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[1.]Norbert BARA, [1.]György DEÁK, [1.]Lucian Augustin LASLO,
[1.]Monica Silvia MATEI, [1.]Mădălina Georgiana BOBOC, [2.]Cristina Ileana COVALIU

SIMULATING CARBON DYNAMICS IN A WARM TEMPERATE MOIST FOREST UNDER A BUSINESS-AS-USUAL SCENARIO – CASE STUDY

[1.]National Institute for Research and Development in Environmental Protection – INCDPM, ROMANIA
[2.]POLITEHNICA University of Bucharest, Faculty of Biotechnical Systems Engineering, ROMANIA

Abstract: This article presents the application of a methodology for estimating carbon dynamics from a forest, in a case study from Romania under a business-as-usual scenario. The results contain the carbon forecasts from the European Scenario Model for European Forest Information software. Based on the input parameters that mainly were determined based on the information from the forest management plan of the study area, the results of the simulation encompass the carbon dynamics in aboveground and belowground biomass, as well as in the harvested timber.

Keywords: carbon, EFISCEN, forests, climate change, sustainable management

1. INTRODUCTION

Climate change is affecting the sequestration capacity of the trees and the vegetation is reacting to high CO_2 levels by increasing photosynthesis and decreasing evapotranspiration (Al-Anezi et al., 2008; Cramer et al., 2001). However, as a result of climate change and ecosystem degradation, the stored carbon is at risk of being released into the atmosphere (Field et al., 2014). Another important sink considered in this study is the belowground biomass, due to its capacity of storing approximately two-thirds of the carbon from forests (Goodale et al., 2002; Nave et al., 2010). Soil C accumulation is significant not just for its involvement in the global C cycle, but also for its impact on forest production (Nave et al., 2010).

Sustainable forest management is widely recognized as one of the most cost-effective climate change mitigation techniques for increasing forests' capacity to store carbon (Pache et al., 2021). Therefore, forest stand information is essential to understand the carbon dynamics trends and how these are changing due to the different ecosystem processes (i.e., growth, disturbances, mortality and management practices) (Bara et al., 2020). At European level forests sequester yearly approximately 10% of the greenhouse gases (GHG) emissions (EEA, 2019; Gren et al., 2018). Thus, forests sequester significant quantity of C that is absorbed through photosynthetic activities, however by deforesting and decreasing forest areas, large amount of C may be released into the atmosphere (Van der Werf et al., 2009; Milionis et al., 2019).

Understanding C dynamics necessitates the development of techniques at subnational level (Mertz et al., 2018). Thus, the aim of this study: to analyse the carbon dynamics in a forest under a business-as-usual scenario using The European Scenario Model for European Forest Information (EFISCEN). The carbon stocks were calculated using the aforementioned model and empirical growth data from the investigated area's management plan. EFISCEN is running on matrices that contain data on forests, usually taken from national forest inventories (Mason and Meredieu, 2011).

2. MATERIALS AND METHODS

From a geographical point of view, the study area is situated in the Moldavian Plateau in eastern Romania (figure 1). The region is dominated by non-irrigated arable lands, followed by grasslands (pastures) and forestland, each with an area of approximately 10000 ha. With a continental climate, the region is characterized by mild to extremely hot summers and moderate to extremely cold winters.

The model used in this study, the European information Scenario Model (EFISCEN) was developed to generate scenarios in order to provide baseline forecasts of European forests (Bostedt et al., 2016). Thus, scenarios may be generated to develop an understanding of the outcomes, for example, of the management practices that are undertaken in a given forest or of the climate change. In order to achieve as accurate results as possible, the input data is comprising information from the management plan of the study area. Based on this, matrices were generated comprising data regarding the state of the forest (i.e., distribution by age classes and volume classes, area and growth). In order to cover a longer timeframe, the simulation starts in 2015 and ends in 2065.

It is crucial to analyse the management practices, since the way the practices are implemented can decrease the capacity of the forests to sequester carbon dioxide, thus, along with its degradation exacerbating global warming (Andronache et al., 2017). Three types of management practices were identified: thinnings, final fellings and no intervention. The harvest periods were determined based on the information from the management plan for each subunit of production (SUP) (table 1). The SUP can be described as follows: SUP A is considered to be regular forest, with common varieties of tree species, SUP Q is formed mainly by Robinia pseudoacacia, within SUP O are forest areas that are going to be returned to their initial owners, SUP K is seed reservation and SUP M and E are forests under special conservation and forests subject to integral protection regimes. Therefore, the simulation has one main region, a forest district with 5 SUP and 4 types of wood (Hardwood, Softwood, Coniferous and other types). The input data contains the age class structure, area, average volume and the current annual increment on age class. The area is used from the management plans and the latter two data were determined using the volume and increment from the same management plans. The aforementioned data were organized in matrices with 7 age classes and 10 volume classes.

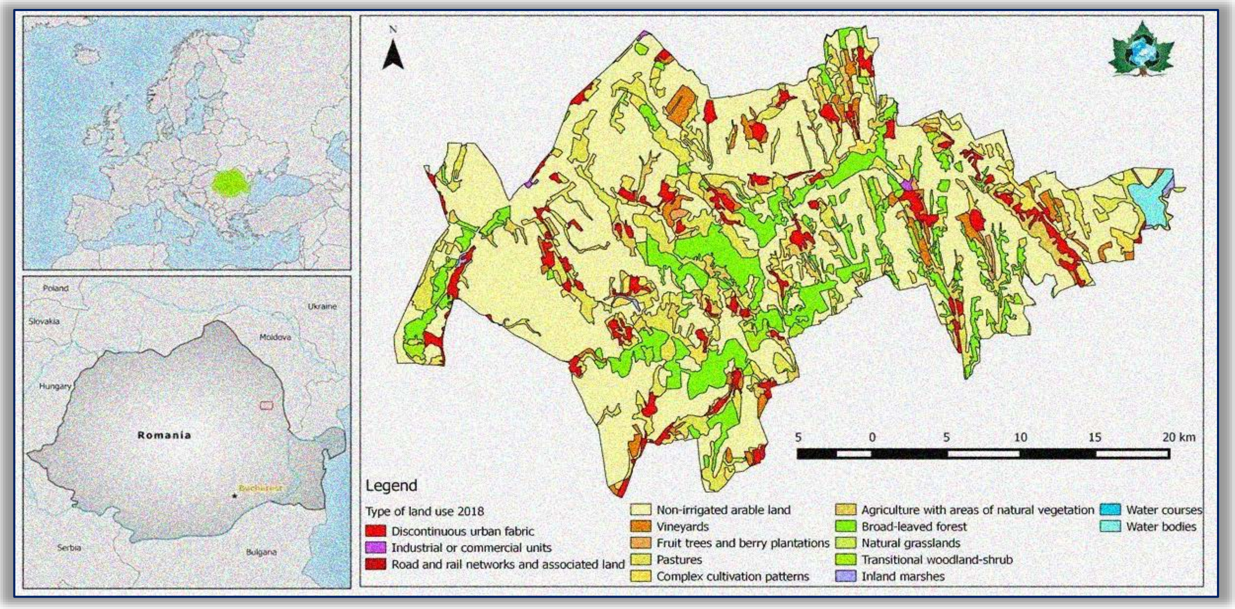

Figure 1 - The study area localization and the types of land cover. The most abundant tree species are oaks

Table 1. The rotation periods used in the simulation

SUP A				SUP Q				SUP O				SUP M+E				SUP K			
HW	SF	C	O	HW	SF	C	O	HW	SF	C	O	HW	SF	C	O	HW	SF	C	O
Age of Harvest (years)																			
Min 97, Max 110				Min 24, Max 25				Min 97, Max 100				0							
Thinning Range (years)																			
Min 20, Max 110				Min 20, Max 25				Min 20, Max 100				0							

Note: HW = Hardwood, SF = Softwood, C = Coniferous, O = Other types of wood

The growing parameters were calculated based on the formula developed by Schelhaas et al. (2007). The biomass share was determined using biomass expansion factors from different studies measurements (Wiedemann, 1936/1942; Wirth et al., 2004; Blujdea et al. 2012; Le Goff and Jean-Mark 2001; Ionescu et al., 1967).

3. RESULTS

The beginning of the simulation proves to contain the highest carbon content, both in soil and aboveground biomass (Figure 2). After this period, the carbon content decreases. Beginning in 2030, forest carbon stocks in living biomass are expected to have a steadily declining sink capacity, resulting in significant changes in residual carbon stocks (Deng et al., 2016; Lewandrowski et al., 2014; Ciceu et al., 2019).

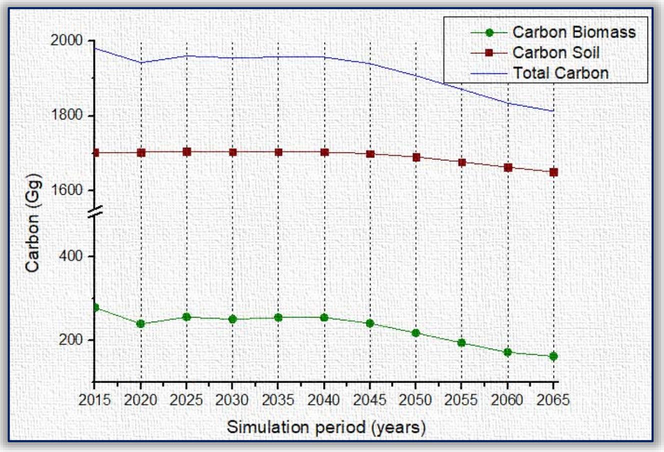

Figure 2. Carbon dynamics in aboveground biomass, soil and the total carbon sequestered in the aforementioned pools

The aforementioned fact, can be observed in this study. However, the decrease was observed to start in 2040, both in aboveground biomass and soil. By the end of the simulation, trees will sequester 2523.93 Gg of carbon and in the soil will be stored a total of 18598.49 Gg of carbon.

EFISCEN offers the possibility to analyse the carbon content even at tree compartment levels (Figure 3). The highest carbon content is sequestered in the stem of trees, followed by the branches coarse roots and the lowest carbon content is sequestered by the fine roots.

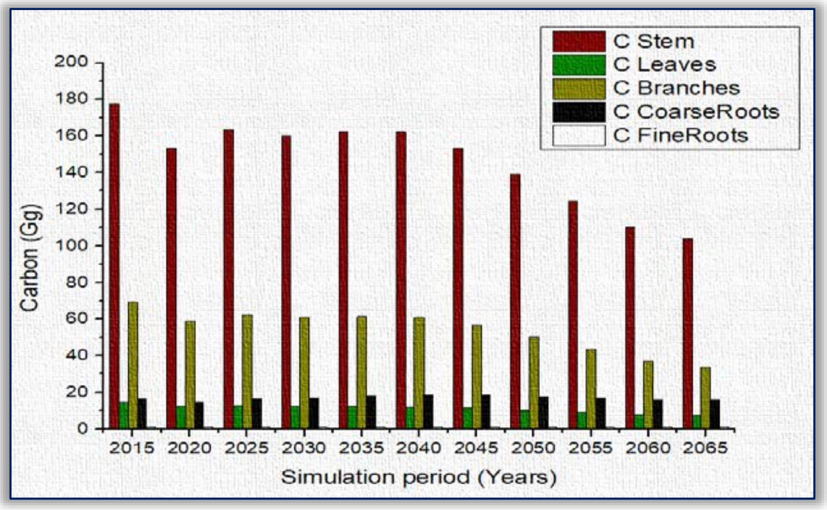

Figure 3. Carbon sequestered in tree compartments

In order to understand the fluctuations in the carbon content in aboveground biomass, it is important to analyse the management practices (Figure 4). Thinnings are undertaken in the first part of the simulation, followed by fellings. The highest volume of carbon removed through thinnings was simulated in 2020 and through the fellings the peak is in 2060. The highest volume of carbon removed in thinnings is 44.95 Gg C and in fellings is 70.39 Gg C. Thus, through the management practices, a total of 628.57 Gg C is removed from the forest.

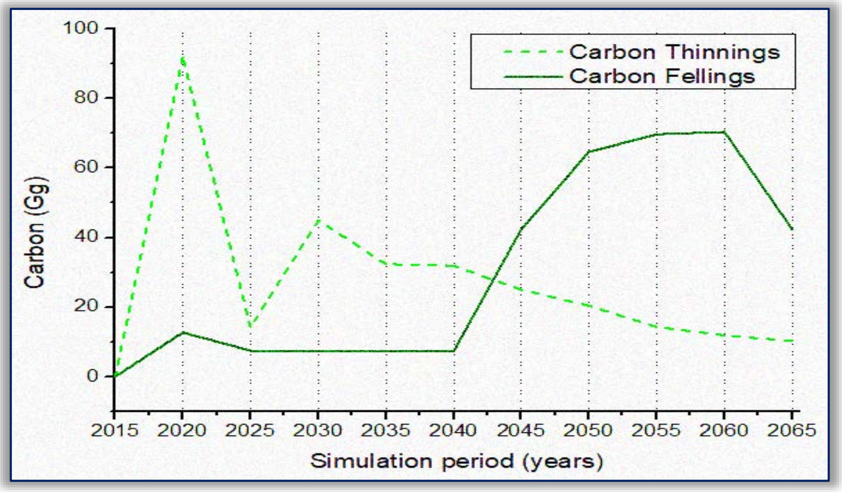

Figure 4. Carbon dynamics in management practices

4. CONCLUSIONS

Within this study the results of a method for estimating forest carbon dynamics are presented. The European Scenario Model for European Forest Information software was used. The input data is based on the management plan of the studied area. This fact increases the confidence level of the results. Thus, making this approach suitable for developing future simulations in order to compare the results with in-situ measurements, other scenarios and to develop future climate change mitigation strategies.

It has been found that in the belowground biomass is sequestered with almost 14% more carbon than in the aboveground biomass. The total carbon content sequestered in the studied area, both in belowground biomass and in aboveground biomass, is 21122.43 Gg C. The management practices influence the carbon content. Therefore, through thinnings a total of 296.93 Gg C are removed and through fellings a total of 331.637 Gg C.

This approach may be utilized to create a methodology for improving the accuracy, quality, and predictability of reporting approaches. However, it is crucial to develop other scenarios in order to identify the best management approach in terms of sustainability and climate change mitigation.

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