SOIL CARBON IN ABANDONED LANDS OF RUSSIA

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ABSTRACT

Annual changes in soil carbon stock are considered of the abandoned managed agricultural lands that were under natural regrowth over the territory of Russia within the period 1990-2002. Total area of abandoned agricultural land is 21,6 millions ha. The projections of changes in the carbon stock have been made for the period from present to 2010. The ROTHC model was employed in the investigation of carbon dynamics in soils. The territory of Russia was subdivided into 40 regions. The average basic soil and climatic parameters, as well as the annual input of organic matter into soils due to natural succession were estimated for each region. Average annual net-emission over the territory of abandoned lands was 2,1 ± 1,8 Tg C/yr in 1990-1999. CO_2 removal from the atmosphere by soils was 5,2 ± 2,8 Tg C/yr on average in 2000-2002. A total increase in carbon stock of the abandoned lands over the country can be as high as 153 Tg C (that corresponds to the removal of 561 Tg of CO_2 from the atmosphere) in 2010. Central regions of the European part of Russia, south of East Siberia and the Far East will have the highest intensity of carbon sequestration.

INTRODUCTION

There is a carbon release or uptake into soils in terrestrial ecosystems and, therefore, soils play an important role in the global carbon cycle. Human activities change carbon stocks in soil through land-use change among other activities. That could be associated with essential carbon dioxide emission into atmosphere or sink into soil and may result in global climate change. According to requests of United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol, land-use change activities should be taken into account by Annex I Parties to meet their quantitative commitments on reduction of greenhouse gas emissions. Global estimates show that tropical rates of deforestation are responsible for the most part of carbon emission, while in the northern hemisphere past changes in land use result in small sink of carbon [*Houghton*, 2003]. In accordance with data of *Houghton* [2003], during 1990s for the territory of the former Soviet Union the average net emission of carbon attributable to land-use change activities was 0,02 ± 0,2 Pg C $year^{-1}$. This estimate is highly uncertain. In 1990s deforestation and conversion of forest land to agricultural in Russia were extremely negligible, while the area of abandoned agricultural lands increased essentially since 1990. Therefore, it is possible to anticipate the growth of net carbon sink on the territory of Russia due to land use change activities in the end of 1990s and beginning of 2000s. The aim of this work was to determine annual and total fluxes of CO_2 on the territory of abandoned land in Russia from 1990 to 2002.

METHODS

Unmanaged agricultural lands abandoned after 1990 were chosen for investigation. Annual data on cultivated area and conversion of croplands obtained from national statistics [*Agriculture of Russia*, 1995, 2002]. For calculation the territory of Russia subdivided into 40 regions basing on administrative division of the country to districts. Some small districts with similar climatic and soil parameters were aggregated.

For calculation of soil carbon fluxes under abandonment of cultivated land in Russia the model ROTHC was chosen [*Coleman, Jenkinson*, 1996]. Among the other existing soil carbon models for agricultural soils, this one considered suitable for climatic conditions of Russia and does not require any specific information except general climatic and soil data. Besides, this model could be used for long-term modeling of soil carbon content and has a monthly time step. The model split into four active compartments (those are decomposable plant material (DPM), resistant plant material (RPM), microbial biomass (BIO) and humified organic matter (HUM)) and a small amount of inert organic matter (IOM) that is resistant to decomposition. As proposed by authors of the model, the initial composition of active compartments in soil before abandonment was determined by the assumption that soil carbon had reached the equilibrium while soil was cultivated. Then model is running with different annual inputs of plant carbon up to 10 000 years until the carbon content in RPM+BIO+HUM reached the average value determined for respective region/district on the base of literature data [*Bolotina*, 1976]. Depending on the climate zone and typical crop produced in the region in accordance

with statistical data [*Agriculture of Russia*, 1995; 2002], residues of winter oats or winter wheat, or its combination, were taken for calculation of initial composition of carbon compartments in ploughed soils. Except the data on initial soil characteristics, the climatic information and data on plant productivity are necessary to start model calculations. To determine the average monthly temperature (°C) and average rainfall (mm) for every district the information of more then 120 weather stations within Russia was collected and analyzed. The magnitude of monthly evaporation for every division was determined in accordance with dependence of *Thornthwaite* [1948] using mean monthly temperature. The input of plant carbon in unmanaged soils was assumed to be equal to the annual grass production during natural succession on abandoned lands and expressed as percent of the full production of grasslands [*Bazilevich*, 1993] for every district.

RESULTS

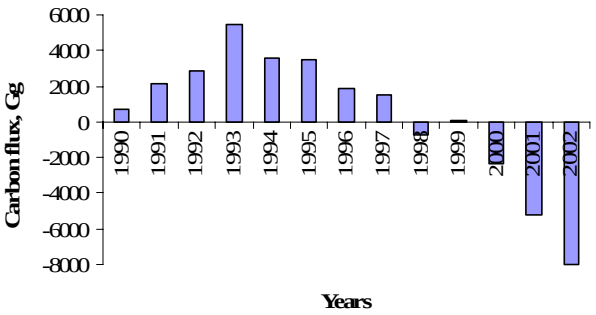

Fig.1 Annual carbon flux on abandoned lands in Russia.

Results of calculations show that total area of unmanaged lands in Russia increased from 717 thousands ha in 1990 to 21.6 million ha in 2002 (that corresponds to 0.5 and 17.5% of total agricultural land in the country, respectively). The general tendency in initial soil carbon content and clay content of agricultural soils is in its increasing toward to central regions of European part of Russia and to Siberian regions. The productivity of aboveground biomass of natural grasslands is increased from northern to central regions of Russia in accordance with shift of vegetation zones from northern taiga to southern taiga and mixed forest. Toward to southern territories of Russia the biomass productivity decreased because of steppe area. Model estimations of the annual carbon flux in abandoned land during 1990-2002 shown on Fig. 1. Positive values on the figure are emissions of CO_2 and negative values correspond to its sink. Before 1998 abandoned land in Russia loses soil carbon. Associated with ageing of soil after abandonment the annual plant production on unmanaged land is growing. That leads to the accumulation of the organic carbon in soils. Therefore after 1998 abandoned lands in Russia are responsible for net-sink of CO_2 with exception for 1999 then new large territories were abandoned as a result of economical crisis in 1998. Average annual net-emission over the territory of abandoned lands was 2.1 ± 1.8 Tg C/yr in 1990-1999. CO_2 removal from the atmosphere by soils was 5.2 ± 2.8 Tg C/yr on average in 2000-2002. Total balance of soil carbon on the territory of abandoned land in Russia for 1990-2002 is offset in the side of emissions and corresponds to 5.5 Tg C (20.2 Tg CO_2) during 13 years. Project estimations showed total increase in carbon stock of the abandoned lands over the country, which can be as high as 153 Tg C (561 Tg CO_2) in 2010. Central regions of the European part of Russia, south of East Siberia and the Far East will have the highest intensity of carbon sequestration due to highest productivity of grasslands in the forest zones.

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