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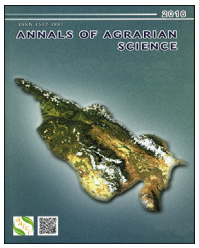

Carbon stock sequestered from the atmosphere by coniferous forests of Eastern Georgia in conditions of global warming

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ABSTRACT

As well as worldwide the acceleration of extreme climate events, directly related to climate change, is observed in Georgia. The warming process is continuing, which may result in significant changes in forest expansion and forest diversity. Unfortunately these processes are already under way.

In the present study we assessed the total biomass stocking in the pinewood cenosis in East Georgia and the carbon stock sequestered in it from the atmosphere.

In Eastern Georgia pine-dominated forests make 66.7 thousand hectares, thus amounting to 72.6% of pinewood in Georgia. The total biomass of pinewood cenosis makes 8.74 Tg, where 4.45 Tg of carbon (is sequestered. In the above-ground and underground biomass of the primary floor 3.04 Tg are sequestered, in the shrub layer (underbrush, young plants) – 350.8 Gg; in the herbaceous layer – 10.4 Gg and in the forest floor there are 1.05 Tg of carbon. Average annual growth of pinewood biomass makes up to 123.7 Gg and annual carbon accumulation is 59.6 Gg. In the living biomass of pine-tree forests of East Georgia annually up to 220 Gg of carbon dioxide is sequestered.

Introduction

Today, climate change is one of the most significant problems on our planet. The process of global warming on Earth is developing even more intensively, than it was predicted. In 1990–2014 CO_2 concentration in the air increased for 36% followed with abrupt changes of climate conditions [1].

Expected danger of global warming has significantly increased the role of a forest as possible sink in the carbon global cycle. If greenhouse gas emissions increase with the existing rate, CO2 concentration is expected to reach 495 ppm in the near future [2]. According to climatological estimates

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irreversible processes will start if the warming process does not slow down in conditions of increase of the air temperature for 2 °C [3].

Numerous intergovernmental summits and conferences are dedicated to this problem. It is worthy to mention the Summit held in Paris in December of 2015 and XXI Climate Change Conference, where participating countries undertook the liability to reduce greenhouse gas emissions [3]. Georgia undertook a liability to reduce greenhouse gas emissions for 15% and in case of pecuniary aid – up to 25%. The Conference calls to undertake measures for reduction of anthropogenic emissions and intensification of CO_2 absorption. Role of forests in the atmospheric carbon sequestration process is extremely significant for this purpose [4,5].

As well as worldwide the acceleration of extreme climate phenomena is observed in Georgia (storms, gales, floods, avalanches, landslides, thermal waves), directly related to climate change processes [6,7]. The warming process is continuing, which may result in significant changes in forest expansion and forest diversity. Unfortunately these processes partially are already under way.

Objectives and methods

Guidelines [8,9] and Instructions [10] of the Intergovernmental Panel on Climate Change include typical methods of estimation of greenhouse sources and flows, used when there are no better data and methods available, but it is emphasized that it is always better to use local, so-called national data and existing methods, stipulating country's specifics.

Estimation of phytomass and carbon resources of the stands' overstory was done according to the conversion-volumetric method [11–13]. Namely pinewood area and wood stock indicators, per specific age groups, were taken from forest management data. Stock (in m^3) of pine biomass compartments (trunk, branches, green mass of the crown) were derived by using biometric tables [14], root biomass is calculated according to FAO recommendations [15]. Biomass fractions and sequestered carbon stocks are calculated by multiplying their stock indicators (in m^3) with density of the wood substance of the respective species [ρ, in $Gg \cdot m^{-3}$] and applying the biomass to carbon conversion coefficients.

Annual growth of biomass and carbon stock in conifer forests was assessed by the method used in inventory taking; namely, calculated differences between wood stock volumes of adjacent age groups are divided by respective group's age interval and in that way an annual wood increment ($m^3\ y^{-1}$) is calculated per each age group. Received data are translated into biomass and carbon annual growth by using density and conversion coefficients [10,16,17]. Root growth was estimated following the method recommended in the "Guidelines" [10].

Assessment of the biomass and sequestered carbon for the young growth and underbrush was made by weighting method: the biomass weight of trunks, branches and leaves were taken from model trees (n = 10). (in absolutely dry condition) which the was multiplied by number of trees, wood density and a conversion factor for carbon (k = 0.45).

The herb layer biomass and carbon contained in it was assessed in the following way: the strata were mowed in each of the 10 sample plots. The resulting biomass was weighed after over-drying (~105 °C). The numbers were adjusted according to percentage of cover. A conversion factor to carbon was used (k = 0.45).

Carbon stock was assessed in the forest floor dead biomass, $t \cdot ha^{-1}$, by multiplication of forest floor stock, coverage percentage and conversion coefficient (k = 0.579) [18–20].

The object of the study were pine forests of the Forest Fund of the Samtskhe-Javakheti Forestry Service. Namely pine-dominated forests of Borjomi-Bakuriani, Adigeni, Akhaltsikhe, Aspindza and Akhalkalaki Forest Fund tracts.

Results and analysis

The total area of forests with dominating *Pinus sosnovskyi* in Georgia amounts to 91,886 ha with stock being 10.995 million m^3 [21]. Pine-dominated forests lands predominantly are situated in the comparatively more continental sites of Eastern Georgia (Samtskhe-Javakheti, Mtatusheti), making in total 66,721 ha (72.6% of Georgia total) with stock being 8.073 million m^3 (73.4%)

Total biomass and carbon stock of pine forests were studied in the Samtskhe-Javakheti Region as the region is the richest one in pine forests. Currently pine-dominated stands amount to 58.2% [22] of pine forests in Eastern Georgia. Samtskhe Region needs to be especially emphasized in this respect.

The amount of biomass and carbon stock in the forest overstory directly depends on the age of the stand, stand density and bonitet class i.e.eventually on the forests' total wood stock. As for the understory layer. with the underbrush and young growth. Its biomass depends on stand's canopy openness and location-based plant growth conditions. But this interrelation is less predictable. Participation of young growth, especially underbrush, in forests of one and the same type is variegated.

In pine-dominated forests biomass and carbon stock of underbrush and young growth is classified in five age groups (young, middle-aged, pre-mature, mature and over-mature) and also per type of forests.

To establish biomass and carbon stock of understory, and also for soil's live and forest floor's dead covers we selected 34 sample areas within pilot regions with typical soil conditions, namely pinewoods of the Borjomi-Bakuriani Territorial Forestry Service, Borjomi State Reserve and Adigeni Forest Area. Their total area is 23,592 ha amounting to 35,4% of total area of pinewoods in Eastern Georgia. This allows generalizing the data in order to get estimates for pine forests of Eastern Georgia.

In order to calculate masses of different forest components (trunk, branch, leaf, soil live and forest floor) country or region specific allometric functions are needed [5]. However in Georgia such specific functions do not exist. Therefore for this study we used literature values and data obtained from the field works.

According to Gigauri [23] one of the most significant determinants of biological diversity of forests in Georgia, as well as in other countries, is the dynamics of accumulation of