

POTENTIAL DISTRIBUTION OF CONIFERS IN THE ALTAI-SAYAN MOUNTAINS, SIBERIA, IN A CHANGING CLIMATE OF THE XXI CENTURY



Fig. 1. Study area is within the window 42-56°N and 82-106°E
Goals

The study was aimed to predict the possible effect of climate change on the potential and actual distributions of major conifers in the South Siberia's mountains: dark-needed *Pinus sibirica*, *Abies sibirica*, and *Picea obovata*, and light-needed *Larix sibirica*, and *P. sylvestris*.

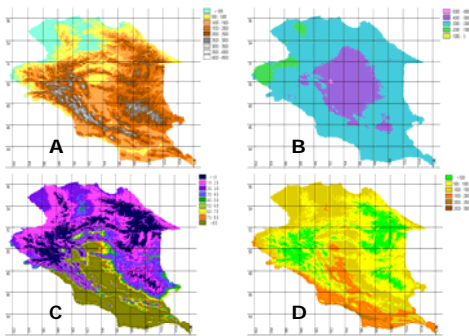


Fig. 2. DEM (A) and layers of climatic indices: GDD₀(B), AMI (C), and GDD5(D) in the ecoregion

Methods

The study area is the Altai-Sayan ecoregion located in central Asia mainly in Russia (the northern half) and Mongolia (the southern part). The elevation range is up to 4000 m in the central Altai. The current climate is of a continental type with cold winters and warm summers, with high annual precipitation up to 1500-2000 mm on highlands and as little as 100-200 mm of precipitation on the inner intermountain depressions.

In current climate, forests dominate montane landscapes over the northern part of the Altai-Sayans (Russian part). The forests here are composed largely of four conifers: 33.5% *Pinus sibirica* (Siberian cedar pine or Siberian cedar); 26.1% *Larix sibirica* (larch); 17.5% *Abies sibirica* (fir); 6.9% *P. sylvestris* (Scots pine). *Picea obovata* (spruce) is found only in 1.8%. Hardwoods (*Betula pubescence*, *Populus tremula*) are found on 14.1% of the forest area. Thus, shade tolerant tree species Siberian cedar, fir and spruce (dark-needed species) dominate 53% of the mountains forests in southern Siberia. Larch and pine (light-demanding species) thrive on 33% of the area. Over the southern part of the Altai-Sayans (Mongolian part), drylands (steppe, semidesert, and desert) dominate over 90% of the area with 10% of forests composed of the same conifers.

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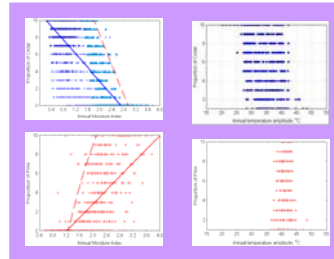


Fig. 3. Climatic limits of tree species defined from forest inventory data

We determined bioclimatic envelopes (climatic limits) for these major conifers from relationships between the climate and forest data derived from different sources: 1) forest inventory (Fig. 3); 2) common garden tests; 3) forest maps; and 4) published studies on Siberian conifers. We used three bioclimatic indices: growing degree days, base 5°C (GDD5), characterising plant requirements for warmth; negative degree days, base 0°C (NDD0), characterising plants' tolerance to cold; and annual moisture index (AMI) characterizing plants' drought resistance (Table 1).

Table 1. Climatic limits of main conifer species of the Altai-Sayan ecoregion

Tree Species	GDD5	AMI	NDD0
Dark-needed	> 350	< 2.0	>-3000
Light-needed	>350	<3.3	>-6000

Climate data from more than 200 weather stations across the Altai-Sayan Mts were used to map current climate variables (Fig. 2). Bioclimatic indices for the future 2080 were calculated using climatic anomalies from the climate change scenarios A2 (a harsh scenario) и B1 (a moderate scenario) of the Hadley Center (IPCC, 2007).

Results

The dark-needed (*Pinus sibirica* and *Abies sibirica*) and light-needed (*Larix sibirica* and *P. sylvestris*) conifer distributions in current climate were mapped by coupling our conifer bioclimatic limits with current distributions of three climatic indices. Our modeled tree species map was compared to the Landscape map of the Altai-Sayan ecoregion (Samoylova, 2001) (Fig. 4).

The comparison was made using the kappa statistics and showed a fair match between the maps with the overall kappa = 0.46, and a very good match for dark-needed conifers (kappa = 0.70)

Simulations indicated that a moderate change in forest vegetation is predicted from the B1 scenario, but more significant changes are predicted from the A2 scenario (Fig. 4). Forest habitats would decrease by 2080 from 52% to 48% according to the moderate scenario and from 52% to 38% according the harsh scenario. The portion of the dark-needed conifers would decrease 10% and the portion of light-needed conifers increase 7% from the B1 scenario and corresponding portions would decrease 19% and increase 6% from the A2 scenario (Fig.4). In a future warm and dry climate of the Altai-Sayan mountains, all conifers could shift upwards about 500 m.

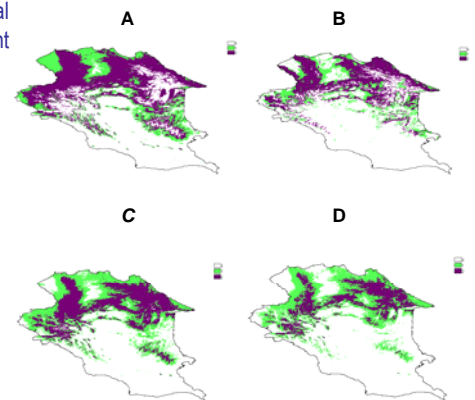


Fig. 4. Potential tree species distribution over the Altai-Sayan mountains in current climate (A), by independent source (B) and 2080 predicted from the climate change scenario HadCM3 B1(C) and A2 (D).

Conclusions.

To conclude, the future climate over the Altai-Sayan mountains should be more amenable for light-needed conifers *Larix sibirica* and *Pinus sylvestris* whose habitats could expand and replace dark-needed conifers *Pinus sibirica* and *Abies sibirica* in lowlands. In turn, dark-needed habitats are predicted to shrink and shift upslope and Siberian cedar and fir could migrate into current tundra habitats in highlands.

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