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a0005 # Postglacial Pollen Records of Northern Asia

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s0005 ## Introduction

p0005 The territory of northern Asia represents approximately 15% of the Earth's land surface and includes a wide variety of climatic and vegetation zones. It is situated between the Ural Mountains (*c*. 60° E) in the west and the Pacific Ocean in the east (*c*. 180° E) and between the Arctic Ocean in the north and *c*. 47° N in the south (**Figure 1**). The later boundary corresponds to the southern limit of boreal coniferous forests in Kazakhstan and Mongolia. West of 90° E the topography is relatively flat. Elevations of the West Siberian Lowland do not exceed 200 m, and hilly plains and low-elevation mountains (up to 1500 m) occur in northern Kazakhstan. East of 90° E the topography is more complex. Lowlands occupy a 50–600-km-wide band along the Arctic coast, while central and southern regions consist of high plateaus and mountains above 1000 m. The highest elevations occur in the Altai (4506 m) and Hangai (3905 m) mountains and on the Kamchatka Peninsula (4750 m).

The climate of northern Asia is cold and continental. A strong Siberian anticyclone controls winter weather. The mean January temperatures vary from −16 C in the south to −48 C in the interiors of East Siberia. The absolute temperature minima registered in the Verkhoyansk Mountains is −68 C. The mean July temperatures (T_{VII}) decrease northward from *c*. 20 C to less than 4 C. More than 65% of the annual precipitation (*P*) falls during the warm season, when the weather is controlled by the westerlies and the Pacific monsoon. *P* reaches 600 mm in the Ural Mountains and *c*. 1000 mm in the Far East. In p0010

f0005 **Figure 1** Map of northern Asia showing the location of cited sites: 1 – Lake Lyadhej-To, 2 – Pur–Taz site, 3 – Salym–Yugan Mire, 4 – Bugristoye Palsa, 5 – Ozerki Swamp, 6 – Lake Levinson-Lessing, 7 – Lake Lama, 8 – Lake Dolgoe, 9 – Lake Khomustakh, 10 – Lake Kotokel, 11 – Lake Hoton-Nur, 12 – Lake Smorodinovoye.

Kazakhstan, Central Yakutia, and Mongolia, situated far from oceanic influence, *P* is less than 300 mm.

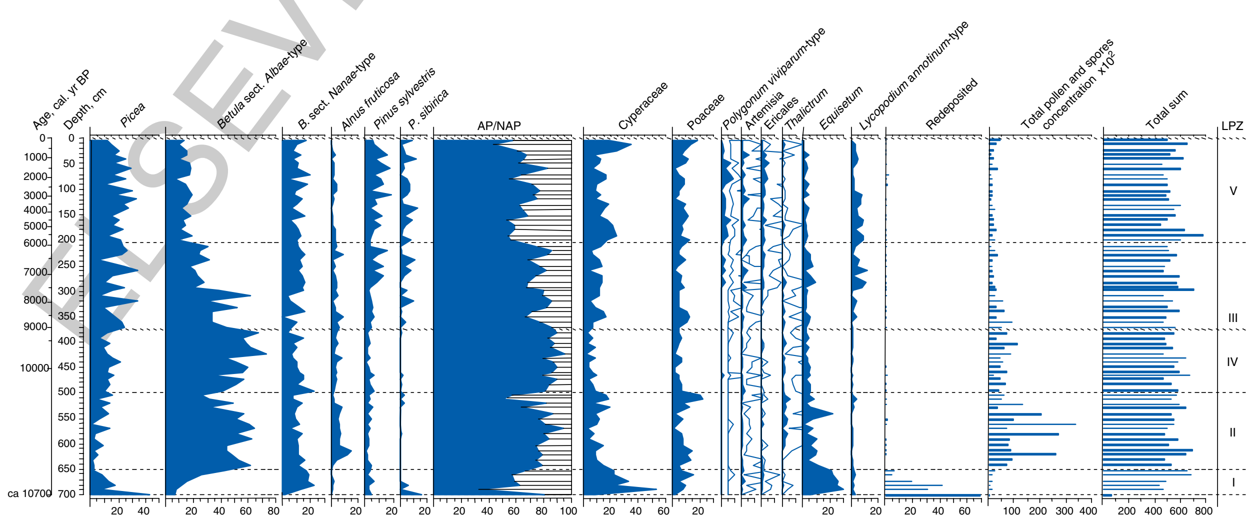
p0015 The spatial distribution of vegetation shows the clear influence of climate. In the mountains it is complicated by altitude and slope orientation. Various moss, grass, dwarf shrub, and shrub tundra types (tundra zone) occupy Arctic lowlands and the upper belt of the mountains and high plateaus. Southward, this is gradually replaced with boreal cold deciduous and evergreen conifer forests (taiga) dominated by larch (*Larix*), Siberian spruce (*Picea obovata*), Scots pine (*Pinus sylvestris*), Siberian pine (*Pinus sibirica*), and fir (*Abies sibirica*). Broad-leaved trees are represented mostly by cold- and drought-resistant birch (*Betula pubescens* and *B. pendula*) and aspen (*Populus tremula*). Temperate deciduous taxa, such as elm (*Ulmus*) and lime (*Tilia*), play minor roles in the modern vegetation. *Ulmus glabra* and *T. sibirica* trees sporadically occur in the West Siberian Lowland and Altai Mountains, and *U. pumila* may grow in the floodplain forests south of Lake Baikal.

p0020 Since Dokturovskii and Kudryashov (1923) have provided pollen identification keys for the main arboreal taxa in northern Eurasia, scientists from the former Soviet Union published numerous articles and monographs reconstructing postglacial changes in northern Eurasian vegetation by means of pollen analysis (for a comprehensive synthesis, see Neishtadt (1957), Khotinskii (1977), Grichuk (1984), Peterson (1993), and Velichko *et al.* (1997)). The collapse of the USSR intensified the level of international cooperation of Russian palynologists, resulting in the appearance of extensive compilations of existing pollen data (e.g., Tarasov *et al.* (1998), Gunin *et al.* (1999), and Edwards *et al.* (2000) and references therein) and in publications of new high-resolution pollen records. Since the late 1970s, there has been a rapid increase in the number of published pollen diagrams from northern Asia. Khotinskii (1977) had used 26 pollen sequences to reconstruct the Holocene vegetation history of northern Asia, but now there are *c.* 200 records archived in the Global and European Pollen databases (http://www.ncdc.noaa.gov).

In this article, we review the Postglacial vegetational and climate changes in northern Asia based on pollen records with reliable chronologies, rather than attempting to synthesize a complete northern Asia-wide picture of Postglacial environmental changes, which requires further refinement of site spatial coverage and chronologies. p0025

The Ural Mountains s0010

The pollen record from Lake Lyadhej-To (68°15′ N, 65°45′ E, 150 m a.s.l., site 1 in **Figure 1**), situated in the shrub–herb tundra zone at the NW rim of the polar Ural, provides information on the Holocene environmental history of this area (Andreev *et al.*, 2005). Pollen of sedges (Cyperaceae), grasses (Poaceae), and dwarf birches (*Betula* sect. *Nanae*) (**Figure 2**) from the lowermost sediments suggests sparse tundra-like vegetation around the lake *c.* 10.7–10.55 cal kyr BP. Approximately 10.55–8.8-cal-kyr-BP birch forest with some shrub alder grew around the lake, reflecting the warmest climate of the Holocene with $T_{VII} = 11–13$ C. Pollen records from the adjacent areas also reflect a major spread of birch p0030 AU2



f0010 **Figure 2** Percentage palynological diagram of selected taxa from Lake Lyadhej-To record. Pollen zonation is according to Andreev *et al.* (2005).

at that time in what is now treeless tundra (Andreev *et al.* (2005) and references therein). Higher values of dwarf birch and sedge pollen and significantly lower pollen concentrations point to climatic deterioration during 8.8–5.5 cal kyr BP. Birch forests completely disappeared from the lake vicinity at *c.* 6 cal kyr BP, and shrub and herb tundra communities became dominant in the regional vegetation after *c.* 5.5 cal kyr BP. Pollen-based reconstruction suggests significant cooling between 5.5 and 3.5 cal kyr BP with T_{VII} up to 8 C leading to establishment of the shrub–herb tundra vegetation similar to the modern one.

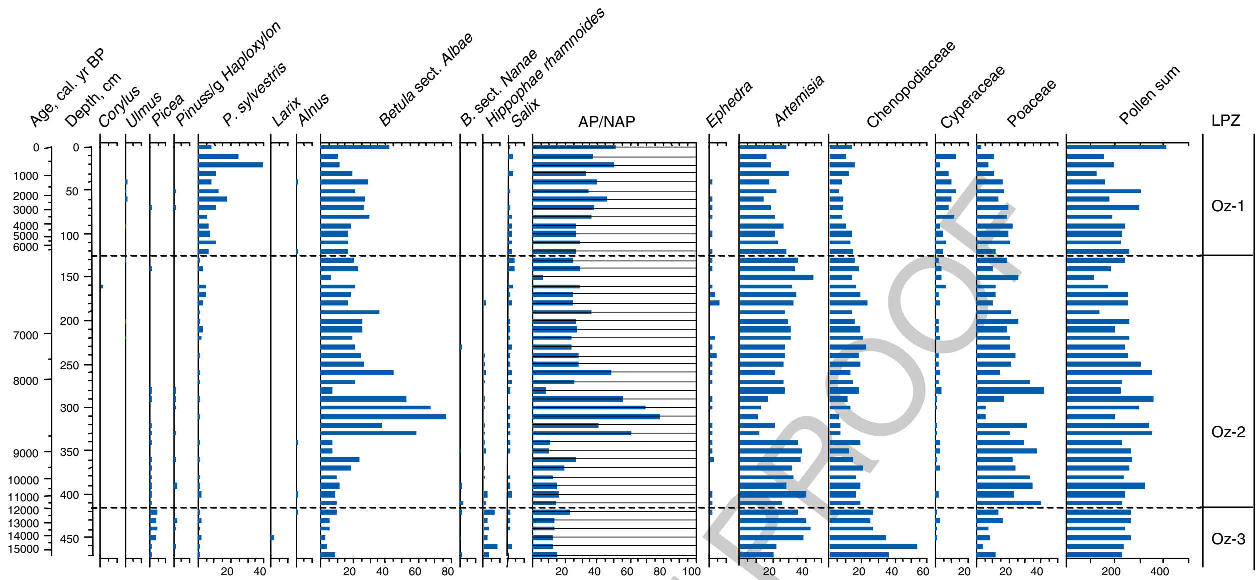
s0015 West Siberia

p0035 Pollen diagrams from the West Siberian Lowland are quite numerous (e.g., Volkova and Mikhailova (2002) and references therein). The Pur–Taz peat section from the flat watershed between the Pur and Taz rivers (66°42′ N, 79°44′ E, site 2 on **Figure 1**) is one of the better-studied sequences from the forest–tundra transitional zone with *L. sibirica* as a dominant tree. It provides pollen and macrofossil records of vegetation and climate history at the Arctic tree line *c.* 10.4–5.1 cal kyr BP (Peteet *et al.*, 1998). The presence of larch and *B. pubescens* pollen in the Lateglacial/early Holocene indicates that regional summer temperatures were warm enough to support the growth of trees. An increase in Siberian spruce pollen between 10 and 5.1 cal kyr BP suggests a movement of spruce into the north as the result of warmer-than-present early Holocene climate. Quantitative pollen-based climate reconstruction (Andreev and Klimanov, 2000) shows that the warmest period (T_{VII} 2.5° higher than today) occurred in the area *c.* 6.8–5.6 cal kyr BP. This is approximately the same time as the dominance of *Picea* macrofossils at the Pur–Taz site. The decrease in evergreen conifer tree pollen and macrofossils registered in the uppermost peat layer suggests a late Holocene shift toward colder environments similar to today (Peteet *et al.*, 1998). AU3

p0040 Pollen data from the Salym–Yugan area (60°10′ N, 72°50′ E, site 3 in **Figure 1**) help to trace the Holocene vegetation history in the southern part of West Siberia (Pitkänen *et al.*, 2002). The modern vegetation of the area consists of forests (mainly Scots pine) and open mire communities. Pollen data suggest that open sedge associations dominated the vegetation between *c.* 10.9 and 9.9 cal kyr BP and trees, such as larch, spruce, and birch, were poorly represented in the regional vegetation. On the other hand, the pollen sequence from Bugristoye (58°15′ N, 85°20′ E, site 4 in **Figure 1**) demonstrates that larch (up 40%), *Picea* (up 25%), and birch (up to 60%) absolutely dominated the pollen spectra as early as 11.4–10.8 cal kyr BP, suggesting significant afforestation of the Ket'-Chulym watershed at that time (Blyakharchuk and Sulerzhitsky, 1999). This conclusion agrees with other West Siberian pollen data (Volkova and Mikhailova, 2002). In the Salym–Yugan area, birch and pine forests established shortly after 9.9 cal kyr BP, but spruce was rather abundant until *c.* 4.3 cal kyr BP, while the Bugristoye pollen record demonstrates a decrease in spruce abundance shortly after 6.3 cal kyr BP, reflecting a gradual climate deterioration. Peat accumulation at the Bugristoye site stopped shortly after *c.* 4 cal kyr BP. After 4 cal kyr BP, modern birch-pine forest dominated the vegetation in southern West Siberia, while large regions were covered with open mire vegetation.

Kazakhstan s0020

Reliable records of the Holocene vegetation and climate dynamics in the vast area of northern and central Kazakhstan were not available until the 1990s (Kremenetski and Tarasov (1992), Kremenetski *et al.* (1997) and references therein). Ozerki Swamp (50°25′ N, 80°28′ E, 210 m; site 5 in **Figure 1**) located in the Irtysh River Valley provides the most complete Postglacial pollen record from the forest–steppe transition zone in northern Kazakhstan. In this area, steppe vegetation is dominated by grasses and *Artemisia* (sage) species and Chenopodiaceae and *Ephedra* grow on hardened soils (Tarasov *et al.*, 1997). High summer temperatures and low precipitation limit the spread of patchy birch and pine forests to the river valleys and low mountains. The Ozerki record suggests that an oxbow depression currently occupied by a swamp was filled with water at about 15 cal kyr BP, suggesting amelioration of the very dry and cold "glacial" climate. The lowermost pollen zone (**Figure 3**) reveals the highest percentages of non-arboreal pollen (NAP) taxa (up to 85%), suggesting rather dry environments and steppe vegetation. However, the occurrence of *H. rhamnoides*, *Picea*, and larch pollen in this pollen zone can be interpreted as the spread of sea buckthorn shrubs and trees (spruce and larch) along the Irtysh valley between 15 and 12 cal kyr BP. These taxa can be found today in the Altai Mountains, southeast of the study site. Since 12 cal kyr BP, the vegetation composition has been similar to that found today in the Kazakhstan steppe. Around 8.5 cal kyr BP, birch pollen exceeded 70%, suggesting expansion of birch forest in the area and probably wetter-than-present climate conditions. After p0045 AU4



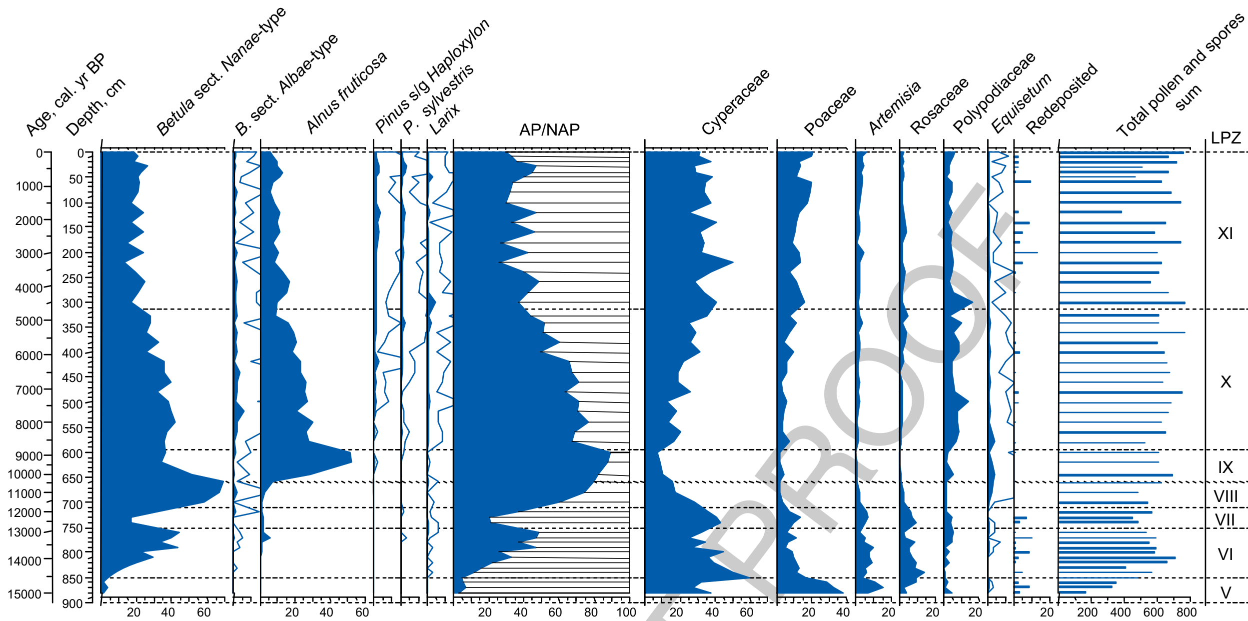
f0015 **Figure 3** Percentage palynological diagram of selected taxa from Ozerki Swamp record. Pollen zonation is according to Tarasov *et al.* (1997).

6.5 cal kyr BP, the pollen spectra reflect the spread of pine from the South Ural and West Siberia to northern and central Kazakhstan. Regional pollen data (Kremenetski *et al.*, 1997; Tarasov *et al.*, 1997) suggest that Scots pine was already established in northern Kazakhstan by 7 cal kyr BP, but did not reach its modern limit in central Kazakhstan until after 2 cal kyr BP. Thus, the afforestation of the steppe zone reached a maximum only during the last millennium (Tarasov *et al.*, 2005). Because none of these changes in vegetation can be attributed to human activities, a climatic explanation should be invoked.

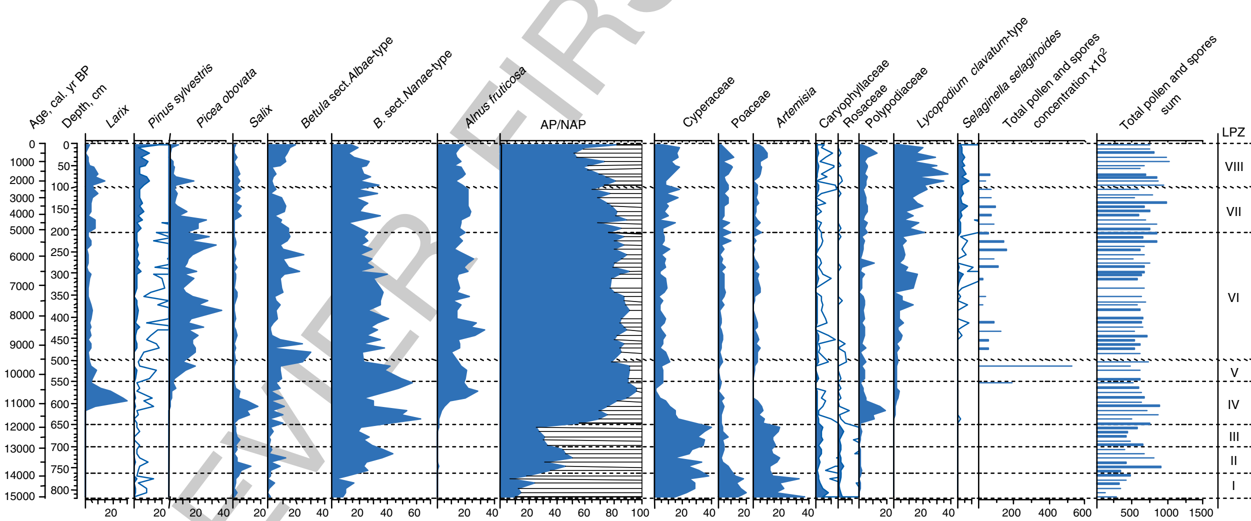
s0025 Central Siberia

p0050 Environmental changes since about 32 ^{14}C kyr BP from northern Central Siberia are recorded in the sediments of Levinson-Lessing Lake (74°28′ N, 98°38′ E, site 6 in **Figure 1**) in the northeastern Taymyr (Andreev *et al.*, 2003). The lake is situated in the tundra zone. Pollen spectra (**Figure 4**) contain large amounts of herbaceous taxa, including grasses and sage, reflecting severe continental climate and scarce, steppe-like vegetation until *c.* 13.7 cal kyr BP. Dwarf shrub and sedge tundra vegetation had limited coverage and survived only in wet habitats. Dramatic increases in shrub birch and willow pollen and in total pollen concentration, associated with a significant decrease in sage, grasses, and other herb taxa pollen, reflect a climatic amelioration after 13.7 cal kyr BP corresponding with the Allerød in Europe. This was followed by an increase in sedge, grass, and herb pollen, likely indicating a cooling associated with the Younger Dryas. Pollen spectra from the Pleistocene/Holocene transition dated to *c.* 11.5–11.2 cal kyr BP reflect a shift in vegetation from herb-dominated to shrubby birch–willow tundra. Shrub alder occurred in the area approximately 10 cal kyr BP and disappeared after 3.8 cal kyr BP. Dwarf birches broadly distributed in the region during the early and middle Holocene also almost disappeared after 3.2 cal kyr BP, when the vegetation became similar to the modern herb tundra. Quantitative paleoclimatic interpretation of the pollen spectra suggests that T_{VII} was 2–4 C higher than present during the early Holocene and became similar to present after 6.3 cal kyr BP.

A continuous pollen record from Lama Lake, from western Taymyr (69°32′ N, 90°12′ E, site 7 in **Figure 1**) provides detailed environmental information for the Lateglacial and Holocene in central Siberia (Andreev *et al.*, 2004). At present, the vegetation cover in the region varies, depending on altitude: dense spruce–larch–birch taiga dominated on the lower elevations, while shrub and herb tundra cover the high-elevation mountains. The pollen data suggest that scarce steppe-like plant communities dominated the vegetation around the lake during the Lateglacial (**Figure 5**). Tundra-like communities with arctic dwarf shrubs, sedges, and Brassicaceae species grew in wetter habitats. Reconstructed climate fluctuations may be correlated with the Bølling/Allerød warming and Younger Dryas cooling. The Lateglacial/pre-Boreal transition occurred at p0055



f0020 **Figure 4** Percentage palynological diagram of selected taxa from Lake Levinson-Lessing record. Pollen zonation is according to Andreev *et al.* (2003).



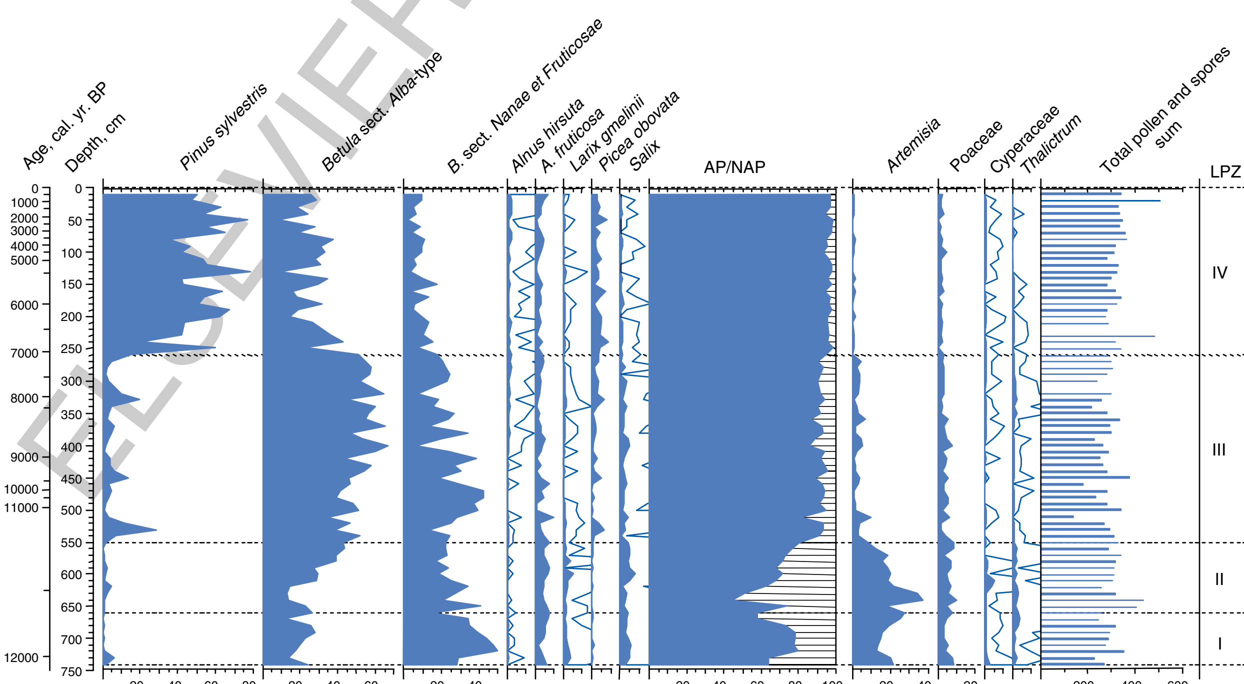
f0025 **Figure 5** Percentage palynological diagram of selected taxa from Lake Lama record. Pollen zonation is according to Andreev *et al.* (2004).

about 11.5 cal kyr BP. It is characterized by a significant increase in *Betula* sect. *Nanae* (shrub birch) and *Salix* (willow) pollen accompanied with a relatively high NAP content suggesting a broad distribution of shrubby and meadow associations. Abundant spores of *Equisetum* (horsetails), *Sphagnum*, and Polypodiaceae indicate wet habitats around the lake. High contents of larch and alder pollen in the early Holocene sediments indicate that larch occurred in the area as early as 11 cal kyr BP, while shrub alder came to the area 200 yr later. Spruce did not reach area before *c.* 10.3 cal kyr BP. The spruce pollen content and the total pollen concentration increase dramatically in the deposits dated to *c.* 10.1–8.8 cal kyr BP, indicating the broad distribution of spruce under the warm summer conditions. Our paleoclimatic reconstruction from the Lake Lama pollen record suggests that T_{VII} during the early Holocene were *c.* 1.5–3.5 C above modern values. Other paleobotanical records (Andreev *et al.* (2004) and references therein) also confirm the broad distribution of spruce in the western Taymyr during this interval. A gradual decrease in spruce pollen in the sediments younger than 5.2 cal kyr BP reflects a gradual deterioration of the regional climate. A significant increase in birch pollen percentages in the upper part of the core likely mirrors the increased role of birches in the local forests after 2.5 cal kyr BP. The sharp decrease in the arboreal pollen (AP) content and the increase in sage pollen content at 30–15 cm depth may be correlated with the Little Ice Age.

s0030 East Siberia

p0060 The pollen record from Dolgoe Lake, situated in the lower Lena River (71°52′ N, 127°04′ E, site 8 in **Figure 1**), is extremely valuable for the reconstruction of paleoenvironments in the present-day larch forest–tundra, dominated by dwarf birch and shrub alder (Pisaric *et al.*, 2001). Sedges, grasses, and sage dominate pollen spectra deposited shortly before 14.5 cal kyr BP, reflecting open vegetation with only a sparse cover of herbs and grasses around the lake. An increase of shrub birch pollen higher in the sequence points to establishment of shrub birch tundra between 14.5 and 13 cal kyr BP. A sharp decrease in shrub birch pollen and rise in Chenopodiaceae, *Dryas*, and Caryophyllaceae pollen percentages between 13 and 11.5 cal kyr BP suggests a return to a more open vegetation cover. The timing of this vegetation shift is synchronous with the Younger Dryas oscillation. After 11.5 cal kyr BP, shrub birch pollen percentages rise, associated with the onset of the Holocene. Around 11 cal kyr BP, birch was replaced as the dominant taxon by alder, likely by a shrub *A. fruticosa* (Siberian alder). The increase in larch pollen percentages after 9.5 cal kyr BP, coupled with the presence of larch in the stomata and macrofossil record, suggests that it grew north of Dolgoe Lake between 9.5 and 3.8 cal kyr BP. At *c.* 7.6 cal kyr BP, spruce increased in abundance in the pollen record. Today, Siberian spruce grows 350 km to the south. However, its presence in the pollen and stomata record from Dolgoe Lake indicates that spruce occurred in the local vegetation between 7.6 and 3.8 cal kyr BP. Low AP percentages and AP concentrations in the sediments dated younger than 3.8 cal kyr BP suggest a change in the environment and a shift from predominantly woodland vegetation to the modern shrub tundra with isolated larch stands.

Khomustakh Lake (63°43′ N, 129°22′ E, site 9 in **Figure 1**) has been selected as a key site for the study of Postglacial vegetation in the central part of eastern Siberia (Velichko *et al.*, 1997). At present, pine forests cover sandy soils in the area, whereas clayey soils are occupied by larch forests. Sedimentation and pollen accumulation in the lake started about 13 cal kyr BP (**Figure 6**), probably as a consequence of the Allerød climate amelioration. Rather high levels of dwarf birch, sage, grasses, and other herbaceous pollen taxa point to their important role in the local vegetation, codominated by open herb and p0065

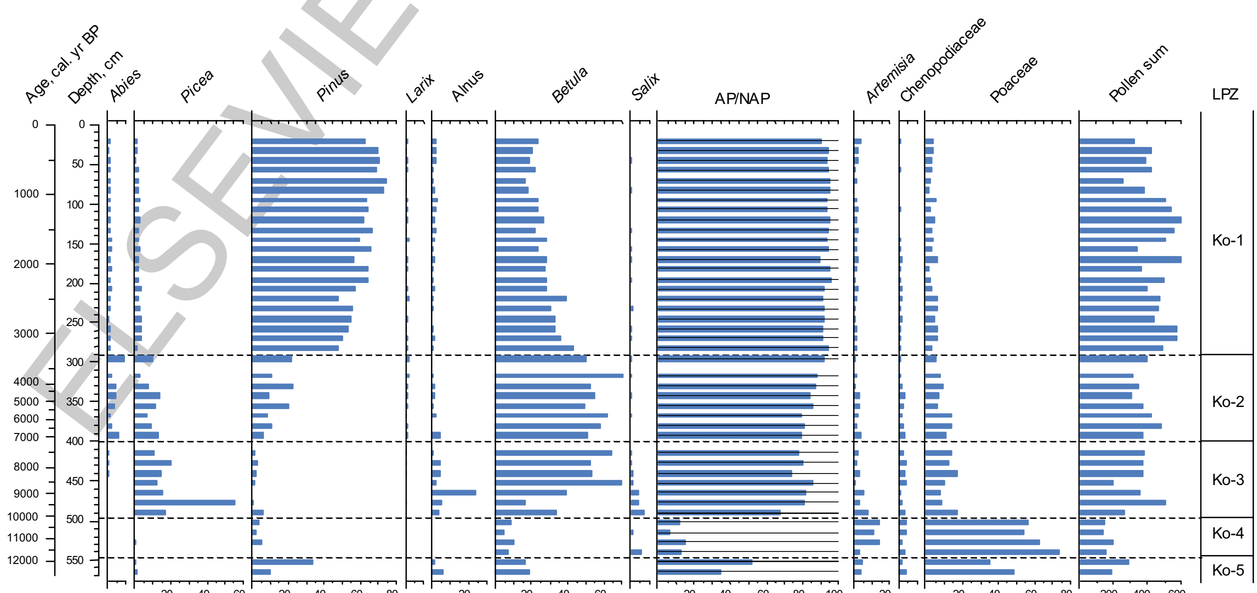


f0030 **Figure 6** Percentage palynological diagram of selected taxa from Lake Khomustakh record.

shrub tundra-like vegetation. A subsequent increase in sage and other herb pollen contents likely reflects the Younger Dryas cooling. The transition to the Holocene is dated to *c.* 11.5 cal kyr BP and is marked by a dramatic increase in tree birch pollen. During the pre-Boreal interval, birch dominated the vegetation; however, the permanent presence of larch in the pollen spectra indicates that it also was an important component in the local forests until *c.* 6.8 cal kyr BP. After 7 cal kyr BP, Scots pine migrated to the area and quickly occupied sandy habitats in central and southern Yakutia. Since 6.8 cal kyr BP, forests composed of pine started to dominate in these regions. Quantitative climate reconstruction based on the Khomustakh pollen record suggests that T_{VII} was up to 1.5 C warmer than present in the middle Holocene, causing degradation of the permafrost and facilitating the spread of pine.

s0035 South Siberia

p0070 This area is extremely important from the paleobotanical viewpoint, as it appears likely that during the last glaciation, the hills and mountains of southern Siberia provided refuges for the tree species that make up the present boreal forest belt (Grichuk, 1984). Postglacial pollen records from this region mainly come from Lake Baikal and its close vicinity (Tarasov *et al.* (2002), and Demske *et al.* (2005) and references therein). The available data suggest that the expansion of spruce along with the steppe vegetation around Baikal can be dated back to the undivided Bølling–Allerød interval (Bezrukova *et al.*, 2005). Steppe landscapes persisted in a large part of the Baikal watershed until *c.* 10.4–10.1 cal kyr BP, when a major forest expansion took place. The pollen diagram (**Figure 7**) from Lake Kotokel (52°46′ N, 108°46′ E, 458 m, site 10 in **Figure 1**), situated near the eastern coast of Lake Baikal, illustrates changes in vegetation since *c.* 12.5 cal kyr BP (Tarasov *et al.*, 2002). At present, the lake is surrounded by boreal forest dominated by Scots and Siberian pine, larch, and birch trees. Shrubby forms of pine (*P. pumila*), birch, and alder are abundant in the mountain tundra belt, above tree line. The record starts with an increase in pine and birch pollen (mainly of shrub varieties) percentages dated to *c.* 12–11.8 cal kyr BP and likely associated with early Holocene climate amelioration. However, pollen of grasses and sage dominate the pollen assemblages prior to 10.1 cal kyr BP, suggesting open steppe and meadow-like vegetation around the lake. Shortly after the beginning of the forest phase, spruce and birch have the highest pollen percentages, suggesting the spread of spruce and birch forests. Relatively high pollen percentages for spruce and fir are registered in the middle Holocene between *c.* 7 and 4.5 cal kyr BP. In northern Asia, fir is the most sensitive boreal tree to available moisture, winter temperatures, and soil quality. Its expansion during the mid-Holocene interval suggests rather mild climate in the Baikal region. Pine pollen percentages gradually increase after *c.* 7 cal kyr BP, reaching maximum



f0035 **Figure 7** Percentage palynological diagram of selected taxa from Lake Kotokel record. Pollen zonation is according to Tarasov *et al.* (2002).

values after c. 3.5 cal kyr BP. Since that time pollen spectra show very little change, likely indicating that vegetation composition and distribution patterns became similar to that of today.

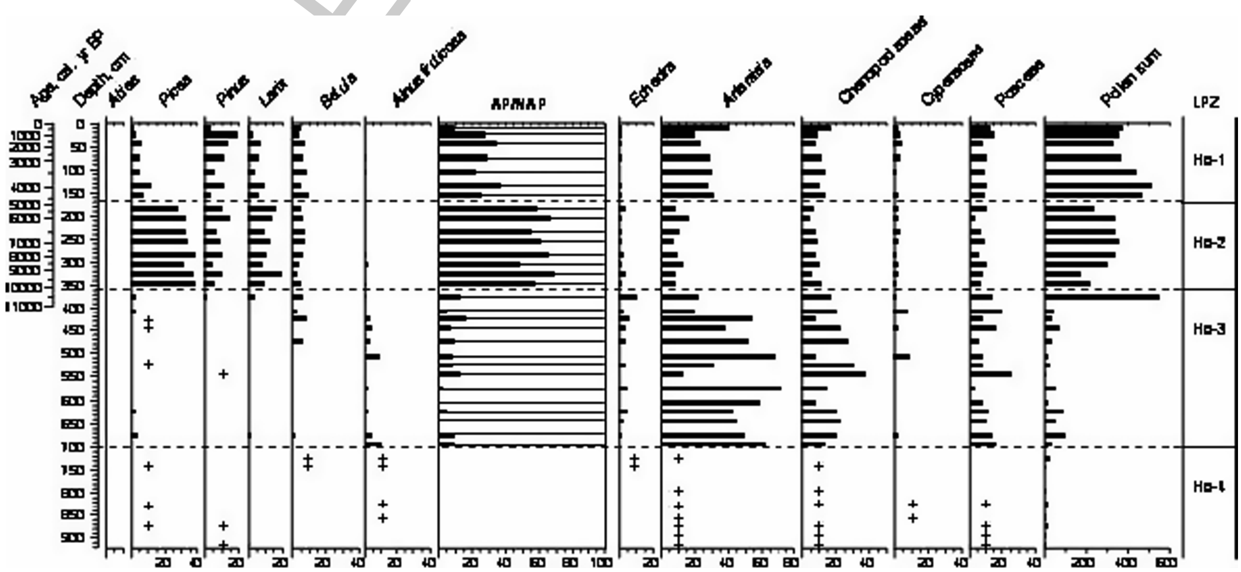
s0040 Mongolia

p0075 A comprehensive synthesis of available pollen and plant macrofossil records in northern and central Mongolia is presented in Gunin *et al.* (1999). This paper presents reconstructions of Lateglacial and Holocene vegetation dynamics. Several other papers discuss vegetation and environmental changes at the regional scale (Tarasov *et al.* (2000, 2004), Fowell *et al.* (2003) and references therein). A radiocarbon-dated pollen record from Hoton-Nur (48°40′ N, 88°18′ E, 2083 m), a large freshwater lake in the northern Mongolian Altai (site 11 in **Figure 1**), spans the whole Holocene interval (**Figure 8**). Pollen concentration and preservation in the lower part of the 9.2-m record from Hoton-Nur was extremely poor, suggesting severe "glacial" conditions and scarce vegetation around the lake. Pollen spectra of the Ho-3 pollen zone showed relatively high frequencies of pollen of arctic-alpine taxa, including shrub alder and shrub birch, sedges, and grasses (Gunin *et al.*, 1999). This suggests a slight amelioration of the Lateglacial climate and the spread of tundra vegetation at higher elevations and river valleys. At the same time, high percentages of sage and Chenopodiaceae pollen in the Ho-3 zone suggest that before *c.* 10.1 cal kyr BP the dominant vegetation close to the lake was dry steppe (Tarasov *et al.*, 2000). In the Ho-2 pollen zone dated to *c.* 10.1–4.5 cal kyr BP, the dominance of spruce, pine (most probably *P. sibirica*), and larch pollen likely indicates that patches of boreal conifers played a more important role in the local vegetation than they do today. Expansion of boreal evergreen conifers in the region would require noticeably wetter conditions than those prevailing today. However, the presence of relatively high percentages of herbaceous pollen suggests quite an open mosaic of forest–steppe-like vegetation. Pollen from the uppermost zone demonstrates that vegetation around the lake became drier and similar to the modern steppe with small forest patches of larch and Siberian pine, for example, taxa less sensitive to the water stress than spruce.

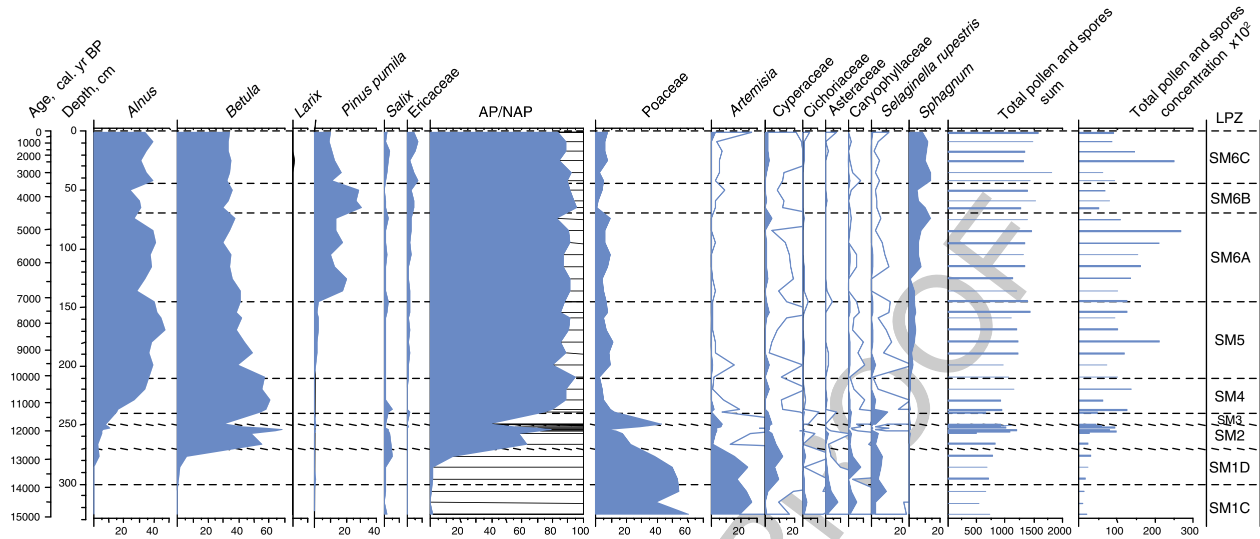
Northeastern Asia s0045

A sediment core from the Smorodinovoye Lake in the Upper Kolyma region (64°46′ E, 141°06′ E, site 12 in **Figure 1**) provides a *c.* 27 cal kyr record of vegetation changes from northeastern Siberia (Anderson *et al.*, 2002). High percentages of grasses and sage pollen and the variety of xeric taxa such as *Selaginella rupestris* (northern selaginella) (**Figure 9**) suggest that open grass–sage vegetation dominated the landscape during the Lateglacial. A dramatic rise in birch percentages *c.* 12.8 cal kyr BP implies rapid establishment of shrub tundra in response to Postglacial warming. Birch–willow shrub tundra dominated the vegetation between *c.* 12.8 and 11.8 cal kyr BP. A p0080

AU7



f0040 **Figure 8** Percentage palynological diagram of selected taxa from Lake Hoton-Nur record. Pollen zonation is according Tarasov *et al.* (2000).



f0045 **Figure 9** Percentage palynological diagram of selected taxa from Lake Smorodinovoye record. Pollen zonation is according to Anderson *et al.* (2002).

decline in shrub birch and an increase in grasses and sage pollen percentages indicate that the vegetation reverted to herb-dominated tundra shortly after 11.8 cal kyr BP. The vegetation change suggests that summer temperatures and precipitation became lower than the previous interval (12.8–11.8 cal kyr BP), but not as extreme as during the Lateglacial. This short-term episode most likely represents the Younger Dryas cooling. An increase in birch and willow pollen from *c.* 11.3–9.5 cal kyr BP suggests that shrub tundra again became dominant with the onset of the Holocene. Alder percentages increased at *c.* 11 cal kyr BP, but alder was not widespread until *c.* 10 cal kyr BP. The presence of a larch needle and single larch pollen grains indicates that larch was present in the area as early as by *c.* 10.9 cal kyr BP. During 9.5–7 cal kyr BP, birch and alder continued to dominate the pollen assemblage, indicating that shrub tundra with isolated larch trees dominated the vegetation. Shortly after 7 cal kyr BP, shrubby *P. pumila* (dwarf Siberian pine) occurred in the area, as suggested by the composition of the pollen assemblages. Pollen spectra reflect that since that time birch, alder, and heath shrubs were common on the landscape and, along with the dwarf Siberian pine, were abundant in the understory of the larch forest. High shrub tundra, dominated by dwarf Siberian pine, also became established on the mountain slopes above the altitudinal tree limit.

Conclusions s0050

Generally, all of pollen records discussed here demonstrate spatially and temporally coherent patterns of environmental changes. Open sage- and grass-dominated communities were widespread in northern Asia during the Lateglacial. A significant increase of shrub pollen registered in a number of records may be correlated with the Bølling/Allerød warming, *c.* 13.7 cal kyr BP. The subsequent increase in NAP reflects the cooling/drying of the Younger Dryas interval. Many records show that the Lateglacial/pre-Boreal transition occurred at about 11.5 cal kyr BP and was characterized by a significant increase in birch, shrub alder, and willow pollen. Records from geographically different sites demonstrate different patterns of vegetation changes connected with local environmental conditions and migration history of the arboreal species. However, the interval from *c.* 10.5 to *c.* 8.8 kyr BP was the warmest Postglacial episode (the Holocene climatic optimum) in the arctic regions of northern Asia (e.g., Andreev *et al.* (2005) and Velichko *et al.* (1997)). In contrast, records from the more southerly sites, within the boreal forest and forest–steppe zone, show an early Holocene climate amelioration that is less pronounced than that of the middle Holocene. The explanation of these phenomena can be found in the unequal influence of the lower-than-present sea level and higher-than-present summer isolation during the Lateglacial and early Holocene. p0085

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Abstract: The article is an overview of postglacial vegetational and climate changes in northern Asia based on pollen records with reliable chronology. The presented pollen records demonstrate spatially – and temporally – coherent patterns of environmental changes. Open *Artemisia*- and Poaceae-dominated communities were widely spread in northern Asia during the Lateglacial. A significant increase of shrub pollen registered in a number of records may be correlated with the Bølling/Allerød warming, *c*. 13.7 cal kyr BP. The subsequent increase in non-arboreal pollen contents reflects a cooling/drying of the Younger Dryas age. Many records show that the Lateglacial/pre-Boreal transition occurred at about 11.5 cal kyr BP and was characterized by a significant increase in birch, shrub alder, and willow pollen. Records from geographically different sites demonstrate different patterns of vegetation changes connected with local environmental conditions and migration history of tree species.

Keywords: Climate, Holocene, Kazakhstan, Lateglacial, Mongolia, Northern Asia, Pollen records, Vegetation changes, Siberia

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