High-latitude Steppe Vegetation and the Mineral Nutrition of Pleistocene Herbivores

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ABSTRACT

High-latitude steppes were widespread and zonal in the Late Pleistocene and formed a landscape basis for the Mammoth Biome. Now the patches of these steppes survived on steep slopes under southern aspects. These steppes serve as unique information sources about the Late Pleistocene "Mammoth" steppe. Numerous data obtained by palynological, carpological, and DNA analysis of plant remains from feces and stomach contents of Pleistocene herbivore mummies, as well as from buried soils and enclosing deposits show that they are similar to modern steppe plant assemblage in taxa composition. Plant's nutrient concentrations are of fundamental importance across Pleistocene grass-rich ecosystems because of their role in the support of large herbivores. The average weight of an adult mammoth skeleton (about 0.5 tons) and of a woolly rhinoceros (about 0.2 tons) clearly suggests this. Detailed studies on fossil bone remains showed mineral deficiency in large Pleistocene herbivores. A three-year study of ash and mineral contents of *two types* of relict steppe vegetation at the Kolyma Lowland, Arctic Siberia has been carried out. Nowadays refugia of similar vegetation are located not far (1 - 15km) from the Yedoma permafrost outcrops were abundant fossil remains are found. Dominant species of the steppe vegetation were sampled. Preliminary studies indicate that the ash-content varied 1.5-2 times in steppe herbs. The Ca, P, Mg, K element contents was higher for most steppe plants than in the local herbaceous vegetation, especially in Ca and P. One of the most important elements of the mineral nutrition, the phosphorus, was always found in higher concentrations in the steppe vegetation than in plants of recently dominant landscapes of the study area. It should be noted that the mineral nutrient content of the modern steppe vegetation of Siberian Arctic is comparable to that of the recent zonal steppe of Transbaikal Region. ***This study supports the hypothesis that aboveground mineral concentrations of late Pleistocene grass-rich ecosystem were consistently higher than that of the recent common species of Siberian Arctic grassland.*** The source of mineral nutrients in the Pleistocene high-latitude steppe vegetation served as one of the reasons for the existence and survival of large herbivores in the Mammoth Biome.

VEGETATION

PETROPHYTIC STEPPES

located along foothill slopes and the river bluff on south aspect. Common species: *Festuca kolymensis, Calamagrostis purpurascens, Carex pediformis, Poa attenuata, Pulsatilla multifida, Phlox sibirica, Veronica incana, Silene stenophylla, Pedicularis venusta, Dracocephalum palmatum, Thymus diversifolius, Arenaria tschuktschorum, Dianthus versicolor, Potentilla arenosa, Galium verae, Allium strictum, Phlojodicarpus sibiricus, Elytrigia jakutorum, Lathyrus spp. Artemisia tilesii, A. kruhsiana, Lychnis sibirica* and others. Plant cover - 30-70% and about 60 vascular species.

THERMOPHYTIC STEPPES

located along Kolyma valley on a very old fire-sites on Yedoma south slopes. Common species: *Artemisia dracunculus, Potentilla tanacetifolia, Calamagrostis purpurascens* and co-dominated *Veronica incana, Pulsatilla multifida, Bromus pumpellianus, Poa attenuata, Allium strictum.* Background plants*: Silene repens, Thymus diversifolius, Elytrigia jakutorum, Myosotis asiatica, Galium boreale Lathyrus spp.* and others. Plant cover - 55-85% and 35 vascular species.

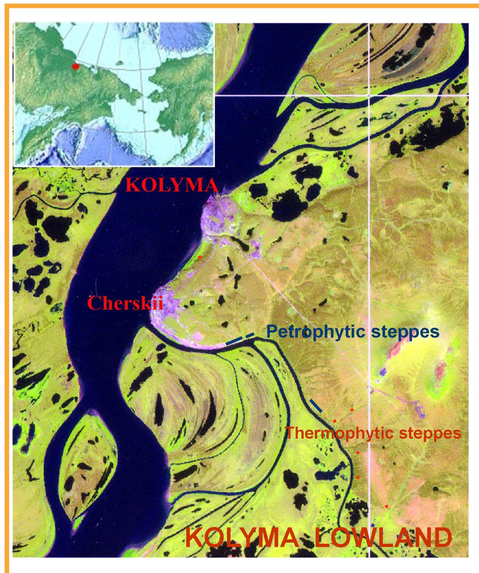
AVERAGE STEPPE OVERGROUND PHYTOMASS STORAGES (g/m^2)

Petrophytic steppe (n = 18)			Thermophytic steppe (n = 19)					
Grass-forb			Forb-grass-sedge			Wormwood forb-grass		
living	dead	total	living	dead	total	living	dead	total
310	365	675	166	340	506	326	1257	1583

Phytomass continues to gain until the fixing of stable negative air tem-

High-latitude steppes or tundra-steppes were vast in North Eurasia and North America in Late Pleistocene. In particular global prosperity of Mammoth Fauna herbivores was connected with these ecosystems.

STUDY AREA



High-latitude steppes located in North-East Kolyma Lowland (Arctic Siberia).

Annual temperature are -7.6 to -13.2° C

Summer temperature are +8.0 to +12° C

Winter temperature are -28 to –35° C

Annual total precipitation are 190 – 300mm and are distributed relatively equally among warm and cold seasons.

STEPPE SOILS

Two types of steppe were studied

Steppe soils are characterized by an extreme temperature and dryness.

Physic-chemical properties cardinally differ from the same properties of zonal soils of north taiga and tundra.

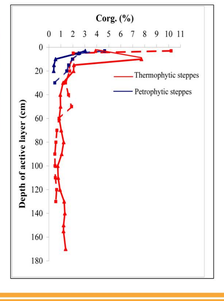
Soils approach to neutral pH, Ca dominates in the exchange adsorption complex.

Steppe soils characterized high content of total and dissolved organic carbon, nitrogen and highest value of labile P (to 500 ppm).

The prevalence of cryoaridic soil processes.

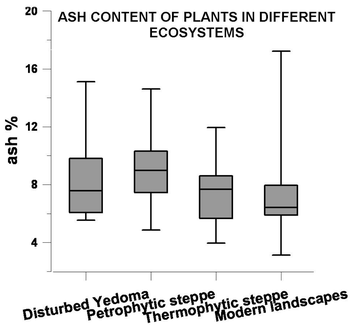
Thermophytic steppe
Mother rock is Yedoma loess-like sediment Active-layer 1.30-1.80m

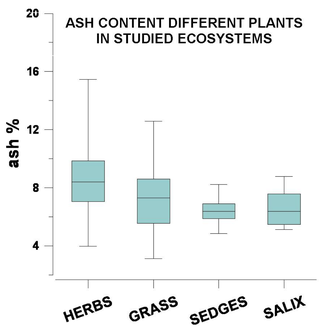
Petrophytic steppes
Mother rock is gravel with rock debris.
Active layer > 2.0m

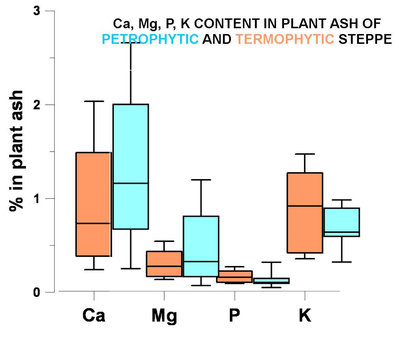


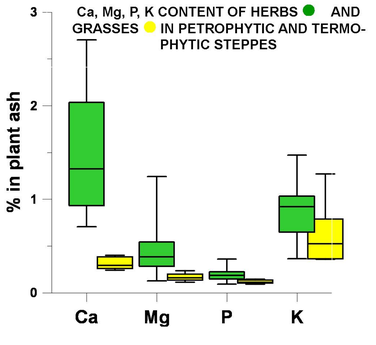
Small grazers influence upon the distribution of organic matter of soils

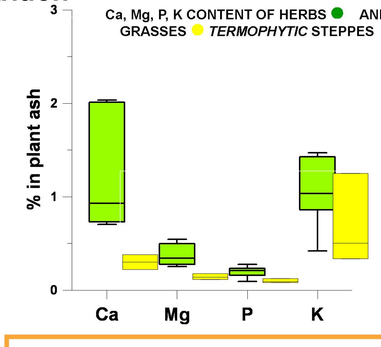
Mineral Nutrition

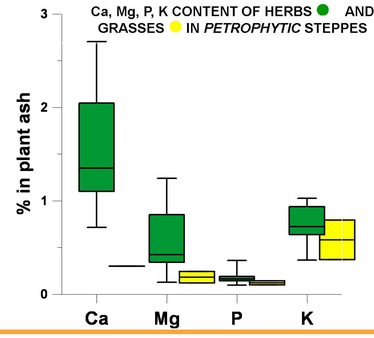












CONCLUSIONS

High-latitude Steppes VS Modern Ecosystems

★ ash content of steppe plants > ash content of recently dominant landscapes
★ ash content of herbs > ash content of other types of vascular plants

High-latitude Steppe. Petrophytic Steppes VS Thermophytic Steppes

★ Ca, Mg, P content of petrophytic steppe vegetation > Ca, Mg, P content of thermophytic steppe vegetation
★ Ca, Mg, P, K content of high-latitude steppe herbs > Ca, Mg, P, K content of high-latitude steppe grasses
★ Ca, Mg, P, K content of petrophytic steppe herbs > Ca, Mg, P, K content of petrophytic steppe grasses

High-latitude steppe herbs/forbs were the mineral nutrition basis of mammoth fauna of herbivores.

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