Journal of Science, Technology and Environment; ISSN: 2227-9296
Volume 5, Issue 1, Article ID 3000258, 12 pages, 2015

Carbon Dioxide Uptake on Abandoned Arable Land in Moscow Region of Russia

Romanovskaya Anna, Smirnov Nikolai, Korotkov Vladimir, Karaban' Rodion, Trunov Alexander

Institute of Global Climate and Ecology
Russian Hydrometeo Service and Russian Academy of Sciences
20B Glebovskaya Street, Moscow, Russian Federation

Abstract: The dynamics of organic carbon in soils of abandoned arable land in the Moscow region was assessed. Soil samples collected on abandoned lands of different ages, arable and virgin soil (forest biocenoses older than 50 years) in several districts. Two sampling cycles were done in 5 years. In the gray forest soils within the 15 years after the cessation of ploughing the carbon accumulation was up to 0.9% C (about 32.0 t C/ha). The soddy-podzolic loamy soil during the same period had accumulated less than 0.3% C (8.9 t C/ha), and soddy-podzolic sandy loam, on average, gained about 0.6% C (17.8 t C/ha). The first stage of regrowth on abandoned land within the same climatic region may have very high or very low productivity of biomass depending on the composition of the dominant species. In soils of young abandoned lands (up to 5 years) the relatively higher or, on the contrary, low organic carbon content compared with arable soils and old abandoned lands has been detected. In average abandoned lands in Moscow region accumulated annually 0.03±0.04 %C (0.8±1.1 t C/ha per year) for ages from 5 to 10 years, 0.09±0.015 %C (2.4±0.4 t C/ha per year) for ages from 8 to 15 years and 0.06±0.01%C (1.7±0.4 t C/ha per year) for ages from 15 to 20 years. The annual soil carbon losses due to conversion of abandoned land back to cropland were found as high as 2.4 t C/ha per year. Cumulative sequestration of the atmospheric CO_2 on the territory of abandoned land in Moscow regions estimated 25080 Gg CO_2 (6 840 Gg C) for 1990-2013.

Keywords: Carbon dioxide uptake, soil carbon, abandoned lands, Russia, climate change, greenhouse gases.

1. Introduction

Dynamics of organic carbon stocks in soils is one of the key components of the carbon cycle in the biosphere and may determine how large is the absorption and/or emission from soils. The increase in the concentration of carbon dioxide (CO_2) in the atmosphere in turn affects global warming. Anthropogenic impact on ecosystems, in particular, changes in the type of land use leads to the changes of organic carbon stocks in soils. Deforestation and cultivation of the virgin lands entail significant CO_2 emissions into the atmosphere, while the regrowth on abandoned arable land leads to a gradual restoration of the natural soil condition and the accumulation of carbon. Quantitative assessment of changes in soil carbon stocks in a result of land use change is required by the conditions of the UN Framework Convention on Climate Change (UNFCCC, 1998) adopted in 1992 and the Kyoto Protocol (1997) (Kyoto protocol, 1998). In the

Russian Federation during the last decades the conversion of the virgin lands into agricultural lands has not been conducted, and the main form of land use change is the restoration of abandoned arable land.

In accordance with the estimates of different experts, the total area of arable land withdrawn from agricultural use over the past 20-25 years, varies significantly from 9.3 million ha in the period 1990-2003 (http://faostat.fao.org/site/418/default.aspx) to 34 million ha during 1990-1995 (PankovaandNovikova, 2000). According to the latest national agricultural census of 2006 (Regions of Russia, 2006), the area of all agricultural land after 1990 decreased by 48.4 million ha, while the area of arable land - by 30.2 million ha. After 2006 the area of abandoned land has not significantly increased, accounting in 2013 about 30 million ha. Significant territory was withdrawn from arable land in the Central Federal district, North- West Federal district, the Volga region, the Urals and the Far East Federal district. The smallest total area of abandoned arable land is observed in central and southern areas of the Russian Federation where the most favorable climate and soil conditions can be found for agriculture.

The carbon content in the former arable soils (post-agrogenic ecosystems) is gradually recovering due to the cessation of alienation of organic residues, the resumption of perennial vegetation and the increase of organic material entering the soil (Luriet al., 2008). There is also enrichment of organic material in the deeper layers of the soil due to the increase of underground phytomass and more active mixing by soil fauna. The changes in soil properties and vegetation in a post-agrogenic ecosystems formed in the last two decades on the territory of spontaneously abandoned arable lands in Russia (or the former USSR) were investigated in detail in the many studies.

The total accumulation of carbon in soils of the Russian Federation as a result of land use change was estimated around 660 Mt C for the area of 34 million ha between 1990 and 2002 (Larionovaet al., 2003). According to the calculations carried out using the model ORCHIDEE (Vuichardet al., 2006), the value of the carbon accumulation in soils of the former USSR is 64 Mt for the period from 1993 to 2000 (for the area of 21.5 million ha) and 214 Mt over the next 10 years (for the area of 22.8 million ha) (Vuichardet al., 2006; BelelliMarchesiniet al., 2006). Estimates of carbon stock changes in former arable soils of Russia obtained using the RothC model showed accumulation in the amount of 248 Mt from 1990 to 2005 (Romanovskaya, 2008).

Preliminary calculations made on the basis of these studies and the few literature data (BelelliMarchezini, 2007) show that the average accumulation of carbon in abandoned ecosystems of Russia in the first 15 years of the restoration was about 245±73 g C m^{-2} $year^{-1}$. For the whole territory of the Russian Federation an additional carbon sequestration from the atmosphere within period from 1990 to 2006 estimated at 1093±326 Mt (for the area of 30.2 million ha (Regions of Russia, 2006)) or 74±22 Mt C per year (Kurganova, 2010). Thus, the additional carbon sink, due to changes in Russian agriculture after 1990, is able to compensate for about 70% of the current level of CO_2 emissions in the agricultural sector of our country (108 Mt C per year) and about 20% in the other industrial sectors (409 Mt C per year).

The aim of this work is to assess the dynamics of organic carbon in soils of abandoned lands in Moscow region of Russian Federation on the base of 5-years field research data.

2. Materials and Methods

Soils of abandoned land in the Moscow region of 7 districts were selected as objects of our research. The agricultural management (ploughing) has been ceased on these lands later than 1990. Similar research has been conducted earlier in the Novgorod region of Russia (Romanovskayaet al., 2012).

For experimental evaluation of the dynamics of organic carbon in July 2005 were collected samples of gray forest and soddy-podzolic (sandy loam and loamy) soils in 7 districts of Moscow region on arable, virgin (forest biocenoses of age at least 50 years) and abandoned soils of different age. Sampling sites of all types of studied biocenoses within one district were chose on homogeneous areas with similar soil properties and landscape. The age of the abandoned land on the sample areas in 2005 were determined by the age of self-seeding woody plants in the study area plus one year.The same fields have been sampled in July 2010 and the age of the abandonment was accepted as age determined in 2005 plus 5 years.

Plots on arable lands of Moscow region were laid on the crops of rye (Secalecereale L.), mixtures of pea (Pisumsativum L.), oats (Avena sativa L.), alfalfa (Medicago sativa L.) and red clover (Trifoliumpratense L.).

On young abandoned lands of the Moscow region in the first 5 years of regrowth dominated following species: a thistle (Cirsiumvulgare (Savi) Nen.), alfalfa, common tansy (Tanacetumvulgare L.), fireweed (Chamaenerionangustifolium (L.) Moench.), and yarrow (Achilleamillefolium L.). In abandoned lands older than 5 years the long-rhizomatous species and unconsolidated grass sod became dominant: thin bent grass, Kentucky bluegrass (Poapratensis L.), cocksfoot (Dactylisglomerata L.), and brome (BromusinermisLeyss.). On old-growth lands abandoned more than 15 years ago a timothy grass (Phleumpratense L.), foxtail (Alopecuruspratensis L.), bushgrass (Calamagrostisepigeios (L.) Roth.), turfy hair grass (Deschampsiacaespitosa (L.) Beauv.), vernal grass (Anthoxanthumodoratum L.), daisy (Leucanthemumvulgare Lam.) and the dandelion (Taraxacumofficinale Web. Subsp. Officinall) are usual. The above grass species, in addition to woody species, may also be used as markers of the age of the abandoned lands on the investigated fields.

On sites of arable fields the 10 soil samples were collected and mixed to obtain a medium sample for plough layer (0-20 cm). On abandoned lands the mixed soil samples were taken for the soil layers 0 – 0.5 (- 6.0) cm (litter), and from 0.6 (6.1) to 20 cm (layer after litter). In the forest soil were collected mixed samples of the litter horizon (0 - 8 (9) cm), humus horizon and the podzolic horizon (if was presented). For one of the trial sites instead of the mixed sample the 10 individual samples for each layer of the studied soils were taken to assess sampling and measurement error. All soil samples were sifted through by hand and dried. The total carbon content of soils was measured by the Tyurin method in modification of Nikitin(Mineev et al., 2001) in three replications. Based on these data, we calculated the average organic carbon content in soil layer 0-20 cm. The results obtained for abandoned lands of different ages were compared with the carbon content in arable soils and virgin ecosystems.

Additionally at all sites the samples were taken at a depth of 5 to 10 cm in the soil profile to estimate the bulk density of the soil. In order to investigate the dynamics and productivity of vegetation on abandoned lands of different ages the sample plots of same size 45 x 45 cm were selected where all above-ground biomass has been cut. The vegetation samples were dried to air-dry mass, weighed and the average productivity of aboveground biomass was estimated.

3. Results

The variation coefficient of the measurement of the soil carbon content in the layer of 0-20cm (including the error in the sampling and error in measurement of the carbon content in the collected samples in the laboratory) is an about of ±10.7% for soddy-podzolic soil of the Moscow region (Table 1). The error in determining the average carbon content in the litter horizon (A0) and for the lower layer of soil (A1), apparently, can be explained by the uneven spatial distribution quasirandom of organic material on the sampling areas. Error obtained in the analysis of soddy-podzolic soil (see Table 1) was accepted for the evaluation of the measurement results of the other investigated soils in the region in the 2005. During the sampling in 2010 the error has been determined separately for each field.

The results obtained in our study show that in all investigated districts of the Moscow region, the carbon content of the soil gradually increased in a sequence tillage – abandoned land – virgin ecosystem. For gray forest soils within the 15 years after the cessation of ploughing in the soil layer of 0-20cm the carbon accumulation was up to 0.9% C (about 32.0 t C/ha). For example in the Serpukhov district the carbon stocks on the arable land amounted to 1.2 ± 0.1% C (30.1 ± 3.1 t C/ha), and on abandoned lands of 14-15 years its content was as high as 2.1 ± 0.2% C (62.2 ± 6.5 t C/ha). The content and stocks of organic carbon on virgin soil were 2.8 ± 0.3% C and 76.2 ± 8.2 t C/ha respectively. On average, gray forest soils studied in 3 districts of Moscow region have gained about 0.5% C (or 14.8 t C/ha) during regrowth from arable land to abandoned land during 15-20 years. The soddy-podzolic loamy soil of 2 districts during the same period has accumulated less than 0.3% C (8.9 t C/ha), and soddy-podzolic sandy loam, on average, gained about 0.6% C (of 17.8 t C/ha) during 15-20 years after the cessation of agricultural use.

One of the results obtained in our study is the detection of relatively higher or, on the contrary, low organic carbon content in soils of young abandoned lands (age up to 5 years) compared with arable soils and old abandoned lands. Thus in the Moscow region the soils of young abandoned land (up to 5 years) at Podolsky, Mozhaisk and Kashira districts were characterized by a decrease in carbon stocks compared to arable land. In contrast, at Luhovizi, Serpukhov and Orekhovo-Zuyevo districts of the Moscow region young abandoned land had carbon stocks larger than in the arable land and in older abandoned lands. Differences can be explained by spatial variability of soil carbon. Another possible reason for the relatively high content of carbon in modern arable soils may relate to the following: prior cessation of agricultural use was for less fertile land, which was initially characterized by low carbon content. We can also assume that on loamy soils in the early years of regrowth the low-productive community of annual and biennial plants may be formed, which causes low intake of organic residues in the soil. In addition, the lack of a soil mixing in the result of plowing and the processes of podsolization – both can result in a decrease of carbon content in the soil layer 0-20cm with heavy texture within the first years after abandonment.

At the same time, the high carbon content of young abandoned land in comparison not only with arable land, but with old-growth abandoned soils (for example, at Luhovizi and Orekhovo-Zuyevo districts) can be explained by the growth of plant communities with such dominant species those have high biomass volume throughout the year (e.g., Calamagrostisepigeios). At this stage of weed vegetation on the abandoned land can be characterized by the highest productivity compared with more advanced stages of succession and that, consequently, leads to the increase of soil carbon stocks.

Basing on the results the overall dynamic of soil carbon on abandoned lands was assessed and results are presented on Figure 1.

As it is shown on Figure 1, for young abandoned lands (up to 5 years) we obtained the highest degree of uncertainty of the estimates of carbon content. That indicates the possibility of soil carbon losses in these lands compared with arable soils and old –aged abandoned lands.

The dynamics of vegetation productivity on abandoned lands in Moscow region is shown on Figure 2. On average, during the first 5-6 years of regrowth there is a sharp increase in the productivity of terrestrial biomass associated with the rapid development of annual and rhizomatous plants (weed stage). Their total annual productivity may exceed the average indicators specific to indigenous grassland communities of the considered vegetation and climatic zones. However the uncertainty (±34.7%) of the average value of biomass productivity at lands abandoned 5-6 year ago is the highest within the whole period of regrowth. Together with the change of the stage of vegetation succession, after 5 – 6-th year a mixed community of long-rhizomatous species with unconsolidated grass sod begin to form on these lands, and overall productivity of grasses is reduced. The minimal value of productivity obtained for abandoned land of 10 – 12 years age. The difference between the productivity of vegetation on abandoned lands of 5-year (5.1 t/ha) and 10-years (3.3 t/ha) old is amounted to almost 35% (to 1.8 t/ha). In subsequent years the regrowth on abandoned land leads to a gradual shift of unconsolidated grass sod species to dense grass sod and, thus, there is a slow formation of native grasslands, and subsequently forest cenoses. Accordingly, the productivity of aboveground biomass of abandoned land gradually increases, approaching the average values of productivity of virgin ecosystems for this zone (Figure 2).

In 2010 the same sampling fields in Moscow region have been investigated. We found that 2 from 20 sampled abandoned fields were ploughed again in 2010. Both these are grey forest soils in Serpukhov district with different age of the regrowth. First one was abandoned just in 2001 and was at very early stage. The carbon stocks in soil changed from 1.7±0.3% C (51.3±8.3 t C/ha) in 2005 to 1.4±0.2% C (39.3±6.3 t C/ha) in 2010 due to ploughing. Considerable losses of soil carbon (-23.3% of the initial stock) suggest that the field has been in usage for few years already and probably was ploughed in 2006-2007. Thus annual soil carbon losses due to conversion of abandoned land to cropland are from 2.4 t C/ha to 2.9 t C/ha per year. Rapid changes in carbon stocks of that soil might be linked to the accumulation of carbon in labile fast-rotate fractions of soil carbon during the short regrowth. The carbon from such fractions is lost first in a result of ploughing.

The second field we found ploughed in 2010 was in the age of 14-15 years already in 2005. That field has been ploughed only for the first two months and carbon stock changes have not shown any losses. It actually was greater of the stocks in 2005: 2.2±0.6% C (66.4±16.7 t C/ha) in 2010 versus 2.1±0.5% C (62.2±15.6 t C/ha) in 2005. Obviously soil did not have enough time to lose noticeable amount of soil organic carbon due to its management yet.

Average change of soil organic carbon in abandoned lands between the sampling in 2005 and 2010 is presented on the Figure 3. The ages of abandoned lands on that figure are years of regrowth as it was in 2005. As it is seen on Figure 3, there is a possibility of future carbon losses on abandoned lands of age of

4-6 years. That might be a result of the high variability in biomass productivity of young abandoned ecosystems (see Figure 2) and the change of stages of biomass succession to community of unconsolidated grass sod and dense grass sod of cereals with lower overall productivity.

4. Discussions

Thus, the conducted research allows us to conclude that the first stage of regrowth on abandoned land within the same climatic region may have very high or very low productivity of biomass depending on the composition of the dominant plants species. Subsequent successional stage (rhizomatous, unconsolidated grass sod and dense grass sod) partially may vary depending on the composition of plants species as well; however, in the absence of the anthropogenic impacts (fires or conversion) the composition of the vegetation and its productivity would be similar. On old-age abandoned lands (over 15 years) it is gradually forming a similar community of the indigenous vegetation with general characteristic of vegetation and climate zones.

The results obtained show that in average abandoned lands in Moscow region accumulated annually about 0.03±0.04% C (0.8±1.1 t C/ha) for ages from 5 to 10 years, 0.09±0.02% C (2.4±0.4 t C/ha) for ages from 8 to 15 years and 0.06±0.01% C (1.7±0.4 t C/ha) for ages from 15 to 20 years.

The results obtained in our study are in a good agreement with literature data for abandoned grey forest soil in Serpukhov district, which was a sink on average of 1.6 t C/ha per year (Davydovaet al., 2007). Similar results were obtained in field research performed at the Institute of Physicochemical and Biological Problems in Soil Science RAS in Moscow region as well (Kurganova, 2010). According to their data abandoned ecosystems in Russia appeared in the place of agroecosystems 4-28 years ago, currently serve as a steady sink of carbon to the magnitude of net ecosystem production (NEP) from +116 to +778 g C m^{-2} $year^{-1}$ (from 1.2 to 7.8 t C/ha). In these ecosystems the carbon losses due to soil breathing is fully covered by its assimilation by plants during photosynthesis. Ploughed arable soils are a source of CO_2 to the atmosphere (NEP ˜ -175 g C m^{-2} $year^{-1}$ (1.75 t C/ha)), and annual carbon balance on recently abandoned lands is close to zero (NEP ˜ +32 g C m^{-2} $year^{-1}$ (0.3 t C/ha)), and depending on weather conditions of the year can act as both a source or sink of CO_2.

Similar dependence has been obtained in our research: carbon balance close to zero estimated for abandoned lands of young age (up to 5 years) with possibility to lose carbon depending on particular circumstances and greater and stable carbon accumulation on abandoned lands with ages after 8 years (see Figure 3). Maximal rate of accumulation was found for ages from 7-8 to 12-15 years. In our study for abandoned lands converted back to croplands the flux of carbon to the atmosphere was estimated with the greater rate (2.4 t C/ha) than in the research of Kurganova(Kurganova, 2010)(1.75 t C/ha). The difference could be explained by the type of croplands investigated in the study of Kurganova – those were permanently ploughed soils – while in our research it was a soil recently converted to cropland.

We have estimated overall carbon accumulation on the territory of abandoned land in Moscow region for the period from 1990 to 2013. Annual rates of carbon accumulation on abandoned lands younger of 5 years were taken 0.3 t C/ha (Kurganova, 2010), for ages from 5 up to 25 the annual rates obtained in that study were used. The results are presented in the Table 2.

As shown in the Table 2 between 2012 and 2013 the net area of abandoned arable land was reduced by 4.5 th.ha. To estimate corresponding carbon flux the rate of carbon losses of 2.4 t C/ha was applied in accordance to the results obtained in our study for ploughed up soil.

During the period of 14 years (from 1990 to 2013), the cumulative uptake of atmospheric CO_2 by abandoned arable soils of the Moscow region amounted to 13.6 t C/ha (49.8 t CO_2/ha). The average annual carbon accumulation rate within the period is about 0.8 t C/ha per year (3.0 t CO_2/ha per year). Total sequestration of the atmospheric CO_2 on the territory of former arable land in Moscow regions is 25080 Gg CO_2 (6 840 Gg C) for 14 years.

References

BelelliMarchesini L, Papale D, Vuichard N, TchebakovaN,Valentini R (2006) Multiple Constrained NEP Assessment of a Natural Steppe of Hakasia (Russia). Paper presented atOpen Science Conference on the GHG cycle in Northern Hemisphere. Sissi-Lassithi, Crete, 14-18 November 2006.

BelelliMarchezini L (2007) Analyses of the Carbon Cycle of Steppe and Old Field Ecosystems of Central Asia. Dissertation.UniversitàdegliStudidellaTuscia, Italy.

Davydova AY, Kurganova IN, Macchina TNet al. (2007) Carbon Balance in Abandoned Ecosystems of Different Age. Paper presented atIV All-Russian conference "Humic Substances in the Biosphere". Moscow, 19-21 December 2007.

Kurganova IN (2010)Emmissiayibalancuglekislogogasa v nazemnyihecosystemahRossii.(Carbon Dioxide Emission and Balance in the Terrestrial Ecosystems of Russia). Dissertation.Institute of Physicochemical and Biological Problems in Soil Science RAS, Moscow.

Kyoto Protocol to the UN Framework Convention on Climate Change (1998).UN-FCCC, UNEP/IUC.

Larionova AA, Rozonova LN, Yevdokimov IV, Yermolayev AM, Kurganova IN, Blagodatsky SA (2003) Land-use Change and Management Effects on Carbon Sequestration in Soils of Russia's South Taiga Zone. TellusB(55): 331-337.

Luri DI, Goryachkin SV, KaravaevaNA,Denisenko EA (2008) ZakonomernostivivodaizoborotaselskohozyastvennuhzemelvRossiiIprocessipostagrogennogorazvitiyazalejei. (Regularities of Withdrawal from Circulation of Agricultural Land in Russia and the World and Processes of Postagrogenic Development of Abandoned Lands).In: Agro-ecological Condition and Prospects of Use of Lands of Russia withdrawn from Active Agricultural Use, pp45-71. Moscow.

Mineev VG, Sychev VG, Amelyanchik OAet al. (2001) Practicum poagrochimii: uchebnoeposobie.(Laboratory Manual on Agrochemistry: Study Book). 2nd Edition.Moscow State University, Moscow.

Pankova EI,Novikova AF (2000) Degradation of Soil Processes in Agricultural Lands in Russia. Eurasian Soil Science 33(3): 319-330.

Regions of Russia: Socio-Economic Indicators (2006). Rosstat, Moscow.

Romanovskaya AA (2008)Zapaciorganicheskegougleroda v pochvahzalejnuhzemel(Organic Carbon Stocks in Soils of Abandoned Lands).In: Agro-ecological Condition and Prospects of Use of Lands of Russia withdrawn from Active Agricultural Use, pp354-357. Moscow.

Romanovskaya AA, Korotkov VN, Karaban' RT, Smirnov NS (2012) Dynamics of carbon balance components in fallow arable lands on the Valdai Upland.RussianJournalofEcology 43(5): 373-377.

UNFCCC, UN Framework Convention on Climate Change (1998). UN-FCCC, UNEP/IUC.

Vuichard N, Belleli Marchesini L, Phillipe C,Valentini R (2006) Carbon Sequestration due to the Abandonment of Croplands in the Former USSR since 1990. Paper presented at Open Science Conference on the GHG cycle in Northern Hemisphere. Sissi-Lassithi, Crete, 14-18 November 2006.

Appendix A: Tables and Figures

Table 1.Carbon content in soddy-podzolic loam soil of abandoned land in Moscow region[a].

Soil layer		Replications										M[b]	±σ[b]	V[b], %	±m[b]	Average for upper 20 cm	
name	cm	1	2	3	4	5	6	7	8	9	10					C%	V, %
A0	2.0	2.44	2.20	2.43	2.58	2.24	2.05	2.04	1.88	2.40	2.56	2.28	0.24	10.40	0.07	1.63	10.68
A1	18.0	1.46	1.35	1.78	1.66	1.58	1.36	1.53	1.66	1.40	1.82	1.56	0.17	10.95	0.05		

[a]9 years after abandonment
[b] M – arithmetic mean, σ – standard deviation, V – coefficient of variation, %; m – medium error.

Table 2.Annual soil carbon accumulation on abandoned lands of Moscow region (Russia) from 1990 to 2013.

Year	Area of abandoned lands, th.ha	Annual carbon accumulation, Gg	Annual CO_2 sequestration, Gg
1990	13.8	4.1	15.2
1991	25.3	7.6	27.8
1992	45.0	13.5	49.5
1993	92.4	27.7	101.6
1994	100.1	30.0	110.1
1995	124.6	44.3	162.4
1996	138.9	54.3	199.2
1997	164.8	71.9	263.8
1998	177.7	99.5	364.9
1999	225.4	117.7	431.5
2000	248.5	158.9	582.7
2001	255.1	186.5	683.7
2002	263.4	233.4	855.9
2003	316.6	331.7	1216.1
2004	323.4	369.9	1356.2
2005	347.5	418.2	1533.4
2006	370.6	443.3	1625.3
2007	387.2	480.0	1760.1
2008	415.5	502.6	1842.8
2009	440.7	584.5	2143.1
2010	468.2	624.6	2290.2
2011	495.4	644.8	2364.5
2012	508.3	652.2	2391.3
2013	503.8	738.7	2708.7

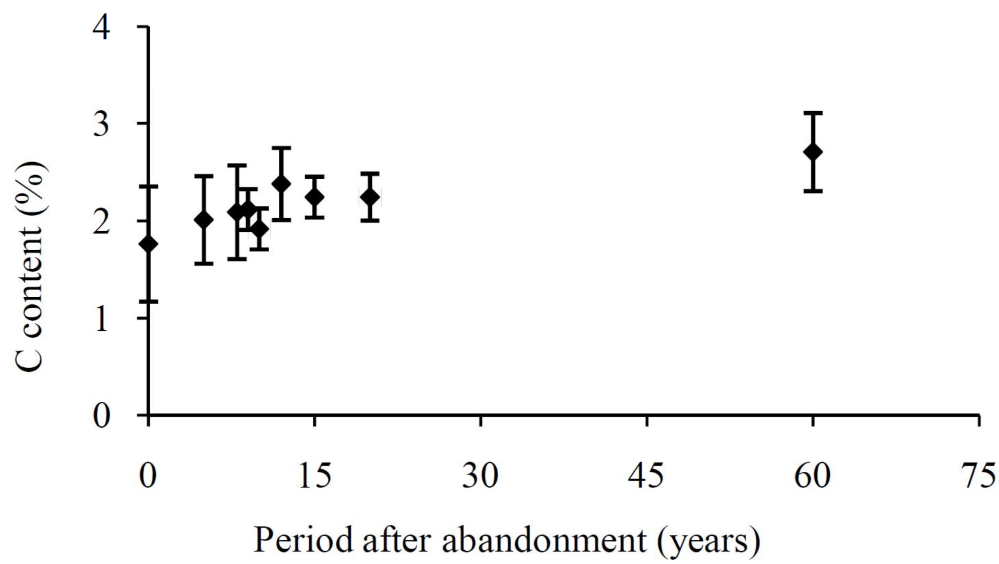

Figure 1: Dynamics of the content of soil organic carbon in abandoned lands of Moscow region.

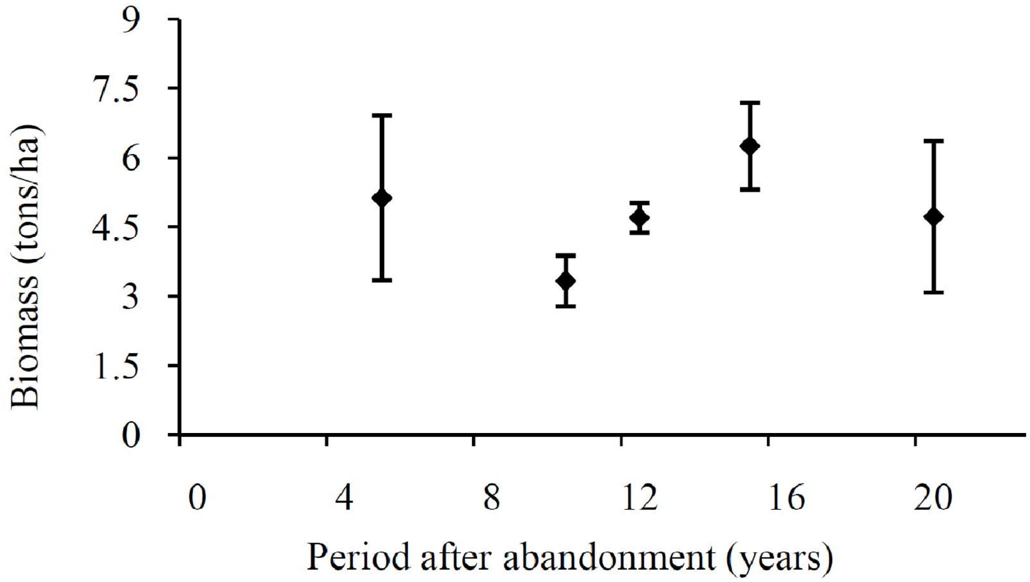

Figure 2: Dynamic of biomass productivity on abandoned lands in Moscow region.

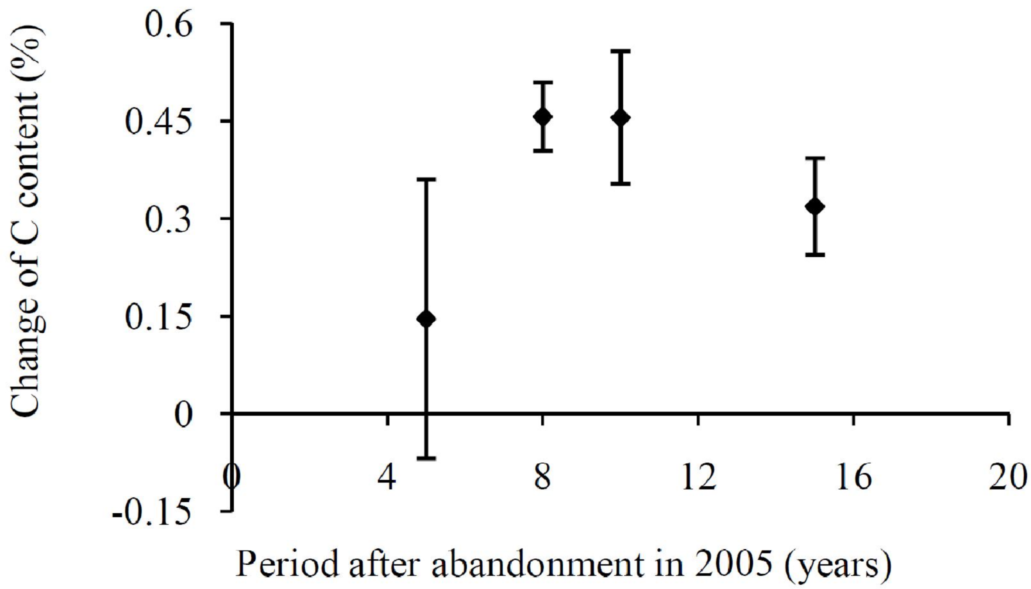

Figure 3: Average accumulation of soil organic carbon in abandoned lands during 5 years (from 2005 to 2010) in upper 0-20 cm layer, C content.