Vegetation Differentiation Across a Topographic Yedoma–Alas Transect in the High Arctic Tundra of Oyogos Yar, East Siberia

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Abstract

Excessive moisture is regarded as the main cause for the fall of Pleistocene tundra-steppe and the rise of modern tundra. The arctic tundra of Oyogos Yar is low in diverse plant species (ca 100). The floral composition is mainly the result of differences in moisture or drainage, respectively. We describe a vegetational profile recorded in August 2007 along a 10 km transect from the top of a yedoma ridge down to the adjacent alas depression between 40 m to 10 m a.s.l. Six main landscape units are described with respect to their floristic composition: yedoma top with thermokarst mounds, mud boils, yedoma slopes, small thermokarst ponds, thermo-erosional valleys, and the bottom of thermokarst depressions. Arctic thermokarst landscapes with yedoma ridges and alas depressions can be well-classified according to their vegetation. The main constituents of the plant cover at well-drained sites are grasses and polar willows, whereas excessively wet sites are occupied by sedges, cotton grass, and peat moss.

Keywords: alas depression; bioindication; moisture regime; thermokarst; tundra vegetation; yedoma elevation.

Introduction

The arctic vegetation cover reflects very well the small-scale periglacial landscape differentiation. Detailed surveys of plant associations are essential for the understanding of biotic responses to changes in permafrost landscapes. Around Beringia, the great influence of topography on arctic vegetation has been described from Alaska (Walker 2000, Kade et al. 2005) and from the Taymyr Peninsula (Matveyeva 1994). Such studies of modern tundra vegetation are, however, little-known from Arctic Yakutia. Within the frame of the joint Russian-German expedition, “Lena–New Siberian Islands 2007,” we studied relief-vegetation interactions at the coast of the Dimitrii Laptev Strait in August 2007.

Regional Setting

Oyogos Yar is the name of the mainland coast of the Dimitrii Laptev Strait (Fig. 1) between the mouth of the Kondrat’eva River in the east and Cape Svyatoy Nos in the west. This landscape is part of the Yana-Indigirka Lowland in Northeastern Siberia. Up to 500 m thick continuous permafrost and wide spread thermokarst characterize the coastal lowland. Oyogos Yar’s topography is dominated by extremely flat plains covered by mires and shallow lakes.

There are two main topographic elements: low elevations, so-called yedoma, which represent the Pleistocene ground level, and thermokarst depressions (alases), which formed as a result of thermal degradation of the ice-rich permafrost that constitutes the yedoma.

According to Aleksandrova (1980), Oyogos Yar belongs

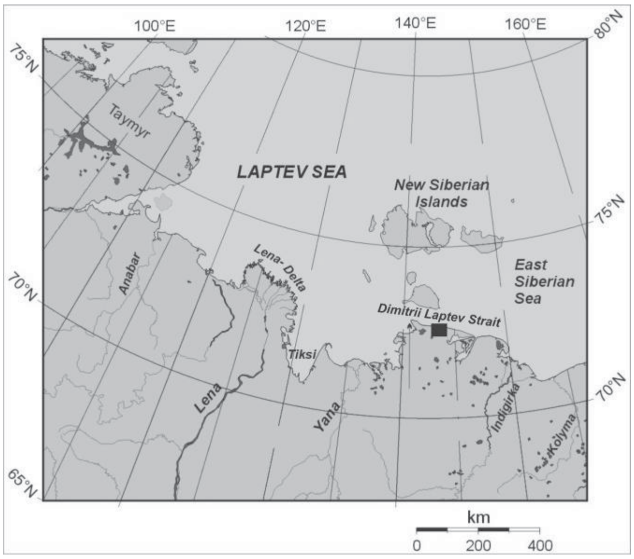

Figure 1. Position of the study area (black square corresponds to Fig. 2) at the mainland coast of the Dimitrii Laptev Strait.

to the Sellyakh Inlet–Indigirka Delta district of the East Siberian province of the southern arctic tundra characterized by the dominance of *Alopecurus alpinus* and *Salix polaris*, the presence of *Carex ensifolia* ssp. *Arctisibirica,* and the absence of subarctic elements like *Betula nana* s.l. According to the Circumpolar Arctic vegetation map (CAVM Team 2003), the study area is covered with sedge/grass, moss wetland (W1) with *Carex aquatilis*, *Arctophila fulva*, *Dupontia*, and *Eriophorum* spp.

The study area is located about 8 km west of the Kondrat’eva River mouth (Fig. 2) opposite to Cape

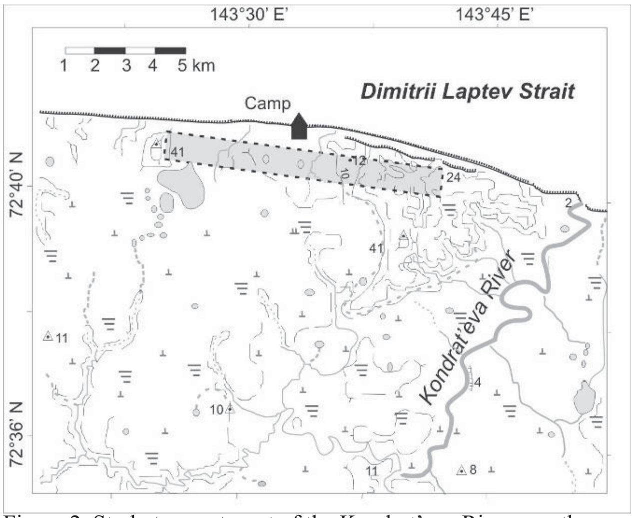

Figure 2. Study transect west of the Kondrat'eva River mouth.

Shalaurova, the eastern edge of Bol'shoy Lyakhovsky Island. The climate is characterized by cold winters, cool summers, and low precipitation. Climate data from the weather station Cape Shalaurova, about 80 km north of the study site, reflect a mean July air temperature of 2.8°C, a mean January air temperature of -32.2°C, and an annual precipitation of 253 mm (Rivas-Martínez 1996–2004).

Site Description

The study transect extends across the bottom of a large alas depression about 10 km in diameter (5 to 10 m a.s.l.) and the adjacent slope and top areas of a yedoma hill of up to 40 m in height (Figs. 2, 3). The alas bottom dominantly consists of polygonal wetland tundra with a 0.5 to 1.0 m thick peat cover. The thermokarst depression is cut by the coast of the Dimitrii Laptev Strait in the north, and additionally intersected by several thermo-erosional valleys that drained to the coast.

Within the recorded transect, the following six main landscape units are described with respect to their floristic composition: the yedoma with thermokarst mounds, mud boils, yedoma slopes, small thermokarst ponds, thermo-erosional valleys, and the bottom of thermokarst depressions.

Vegetation Characteristics

Thermokarst mounds on the yedoma

Thermokarst mounds are the best-drained habitats in the study area (Fig. 4). Their plant cover is mainly composed of *Salix polaris*, *Dryas punctata,* and *Alopecurus alpinus*. Other grasses, such as *Festuca brachyphylla* and *Deschampsia borealis,* and dicots, like *Potentilla hyparctica, Oxyria digyna, Papaver polare,* and *Valeriana subcapitata,* also occur.

Mud boils

Mud boils are the result of cryoturbation caused by frost pressing. In consequence, muddy soil flooded the ground.

Figure 3. View from the alas bottom to the yedoma hill.

Figure 4. Thermokarst mounds on the yedoma at Oyogos Yar.

The substrate is silty and well-drained. Mud boils occur at places most exposed and windswept on the Yedoma. Plants occur here only between such mud spots; the coverage is consequently very low with 20 to 40% (Fig. 5). *Potentilla hyparctica, Salix polaris,* and low growing grasses, and rushes like *Festuca brachyphylla, Deschampsia borealis,* and *Luzula confusa* are the main constituents of such habitats In addition, herbs such as *Lloydia serotina, Cardamine bellidifolia, Androsace triflora*, and *Tephroseris atropurpurea* occur in lower abundance.

This vegetation is similar in composition to cryptogam, herb barren (B1) or to the gramioid tundra (G1), described in the Circumpolar Arctic vegetation map (CAVM Team 2003).

Yedoma slopes

At yedoma slopes, the coverage is in general >80%. In the upper parts of slopes in SW exposition, *Dryas punctata* is one of the main constituents. *Salix polaris* and several grass species (*Alopecurus alpinus, Deschampsia borealis,* and *Festuca brachyphylla)* and *Luzula confusa* are characteristic of yedoma slopes. In lower parts of the slopes, where it is less drained and, consequently, moister, *Arctagrostis latifolia, Petasites frigidus,* several saxifrages (*S. nelsoniana, S. cernua, S. hieracifolia*) and other herbs (*Gastrolychnis apetala, Tephroseris atropurpurea, Ranunculus spp.*) are typical (Fig. 6).

Figure 5. Mud boil at the top of the yedoma visible in Figure 3.

Figure 6. Lower part of a yedoma slope with dominating *Arctagostis latifolia.* In the background, a thermo-erosional valley with reddish spectral signature (here: dark) is visible.

Figure 7. Thermokarst pond with dominating *Pleuropogon sabinei* growing immersed in the water (inserted photo).

Small thermokarst ponds

In small depressions on the yedoma, ponds with *Pleuropogon sabinei* and on the shore, *Arctophila fulva*, *Arctagrostis latifolia, Ranunculus hyperboreus, Dupontia fischeri*, *Eriophorum polystachion,* and *E. scheuchzeri* occur (Fig. 7).

Interestingly, genuine aquatics were widely lacking. Only *Hippuris vulgaris* was solitarily found in a sterile form. The white-flowered *Ranunculus pallasii* and *Caltha palustris* grew immersed in some ponds within the Alas depressions.

Figure 8. Thermo-erosional valley intersecting the yedoma of Oyogos Yar. Main constituent here is *Eriophorum scheuchzeri* causing a green spectral signature.

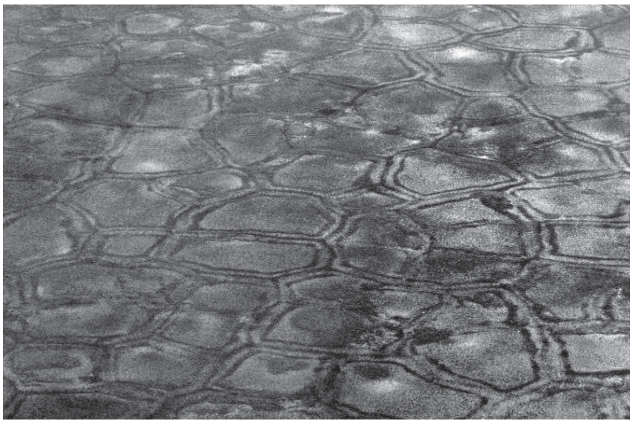

Figure 9. Bottom of a thermokarst depression with a water table above the ground. The polygonal surface patterns are visually strengthened by vegetational differentiation (compare Fig. 10).

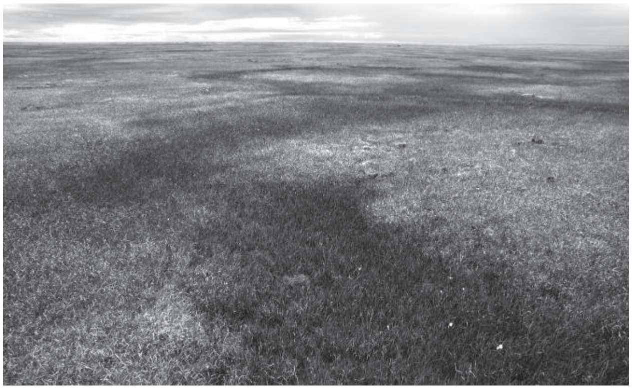

Figure 10. The wettest places in high center polygonal wetland tundra are the inter-polygonal trenches. Here, *Eriophorum polystachion* is the main constituent, causing a reddish (here dark) pattern.

Thermo-erosional valleys

Thermo-erosional valleys are permanently supplied by running water. They are characteristically colored and recognizable from a far distance (Fig. 6). Dark green and reddish signatures are mainly caused by different *Eriophorum* species: green – *E. scheuchzeri*, and red – *E.*

polystachion (Figs. 6, 8). Other plants of thermo-erosional valleys are *Petasites frigidus* and several crowfoot and grass species (*Dupontia fischeri, Calmagrostis holmii*).

Bottom of thermokarst depressions

The bottom of thermokarst depressions, alases, is in contrast to thermo-erosional valleys characterized by stagnant water and covered mainly with sedges (*Carex ensifolia* ssp. *arctisibirica*) and cotton grass (*Eriophorum polystachion*).

The vascular plant diversity here is the lowest in the study area. *Sphagnum* moss is widely present, causing irregular pale green spots in polygonal wetlands where the surface of water is above the ground (Fig. 9).

At sites outside water bodies, rushes (*Luzula nivalis, L. confusa*) cover large areas, together with several grasses (*Dupontia fischeri, Calamagrostis holmii, Poa alpigena,* and *Arctophila fulva*). The wettest places are almost exclusively occupied by *Eriophorum polystachion*, which produces reddish patterns on the ground indicating the water trenches between polygons from afar (Figs. 9, 10).

Conclusions

The main landscape units in thermokarst-affected landscapes can be well distinguished by their vascular plant cover.

Moisture or drainage, respectively is the most important ecological factor in the study area resulting in the strongest vegetation differentiation.

Subordinate factors are exposure and declination. There were no really dry places in the study area.

Excessive wetness is well-indicated by plants with characteristic spectral properties and, therefore, visible from far distances.

The plant species composition can alter quickly on short distances reflecting moisture changes resulting from the damming effect of the frozen ground.

The existence of such small-scale variations in the plant cover has important implications for the interpretation of palaeobotanical records.

Acknowledgments

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