Facing Climate Changes: Forest Carbon Stock in Ukrainian Polissya and Disturbances Impact

Andrii Bilous, Viktor Myroniuk, Maksym Matsala, Petro Dyachuk

Department of Forest Mensuration and Forest Management, National University of Life and Environmental Sciences, UKRAINE, Kyiv, Heroiv Oborony 15, E-mail: bilous@nubip.edu.ua

Under increasing pressure of negative changes in climate and land use temperate forests continue to provide carbon sequestration. We examined impact of natural disturbances and harvest on forest carbon stocks in Ukrainian Polissya, using ground-based and remote sensing data. Those account for 21 % of total C emission from study area.

Keywords – ecosystem services, climate change mitigation, remote sensing, wind breakage, wildfires, insect outbreaks, timber harvest.

Introduction

Global warming, being actively discussed for the last decades, is likely to demand broader understanding of crucial role of global forest cover that can mitigate negative consequences of climate changes [2]. Temperate forests remain in special focus of internetational society: its possibility to being net carbon sink is hitherto uncertain. Moreover, carbon offsets, comparing to croplands, still can be overcome by differences in albedo and evapotranspiration parameters. Natural disturbances and timber harvest, including salvage, sanitary and illegal loggings, might substantially influence on forest ecosystem services, including carbon sequestration. Such alterations, as well as land use changes (including afforestation through natural successions), define carbon balance on local, regional and national spatial scales [4].

Forests of Ukrainian Polissya, being a part of Mid-Latitude ecotone, are definitely important, considering economical, social and ecological values for entire East European region [1]. Facing increasing pressure from emerging interactions between climate changes and natural disturbances, those need strict and reliable examination of all factors that cause substantial impact on forest carbon cycle if climate mitigation targets are wanted to become credible [2].

Method and Data

Estimation of forest biomass compartments for further examination of local carbon stocks was carried out on experimental polygon (area – 45 km^2) established in Snovsk district of Chernihiv region. There are three main tree species in the study area: Scots pine (*Pinus sylvestris* L.), Silver birch (*Betula pendula* Roth.) and Black alder (*Alnus glutinosa* L.), admixtures of aspen, oak and others also were considered. Own research-based forest inventory was conducted within units of three local forest enterprises. Round (r = 12.62 m) and square sample plots were established, with aim to collect more precise estimation of biomass compartments.

Developed models were used for estimation of biomass in dry weight: for live components (stemwood over bark, foliage, branches and roots) and dead (snags, logs, litter of coarse branches and fine litter). Carbon stocks were examined, using guidelines of Intergovernmental Panel on Climate Change. For estimation of carbon fluxes and stocks due to method by Shvidenko et al. (2014) [1], data of Mukhortova et al. (2015) [3] was used (assessment of hetherotrophic soil respiration, HSR), while Shvidenko et al. (2014) [1] models were taken for calculation of net primary production (NPP).

Ground-based forest inventory data (FID) was harmonized with remote-sensing (RS) data. With use of two high-resolution satellite imageries (Spot-6, acquised in 2010 and Sentinel-2, acquised in 2015), carbon stocks and fluxes were mapped for 5-year period. For land cover

classification and biomass modelling in RS data, RandomForest package and *k*-Nearest Neighbours (*k*-NN) method through yaImpute package in R system were used.

Data on harvest and natural disturbances (wildfires, wind breakage and insect outbreaks) were obtained from FID. Forest stands, damaged by storms and bark beetles, then were typically harvested with salvage loggings. Burned sites in young forests remained untouched. Data on afforestation on abandoned agricultural lands was obtained from RS evidence.

Results and Discussion

For the studied period (2010-2015), forest ecosystems within the experimental polygon were the net carbon sink. Flux-based method has shown well agreed results between FID and RS data: net C annual gain is 5.4 Gg C $year^{-1}$ and 5.6 Gg C $year^{-1}$, respectively. Difference between outputs, obtained via stock-based method, is sighnificantly higher: increasing of C stock is 0.7 % (FID) and 16.2 % (RS data). Total C stock in 2015 is 567 Tg C (FID) and 592 Gg C (RS), where live biomass (27 %), coarse woody debris (1 %) and soil (72 %) carbon accounts for.

Natural disturbances and harvest cause 21 % of carbon emission for study period, with following composition by agents: 57 % – harvest, 34 % – storm, 6 % – bark beetles, 3 % – wildfires. Wind breakage of high severity in 2013 turned local forests into net carbon source for one year (Fig. 1). Substantial forest afforestation, observed by RS data, was not considered in the forest fund of local enterprises, thus on Fig. 1 only official reforestation is presented.

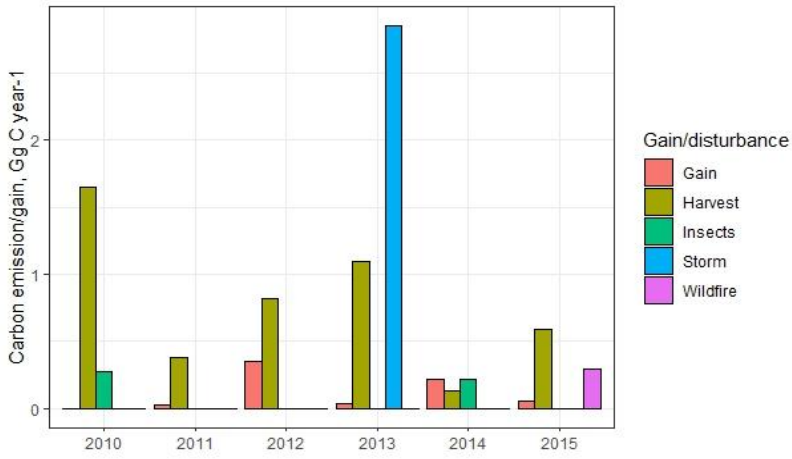

Fig.1. Composition of natural disturbances, harvest and reforestation within study area.

That is, understanding of processes that encompass and affect carbon sequestration capacity on such local scales, might help to broad knowledge for climate change mitigation efforts and sustainable development implementations in Ukrainian forests.

References

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