FOREST GHG MANAGEMENT

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1. Introduction

Emissions of greenhouse gases have increased in all industrialized countries (Wolff 2011) despite the fact that these countries have signed international protocols that requires them to reduce emissions. Efforts are needed to increase the carbon storage in forest ecosystems (forests) and others (eg. Pastures, hayfields) acting as carbon sinks. Carbon dioxide is the gas with the largest contribution to the greenhouse effect quantitative role in mitigating forest ecosystems. The first IPCC report (International Panel on Climate Change), Houghton et al. (1992) suggested that an aggressive mitigation strategy by creating forests by planting at a very high (one billion hectares, over 130 times the forest area of Romania), while stopping logging (deforestation) could result in the absorption of 0.5Gt of carbon per year after 2050. The idea to balance GHG emissions through forest policy is interesting, however, faces several obstacles. First, the contribution of forest ecosystems to carbon storage, or their ability to capture and sequestration, are not known with precision. Secondly, researches conducted in this area have shown the ability to capture and storage is dynamic and can potentially be affected by climate changes. These gaps served as motivation for several projects worldwide (eg. CarboEurope, http://www.bgc-jena.mpg.de/public/carboeur/). However, the most important issue of GHG emissions reduction plan is that forests are not managed to be sinks or stocks of carbon, forest management being rather optimized for the production of wood or of diverse environmental purposes (eg. protect land). The effect of measures of forest management on carbon stock and its storage capacity is less documented, being only recently the center of attention. EU-funded project FP7 "GHG Europe" (www.ghg-europe.eu) aims to determine how and to what extent the carbon cycle GHG emissions from terrestrial ecosystems can be managed through proper management of ecosystems. In this project, the Forest Research and Management Institute has the task of studying the impact of land management on regional GHG balance in selected regions rich in information, in Europe. To study the impact on the budget management of GHG was constituted a gradient of forest management in beech, with controled soil conditions and minimized counfonding factors.

2. Obiectives

The project aims to determine the impact of forest management on GHG fluxes of forest ecosystems by extending the gradient constructed within the project FP-7 “GHG Europe”. This includes specific situations present in Romania, but otherwise quite rare and undocumented.

The gradient of GHG project management built within the project GHG Europe is developed for beech, which is the main species in Romania in terms of standing volume or growinsg stock. This species is, at the same time, widespread in Europe, with great economical and ecological relevance at national and European level. The gradient currently consists of 12 sample plots representative of the current management of forests, with the only contrasting elements being the frequency and the intensity of the silvicultural interventions.

The lack of extreme conditions can be reported as a shortcoming of this gradient: lack of natural stands - stands "control" true reference for any study of management (management). Romania, with over 200,000 ha of natural forests is an appropriate place for such a study. In addition, there is a controversy in the scientific world about the secular forests and their ability to function as carbon traps (Knohl et al., 2003, Luyssaert et al., 2008, Wirth et al., 2009), many researchers considering these forests as rather neutral on carbon flux. The acquisition of experimental data of the project will allow further clarification of the status of natural forests in Europe and their behavior vis-à-vis GHG flows. In this sense, the objective is to obtain data from experimental measurements of flow and fund GHG.

Phases' objectives. The goal of this phase was to set up permanent sample plots, which were installed for monitoring the greenhouse gas fluxes, supporting the dendrometric measurements required to estimate the carbon stocks (above ground) and start the gas flux measurements monitoring.

3 Results

3.1 Method development. The greenhouse gases studied are the carbon dioxide, methane and nitrous oxide. Among these three gases, in terms of physical properties, nitrous oxide is the one that presents the greatest capacity to capture ultraviolet radiation: global warming potential (GWP) is 298 times higher than the dioxide carbon (Lashof & Ahuja, 1990). Dioxide is - absolutely - the two most important molecule in the greenhouse effect, as water vapor, despite a low global warming potential. Methane has a GWP's value much higher than CO2. Studied gases are therefore the most important contribution to the greenhouse effect.
The fluxes of carbon dioxide and methane are part of the carbon cycle (Schulze et al., 2011). The ecosystems' carbon budget is based on three main streams: the input - through photosynthesis, the allocation and output. Carbon budget can be estimated by monitoring the flux, being widely used method "Eddy covariance". In this method, the gas flows exchanged (emitted or absorbed) between ecosystem and atmosphere are measured directly using air concentration analysis apparatus located above the tree canopy, with some micro-meteorological measurement devices. These devices - and associated tower - are very expensive and do not allow further analysis of surfaces. Although this was considered the reference method for estimating carbon stock at the stand, recent research has shown its limits and especially tend to overestimate the amount of carbon absorbed (Curtis et al., 2011).
The budget may also be expressed as the difference between the stock observed at two different times. This approach is the least expensive and currently the only one allowing the analysis of a great number of plots simultaneously. The principle is to convert measurable characteristics of trees into carbon stock.

3.2 Estimation of carbon stocks. The measurements required to estimate carbon stock of a stand are classical allometric measurements. To transform the amount of biomass estimated into carbon stocks, in the absence of more specific estimations, we used the classic 0.5 transformation factor. Of course, there is some deviation in the amount of carbon per unit volume of wood (g C per g of biomass). But the error in the estimation of the amount of carbon far exceeds the error resulting from the simplification is the use of a constant coefficient for conversion of biomass carbon (Joosten et al., 2004).
The measurements made on living trees carried out in a systematic inventory typical diameter and tree height were recorded for each area. To estimate the amount of carbon in dead wood, measurements are more complicated because the decay status influences the amount of carbon that remains in the wood (Olajuyigbe et al., 2011). The inventory should be made taking into account the quantity and quality of dead wood, which is done typically by classifying the dead wood into decomposition classes.

In the Giumalău secular forest, the amount of dead wood is very high (Figure 1) and has a high degree of spatial variability within the plot studied. Here, we studied the relationship between the degree of decomposition and the wood density. This study was needed to convert the quantities of carbon stored in the deadwood. The study was published in a scientific article (Teodosius & Bouriaud, 2012).

Figura 1 Plot 1 in Codrul Secular Giumălău. Note the large amount of deadwood.

The specificity of natural mountain spruce forests is precisely the great quantities of dead wood, which is a mediator and a support of biodiversity. From the biomass estimations made, it was noted that the stock was the largest in natural forests of beech (Table 1). The amounts of carbon stored in natural beech stands is indeed the greatest (with ca. + 70%). The effect of management is very significant: natural forests sequester 50% more carbon than the cultivated ones..

Tabelul 1. Comparative values of the quantities of carbon stored in trees studied:

Region	Plot type	Max biomass of a single tree (t)	Biomass mean/tree	Biomass living trees ($t.ha^{-1}$)	Biomass dead wood ($t.ha^{-1}$)	Total biomass ($t.ha^{-1}$)
Vest (Nera)	1 - natural	9.36	1.48 ± 1.63	458.35	20.78	479.13
	2 - natural	8.63	1.21 ± 1.43	488.77	52.61	541.38
Vest (Văliug)	3 – cultiv.	1.95	0.91 ± 0.39	306.72	9.13	315.85
	4 – cultiv.	2.42	0.93 ± 0.53	166.98	7.52	174.50
Est (Giumălău)	1 - natural	4.89	1.55 ± 1.43	228.82	84.59	293.41
	2 - natural	5.95	1.26 ± 1.19	245.54	74.42	309.96

3.3 Estimating carbon stock dynamics. The estimations of carbon stocks in the forests studied used a methodology based on dendrochronology (Cook 1987). Unlike the classical dendrochronological studies, the estimation of the carbon stock dynamics do not focus on dominant trees and the variations reflected by the annual ring width variability are not standardized to remove some internal factors such as age. The sampling conducted in the reconstruction of radial growth at the stand must take into account the high degree of differentiation in the growth rate of trees that are not focused on a small number of large trees, but trees include all sizes. Systematic sampling is the most appropriate, in this case. An adequate method of sampling and data processing devoted to reconstruct the productivity of stands (in the carbon balance) was therefore developped and is described in detail in Babst, Bouriaud & Frank (2012) and applied in the project stands studied (Fig 2).

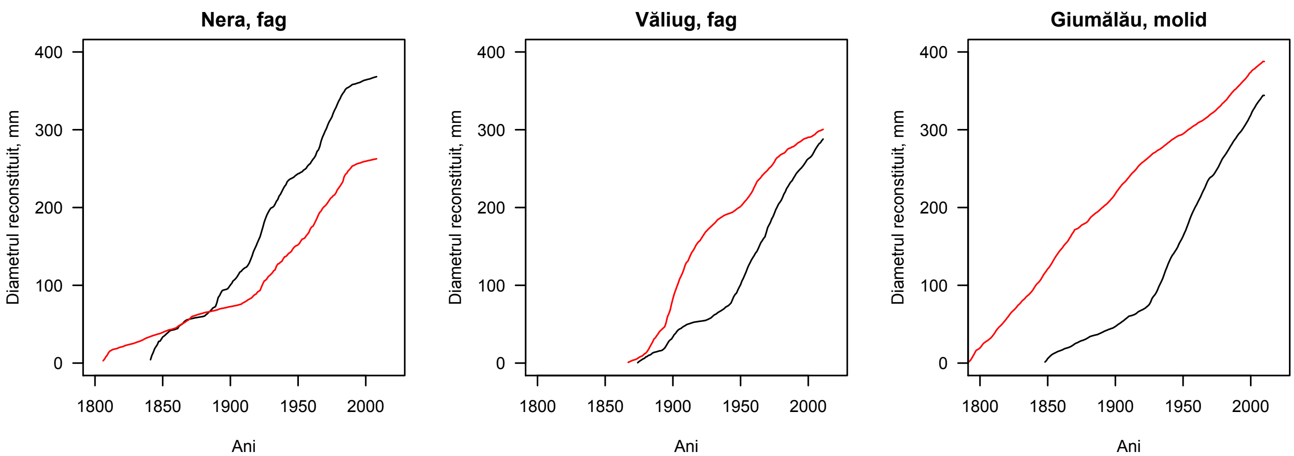

Figura 2. Examples of retrospective diameter reconstruction with different growth rates of the 3 regions studied

The reconstruction of the carbon stock dynamic in a stand involves the application of biomass equations, which are generally depending on the diameter of the tree (including bark). In our case (beech), it was observed that the bark width variability can induce errors in historical reconstruction external diameter trees. Indeed, the method of reconstitution of the diameter is based on either the assumption of (i) the width of the bark is proportional to the diameter, or either that (ii) increasing the bark is proportional to the radial width of the ring. These two hypotheses were proved to be documented beech, being specifically studied in the project. In this respect, were taken 240 samples of bark, to see which of the two hypotheses is the most plausible. The study results led to writing a scientific article nearing completion, submitted for evaluation: Turcu,Bouriaud & Ponnette 2013 (in preparation).

The retrospective estimation of trees biomass (or converted into carbon stocks) requires the reconstitution of the total tree height - the second input element in the functions applied (volume or biomass directly). The increase in height must be deducted from the radial growth as growth trees is not documented. For stands studied was established curve heights depending on the diameter, using an exponential model derived from logistic models. Adjustment method is presented for Parresol et al. (1999) for nonlinear models showing a heterogeneity of variance (heteroscedasticity) and are based on weighted iterative adjustments according to heteroscedasticity observed at each step. The equation is adjusted with Gauss-Newton iterative algorithm based on likelihood optimization. As for models with predictive purposes, it is necessary to establish statistical estimates to meet the essential criteria: absence of bias, residual variance constant. The analysis of the residuals PRESS was performed.

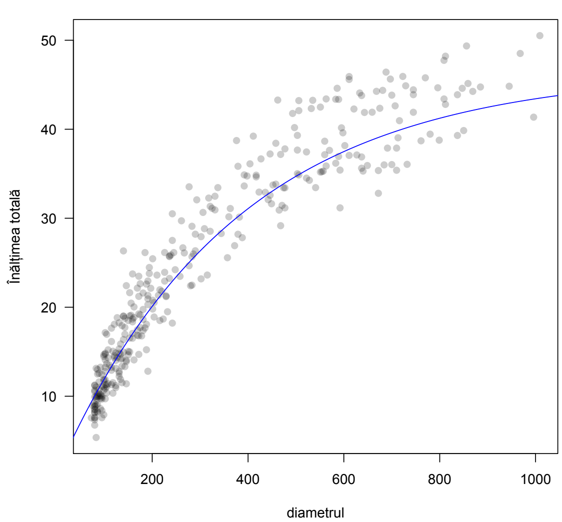

Figura 3. Height-diameter observation points and modeled height for the plot 1 Izvoarele Nerei

Monitoring the flux of GHGs. Additions to the methodology of monitoring greenhouse gases were made at the FP-7 GHG Europe project meeting organized in Romania (Arges - Romania, 17-20.04.2012), when it was proposed modification of the method of sampling gas field. The tightness of the respiration chambers used has been improved on this occasion, being reconfigured caps. Another issue was the quality of the vials septum used, made of a material very different from those used in Germany. However, chromatographic analyzes conducted later demonstrated that the envisaged septum team in Germany defective important purpose incompatible measurements, that absorbs carbon.

The drought. The year 2012 was a very special year in terms of climatological and total unfavorable conduct monitoring in that the soil was very dry and breathing phenomena to be monitored were quasi-inexistent. Drought and high sealing rings problems, some cracks in the soil is already visible in June. Heavy very small amount leading to rapid drying of the soil in depth, and the wind led to a rapid drying of the top of the soil, so that the top 5 cm were almost always dried. At the same time, the temperature, described as the main element in determining the intensity of breath, it is also influences the decomposition of organic matter. In severe drought conditions, such as those encountered in 2012, drastically reduce moisture deficit in the soil biological activity. Literature (Davidson et al., 2008; Epron et al., 1999; Reichstein et al., 2003) shows that GHG flows are more intense in certain conditions of temperature and humidity, but not fulfilled during 2012. As a result is expected to be issued flows in the spring of 2013, under normal circumstances, would be very high, according to the rule of compensation. Consequently, when will uilizate, located breathing room will surprise and consequences due to the extraordinary drought and possible compensation for the greenhouse gas emissions.

3.2. Results dissemination. The researches were written in several scientific articles, and dissemination was done by presenting the project at an international conference, as follows. ISI articles published / accepted: Teodosius & Bouriaud (2012), Walentowski et al. (2012). Items on work: Bouriaud, Turcu & Ponnette (2013) Modeling bark tree growth as a function of age and diameter in common beech; Bouriaud et al. 2013. Comparative analysis of the amount of carbon stored in forests of beech depending on the type and intensity of forest management. International Conference Pitesti, Romania, April 2012. GHG Europe Annual Meeting.

4. Conclusions

The sampling performed was aimed at assessing the carbon stocks of beech-dominated or spruce forests. We studied specifically the density of dead wood in forests of spruce, where the lying dead wood is very important in terms of quantity (and quality for its relationships with biodiversity). Retrospective analysis of tree growth revealed a lack of information regarding the growth dynamics of the bark. An article is being written on this subject. Monitoring the network established GHG emissions was started as planned but the drought has severly impacted the gas emissions studied. The chambers will enable to capture the consequences of this long-lasting drought and the possible compensations for the greenhouse gas emissions.

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