STUDIES ON THE ANNUAL RADIAL INCREMENT OF PINE TREES FOR RECONSTRUCTION OF CHANGES IN THE WATER LEVEL OF RAIFA LAKE

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The role of key factors determining the functioning of tree stands can be identified by studying the annual radial increments of trees, which enables reconstruction of environmental conditions with a high temporal resolution (Shiyatov et al., 2000). Climate and hydrological conditions can be reconstructed using tree-ring chronologies built form a relatively large number of trees belonging to a single or several species and growing within the same habitat or in several habitat types (Shiyatov et al., 2000). This methodology could be used to reconstruct the water level history of lakes, as in these published studies: Lake Baikal in Russia (Galazii, 1972), Lake Bienville in Canada (Begin, 2001), Great Salt Lake in the USA (Gillies et al., 2015), etc.

The purpose of current research was to study the annual radial increment of pine trees growing around Raifa Lake in order to reconstruct its hydrological regime.

Raifa Lake is the main water body of the Volga-Kama State Nature Biosphere Reserve (Republic of Tatarstan, Russia). The lake contains more than 82% of all waters of the surface water bodies in Raifa. The main source of the lake water supply is snow melt water, whereas rain, ground, and swamp sources bring smaller amount of water (Taisin, 2006). According to (Taisin, 2006), the size of Raifa Lake decreased very rapidly up to the 1990s. In the 1840s-1890s, rate of changes of lake length increased from 3m per year to 7 m per year, after the 1890 the rate of changes intensified and reached a value of more than 21 m per year by 1920. In the 1970s, the rate of changes of lake length reduced to 12-15 m per year. The lakes's water surface area and the water volumes diminished accordingly to these rates of change in length. However, the maximum depths varied little. By 1990 the lake length reduced to 1316 m, water surface area reduced to 32.3 ha, maximum depth was 19.6 m (Taisin, 2006).

The trees were cored in the summer of 2016. Two sampling sites were established on the northeastern shore of the lake: "Shore" and "Control". In the Shore group, trees grow at a distance of 0.5-6 m form the water edge within the first floodplain terrace. For these trees, the water level of the lake is an important factor influencing the dynamics of soil humidity. The Control group included trees growing at a distance of 50-100 m from the shore line and at the height of 6-7 m above the water surface within the third above-floodplain terrace. This location of the control trees suggests that the hydrological regime of the lake has a minimal impact on their annual radial increment (Fig. 1).

Sampling was performed with the help of an increment borer. Core samples were obtained from the trees of Scots pine (*Pinus sylvestris* L.) at the height of 1 m from the root collar. The age of tree and annual tree-ring widths can be identified more accurately if two core samples are taken from it, so a total of 26 core samples were taken from 13 trees: 20 core samples (10 trees) of the Shore group and 6 core samples (3 trees) of the Control group, respectively. The tree-ring study was performed by the standard dendrochronological methods (Shiyatov, 2000). The widths of annual tree-rings were measured on a LINTAB semiautomatic system using the TSAPWin software (Rinn, 2011).

Tee-ring chronologies and tree-ring indices with age-related trend removed were calculated using the Arstan software (Holmes, 1995). The data were processed by the statistical methods standard for dendroecology. Calculations were performed by the PAST (version 3.8) software (Hammer, 2001). The study of impact of climatic factors on the dynamics of tree-ring indices was based on the average monthly temperatures and monthly total precipitation amount provided by the "Kazan-University" weather station, which holds an exceptionally complete data set for the period of 1901-2014.

Dendrochronological analysis helped to identify the pine, which is the oldest in both the Volga-Kama State Nature Biosphere Reserve and the Republic of Tatarstan. This tree is 288 years old and it has been growing on the shore of Raifa Lake since 1728. Two 250-year tree-ring chronologies were obtained on the basis of standardized tree-ring indices.

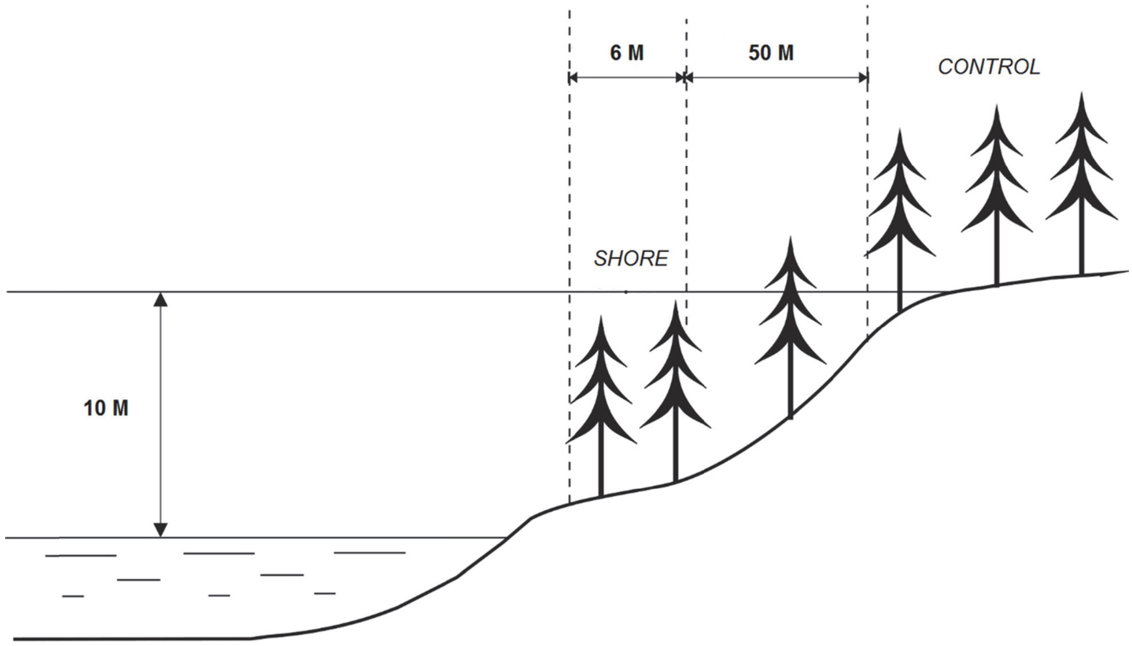

Fig. 1. The scheme of location of trees in the "Shore" and "Control" zones
on the northeastern shore of Raifa Lake

The analysis of the Shore zone tree-ring chronology allowed to determine the years with minimum (1771, 1812, 1906, 1942, 1964, 1982, 2010) and maximum 1781, 1795, 1821, 1913, 1990, 2000) widths of annual rings. For the chronology of the Control zone, the years with maximum (1777, 1836, 1910, 1947, 1963, 2000) and minimum (1793, 1829, 1891, 1921, 1944, 1965, 1992, 2006) widths of annual tree-rings were also registered.

The water level of Raifa Lake depends mainly on the volume of water masses brought by the Ser-Bulak and Sumka Rivers. From the nature records of the Volga-Kama State Nature Biosphere Reserve, it was discovered that the hydrological regime of the lake has underwent no dramatic and long-term changes during the recent 50 years. The water level in the lake was high in 1978, 1993, and 2008. Floodings were short-term and seasonal. In the above years, no sharp fluctuations in the annual radial growth were observed for trees in the Shore zone. Short-term rises in the water level of the lake likely have no significant impact on the dynamics of annual radial growth of trees growing on the lake shore. The effect of the hydrological regime seems to be indirect and manifested itself through changes in the sensitivity to other factors. This is an open question that requires further and detailed study.

The chronologies are weak correlated (R=0.2, p=0.01, n=254) (Fig. 2). The similarity between the two chronologies increases in the 1840s, 1920s, and after 1990s. Asynchrony was observed during the period of 1790-1810 and in the 1890s. We attribute the observed differences in the annual radial growth of trees in two zones under study to the changes in the hydrological regime of Raifa Lake. There could have been a short-term rise in the water level of the lake at the above times.

To estimate the impact of meteorological factors on the annual radial growth of trees, we performed a correlation analysis of the annual tree-ring indices with the air temperature and precipitation for the period of 1970-2014. The annual radial growth of trees in the Control zone is correlated to the precipitation in June ($R=0.51$, $p<0.001$). And this is quite logical, because trees in the Control zone grow in the dry forest sites, thereby being well-adapted to the lack of atmospheric precipitation. The tree-ring indices of radial growth of pine trees in the Shore zone have a low correlation with the weather factors: they correlate positively with the precipitation in February and negatively with the temperatures in May and August. This weak climatic signal can be explained by the high humidity of the substrate due to the continuous influence of the lake backwaters.

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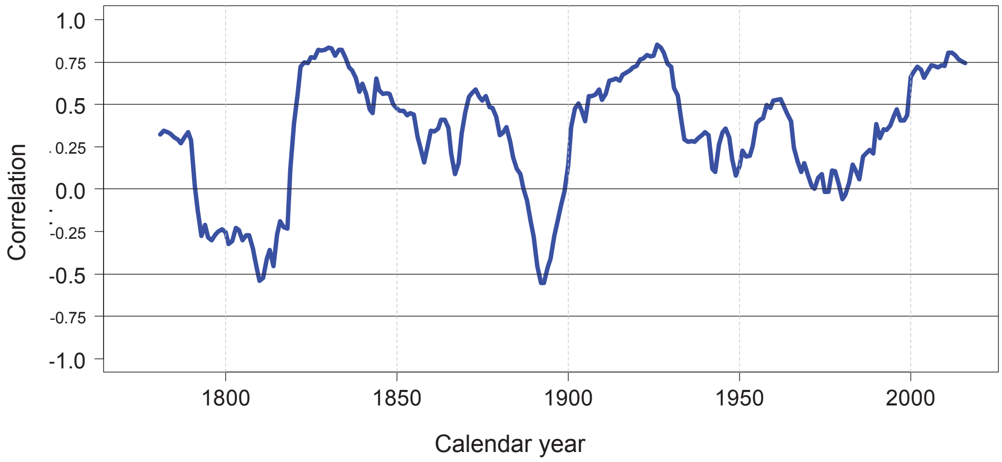

Fig. 2. The moving correlation between "Shore" and "Control" chronologies (the size of the moving window is 20 years).

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EXTINCTION AND RECOVERY OF NON-MARINE BIVALVES FROM THE MIDDLE AND UPPER PERMIAN LAKE DEPOSITS OF THE SEVERNAYA DVINA RIVER BASIN

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More than 20 non-marine bivalves' localities are known from the Middle and Upper Permian continental (lake) deposits of the Severnaya Dvina River Basin (north-west part of the East-European Platform) (Plotnikov, 1945, 1949; Gusev, 1955, 1963, 1977, 1990; Kanev, 1986; Betekhtina and Tokareva, 1988). Revision of the systematics of the Permian non-marine bivalves from this area has been performed by the author in 2014-2018 and has allowed specifying their diversity (35 species, 9 genera, 5 families, 4 superfamilies, 1 subfamily and 3 orders).

Remains of non-marine bivalves are represented by shells, internal and composite molds, and imprints. Usually, separate bivalve valves located parallel or subparallel to the bedding planes.