



Dynamics of soil carbon stocks due to large-scale land use changes across the former Soviet Union during the 20th century

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Land use change is a major driver of land-atmosphere carbon (C) fluxes. The largest net C fluxes caused by LUC are attributed to the conversion of native unmanaged ecosystems to croplands and vice versa. Here, we present the changes of soil organic carbon (SOC) stocks in response to large-scale land use changes in the former Soviet Union from 1953-2012. Widespread and rapid conversion of native ecosystems to croplands occurred in the course of the Virgin Lands Campaign (VLC) between 1954 to 1963 in the Soviet Union, when more than 45 million hectares (Mha) were ploughed in south-eastern Russia and northern Kazakhstan in order to expand domestic food production. After 1991, the collapse of the Soviet Union triggered the abandonment of around 75 Mha across the post-Soviet states.

To assess SOC dynamics, we generated a static cropland mask for 2009 based on three global cropland maps. We used the cropland mask to spatially disaggregate annual sown area statistics at province level based on the suitability of each plot for crop production, which yielded land use maps for each year from 1954 to 2012 for all post-Soviet states. To estimate the SOC-dynamics due to the VLC and post-Soviet croplands abandonment, we used available experimental data, own field measurements, and soil maps. A bookkeeping approach was applied to assess the total changes in SOC-stocks in response to large-scale land use changes in the former Soviet Union. The massive croplands expansion during VLC resulted in a substantial loss of SOC - 611 ± 47 Mt C and 241 ± 11 Mt C for the upper 0-50 cm soil layer during the first 20 years of cultivation for Russia and Kazakhstan, respectively. These magnitudes are similar to C losses due to the plowing up of the prairies in USA in the mid-1930s. The total SOC sequestration due to post-Soviet croplands abandonment was estimated at 72.2 ± 6.0 Mt C per year from 1991 to 2010. This amount of carbon equals about 40% of the current fossil fuel emission for this territory or about 7% of global C loss due to land-use change. However, recent recultivation of abandoned croplands in Russia and Kazakhstan can lead to release more labile forms of SOC stored on abandoned lands during last two decades. Since 2001, about 80 Mt of new sequestered SOC has been lost due to current programs on agricultural development in Russia and Kazakhstan. Our results demonstrate the large effects of land-use policies and institutional changes for the national and global C budgets during the last century.