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MITIGATION POTENTIAL FOR CARBON SEQUESTRATION THROUGH FORESTRY ACTIVITIES IN RUSSIA

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ABSTRACT

The goals of the present work are to provide an assessment of the carbon budget of the Russian forests and to estimate possible carbon sequestration through forestry and land use activities. The carbon pool in living vegetation of the Russian Forest Fund has varied during the last 35 years between 33 and 35 Gt C, depending on the year. The soil carbon pool is significantly larger than the vegetation pool and varies from 178 to 184 Gt C. The annual accumulation of carbon in growing forests has increased, since 1966, from 185 to 252 Mt C per year. The amount of carbon in wood removed and logging residue decreased from 160 Mt C per year in 1966, to 70 Mt C per year in 1998. The area suitable for reforestation constitutes 45 million ha; an additional 11.0 million ha are designated for afforestation for soil protection purposes. The maximum total annual amount of sequestration due to reforestation and afforestation is 81 Mt C per year. The accumulated carbon pool in the woody biomass of newly established forest stands potentially amounts to 4.1 Gt C.

INTRODUCTION

Forests occupy enormous areas in Russia and play an important role in the global carbon cycle. Nevertheless, the problem of carbon assessment in the forest lands has not been fully solved. The few available scientific estimates are rather contradictory, especially in respect to carbon fluxes and balances [1, 2, 4, 5]. There has been no purposeful carbon inventory prepared for Russia in the past as well as the present. Special official programs to estimate the carbon budget of the country also are absent. As a result, the potential use of Russian forest lands to mitigate global change remains insignificant. The existing data on a Russian forest land inventory allows us to produce an initial approximation of the carbon cycle of forest ecosystems. The goals of the present work are to provide an assessment of the carbon budget of the Russian forests and to estimate possible carbon sequestration through forestry and land use activities.

MATHERIALS AND METHODS

The main sources of information for the present research were the Federal Forest Accounts (surveys of forest inventory data carried out every five years), the annual statistical report on forestry, and experimental information on forest ecosystem biomass, productivity and soils. The forest inventory system in Russia has a 70-year history and is relatively well developed. The Russian forest inventory information consists of

several different types of data, however, that are produced by different methods. These methods include ground observation (63% of the total area of the Forest Fund), remotely sensed information (32%) and visual observation from the air (5%). Another important characteristic is that the Federal Forest Account, being a survey of inventory information held by local forest management agencies, includes information from local forest inventories carried out at different points in time.

The pool of tree biomass carbon was estimated from the growing stock of stemwood, using conversion factors [1, 2]. The biomass of bushes, grasses, mosses, and lichens was estimated through their total area and an average carbon density per hectare. Organic carbon in the soil was assessed through the amount of humus in the one-meter top layer for different soil types and forest types. The amount of carbon sequestration in forest vegetation was estimated based on the carbon pool change in stands of different age classes. Carbon fluxes from tree harvesting were assessed using conversions factors for the relationship between biomass and wood volume. Fire emissions were determined from the type of the burned land and the amount of forest material burned in canopy fires, ground fires, and soil fires.

CARBON POOL AND FLUXES OF RUSSIAN FORESTS

The Federal Forest Account contains data on the area and growing stock of forest land with and without forest cover, as well as for non-forest lands. The area of the land categories of the Forest Fund has been relatively stable from 1966 through to 1998 (Figure 1, top panel) with 25 million ha (2%) increment between 1973 and 1978. The latest account [3] gives the total area of the Forest Fund as 1179 million ha, of which 774 million ha are covered with forest, 108 million ha are not covered with forest, and 296 million ha constitute non-forest land. The forested area has increased somewhat since 1966 while the area without forest cover has decreased. Coniferous stands dominate, covering about 70% of the total forest area. Mature and overmature forests dominate, but decreased their share from 63% to 47%. The area of young forest almost doubled since 1966, while the area of middle-aged forest increased by half. Forest land not covered by forest consists of sparse forest, burned areas and dead forest, cutovers without regrowth, and wastes and glades. The total area has decreased from 137 to 102 million ha since 1966. Sparse forest and burned areas dominate this category, making up 69 and 25 million ha, respectively. The total area of non-forest land is 297 million ha, out of which bogs make up 128 million ha.

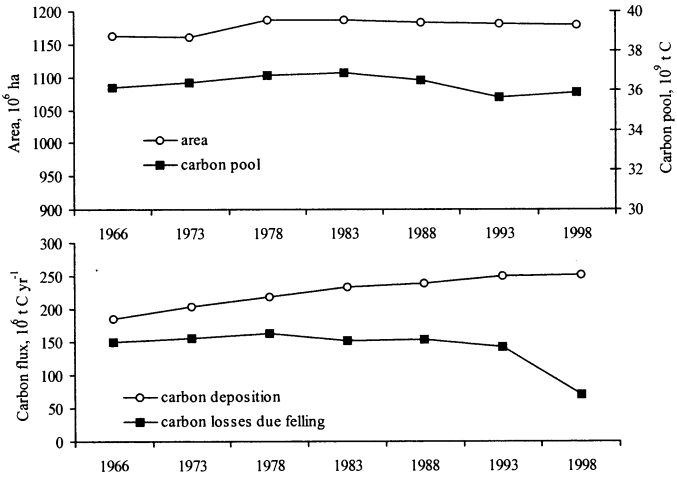

Figure 1: Dynamics of area and carbon pool in biomass (top panel), annual carbon deposition in woody biomass and carbon losses associated with felling (bottom panel) in Russian Forest Fund since 1996

The results indicate that the tree vegetation carbon pool is stable, both in size and in distribution among different forest types as classified by dominant species. The carbon pool varies between 33 and 35 Gt C (Figure 1, top panel), depending of the year of account. The soil carbon pool is significantly larger than the vegetation pool and varies from 178 to 184 Gt C. The structure of the soil carbon pool is similar to the structure of different soil types by area. The contribution of non-forest soils is comparatively large, however, as bogs are included in this category.

An important characteristic of carbon flux is annual carbon deposition in living woody biomass. This value is equivalent to an annual increment of the carbon pool in woody biomass, in the absence of harvesting, forest fires and other destructive influences. The annual deposition of carbon in Russian forests grew from 185 to 252 million tons per year (Figure 1, bottom panel). This increase is associated mainly with changes in forest age structure, but mainly with the increase in the area of young and middle-aged stands.

Logging and forest fires have significant influence on the size and changes in the Russian forest carbon pool. The harvested volume fell between 1990 and 1998 from 330 to 125 million m^3. The amount of carbon in removed wood and logging residue during the period from 1966 to the beginning of the 1990's was around 150-160 million t C (Figure 1, bottom panel). Around 86-94 million t C were removed from the forest, while 62 to 69 million t C are estimated to have remained in the forest as logging residue. By 1998, these numbers had decreased to 40 and 30 million t C, respectively.

Only part of the Forest Fund is protected from forest fires. During the period 1990-1999 between 15 and 36 thousand forest fires were registered annually within this part, covering between 0.5 and 5.3 million ha of land. The magnitude of direct carbon emissions from forest fires varies between 4 and 50 million t C per year with average level 15 million t C per year. Most of these emissions were caused by ground fires. The burned area within the unprotected part of the Forest Fund is similar to that of the protected part. It is therefore reasonable to estimate that the total emission from forest fires is approximately twice as large (near 30 million t C per year). The forest fires lead not only to direct CO_2 emissions to atmosphere but also to postfire tree mortality. The carbon flux, associated with above mortality, is approximately three times more than direct emissions [2]. It is possible estimate the postfire tree mortality flux as 90 million t C per year and total fire influence as 120 million t C per year.

The above estimations create the basis for preliminary budgeting of the carbon pool in living woody biomass. By the late 1990s, annual carbon deposition was about 250 million t C per year; the fire influence (including postfire mortality) constitutes120 million t C per year and harvesting led to carbon losses of 70 million t C per year. Balancing of these fluxes leads to the conclusion that the biomass of Russian forests increases at the level of 60 million t C per year. The above value corresponds well with the dynamics of the carbon pool during the years 1993-1999, when the pool increased annually at the rate of 50 million t C per year.

MITIGATION POTENTIAL

Reforestation means the establishment of new stands on forest land without changing its management goal (i.e. its land use classification). The carbon sequestration potential of reforestation depends on the area and productivity of the stands created as well as the method by which they were established. Several types of forest land are considered suitable for reforestation: cutovers, burned areas within the zone protected from forest fires, forests that are sparse due to human intervention, wastelands and glades. The latest Federal Forest Account [3] estimates the area of these at 45 million ha. On 30 percent of this, reforestation is only possible by means of artificial regeneration. The remaining 70 percent are considered suitable for aided natural regeneration. An additional 11.0 million ha are designated for afforestation for protection purposes, according to the Federal program for increasing soil productivity. These stands can only be established by artificial means. When calculating the carbon potential of reforestation and afforestation, the productivity of the stands established by promotion of natural regeneration was assumed to equal that of natural stands. The productivity of artificial forests was assumed to equal that of already established artificial stands. The period of establishing these new forests was assumed to be 25 years, with equal areas being treated each year. The accumulated pool of carbon in these stands was assessed over a period of 80 years.

The annual carbon sequestration due to reforestation and afforestation grows continuously as an effect of an even growth in area and an exponential growth in tree biomass (Figure 2). Established stands reach their highest rate of carbon sequestration at the age of 50-60 years. The maximum total annual amount of carbon deposition due to reforestation and afforestation is 81.4 million t C per year, of which, afforestation (planting of protection forests) accounts for 31.1 million t C per year. This means that the carbon deposition capacity of Russia's forests can potentially be increased by more than a quarter. The accumulated carbon pool in woody biomass of newly established forest stands potentially reaches 4.1 Gt C towards the end of the 80-year period, not counting soil and debris carbon (Figure 2). This is more than 10 percent of the current pool of carbon in woody biomass in Russia.

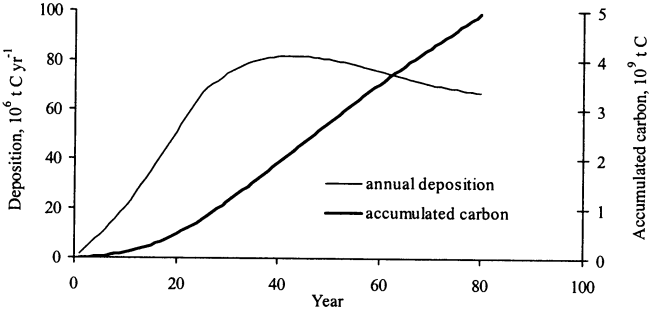

Figure 2: Trends of annual carbon deposition and accumulated carbon pool as a potential result of reforestation and protective afforestation in the Russian Federation

To realize the potential described, the reforestation activity must implement 1.3 million ha per year by aiding natural regeneration and 0.9 million ha per year by planting. Actual levels (1999) are 0.71 and 0.25 million ha per year correspondingly. Note, that ten years ago, the level of reforestation activity was much higher: 1.26 million ha per year for promoting and 0.56 million ha per year for planting. Increasing of reforestation activity and afforestation is connected with availability of funding, including international projects in the field of mitigation of global change. Russia has some examples of successful international projects on carbon crediting of forestry (Saratov and Altai regions).

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