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Opinion

Tree Biomass Models for Laser Sensing in the Context of the Liebig-Shelford Principle

Usoltsev VA[1,2]* and Tsepordey IS[2]

[1]Ural State Forest Engineering University, Russia

[2]Botanical Garden, Russian Academy of Sciences, Russia

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***Corresponding author:** Usoltsev VA, Ural State Forest Engineering University, Botanical Garden, Russian Academy of Sciences, Ural Branch, Yekaterinburg 620144 Russia

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Forest ecosystems play a major role in climate stabilization, and their continuous monitoring is of paramount importance. Plant properties reflect the adaptation of vegetation to changing environmental conditions, including climate. Therefore, it is important to know the adaptive capabilities of each tree species and the specifics of the response of its biomass to climate changes. According to the principle of limiting factors by Liebig-Shelford, a limiting factor of growth can be not only a lack, but also an excess of the factors such as light, heat and moisture [1]. The modern technology of air-borne laser scanning, which provides detailed information in three dimensions about the structure of the canopy, allows us to measure such morphometric characteristics of trees as the crown width and tree height. Their inclusion in the allometric model of saxaul (Haloxylon Bunge) biomass showed the presence of the determination coefficient from 0.841 to 0.854 [2]. The inclusion of temperature and precipitation as additional independent variables in allometric models of larch tree biomass made it possible to predict changes in biomass in Chinese forests during climate shifts [3]. In order to obtain adequate models sensitive to climate change, it is necessary to have experimental data on productivity and climate variables at the global or continental levels. In our study, we used a database of 4,440 sample trees of forest-forming species (genera) growing on the territory of Eurasia, with measured indicators of aboveground biomass, tree height and crown width, including two-needled *Pinus sp.*, *Picea spp., Abies spp., Betula spp. and Populus spp.*, i.e., 2128, 961, 300, 755, and 296 trees correspondingly [4]. The models calculated include as independent variables the crown width, tree height, as well as indices of the average January temperature and average annual precipitation, explaining from 93 to 96% of the variability in the biomass of trees of these genera. By substituting in the models the average values of the crown width and tree height, equal to 2.9±0.3m and 13.9±1.3m, respectively, the propeller-shaped 3D patterns of changes in biomass in temperature and precipitation gradients are obtained. Similar patterns were shown for aboveground *Larix spp.* biomass [5]. When using our pattern, we compare the response of the genera's biomass on the maximum and minimum values of climatic factors that contribute to an increase or decrease in the tree biomass. The obtained regularities are of a general nature, confirming the principle of the limiting factors by Liebig-Shelford: in conditions of a lack of moisture (300mm of precipitation), an increase in temperature exacerbates water deficit, and the biomass decreases, and in conditions of sufficient moisture (800mm of precipitation), an increase in temperature causes the opposite effect. In cold regions (-25 °C of January temperature), an increase in precipitation causes "excess" waterlogging, and the biomass of trees decreases, while in warm regions (5 °C of January temperature), the effect is opposite, and the biomass increases.

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