention is paid to these problems. It is possible to make a case for string bogs constituting dynamic landscape elements critical in their adjustment to prevailing environmental factors, and thereby demonstrate that changes in the physical form and ecological character of string bogs over time are vital in the development of theories about the direction, intensity and frequency of environmental change in the subarctic. Before this stage is reached, it is necessary to establish a more thoroughly documented framework of current physical processes operating in string bogs throughout the year. It is to this end that the present note is directed.

Two problems immediately present themselves in any discussion of string bog genesis. First, there is the need to explain the initial establishment and maintenance of the ridge-hollow pattern; and second, the related problem of the concentration of string bogs in the boreal forest. The latter question has been discussed in some detail by Knollenberg[6] and will be briefly referred to below. However, observations near Schefferville, Quebec (54° 50′N., 67°W.) in the spring of 1970 are specially pertinent to explaining patterns within string bogs. Permafrost is absent from beneath these string bogs[7]. Transportation of organic debris across the frozen surface of the bog was noted to form "tide-line-like collections", a phenomenon reported by Auer[8] and Drury[1].

There is no doubt that in the subarctic, spring thaw is rapid and debris of various kinds is transported by the meltwater over the frozen surface of the bog. Several stages in the melt-transportation process can be recognized.

1) The thaw is first evident on the thin snow cover of the bog with the development of a mixture of slush, ice and open pools.

2) Additional melt involves the removal of snow from the surface of the bog. Drainage takes place across the still frozen surface in a series of discontinuous sheets which move from one standing pool to another. The underlying bog topography is mostly buried by a blanket of ice and water and appears to have little effect on the pattern of drainage at this stage.

3) Pools become linked as the volume of meltwater increases with advance of the thaw. Drainage coordination lowers the level of water standing in the pools; a 2-inch (5 cm.) drop in water level was observed in one pool overnight (30 to 31 May) with the development of a temporary channel draining down-bog. Exposure of plants colonizing the ridges takes place at this stage (Fig. 1).

4) Continued and perhaps more rapid melt of snow lying adjacent to the bog from within the spruce forests, augments the sheet flow. Meltwater on the frozen surface expands laterally with the overflow of pools. The flow contains organic debris of varying size and shape. Sedge tussocks protruding through the frozen bog and water surface are local sites for temporary and permanent debris accumulation. Lines of colloid suspended in froth occur in sites at the edge of drained pools, and larger organic particles can be discerned on the rapidly decaying ice beneath the chang-

FIG. 1. Frozen surface of a string bog near Schefferville, Quebec, 31 May 1970. Meltwater drains from left to right through the plant cover of a "string".

ing water surface. It thus appears that two forms of debris accumulation are in operation simultaneously: tide-like lines at the fluctuating pool edges, and damming behind obstacles protruding through the frozen surface. The direction of flow on the bog controls the general orientation of both deposits as they are at right angles to the path of water motion. The deposits also tend to be sinuous in plan.

5) With the removal of the bog ice cover, sheet flow over the bog ceases, and the meltwater becomes more channelized. Debris lines are left stranded at this stage.

In the bog near Schefferville where these processes were observed, incipient accumulations of the type described were only noted at the upstream end of a bog in which strings had already been developed down-bog. Where strings were already in existence, the damming effect was most apparent, although its importance declined down-bog as the floating organic debris was trapped or filtered by plants up-bog. Lines of debris accumulation are therefore considered initially to develop into permanent sites for plant growth at the downstream end of the bog, and then progressively build in an up-bog direction always at right angles to flow patterns of spring meltwater. "Younger" strings, according to this view, will occur at progressively higher elevations within any given bog.

Following the reasonings of Drury[1] and others, it is assumed that the sites of detrital deposition become the preferred sites for plant growth because of their relatively better-drained condition.

> Any slight advantage is important in the short, intensive growing season. . . . Once started, such a process will accelerate by its own effects. The initial elevation allows the formation of hummocks which grow by lateral extension. Hummocks coalesce and act as further dams for slush and floating debris. At this stage the element of frost-push from winter ice in the hollows enters, narrowing and elevating the ridge and preventing its expansion downslope. . . . Mid-winter ice push thrusts hardest along the long axis. These forces tend to elongate hollows across the slope too [1:68].

I would qualify the role of ice-push by stating that its effectiveness is limited to strings which already possess a pronounced ridge form backed by hollows 1 to 3 feet (0.3 to 1 m.) in depth. Incipient strings show no signs of lateral compression.

Although excavations in the Schefferville area were not conclusive, Wenner[9] and Drury[1] have shown that the hypothesis of *in situ* growth of strings was supported by bog stratigraphy. In southeast Labrador, Wenner[9] found that ridge and hollow retain their separate identities to the base of the bog without alternation of hummock and hollow positions. Similarly, in Alaska, simple superposition of one sphagnum species upon another was observed, and there was no indication of slipping or horizontal movement of peat or surface displacement of strata. Drury goes on to note that the horizontal bedding of the peat precludes any formation by frost heaving[1:69]. In northwestern Minnesota, a more complex stratigraphic pattern was reported by Heinselman[2:360], who concluded "that the initial stages of peatland development were sometimes quite different in areas now characterized by *Strangmoor*".

Observations near Schefferville where permafrost is absent tend to confirm many of the ideas concerning the genesis of string bogs developed by Drury[1] in his study of the Kuskokwim region of Alaska. Emphasis is placed on the primary role of organic accumulations during early phases of the spring thaw, a period of the year when few observers have had the opportunity to examine such bogs. A vital role is attributed to the more intense plant growth on initial shallow deposits which leads to the formation of the ridge. Ice-push and frost heave appear to play secondary and perhaps localized functions. Solifluction, differential settling and tilting due to permafrost melt, and compaction of peats under varying loads, are not factors which appear to be of great importance in string bog development.

There remain several critical problems which require further study:

1) Substantiation of the view that the older strings are downstream whereas younger and incipient strings are being formed near the head of the bog during spring thaw.

2) A more detailed examination of string bogs at different stages of development in order to determine critical hydrodynamic properties of spring meltwaters responsible for the transportation and deposition of organic debris.

3) The peat and pollen stratigraphy of different types of string bogs needs to be investigated to document with more thoroughness the structure of organic accumulation. Previous excavations have not revealed a basal transported layer; perhaps humification at the base of the string makes detection difficult. Within any given bog it may be useful to establish the spatial as well as depth variation in age of peat.

4) In those bogs in which the strings appear in concentric lines on an arched surface, it is critical to see whether sheet flow radiates out from the bog centre to produce the debris

accumulations, or whether other factors are involved.

5) From a botanical standpoint, there is much to glean from further studies of plant succession, physiognomy and physiology in this complex and dynamic vegetation pattern. Changes in drainage conditions over time, as well as seasonally, seem to lead to the variety of bog types that were characterized by Allington[7]. Equally important to string bog ecology are the effects of bedrock and adjacent vegetation on water chemistry and nutrient levels.

It is possible that run-off generated by torrential rains in summer produces debris accumulation at the head of bogs in a manner similar to that developed in the thaw. However, on 1 August 1970, a 2-inch (5 cm.) rainfall in 3 hours at Schefferville simply served to fill up the pools. This highlights the factors responsible for the concentration of string bogs in the subarctic (boreal forest) zone. The summer is the season of plant growth. The flooding responsible for the sinuous ridge pattern occurs during the early spring thaw when the bog surface is frozen. Once the melt is completed and flow between pools ceases, the limitations of the growing season in the subarctic take effect. Until more systematic studies are conducted on the growth characteristics of plants in string bogs, as compared with similar plants to the north and south of the zone of string bog development, there must be severe questioning of any explanation of string bog genesis from both botanical and hydrological standpoints.

If a program could be set up in the Subarctic which permits seasonal observation of the physical processes, together with an examination of plant growth mechanisms, then the presumed critical role of string bogs in understanding environmental change may become further elucidated.

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An Albino Muskox Near the Atkinson Point River, Northwest Territories

Gavin[1] during his stay near the mouth of the Perry River (67°48′N., 102°16′W.) from 1937-1941 reported only few muskoxen. The largest herds were 12 and 15, seen in 1938 on the mainland a few miles west of the mouth of the Perry River. Aleksiuk[2] saw no muskoxen during his period of field work in the Perry River area from 21 May to 10 August 1963 but reported that, according to local Eskimos, muskoxen were still found in the region of MacAlpine Lake, at the headwaters of Perry River.

During waterfowl surveys on 11, 15, and 16 August 1971, between Perry River and the Atkinson Point River (103°18′W.) and between 67°10′N. and 67°45′N. we saw the following numbers of muskoxen: 1, 26, 48, 1, 1, 23, 16, 1, 1. Dates of observation of herds, their location and numbers of yearlings preclude the possibility of duplication.

Of particular interest was the occurrence of a light-coloured individual in the herd of 23 observed on 15 August along the Atkinson Point River at 67°45′N., 103°18′W. The animal in question was a large adult of a pale creamy-yellow colour. Photographs taken at