



Last millennium coniferous expansion on Kamchatka: is it result of vegetation succession or climate-forced phenomenon?

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A notable feature of recent vegetation of Kamchatka is an enclave of coniferous taiga forest at the Central Kamchatka Depression (“Coniferous Island”) while the main part of peninsula is covered with deciduous forests and bushes. Within the Depression, spruce (*Picea ajanensis*) grows in two separated spots, which both are enclosed into larger larch (*Larix cajanderi*) forest area. Beyond the Depression, native coniferous trees are rare: isolated larch-spruce stands and the only fir grove (*Abies sachalinensis*) occur at the eastern coast of the peninsula. Despite the long history of botanic studies, the origin and development of “Coniferous Island” is still under discussion. To clarify the evolution of local coniferous forest, available botanic and macrofossil data, pollen records and other climate proxies were synthesized for Kamchatka. According to multi-proxy data, present-day coniferous tree species exist since the Pliocene. During the Pleistocene, these species have been common in Kamchatka forests, which advanced and retreated synchronously to the Interglacial/Glacial cycles. At the LGM time (ca. 25 ka), coniferous forests were almost extinct. Extra-limited coniferous populations appear to have been survived in a few refugia within the Central Kamchatka Depression and were oppressed the most of Holocene, while more adapted birch and alder tree species spread overall the peninsula. After Neoglacial cooling, coniferous succession began by larch advance since ca. 3000-2500 yrs BP and then spruce at wetter ca. 2000-1000 yrs BP time. The most impressive vegetation change occurred during the last millennium. Both larch and spruce started to expand rapidly since ca. 900 yrs BP and progressed so that by ca. 300 yrs BP these trees forced stone birch

out of lowlands to the mountains. In addition, evidences for first Holocene appearance of fir at the Pacific coast dated between ca. 1100 and 900 yrs BP. From ca. 300 yrs BP to the present, spruce and larch spread widely and formed coniferous forest in the interior of peninsula, and during the same time spruce began to outrun larch in expansion rates and push it off as well. There is no a comprehensive explanation for the last millennium coniferous expansion. One of probable reasons is greatly increased climate continentality during the late Holocene that could encourage coniferous invasion and replacement of maritime tree species in forest. However, this explains neither fir habitat at the Pacific coast, no dynamics of spruce, whose prominent advance occurred under wetter, cooler and less continental conditions of Little Ice Age. The present-day warming trend, which is well expressed by upslope shift of timberline in Kamchatka mountains, seems to do not prevent spruce forest from spread. Modern observation shows high-rate expansion of spruce in the interior at its both upper and lower altitudinal boundaries that force larch and stone birch out from their habitats. Moreover, larch and spruce both started recently to spread out of the Central Kamchatka Depression towards the Pacific coast. One could suggest that coniferous trees did not reach yet their climatically limited ranges on Kamchatka and forest species competition are in progress. In support of native coniferous success, several exotic coniferous species planted tens years ago beyond the Depression are mostly survived and now able for reproduction. All evidences synthesized suggest (1) very young age of coniferous taiga forest on Kamchatka in the frames of Holocene and (2) complicate relationship between recent climate trend and vegetation dynamics that needs further investigations.