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PINGOS IN THE YUKON-KUSKOKWIM DELTA, ALASKA: THEIR PLANT SUCCESSION AND USE BY MINK*

The Yukon-Kuskokwim delta of southwestern Alaska is a triangular piece of land lying between the Yukon and Kuskokwim rivers (Fig. 1). Almost 90 per cent of this delta is a subarctic lowland with numerous ponds and lakes ranging in size from a few yards to more than 15 miles in length. This plain has developed on unconsolidated surficial deposits of silt, sand, gravel, and organic materials[1]. Relative relief rarely exceeds 100 ft. and is mostly 10 ft. or less. The remaining area is occupied by isolated volcanic outcrops. Highest altitudes occur in the Kusilvak Mountains, which rise from almost sea-level to 2,450 ft.[1]

This delta is the largest area of homogeneous mink habitat in Alaska, producing an average of 18,000 pelts a year. In 1960 and 1961 a study was conducted to obtain information about the ecology, management, and economic importance of mink in this area. Further investigations of pingos were made in 1963.

The area lies in the zone of discontinuous permafrost, but permafrost was found in all habitats suitable for mink. The perennially frozen ground was found to have an indirect influence on mink because of its direct influence on vegetation, thaw lakes and pingos.

In the extensive low-lying areas of the delta, around the villages of Nunapitchuk and Kasigluk (60°53′N. 162° 30′W.) pingos play an important role in the ecology of mink by providing the majority of sites suitable for natal dens. The area around these villages is a large expanse of low swampy and marshy terrain. Banks of the numerous lakes and streams are low and often a stand of emergent vegetation, with one or more channels winding through it, is the only separation between one lake and another. The area between these villages and Nelson Island (approximately 65 miles to the west) gives the impression of having been occupied by a shallow body of water. It is in this area that pingos are most abundant and much used by mink as den sites.

Independent studies of maps of this area by D. M. Hopkins and W. H. Condon of the U.S. Geological Survey has led them to believe that during early

* Investigations conducted by the Cooperative Wildlife Research Unit, University of Alaska and the Alaska Department of Fish and Game, financed through Federal aid to Wildlife Restoration Funds, Research Project W-6-R. Parts of this paper were presented at the 14th Alaskan Science Conference, Anchorage, Alaska.

Recent time, perhaps 4,000 to 6,000 years ago, the Kuskokwim River probably flowed due west from the present village of Kalskag along the course of the Kvichalavak River and then west to Baird Inlet. They believe that the river first built a subdelta north of Nelson Island and later another south of the Kolovinerak River. These conclusions were borne out by the author's observations of the topography in the area. The modern course of the river may have been adopted fairly recently, perhaps within the last 2,000 to 3,000 years (Hopkins, pers. com.).

As Hopkins has indicated, any ground that was in the central stem of the river was not frozen at the time the river ran there. After the river had changed its course, it would have become frozen in a certain period of time. The sediments were saturated with water and pingos may have developed as this water became segregated into large ice lenses during the freezing process.

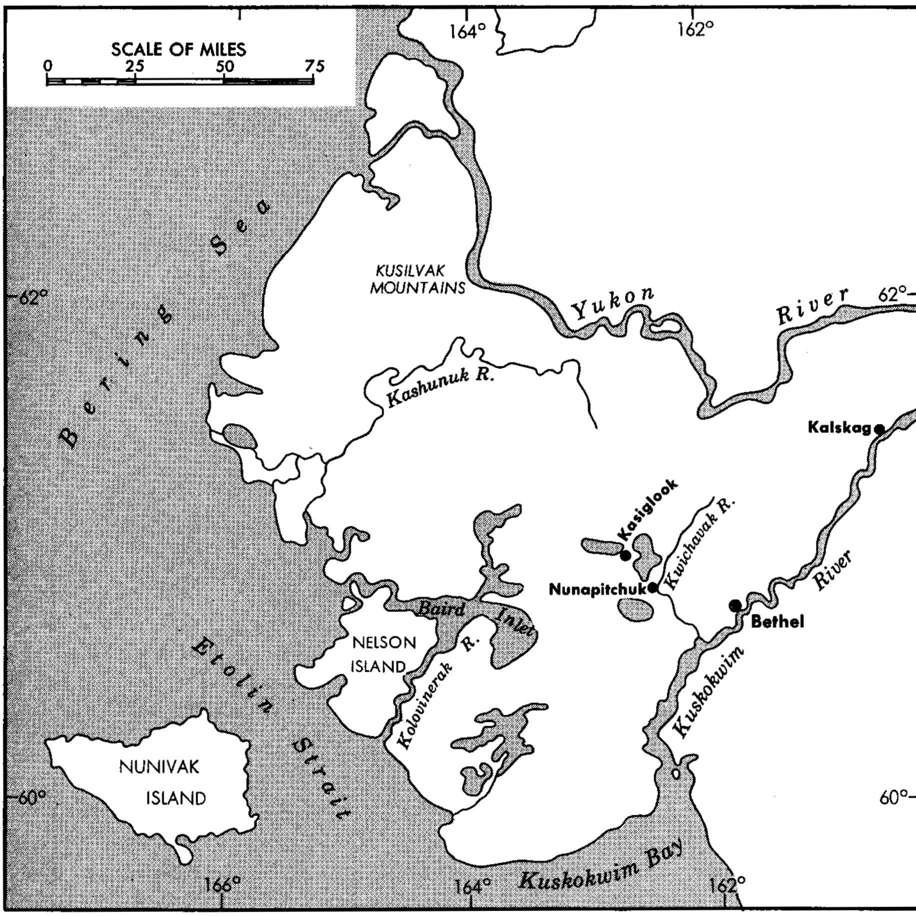

Fig. 1. The Yukon-Kuskokwim delta area, Alaska.

In addition to their importance to mink, pingos in this area are of interest for several other reasons: (1) according to Hopkins, pingos in the Yukon-Kuskokwim delta are the southernmost pingos known in Alaska and they are possibly farther south than anywhere; (2) the pingos appear to be actively growing at present; (3) all the several hundred pingos that I have observed in the delta are of the closed- system type, which has thus far been recorded only from areas of continuous permafrost[2] (Figs. 2 and 3). Closed-system pingos result from the segregation of contained interstitial water[3].

The pingos in the Yukon-Kuskokwim delta are circular, oval, elliptical, or irregular in plan, 15 to 200 ft. across and usually less than 30 ft. high. In profile they usually are ovoid or conical. Older pingos often have flat tops. Surface

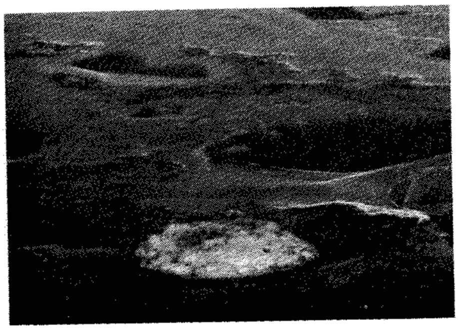

Fig. 2. Aerial view of a relatively large pingo near Nunapitchuk, Alaska.

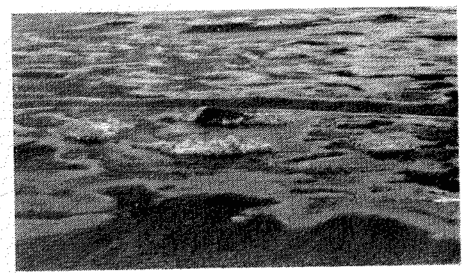

Fig. 3. Aerial view of several pingos in the basin of a receding lake near Nunapitchuk, Alaska.

Fig. 4. A grass-type pingo approximately 15 ft. high. The two major species are *Calamagrostis canadensis* on the pingo and *Carex aquatilis* in the foreground.

As the closed-system pingos of more northern latitudes, those in the Yukon-Kuskokwim delta usually occur in shallow or drained lake basins microrelief depends on the stability of the pingo. Actively growing mounds are the least stable and are ringed by numerous cracks that appear to be the result of slumping around the edges. Associated with slumping is the disturbance of the vegetation as illustrated in Fig. 4. The older, more stable pingos (relative age is based on the stage of plant succession, see below) do not have as many cracks and those present are confined to the least stable areas, the sides. Very few pingos had the characteristic median cracks described by other investigators[4,5,6,7,8]. None had springs associated with them. Occasionally depressions are present, usually on mounds of irregular shape.

Fig. 5. Core of a mixed-vegetation type pingo near Kasigluk, Alaska. The core is a lens of ice overlain by frozen mud.

Cross-sections of six pingos revealed frozen cores of two types. The cores of three relatively small (30 to 60 ft. in diameter, less than 15 ft. high), unstable, grass-covered pingos were lens-shaped, and of frozen mud. The cores of three older and more stable pingos were lenses of ice, overlain by frozen mud (Fig. 5).

Residents of Kasigluk say that two small pingos near that village have been increasing in size. Growth is also indicated by the presence of recent areas of slumping and disturbed vegetation. The only crosses that stand vertical in a graveyard at the abandoned village of Nunachuk are on the top of a rather long, more or less eliptical pingo. The crosses away from the centre of the pingo slant in the direction of the exposure. This probably also indicates continuing growth of this pingo.

In analyzing the vegetation of these pingos a definite plant succession was found and they could be divided into three types according to the plant communities they support. The three types can be called the grass type, the mixed-vegetation type, and the tundra type.

Secondary succession on pingos is caused by localized changes in relief, drainage, exposure, and ground ice conditions. The first plant to colonize a growing pingo is *Calamagrostis canadensis,* commonly called bluejoint. This grass was found on the smallest features identified as developing pingos. The length of time during which this species is dominant depends on the rate of accumulation of organic materials in the soil and the stability of the pingo. While the mounds are forming they are comparatively unstable and areas of extensive slumping are present. They are criss-crossed by deep cracks, particularly around the sides. Without exception all pingos in this stage support communities composed almost entirely of bluejoint (Fig. 4).

As the stability of the pingo increases and more organic matter becomes incorporated into the soil, a second species, *Spiraea beauverdiana* (a shrub) becomes established. Pingos supporting this community type are here called "mixed-vegetation pingos" when the shrub occupies over 20 per cent of the total area. The codominant species are bluejoint and *S. beauverdiana,* with the former declining as the latter increases in importance. *Spiraea* did not occur in pure stands occupying an entire pingo; the largest proportion of ground covered by this species on any one mound was 75 to 80 per cent of the total area. Other plants found on mixed-vegetation pingos include *Angelica lucida* (seacoast angelica), *Artemisia tilesii* (wormwood), *Petasites frigidus* (arctic sweet coltsfoot), and *Epilobium angustifolium* (fireweed) (Fig. 6).

Fig. 6. Side of a mixed-vegetation type pingo showing the two codominant species *Calamagrostis canadensis* and *Spiraea beauverdiana*.

The next stage in the succession is the appearance of mosses and lichens. They colonize first the areas under the shrubs. Perhaps the moss and lichen mat prevents the germination of the *Spiraea* seeds and this leads to the elimination of the shrub. The mat also insulates the soil and thus reduces the depth of annual thaw, which eventually causes the death of the rootsystem of *Spiraea*. When the thickness of the mat increases other plants begin to invade it. One of the first is *Rubus chamaemorus* (cloudberry). The sequence of other species that follow is uncertain, but it includes *Ledum palustris decumbens* (Labrador tea), *Vaccinium vitis-idaea* (cranberry), *V. uliginosum* (blueberry), and others found in the surrounding tundra.

Pingos become finally covered by typical tundra, except on the sloping sides. Their instability, leading to slumping and cracking, disrupts the normal succession. The vegetation of these disturbed sites is of the grass or mixed-vegetation type (Fig. 7).

The occurrence of vegetation types under varying conditions found on adjacent or asymmetrical pingos is an indication of the factors affecting relative rates of succession. Figure 8 shows an asymmetrical pingo on which all three community types occur. The grass community is not well developed and is restricted to the disturbed areas and to sites where a well-formed litter layer cannot normally build up. The mixed-vegetation type of community is found on the highest parts of the pingo. Since the top is more stable than the sides organic material can here accumulate in the soil. On this particular site, however, exposure to wind and blowing snow has apparently slowed down the development of the usual succession, but not to the same extent as slumping and cracking. The general cause of the elimination of *Calamagrostis canadensis* is not known, but it is assumed that once *Spiraea* has become established it can successfully compete with the grass.

As stated earlier, much of the delta is underlain by a thick layer of permafrost, which comes very close to the surface, especially under certain types of vegetation. The depth to permafrost was measured periodically from July 7 to 17, 1961, when little, if any change was noted. The active layer was thinnest under the tundra type of vegetation, where it was from 4 to 13 in. thick, with an average thickness of about 7 in. On tunndra-type pingos the thickness was slightly greater, with an average of 8 in.

Grassy pingos had a thin litter layer, which was usually saturated and offered little insulation. Many holes used by mink were found on these pingos, but

Fig. 7. A tundra type pingo. Plants include mosses (mostly *Sphagnum* spp. and *Polytrichum* spp.), lichens (*Cladonia* spp.), *Rubus chamaemorus, Empetrum nigrum, Ledum palustre decumbens, Spiraea beauverdiana*, and *Calamagrostis canadensis*.

The climax community, which in this succession is the tundra type, occupies the better protected broad sides, because the favourable conditions found there make its rapid development possible. In such protected areas organic material accumulates faster and wind and snow have less influence here than on more exposed sites. Eventually tundra vegetation will occupy the greater part of the pingo. On this particular pingo the broad flat side does not show the slumping and cracking of the steeper ends.

no natal dens were discovered.

Mixed-vegetation type pingos consistently had the greatest depth to frozen ground, which ranged from 8 to 18 in., with about 17 in. on the majority of pingos having occupied dens. This type of plant cover affords other advantages in addition to unfrozen soil. A crude test for the water saturation of the soil (squeezing a handful to determine the friability) indicated that the soil was most friable under willows (*Salix* spp.) and *Spiraea*. Rootsystems of these plants extended farther into the soil, probably accounting for the increased friability owing to removal of soil moisture to greater depth. The roots also impart stability to subterranean tunnels. Grass-covered pingos are the least stable and prone to slumping and cracking, especially during wet periods.

Although the Yukon-Kuskokwim delta encompasses large areas of suitable mink habitat, the extensive, flat, low-lying areas of the southern part do not provide many stream banks, brush piles, or extensive tree root systems that mink use for natal dens. In this area suitable places are largely restricted to pingos of the mixed-vegetation type. However, pingos in all stages of plant succession were much used by mink as hunting, feeding, and resting areas, scent posts, and for temporary dens.

Of 11 natal dens found on pingos all were on those of the mixed-vegetation type and all were situated under cover of *Spiraea*. Mixed-vegetation type pingos provide the necessary conditions of soil dryness, friability, stability, and favourable ground ice conditions, necessary for the successful rearing of young mink. Seven additional natal dens were found in other areas of the delta where pingos are not common. These were all in stream banks or in the banks of small lakes. At these sites the dominant plants were willows with some bluejoint. Conditions at these sites were similar to those on mixed-vegetation type pingos.

The author wishes to thank Dr. D. M. Hopkins for his encouragement, help and the review of this paper; also Dr. David Klein and Dr. Troy Péwé for reviews and comments.

JOHN J. BURNS*

Fig. 8. An asymmetrical pingo showing a combination of the three vegetation types illustrated in Figs. 4, 6 and 7.

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The Laboratory of Zoophysiology of the University of Alaska

This laboratory, which has been established under program support from the U.S. National Institutes of Health, is the initial component of the Institute of Arctic Biology created in 1963 by the State of Alaska. Research in various aspects of zoophysiology and environmental physiology is supported by State and Federal funds. The companion Institutes of Marine Science and of Geophysics, and the academic departments of Biology, Anthropology, Geology, Chemistry, and Wildlife Management offer valuable assistance and collaboration in many phases of zoophysiological research.

The building to house the Laboratory of Zoophysiology includes laboratories for metabolic, nutritional, biochemical, and electrophysiological research, as well as shops, data processing centre, and cold storage and work space. A ground floor extension provides for animal maintenance with indoor and outdoor caging and for controlled environment facilities. In the wooded area to the north enclosures provide semi-natural areas for holding larger animals.

Opportunities exist for both pre- and post-doctoral research. The University offers the Ph.D. in Zoophysiology. Persons with background training in zoophysiology or environmental physiology are encouraged to continue in this area, as are persons with substantial training in another field such as zoology, medical physiology, biochemistry, ecology, meteorology, etc., who wish to enlarge their competence or to specialize at a scientific interface. Summer opportunities for research participation at both undergraduate and high school levels are expected.

Interested persons should write to Dr. Laurence Irving, or Dr. Peter Morrison, Laboratory of Zoophysiology, Institute of Arctic Biology, University of Alaska, College, Alaska 99735, U.S.A.

The Friends of Polar Research have concluded another successful year of meetings at the Geophysical and Polar Research Center, University of Wisconsin. *The Friends* are an informal organization of university staff and students interested in the broad field of polar studies. The members of the organization come from sixteen departments ranging from Anthropology to Zoology and attendances vary from 20 to 35 persons. At each meeting a lecture is given, followed by a lively discussion among the group. The evening concludes with coffee and informal discussions.

The speakers and topics during the past academic year have been: "Population patterns in Alaska", Richard Smith (Geography); "Structure of Antarctica and its ice cover", Prof. Charles R. Bentley (Geology); "Geologic comparisons between the southern continents", Prof. R. H. Dott (Geology); "The polar regions and the earth's crust", Prof. Ned A. Ostenso (Geology); and "Northern Alaska prehistory and ecology — the background of Eskimo occupation of the Brooks Range", William Irving (Meteorology).

A similar program is planned for the 1964-5 academic year.

Christmas Cards of the Canadian Save the Children Fund

A leaflet describing the Christmas Cards for 1964, ranging in price from \$1.00 to \$1.50 for a box of 10 cards, may be had from the Fund at P.O. Box 512, Guelph, Ont.