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Dendroclimatic Monitoring in the Boreal Forests of Russia: State and Perspectives

Dendroclimatic monitoring in the boreal forests is an important and constituent component of the forest monitoring system. Under the dendroclimatic monitoring we understand an information system for observation, evaluation and prognosis of climate-dependent tree growth variability and limiting tree growth climatic factors with the aim of prevention the critical situations in forest ecosystems and environment (Shiyatov, Vaganov, 1998).

The significance of such information system is dictated by the following. Trees are the best natural monitors due to availability of distinct tree layers (or rings), longevity and wide-spread occurrence. Besides, in many regions of the boreal biome tree rings contain a very strong climatic signal. It allows to obtain continuous, absolutely dated and long-term tree-ring and climate chronologies on the basis of single investigation. The tree-ring information obtained is important for reconstruction, evaluation and prognosis of forest ecosystem dynamics and climate variability. Organisation of dendroclimatic monitoring is especially essential in the boreal forests of Russia as the main forested areas are situated here, and the influence of climatic factors on composition, structure, productivity and dynamics of forest ecosystems is great. By means of tree-ring chronologies, many important climatic parameters can be reconstructed, mainly temperature, precipitation, air pressure for various seasons.

The main objectives of dendroclimatic monitoring system are the following:

- retrospective evaluation of climate-dependent characteristics of annual tree growth (ring-width, density and chemical composition of wood, cell structure of wood layers) for many centuries;
- investigation of the relationships between tree growth and climatic parameters, modelling the annual and seasonal tree growth;
- reconstruction of various climate parameters using tree-ring chronologies;
- evaluation of recent trends in radial tree growth, climatic changes, forest ecosystems dynamics and prognosis of their possible changes;
- dendroclimatic zonation of territory.

There is no developed conception of organisation of dendroclimatic monitoring system. Methods of sampling, developing a different kind of tree-ring chronologies, spatial-temporal reconstruction of climate parameters are more or less developed until now (Methods of Dendrochronology, 1990).

Coniferous tree species growing at their geographical and ecological limits of distribution in the boreal forests are the most suitable for dendroclimatic analysis (Larix sibirica Ldb., Larix Gmelini Pilger, Larix Cajanderi Mayr, Larix kurilensis Mayr, Pinus sylvestris L., Pinus sibirica (Rupr.) Mayr, Pinus koraiensis Sieb. et Zucc., Picea obovata Ldb., Picea excelsa Link., Picea koraiensis Nakai, Abies sibirica Ldb., Abies nephrolepis Maxim.). Most of the species have huge areas and that is favourable for obtaining homogeneous tree-ring chronologies and comparison of data obtained. Deciduous trees can be also used for dendroclimatic analysis, especially such species as Quercus robur L., Quercus mongolica Fisch., Ulmus laevis Pall., Ulmus scabra Mill., Betula ermani Cham., Betula pendula Roth., Betula pubencens Ehrt., Betula platyphylla Sukacz., Tilia cordata Mill., Tilia amurensis Rupr., Populus tremula L., Populus suaveolens Fisch., Salix alba L. etc. Chronologies developed from trees growing at the polar, southern, upper and lower tree limits contain the most strong climate signal and such regions are of primary importance for organisation of dendroclimatic monitoring. The different types of tree-ring chronologies can be obtained (individual, mean and generalized ones).

To organise the dendroclimatic monitoring system in the boreal forests of Russia, it is necessary to develop a rather dense network of test-polygons. Every test-polygon contains some monitoring plots. The following three types of test-polygons can be established:

1. *Basic test-polygons.* Such test-polygons are used for obtaining the most various information concerning tree growth and climate parameters variability and they characterise the condition of the largest climatic regions (the climatic districts and subdistrics, after Alisov, 1956). The monitoring plots (no less than 12) must be established in different forest types and sites, especially in sites unfavourable for tree growth. The basic test-polygons should be separated by 500-1000 km and situated mainly in protected areas. The territory of boreal forests was divided by B. P. Alisov (1956) into 23 climatic districts and subdistricts. It is necessary to establish no less than 28 basic test-polygons (considering that there is a necessity to establish no less than two basic test-polygons within each of the 5 largest climatic districts and subdistricts in Siberia).

2. *Regional test-polygons.* It is impossible to evaluate a spatial variability of tree growth and climate changes and to develop reliable climatic models using a comparatively sparse network of basic test-polygons and meteorological stations. To overcome these difficulties, it is necessary to obtain such information from regional polygons separated by 100-500 km (Israel, 1984). Every regional test-polygon should have no less than 4-5 monitoring plots established exclusively in the most unfavourable for tree growth sites. Approximate calculation shows it is necessary to establish 220-230 such test-polygons.
3. *Local test-polygons.* In some cases it is useful to have additional monitoring plots situated on rarely encountered sites which are extremely unfavourable for tree growth; tree-ring chronologies from such sites contain a very strong climatic signal. The number of local plots will depend on availability of such sites and the necessity of receiving additional information.

Thus, the total number of monitoring plots in the case of developing one chronology from each plot are approximately 1800. Preliminary calculation shows that for 50 % plots two chronologies from various tree species can be obtained. In such case it is necessary to establish 900 monitoring plots. Until now about 350 tree-ring chronologies which reveal a rather strong climatic signal are developed, mainly for the European North, Ural Mountains, Siberian Subarctic, Southern Siberia Mountains. These chronologies can be incorporated in the dendroclimatic monitoring system. To finish developing this system, it is necessary to obtain 1450 mean chronologies for 725 monitoring plots. At present, the Laboratories of Dendrochronology in Krasnoyarsk and Ekaterinburg together with Swiss Federal Institute for Forest, Snow and Landscape Research (Birmensdorf) perform dendroclimatic investigations in different regions of Russia. They concentrate attention mainly on the subarctic and mountain regions as the most promising for dendroclimatic reconstructions.

Accumulation, storing and utilization of dendroclimatic information are of the important tasks of dendroclimatic monitoring. At present the regional tree-ring data banks and GIS are in the course of developing in Krasnoyarsk and Ekaterinburg.

The top priority tasks of organisation of the dendroclimatic monitoring system in the boreal forests of Russia are the following:

- elaboration and publication of the special handbook concerning all sections of dendroclimatic monitoring organisation in the boreal forests;
- refining the network of dendroclimatic test-polygons and plots;
- intensification of works on dendroclimatic investigations in the boreal forests of Russia.

Literature

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