A Palynological Study of Late Holocene Vegetation and Climate in the Healy Lake Area of Alaska[1]

J. H. ANDERSON[2]

ABSTRACT. A preliminary palynological study of the Healy Lake area in east-central Alaska is reported upon. Interpretations extend to 4,600 radiocarbon years BP. With the minor exception of pine, pollen profiles show no trends that can be interpreted as environmentally-induced departures from modern conditions, percentages at depth being similar to those for surface samples. Therefore it is tentatively concluded that no major changes in vegetation occurred in conjunction with late Thermal Maximum and Neoglacial climatic changes. There is some indication that lodgepole pine has migrated towards the area from the southeast during the Holocene.

RÉSUMÉ. *Etude palynologique de la végétation et du climat fini-holocène dans la région du lac Healy en Alaska.* L'auteur rend compte d'une étude palynologique préliminaire dans la région du lac Healy, dans le centre-est de l'Alaska. Ses interprétations s'étendent jusqu'à 4,600 radio-années A.P. Sauf pour l'exception mineure du pin, les profils polliniques ne montrent aucune tendance qui puisse être interprétée comme une disparité par rapport aux conditions "modernes", les pourcentages en pronfondeur étant semblables à ceux des échantillons de surface. L'auteur en conclut donc, sous toutes réserves, qu'il ne s'est produit aucun changement majeur dans la végétation en conjonction avec le récent "Maximum thermique" et les changements du climat au Néoglaciaire. Il y a des indices d'une migration du Pin de Murray vers la région, à partir du sud-est, pendant l'Holocène.

РЕЗЮМЕ. *Палинологическое изучение растительности и климата периода позднего голоцена в районе о. Хили на Аляске.* Сообщается о предварительном палинологическом изучении района о. Хили в центральной части восточной Аляски. Интерпретация радиоуглеродных данных распространяется на 4600 лет до новой эры. С незначительным исключением в случае сосны процентное содержание в глубинных образцах сходно с содержанием в поверхностных образцах, и пыльцевые диаграммы не проявляют тенденции, которую можно было бы объяснить условиями среды, отличными от современных. Поэтому в порядке рабочей гипотезы делается заключение, что никаких существенных изменений в связи с поздним тепловым и неоледниковым изменением климатических условий в растительности не произошло. Имеется указание на то, что сосна Муррея мигрировала в данный район с северо-востока в период голоцена.

INTRODUCTION

The Healy Lake area, in the upper mid-Tanana River valley in east-central Alaska (Fig. 1), was studied archaeologically by Cook (1969) and Cook and McKennan (1970a, b), and geomorphologically by Ager (1972) and Hamilton (1973). Principal findings: (a) a human population has lived in the area at least intermittently for approximately 11,000 years, (b) the geologic component of the landscape has changed significantly during this time as a result of late- and post-glacial fluvial,

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[2]Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska, U.S.A.

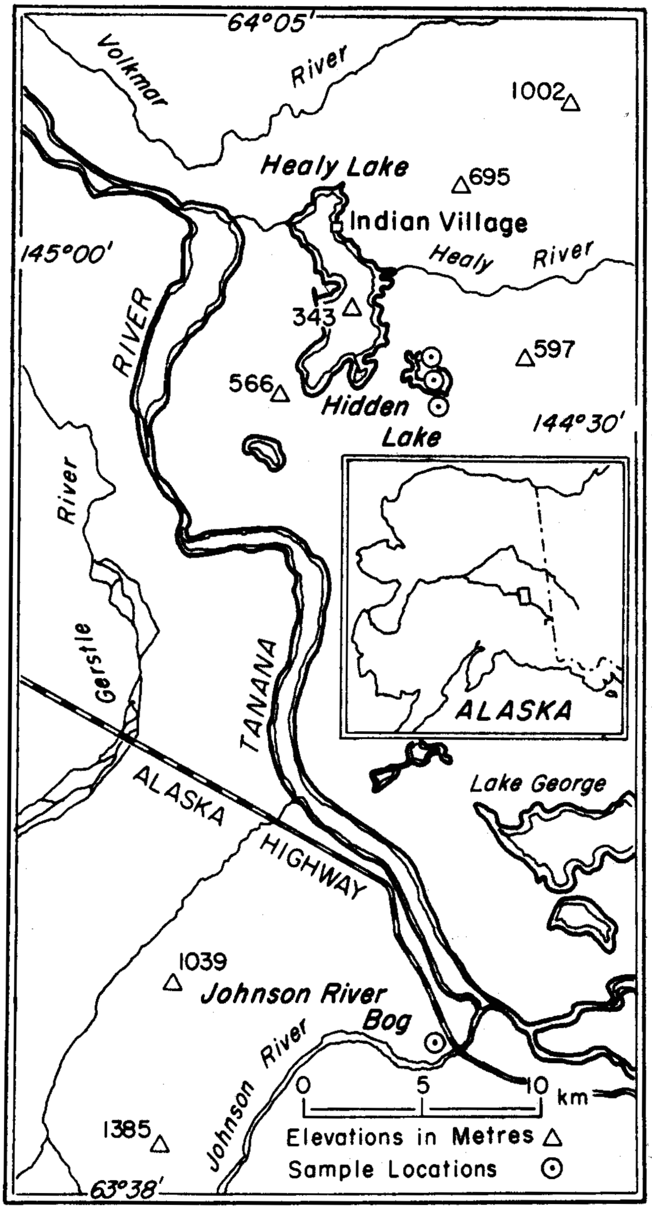

FIG. 1. Map of the Healy Lake area.

aeolian and cryopedologic processes, (c) the present Healy Lake probably is young, with an age of only some 3,500 years, and (d) macroclimatic changes associated with the Thermal Maximum and Neoglaciation have occurred.

In conjunction with this research a palynologically-based attempt was begun in 1970 to determine something of the regional vegetation history of the area and more of the macroclimatic history as inferred from vegetation. Specific objectives were: (a) further information on the environment in which early human activity took place, (b) geobotanical information to complement geomorphologic studies and (c) new palaeophytogeographic and palaeophytocenologic knowledge of the interior Alaska boreal forest. Analysis of some of the palynological samples resulted in minor progress towards meeting these objectives. A preliminary view was achieved and initial interpretations made of the record for possibly the past 4,600 radiocarbon years, less than half the span of the geologic and archaeological interpretations. In view of the importance of the area for studies of the past, particularly with respect to the human colonization of the Americas, more should be done towards extending and refining knowledge of the geobotanical record.

STUDY AREA

Healy Lake (64°00′ N, 144°45′ W) lies at an elevation of 343 m (Fig. 1). Aspects of the geology, climate and vegetation of the area were described and referenced by the investigators cited above, and information on regional vegetation was published by Lutz (1956), Spetzman (1963), Matthews (1970) and Viereck (1973).

Ordinarily the character of only the upland vegetation may be identified with some degree of reliability in the palynological record, as plants of lowland habitats such as bogs tend to be poorly represented. In the Healy Lake area the upland vegetation comprises white and black spruce (*Picea glauca* and *P. mariana*), paper birch (*Betula papyrifera),* aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), willows (*Salix* spp.), shrub birch (*Betula glandulosa*), and a number of other woody plants, plus numerous herb and cryptogam species. The species listed contribute most to the physiognomy, plant biomass and pollen rain of the upland vegetation from the lowest elevations to treeline at around 900 m. Mixtures of two or more dominant species are most widespread, but among forest communities stands dominated by one species are common. The vegetation is overall a mosaic of stands, often intergrading, of various forest, scrub and other communities. It would not be possible to identify in the palynological record the stands constituting past plant communities with respect to diversity, relative abundance and distribution, except perhaps by detailed studies of samples from many sites throughout the area. Instead, a composite picture of the vegetation for any given point in time has to suffice.

Non-quantitative field observations indicate that among the more conspicuous species, paper birch is most important areally, followed in order by aspen, white spruce, black spruce and balsam poplar. Alders and willows are less important in forest communities but are common in upland scrub and in scrub vegetation types along streams and lake margins. Willows and shrub birch are important in bog communities. An Earth Resources Technology Satellite image (scene NASA ERTS E-1029-20383) was visually interpreted as showing forest and scrub over an estimated 60 per cent of the Healy Lake area. The rest of the area appeared covered by non- and sparsely-forested bogs and, above the treeline, by various alpine tundra communities. Ager (1972) presented illustrations of the distribution of vegetation types according to elevation, slope, aspect, soil type and permafrost.

The vegetation is related to a boreal continental macroclimate. Characteristically summers are short, warm, moderately dry and occasionally breezy. Frontal storm systems prevail perhaps 25 per cent of the time, keeping temperatures in the 10-15° (C) range and providing the bulk of precipitation. During clear weather daytime temperatures commonly are 20-25°, and a substantial amount of rain may fall locally in short-duration convection storms. Summer insolation is high, and this combined with warmth and adequate moisture promotes rapid plant growth.

Winters are long, cold and dry, and the winter landscape features a continuous, moderately-thick snow cover. Wind is insignificant, except during infrequent frontal storms entering from the north Pacific, which are the primary source of winter precipitation. Mid-winter insolation is very low.

Winter and summer are separated by a short spring and fall. Plant growth begins in mid-May and ends in early September. Permafrost is of consequence to plant growth in the low-lying, poorly-drained bogs and on north slopes. Permafrost terrain occupies perhaps 40 per cent of the Healy Lake area.

Johnson and Hartman (1969) published maps from which values of several climatic variables in the Healy Lake area were approximated. These are presented in Table 1.

TABLE 1. Mean values of selected macroclimatic variables in the Healy Lake area, approximated from maps published by Johnson and Hartman (1969).

Temperature (° C)		Precipitation		Sunlight	
Annual	−4.4	Annual	280 mm	Late June	22 hours
January, min.	−26.7	Snowfall	1,270 mm	Late December	4 hours
January, max.	−17.8	Wet day probability**:			
January, mean	−22.2	June-August	0.18		
July, min.	10.0	Sept.-Oct.	0.10		
July, max.	21.2	Nov.-March	0.13		
July, mean	15.5	April-May	0.05		
Seasonal variation	18.8*				

*This is about mid-way in the range given for a continental climate.
**At Big Delta, approx. 55 km northwest.

METHODS

Sample locations are shown in Fig. 1. In the vicinity of Healy Lake, Hidden Lake was chosen for sampling because it is located in a small basin enclosed through approximately four-fifths of its circumference by nearby uplands. Drainage through the basin is by small, low-energy local streams, and it appears from this that sedimentation has been slow and sediment mixing minimal over at least the past 4,600 years. Hence deposits here should be reasonably suitable for palynological purposes. Ager (1972) discussed evidence for depositional, erosional and thermokarst activity which would make the main Healy Lake basin unsuitable.

The Johnson River bog appears to have evolved through the filling in by partially-decayed plant remains of a glacial kettle pond. The geologic setting of this bog was discussed by Holmes and Foster (1968).

A square-rod Livingstone sampler was used. In Hidden Lake the depth of penetration, hence the time spans of the several cores, was limited by the moderately-heavy consistency of the sediments and the difficulties presented by the fact that three persons had to work over the side of a light boat. The average length of the three cores selected for analysis was 58 cm. Water depths at coring locations were 79-183 cm. All samples from Hidden Lake were mucks, consisting of silt and fine-grained, dark organic materials in varying proportions. Upper samples were highly organic, and lower samples were predominantly silt.

In the Johnson River bog, where a lack of machinery for driving and extracting the sampler was again a limiting factor, a 287-cm core was obtained. Subsequently T. A. Ager (personal communication 1972) obtained longer cores here, the analysis and dating of which are under way. Johnson River bog samples were coarse-grained, reddish, sedge peats.

Extra material was obtained near the lowest core levels for radiocarbon dating at the Institute of Marine Science, University of Alaska.

Palynological preparations were made according to standard procedures (Faegri and Iversen 1964). Most pollen identifications were made, and counting done, under 100-power magnification. A minimum of 200 grains were counted on most slides for calculating percentage occurrences of the nine taxa judged to be numerically and ecologically the most important. Fewer were counted on some slides where grains were scarce. The percentages were plotted against depth to produce standard pollen diagrams.

RESULTS AND DISCUSSION

The pollen diagrams (Fig. 2) show relative percentages of fossil pollen grains at each sample depth and radiocarbon dates. As no date was obtained for the Johnson River bog, an estimate for the bottom level was made from peat accumulation rates in similar environments as given by Hansen (1953) and Anderson (1970). Whereas the cores when removed from the sampler were compressed, the sample depths plotted are adjusted to original levels, assuming a linear compaction rate. The dashed parts of the curves for Hidden Lake, South, are meant to indicate uncertainty over a comparatively long span of depths within which no sample was analysed.

Radiocarbon dating revealed that the part of the palynological record brought to light extends from around 4,600 years BP possibly to the present. With the minor exception of pine, the pollen profiles show no trends that can be interpreted as environmentally-induced departures from modern conditions, percentages at depth being similar to those for surface samples. These percentages are more or less the same as those for surface samples elsewhere in the boreal forest of interior Alaska as determined by Matthews (1970). Therefore it appears that the composition of the upland vegetation of the Healy Lake area, to the extent that it is reflected here, has been constant for a least the past 4,600 years. This would seem to indicate that the macroclimate has not changed during this time.

Geologists, however, have found evidence for a regional Neoglaciation, with an accompanying Neoglacial climate, beginning approximately 3,500 years BP and

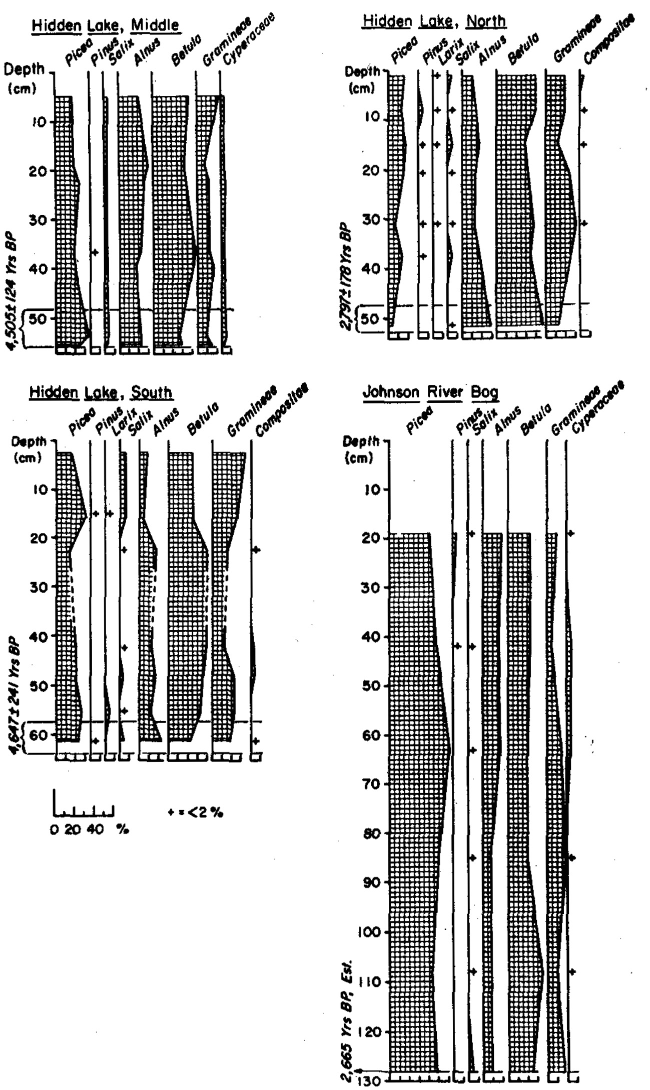

FIG. 2. Pollen diagrams from the Healy Lake area.

lasting to within the past few decades (Ager 1972; Hamilton 1973). In addition, geobotanical evidence of a preceding Thermal Maximum, ending between 3,000 and 4,000 years BP, has been found in nearby areas (Heusser 1960; Anderson 1970; Rampton 1971). Therefore it is concluded that late Thermal Maximum and Neoglacial changes in vegetation, if any, in the Healy Lake area were slight. This supports Ager's (1972) conjecture: "Cooler (Neoglacial) temperatures may have slightly reduced the elevation of timberline, but vegetation in general probably was not affected." A more intensive palaeobotanical study might reveal some changes in vegetation. Also, absolute pollen counts, rather than percentage counts, are desirable.

In interpreting percentage-based pollen diagrams it is normally necessary to apply the modern analogues technique or the technique of determining correction factors relating pollen percentages with vegetation composition. Here, the fluctuations in pollen percentages (Fig. 2) are considered within the margins of error of the procedure of sampling and analysis. Therefore the modern vegetation seems to serve as an analogue of that of earlier times within the span of the present record.

Heusser (1967) and Anderson (1970, 1971) worked on a hypothesis that the present population in northwestern Canada of lodgepole pine, *Pinus contorta* ssp. *latifolia,* the inland subspecies, derives from a Wisconsin Age population in a glacial refugium in northeastern British Columbia and northwestern Alberta. Anderson presented palynological information from northwestern British Columbia and south-central Yukon Territory consonant with a slow migration from the southeast during the Holocene.

More recent considerations promote the idea that a refugium probably did not exist here during the Wisconsin glacial maximum, and that pine probably persisted only south of the continental ice sheet at this time (Terasmae 1973). It appears to the author that a corridor between the Cordilleran and Laurentide ice sheets opened northward early in deglaciation, allowing migration of pine, and no doubt other species, to the northeastern British Columbia area, possibly by the close of the Wisconsin around 10,000 years BP. From this area Holocene migration could have continued northwestward. The current northwestern limit of lodgepole pine is southwestern Yukon Territory. It is possible that the species is still slowly migrating, as it grows well and sets seed when planted in interior Alaska much farther to the northwest, although establishment of seedlings under natural conditions has not been observed here.

Minor occurrences of pine pollen in the upper Johnson River bog sediments and in one of the Hidden Lake cores (Fig. 2) are further evidence for this pine-migration pattern, assuming that the few grains found would not have been wind-transported to these sites until the species had migrated as close to them as it has.

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