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Late Quaternary and Future Biome Simulations for Alaska and Eastern Russia

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We simulated Arctic biomes across a region including Alaska and Eastern Russia using the BIOME4 biogeochemical and biogeography vegetation model. BIOME4, which produces an equilibrium vegetation distribution under a given climate condition, was forced by CMIP5/PMIP3 climate data. We are exploring vegetation and permafrost distributions during the last 21,000 years and future projections (2100 C.E.) to gain an understanding of the effects of climate shifts on this complex subsystem. When forced with the baseline modern climatology, compiled from the University of Delaware temperature and precipitation climatology and ERA-40 sunshine data, our biome simulations were generally consistent with current vegetation observations in the study region. Much of the study area was simulated to have evergreen and deciduous taiga and shrub tundras.

Paleoclimatological simulations were compared with pollen data samples taken through the study region. Simulations for the Last Glacial Maximum show the Bering Land Bridge covered almost entirely by cushion forb, lichen, and moss tundra, shrub tundra, and graminoid tundra. Three out of the five models' climate data produce evergreen and deciduous taiga in what is now southwestern Alaska. The distributions of cushion forb, lichen, and moss tundra and graminoid tundra differ noticeably between models, however, shrub tundra distributions are generally in agreement. Simulations for the Mid-Holocene are in better agreement on pollen-based distributions of biomes. Shrub tundra is simulated along the Arctic coast, and in some cases along the eastern coast of Russia. All models show evergreen taiga along the southern coast of Russia as well as covering the southern half of present-day Alaska. Deciduous taiga is simulated in the interior regions of eastern Russia and Alaska, though the distributions in Alaska differ between models. Pre-Industrial biome simulations were very similar to Mid-Holocene simulations. Differences include more shrub tundra in both Russia and Alaska to the north, as well as less deciduous taiga in Alaska. Cushion forb, lichen, and moss tundra, while hardly simulated for the Mid-Holocene, appear in larger areas in northeast Russia and northeast Alaska, although still not covering a significant portion of land area.

Future simulations exploring projected changes in climate conditions in the region under a RCP8.5 climate scenario show a northward shifting tree line while shrub tundra and graminoid tundra regions decrease significantly by 2100. Intrusions of cool mixed, deciduous, and conifer forests above 60°N, especially in southwest Alaska, were marked and were not modeled for present day. Across eastern Russia, deciduous taiga begins to overtake evergreen taiga, except along the coastal regions where evergreen taiga remains the favored biome. The implications of vegetation shifts in the Arctic are vast and include effects on snow cover, soil properties, permafrost distribution, and albedo, not to mention impacts on local fauna and people of the Artic.