RESEARCH REPORT

THE DEVELOPMENT AND STATE OF DENDROCHRONOLOGY IN THE USSR

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ABSTRACT

The first dendrochronolcgical investigation in the USSR was carried out at the end of the past century. Systematic study of tree rings for the purpose of dating different events and reconstruction of natural conditions began in 1950-1960's. Tree-ring analysis is most intensively used in the studies of forest ecosystem dynamics, timing and frequency assessment of catastrophic phenomena, reconstruction of radiocarbon content in the Earth atmosphere, and dating of historical wood. Much attention is given to the development of long-term prognoses of tree growth and forest environments.

The first dendrochronological investigation in the USSR, which has not been recognized so far, was carried out by Professor Shvedov in 1882 on two trees of black locust (*Robinia pseudoacacia* L.) growing in the streets of Odessa (Shvedov 1892). He discovered that there is a close relation between ring widths and precipitation of the hydrological year (from September to August) and that the narrowest wood layers form in very dry years, which are regularly repeated in three and nine years. On the basis of this periodicity, he predicted a drought for 1891. This prognosis proved to be accurate and Shvedov subsequently published the results of the investigations. He demonstrated the possibility of "dendrometric method" for reconstruction of climatic conditions of the past. Shvedov should be rightfully considered as one of the founders of dendrochronology.

Unfortunately these investigations, which began so successfully, were not continued over a long period of time. Only in the 1930's dendrochronological papers began to be published. These articles were basically methodological (Zaozersky 1934; Tolsky 1936) and only the work by Kostin (1940) was devoted to the reconstruction of droughts in the European part of the Soviet Union. At the same time abstracts of the research of American dendrochronologists (A. Douglass, W. Glock) were published (Jashnov 1925; Krishtofovitsh 1934; Chrgian 1938) and these were valued very highly.

Systematic investigations in the field of dendrochronology began only from the 1950's. Rudakov (1951, 1958, 1961) popularized the dendroclimatological method. In particular, he made popular the moving average method for determination of the age trend and the calculation of growth indices. Some investigations were carried out to discover the effects of climatic factors on tree-ring growth: in the Latvian SSR (Zwiedris and Sacinieks 1960; Zwiedries and Matuzanis 1962), in the Karelian Neck (Dmitrieva 1959), in the Eastern part of the European territory of the USSR (Liseev 1962; Rudakov 1958, 1961), and in the Lithuanian SSR (Bitvinskas 1965). Interesting work on qualitative reconstruction of humidity in the Middle Asia highlands during the last millenium on the basis of the ring-widths study of Turkestan juniper (*Juniperus turkestanica* Kom.) was carried out by Gursky et al. (1953). Tree rings were extensively used by Galazy (1954) for reconstruction of climatic conditions

and the upper timberline dynamics in the Zabaikalie and for estimation of the dates of high water levels in Lake Baikal (Galazy 1955, 1967). Kostin (1960, 1963) has studied ring-width variability for the purpose of reconstruction of severe droughts in the last 200-300 years in the steppe zone. Shiyatov (1965) has made a qualitative reconstruction of the thermal conditions in summer months in the Polar Urals.

At the end of the 1950's dendrochronological methods began to be used for dating historical and archaeological monuments and relics. Zamotorin (1959, 1963) carried out relative dating of the Altai-Sajan Barrows. In 1959 the first Dendrochronological Laboratory at the Institute of Archaeology of the USSR Academy of Sciences (Moscow) under the leadership of Professor Kolchin was organized (Kolchin 1963). The Laboratory was engaged in absolute dating of medieval buildings, churches, and paved wood roadways in the northwestern part of the Soviet Union, in Novgorod in particular.

From 1968 until the present, there has been a period of broad application of dendrochronology in the study of variability of various natural and anthropogenic processes and dating of various events. That year the First All-Union Conference on Dendrochronology and Dendroclimatology (in Vilnius) was held and the Dendroclimatochronological Group at the Institute of Botany of the Lithuanian Academy of Sciences (in Kaunas) was organized. In 1976 this Group was reorganized into the Dendroclimatochronological Laboratory and at present this Laboratory is the largest scientific subdivision in the Soviet Union that specializes in dendrochronology (Bitvinskas 1978).

In the Soviet Union during the last two decades, tree-ring analysis has been most intensively used for the study of forest ecosystem dynamics. First of all this is related to the fact that the majority of Soviet dendrochronologists are foresters and they work in Forestry and Ecological Institutes.

The work of Soviet dendrochronologists is based on a form of forest ecosystem dynamics called the cyclic form. Within the cold and temperate zones, annual fluctuations and long-term changes in climatic conditions significantly affect the composition and structure of forest ecosystems. Changes of forest environments caused by climatic variations (moisture and heat supply, droughts, fires, floods, snow avalanches, and other catastrophic phenomena) are the main reasons of the cyclic forest dynamics. The duration and amplitude of processes which are not strictly periodic, but change to some extent, allowing the estimate of the oscillation parameters by statistical methods are called cyclic. Not only short-term fluctuations (daily, seasonal, annual, intrasecular), but long-term and essential ones (secular and oversecular) should be attributed to cyclic forest dynamics, including forest vegetation succession into woodless vegetation and back.

The cyclic processes can be observed in the changes of almost all components of forest ecosystems. Most of all they are expressed in tree growth. There are various length cycles in the dynamics of separate components of forest ecosystems (polycyclicity). But there are usually only a few dominant cycles, which bring about the highest contribution in the variability of the process.

The presence of certain cycles are characteristic of various forest ecosystem components and processes. For example, seed crop dynamics are characterized by short-term cycles, less than 10 years. Forest successions are determined by long-term climatic cycles (secular and oversecular). The cyclic processes are expressed primarily in regions which unfavorable for tree growth (arid and cold regions and sites). The greatest contribution to the study of forest dynamics was made by the following research: Komin (1963, 1970); Bitvinskas (1964, 1974); Kolishchuk (1966, 1979); Shiyatov (1972, 1975, 1986); Gortinsky (1968); Malokvasov (1974); Olenin (1976, 1977); Polyushkin (1979); Mazepa (1986); and Dyrenkov et al. (1987).

Frequently dendrochronology is used for estimation of the effectiveness of various forest measures (melioration, fertilization and so on). The comparison of the growth of trees which are or are not subject to the effects of the studied factors are used most of all (Bitvinskas 1965, 1974; Buzikin 1978; Evdokimov 1979; Pshenichnikova 1987).

In the coniferous boreal and broad-leaf forests of the Soviet Union severe insect outbreaks are often observed. As the result of the full defoliation large massives of forests are dried out. Therefore an important task is estimation of the timing and intensity of insect outbreaks. For reconstruction of outbreaks such indicators as growth of host and non-host species and trees, the width and index of summer wood, dimension and number of cells in the annual rings, and histograms of indices for each calendar year are used (Litvinenko 1972; Vaganov et al. 1972; Isaev and Kiselev 1987; Kucherov 1987).

Several investigations regarding the influence of seed crops on the annual growth of trees have been carried out. The dark-needled trees (*Picea, Abies*) grow at a reduced rate of about 50 percent during the harvest year in comparison with non-seedbearing trees. Reduction of the summer wood percentage in annual rings and a sharp decrease of apical growth were observed (Danilov 1953; Kolishchuk et al. 1975; Voronin 1986).

The influence on the tree growth of such anthropogenic factors as pollution and recreation are studied intensively at present. More frequently comparison of tree growth, which is influenced or not by the examined factor is conducted (Lairand et al. 1979; Lovelius 1979; Laletin 1987; Yuknees 1987; Sabirov 1987). In studies of forest decline, climatic response models have not yet been used.

For estimating pollution effects on forest ecosystems, a determination of chemical elements, especially heavy metals in the annual wood layers, has been determined (Chetverikov 1986; Adamenko et al. 1987). It is interesting that the ratio of potassium in the annual wood layers was determined (Chetverikov 1986).

Soviet dendrochronologists also pay much attention to reconstruction of the timing and frequency of such catastrophic phenomena as snow avalanches, mud slides, land slides, fires, and windthrows (Melechov 1948; Karpenko and Medvedev 1963; Turmanina 1971, 1979; Zabelin 1979; Gorchakovsky and Shiyatov 1985; Nesvetailo 1986; Shiyatov and Uljanov 1987). For dating these phenomena the following indicators are used: evidence of mechanical damages on trees, reaction wood, new vertical shoots, and appearance and determination of when the trees sprouted and died. The greatest contribution to this research was made by scientific workers of the Problem Laboratory of the Geographical Faculty of the Moscow State University (Turmanina 1971, 1972, 1979; Akifieva and Turmanina 1970; Lukjanova and Mjagkov 1979).

Presently intensive investigations dating past forest fires are being carried out in Siberian forests (Furyaev 1987; Valendic and Ivanova 1987; Evdokimenko and Koptsev 1987).

Although dendroclimatic reconstructions are being carried out by many researcher (Glebov and Pogodina 1972; Bitvinskas 1974; Muchamedshin 1974; Bitvinskas and Kairaitis 1975; Lovelius 1979; Borshova 1981; Shiyatov 1986; Adamenko 1986), only simple linear and non-linear regressive models are being used. There are no spatial reconstructions because the network of dendrochronological stations is not yet fully developed in many regions of the USSR.

Dating of historical and archaeological wood is being conducted mainly in the European territory of the Soviet Union (Kolchin and Chernich 1977; Kolischchuk et al. 1984; Brukstus 1986). In the eastern and southern regions, such dating has been performed rarely (Shiyatov 1980; Komin 1980). This is because of the absence of specialists and laboratories in these regions.

In the Soviet Union, research on the problem "Astrophysical Phenomena and Radiocarbon" have been carried out for the past 20 years. The purpose of these researches is the annual reconstruction of the radiocarbon content in the Earth atmosphere on the basis of estimation of its contents in annual wood layers (Dergachev and Kocharov 1981). The Dendroclimatochronological Laboratory (Kaunas), the Ioffe Physico-Technical Institute (Leningrad) and many Radiocarbon Laboratories participate in this research (Bitvinskas 1981). The annual reconstruction of radiocarbon contents for the last 200-300 years has been calculated. The close relation of radiocarbon content in the annual layers of trees growing in various regions of the country has been demonstrated. The relation between solar activity, especially in 11-, 22- and 80-year cycles and radiocarbon content in wood has been suggested (Bitvinskas 1984).

Dendrochronological methods are used for determining the time and place of criminal actions, especially regarding the illegal cutting and selling of timbers (Rosanov 1965, 1968).

Soviet dendrochronologists give much attention to the development of the long-term prognoses of tree growth and forest environments. Such prognoses are of a great importance, especially in regions of insufficient moisture and warmth. Economic effects of prognoses may lead redistribution and more effective utilization of investment, as well as due to the increase of forest productivity and forest protective functions. The polyharmonic models are most frequently used (Komin 1972; Polyushkin 1979; Shiyatov 1986; Mazepa 1986; Kairiukstis and Dubinskaite 1986). They are based on establishment, approximation, and extrapolation of the most important cyclic components in dendrochronological series. To determine the necessary parameters of cycles (length, amplitude and phase), Mazepa (1986) used data of spectral density and narrow-band filtration. The approximation of the cycles was conducted by sinusoids. Usually from 11 to 20 cycles are used in approximation and extrapolation of each chronology. The correlation coefficient between the original and approximated chronologies ranges from 0.5 to 0.8 (Shiyatov and Mazepa 1986).

For prognoses of growth indices, predicted data of solar activity (Bitvinskas 1984) and calculated data of distribution of the maxima atmospheric tides of the Moon and of the Sun (Javorsky 1975) are also used.

In many regions of the Soviet Union, seasonal growth of trees and factors which determine the duration and rate of growth are studied. The microscopic method is used most frequently in studying seasonal growth (Kairiukstis and Yuodvalkis 1970; Lobzhanidze 1975; Kishenko 1978; Goryachev 1987). Presently the most intensive research of seasonal and cell growth are carried out at the Biophysical Institute of the Siberian Division of the USSR Academy of Sciences (Krasnoyarsk). At this Institute, a special device "Ring Structure Measurer" which semiautomatically registers the number and dimension of cells in the annual rings is constructed (Vaganov et al. 1985).

Up to the present, about 370 tree-ring chronologies have been published in the form of indices. From these chronologies, only 115 are from the eastern and southern regions of the USSR (including the Urals). Most of the chronologies have been obtained from coniferous species (*Larix, Pinus, Picea, Abies*), while only about 60 chronologies are from broadleaf-bearing species (mainly from *Quercus*). Very few chronologies have been developed in Siberia, the Far East, Middle Asia, or the Caucasus. The longest published chronologies are the following: for *Juniperus turkestanica* Kom., Middle Asia, 1224 years (Kolchin and Chernich 1977), for *Pinus sylvestris* L., Novgorod, 1200 years (Kolchin and Chernich 1977), for *Larix sibirica* Ldb., Polar Urals, 1010 years (Shiyatov 1986), for *Larix siririca* Ldb., North of Western Siberia, 867 years (Shiyatov 1975), and for *Larix sibirica* Ldb., Altai Mountains, 677 years (M. F. Adamenko 1978).

Dendrochronological investigations in the USSR are coordinated by the Commission for Dendroclimatology of the USSR Academy of Sciences. This Commission sponsors all the All-Union Conferences on problems of dendrochronology and dendroclimatology (1968 - Vilnius, 1972 - Kaunas, 1978 - Archangelsk, 1983 - Irkutsk). On the initiative of the Commission in 1980 the Dendrochronological Bank of the Soviet Union (DBSU) at the Dendroclimatochronological Laboratory and the Lithuanian Forest Research Institute (Kaunas) was organized. With the Commission assistance, three volumes of "Dendroclimatological Scales of the Soviet Union" (1978, 1981, 1984) and the bibliographic reference "Dendroclimatochronology, 1900-1970" (Vilnius 1978) were published.

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