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Climate change, forest management and nitrogen deposition influence on carbon sequestration in forest ecosystems in Russia: simulation modelling approach

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Russian land ecosystems occupy more than 1/9th global land area. Therefore its carbon budget is an essential contribution to the global carbon budget. The first rough estimate of carbon balance on Russian territory was made on comparison data on total soil respiration (Kudeyarov et. al., 1995) and NPP calculated on data on biological productivity of different ecosystems over Russia. The carbon balance was evaluated as a C-sink. Further estimates of Russian C budget by V.Kudeyarov et al., (2007) and I.Kurganova et al., (2010) were more correct and included soil microbial flux, and non-respiratory processes: fossil fuel, agriculture, forest fires and post-fire emissions, insect damage, etc. According to estimates the total C-sink of Russian territory for early nineties was about -0.8-1.0 Pg C per year. The later IIASA account developed by A.Shvidenko et al. (2010) has provided current estimates of C fluxes and storages in Russia and showed that its terrestrial ecosystems served as a net carbon sink of -0.5-0.7 PgC yr^{-1} during the last decade. Taking into account big uncertainties of determination of carbon balance constituents one can say that results by IIASA and our Institute are rather close. Resulting effect of two processes (sequestration and CO_2 emission) can be analysed by mathematical modelling only. Corresponding system of models of organic matter dynamics in forest ecosystems EFIMOD was developed in our Institute last decade and applied in Russia and other countries for evaluation of impacts of climate changes, forest management and forest fires. The comparative simulations of carbon and nitrogen dynamics in the mixed forest ecosystems of Central Russia from different climatic zones and site conditions have been made. Three large forest areas with the total square of about 17,000 km2 distinct in environmental conditions were chosen. We used the data of the forest inventory for model initialization. Four simulation scenarios (without disturbances, with forest fires, with selective cuttings and with clear cuttings) coupled with two climatic ones (stable climate and the scenario of climate change) were applied. Additionally, simulations were carried out at different levels on nitrogen deposition. The main sources of uncertainties were analyzed using Monte-Carlo procedure. Modelling showed that the most carbon accumulation was observed under natural development scenario. Fires resulted in significant losses in soil organic matter and tree biomass throughout direct and indirect carbon dioxide emissions. Other scenarios showed decrease in carbon pools, the most in scenario with clear cuttings due to timber removal and burning of felling residues. Increased nitrogen deposition from the atmosphere resulted in increased growth rate of trees and, therefore, in increased litter flow. Higher nitrogen content in litter had an additional positive effect on mineralization rate. Climate change also accelerated the decomposition processes in soil and led to the increased carbon dioxide emission. The increased income of plant residues to soil resulted in increased soil organic matter content in mineral soil. Conversely, climate change led to the decrease of organic matter content in organic soil horizons. The net effect of these processes is the increase in total soil organic matter.