



# EVALUATION OF CARBON SEQUESTRATION ECOSYSTEM SERVICES IN VANATORI NEAMT NATURAL PARK USING COMPARATIVE MANAGEMENT SCENARIOS

Bogdan Popa<sup>1\*</sup>  
Dan Mihai Nița<sup>1</sup>  
Ionut Dutca<sup>1</sup>  
Codrin Codreanu<sup>1</sup>

<sup>1</sup> Faculty of Silviculture and Forest Engineering, Transilvania University, Brașov  
no.1 Șirul Beethoven St., 500123, Brașov, Romania

## Abstract

Present paper addresses the climate regulating services provided by forest ecosystems in one of the most important protected area in Romania. Aiming to support decision making process in the matter of protected areas funding, the sequestered carbon quantities and values are presented using Sector Scenario Analysis approach – a comparison between business as usual and sustainable ecosystem management scenarios, applied on Vanatori Neamt Natural Park. A certain reduction in the wood harvested quantities can be at least partially compensated by accessing the opportunities of international carbon market.

**Keywords:** protected areas, ecosystem services, carbon sequestration.

## INTRODUCTION

Millennium Assessment (MA, 2005) classifies the ecosystem services (ES) into the following categories: *provisioning* services (i.e. direct values of products), *regulating* services (i.e. indirect values), cultural services and supporting services. Forest ecosystems provide an important climate regulating service through carbon sequestration (World Bank, 2013). In the present Romanian context of severe underfunding of protected areas (PAs) management (Birda, 2011) the initiative of presenting the economic monetary value of the sustainable ecosystem management by using the Total Economic Value (TEV) framework is of major importance and some important steps were already done (Bann et al., 2012; Ceroni, 2017; Poynton et al., 2000). The carbon sequestration ES is included among the services that can bring important monetary values

to the economy (TEEB, 2010) while the main scope of the PAs – biodiversity conservation – can be fulfilled by better funding the sustainable management and but bring diminishing harvested wood quantities.

The value of this service is not currently captured in Romania, although an international carbon market presents potential opportunities for doing so. Emissions quotas were calculated for Romania in the 90s (Poynton et al., 2000), after signing the Kyoto Protocol, which took into consideration heavily polluting old communist style industries, which were in decline. This consequently left Romania with 'reserves' in terms of carbon emissions and little incentive until recently to increase carbon sequestration. As a result, Romania has an important carbon reserve that could be traded on international carbon market (World Bank, 2013). Furthermore, carbon potential is high since forests in and around protected areas has been well regulated, and afforestation of degraded and

\* Author to whom all correspondence should be addressed: e-mail: [popa.bogdan@unitbv.ro](mailto:popa.bogdan@unitbv.ro)

EVALUATION OF CARBON SEQUESTRATION ECOSYSTEM SERVICES  
 IN VANATORI NEAMT NATURAL PARK USING COMPARATIVE MANAGEMENT SCENARIOS  
 Bogdan Popa, Dan Mihai Nița, Ionut Dutca, Codrin Codreanu



"Vasile Goldiș" Western University of Arad

agricultural land has been undertaken. However, institutional and legal arrangements for participating in carbon markets are not in place (World Bank, 2011).

## MATERIALS AND METHODS

The study is based on using the Sector Scenario Analysis (SSA) a methodology that was already applied in a series of assessments (Bann et al., 2012; Bovarnick et al., 2010), and the guide for this methodology was recently published (Alpizar et al., 2014) for general use. The method consist in: developing two scenarios: business as usual (BAU) and sustainable ecosystem management (SEM) for different revenue creating sectors, comparing the TEV of the ES for the two scenarios and present the results in a friendly manner for decision makers (using financial indicators as present value). Under BAU, planning and management functions are typically supported by limited human, financial, institutional, and informational resources (Popa et al., 2013). Too often, PA conservation goals and objectives are poorly linked to conservation programs and costs, and existing budgets are not linked to programmatic priorities (Bovarnick et al., 2010). Under SEM, funds are available to meet biodiversity conservation needs. In SEM, PAs protection aims are correctly elaborated and implemented benefitting from sufficient funding (Bovarnick et al., 2010). The method has an important time dimension, the scenarios being compared for a 25 years period and the BAU values are expected to decrease over time as the ES providing capacity is decreasing while SEM values, even if are initially decreased, increase over time to a sustainable relative constant value, ecosystems being able to provide services and products in a sustainable way.

Vanatori Neamt Natural Park (VNNP) is located in north – east part of Romania, eastern slope of the Oriental Carpathians and hills of Neamt, stretching over the Neamt County. VNNP was established in 1999, aimed at the protection of the natural, spiritual and cultural heritage of the area, sustainable forest management, landscape and local traditions conservation, bison repopulation, and the encouragement of ecotourism (VNNP, 2008). VNNP is the park of the natural forests, churches and monasteries and *Bison bonasus*. Complex forests, the majority of them being very close to their natural condition in a hilly area creates an unforgettable landscape (famous places include Silver Forest – with birch and Copper Forest) (VNNP, 2008).

In order to value carbon sequestration of forest ecosystems within VNNP, BAU and SEM scenarios

were described in terms of wood harvested quantities (Table 1). Scenarios were described based on assumptions developed by the authors and refined through meetings with relevant stakeholders, organised within the *GEF/UNDP Project: Improving the Financial Sustainability of the Carpathian System of Protected Areas* in 2011. BAU assumes a continuation of wood harvesting at present levels (as a percent of annual increment of forest stands), keeping the present area of strictly protected forests and some illegal logging. Under the SEM scenario, illegal logging is eliminated, T1 and T2 forest areas are expanded and the fall in harvested wood quantities in production forest eventually leads to an increase in sequestered carbon.

T1 – T5 represents types of cuttings in Romanian forest management planning system. Carbon sequestered by other ecosystems has not been estimated.

**Table 1** BAU and SEM scenarios description (Popa et al., 2013)

Scenario	T1 and T2 areas - strictly protected areas	T3, T4 and T5 areas	All areas
BAU	T1 and T2 areas remain constant	Legal logging at national 2010 average (i.e. 59% of annual increment)	Illegal logging at 5% of annual allowable quota
SEM	Increase in T1 and T2 areas	Legal logging at national 2010 average (i.e. 59% of annual increment) (MECC, 2010) decreasing 7% per year between 2016 and 2030. Constant after 2030. Decrease in T3 and T4 areas.	No illegal logging after 5 Years

The CO<sub>2</sub> accumulated stock was modeled using GIS based on forest stands description from PAs administration (VNNP, 2008). For every species and production class a regression equation was defined to



"Vasile Goldiș" Western University of Arad

determine the standing volume per ha. Based on the stand area and the consistency of the stands, the total standing volume was determined for each stand (Giurgiu, 1972). The Biomass Extension Factor used was 1.2, this value being the minimum value proposed by the Intergovernmental Panel on Climate Change (IPCC) Guide (IGES 2006). The average wood density values used are also conservative and based on IPCC guidelines. Corresponding coefficients for carbon concentrations within wood biomass were used by species, and based on IPCC guidelines, CO<sub>2</sub> quantities were estimated for every forest stand. The values were calculated using direct market pricing (TEEB, 2010). There are some areas (Figure 1) that are not included in the study due to lack of data availability.

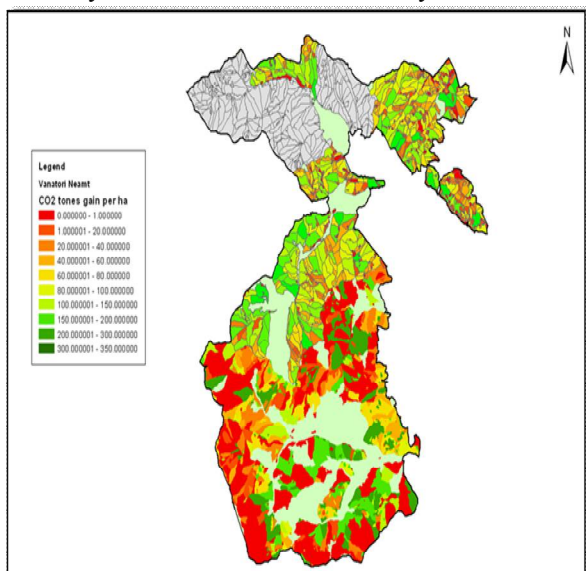


Fig. 1 Results of CO<sub>2</sub> modelling

## RESULTS AND DISCUSSIONS

The BAU and SEM scenario characterization for CO<sub>2</sub> consisted of applying the above described methodology for stand volumes based on the harvested wood volumes. For CO<sub>2</sub> only additional volumes from year to year were considered. It can be seen that a greater additional quantity of CO<sub>2</sub> is accumulated in the protected forests as well as in the youngest stands (Figure 1).

The total amount of additional CO<sub>2</sub>e in the VNNP from 2009 to 2010 is estimated at 22.336 tones. Based on the reported average price for CO<sub>2</sub>e, estimated by New Energy Finance and Ecosystem Marketplace (Ecosystem Marketplace 2011) for Clear Development Mechanism under Kyoto protocol, active in Romania (World Bank, 2004) (\$4.5/tCO<sub>2</sub>e in 2010, decreasing

from \$4.7/tCO<sub>2</sub>e in 2009), the baseline value of CO<sub>2</sub> sequestered in VNNP is around €0.07 million.

Table 2 CO<sub>2</sub> sequestered quantities in 2010 and in a 25 years period in BAU and SEM scenarios

Additional CO <sub>2</sub> , 2009-2010 (t)	22.336
Baseline indirect use value 2010 (EUR)	77.137
Additional CO <sub>2</sub> in 25 years – BAU (t)	499.335
Additional CO <sub>2</sub> in 25 years – SEM (t)	976.642

A continuation of business as usual will result in a slow decline in carbon sequestration values due to a decline in harvested volumes (based on age class distribution detailed in forest management plans), and hence less CO<sub>2</sub> sequestered. Under the BAU scenario, the present value (PV) of the carbon sequestration service of VNNP over the next 25 years is around €0.64 (Figure 2)

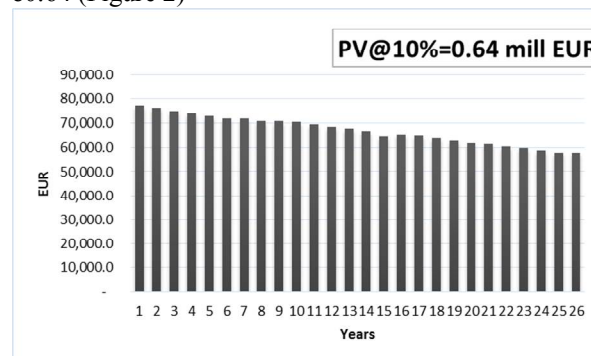


Fig. 2 Indirect use values - BAU – carbon sequestration (PV@10%=0.64million EUR)

Proper PA management and law enforcement under SEM will initially result in a decline in PA carbon sequestration value as the harvested volumes are not significantly smaller than in BAU scenario in the first years. After this, due to a fall in the volume harvested, using the same reduction scheme used for forestry sector valuation (Popa, 2013) carbon accumulation increases. By the end of the appraisal period, increased increments, together with relatively constant harvested volumes, result in a stable value. Under the SEM scenario the PV of carbon sequestration over the next 25 years is just over 0.92 million for VNNP (Figure 3). The total cumulative value of SEM relative to BAU is estimated at €0.92 million. The declining slope in the last years of SEM is due to particularities of the stands: increasing age and decreasing accumulation.

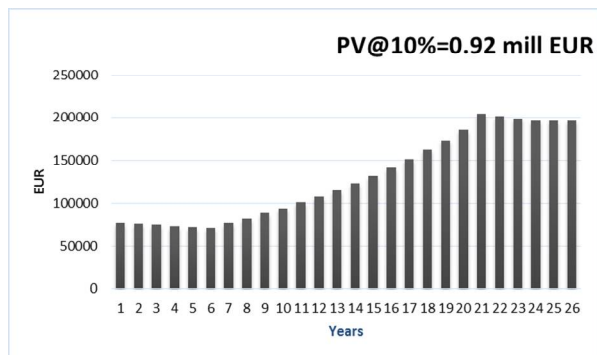


Fig. 3 Indirect use values - SEM – carbon sequestration (PV@10%=0.92 million EUR)

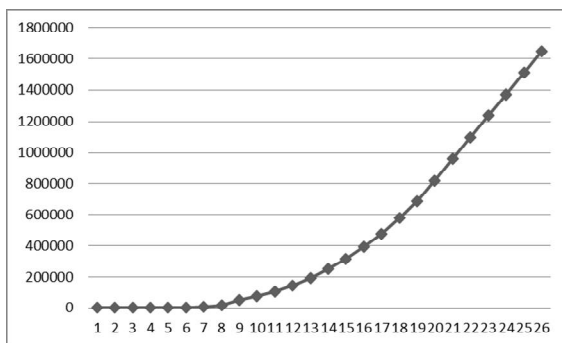


Fig.4 Cumulated added value for Carbon sequestration in VNNP for 25 years SEM over BAU

## CONCLUSIONS

This paper is just an attempt to value the ES provided by forest ecosystems advocating for a sustainable ecosystem management of the PAs. Further research and evaluation assessment will favor the implementation of the concept of "internalization of forest externalities". With the proper legislation in place, both public and private forest owners will be able to realize some benefit in the future assuming the ongoing supply of carbon funding, benefit that can at least partially compensate the economic lost triggered by reduced logging in the protected areas, managed for conservation of high biodiversity conservation values of Carpathians forests. However, it will not be possible for Romania to access the voluntary carbon markets, and thereby capture the value of sequestered carbon in protected areas, until central authorities adopt a clear legal framework and institutional arrangements permitting this (e.g. to monitor and guarantee the sequestered quantities).

## ACKNOWLEDGEMENTS

The results presented in this study were obtained in the *GEF/UNDP Project: Improving the Financial Sustainability of the Carpathian System of Protected Areas*, Transilvania University being financed through the project. The authors owe thanks to the implementation team of the project (from United Nations Development Programme and National Forest Administration Romsilva) as well as to the technical national and international experts involved in the project. A special mention must be made for Camille Bann and Marlon Flores.

## REFERENCES

- Alpizar F, Bovarnick F, (2014) Targeted Scenario Analysis: a new approach to capturing and presenting ecosystem services values for decision making. United Nations Development Programme, Washington DC.
- Bann C, Popa B, (2012) An Assessment of the Contribution of Ecosystems in Protected Areas to Sector Growth and Human Well Being in Romania. United Nations Development Programme, Bucharest.
- Birda A, (2011) Financial Analysis of the Natural Protected Areas Targeted by the Project "Improving the Financial Sustainability of the Carpathian System of Protected Areas". United Nations Development Programme, Bucharest.
- Bovarnick A, Alpizar F, Schnell C, Editors, (2010) The Importance of Biodiversity and Ecosystems in Economic Growth and Equity in Latin America and the Caribbean: An economic valuation of ecosystems. United Nations Development Programme, Washington DC.
- Ceroni M, (2007) Ecosystem Services and Local Economy in Maramures Mountains Natural Park, Romania, United Nations Development Programme, Bucharest.
- Ecosystem Marketplace, (2011) State of the Forest Carbon Markets 2011, From Canopy to Currency, [www.ecosystemsmarketplace.com](http://www.ecosystemsmarketplace.com).
- Giurgiu V, Decei I, Armasescu S (1972) Biometria arborilor si arboretelor din Romania. Ceres, Bucharest.
- IGES, (2006) Institute for Global Environmental Strategies for IPCC, Guidelines for National Greenhouse Gas Inventories ([http://www.ipcc.ch/publications\\_and\\_data/publications\\_and\\_data\\_reports.shtml#4](http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#4)).





- 
- MA, (2005) Millennium ecosystem assessment. Ecosystems and Human Well-being, Island Press, Washington.
- MECC, (2010) Ministry of Environment and Climate change. Romanian Forest status. Annual Report prepared by Forest Department (in Romanian). Available at [www.mmediu.ro/paduri/management\\_forestier.htm](http://www.mmediu.ro/paduri/management_forestier.htm).
- Poynton S, Mitchell A, Ionascu G, McKinnenn F, Elliott J, Abrudan IV, (2000) Economic Evaluation and Reform of the Romanian Forestry Sector, Pentru viata Publishing House, Brasov.
- Popa B, Pascu M, Nita DM, Borz SA, Codreanu C, (2013) The value of Forest Ecosystem services in Romanian Protected Areas – A comparative analysis of management scenarios, Bulletin of the Transilvania University of Brasov, Vol 6(55) No. 2-2013.
- TEEB, (2010) Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB, The Economics of Ecosystems and Biodiversity Initiative, Washington DC.
- VNNP, (2010) Management Plan of Vanatori – Neamt Natural Park. National Forest Administration – Romsilva Bucharest.
- World Bank, (2004) Afforestation of degraded agricultural land project in Romania, based on Emission Reduction Purchase Agreement (ERPA National Forest Administration – ROMSILVA, Bucharest.
- World Bank, (2011) Functional Review, Environment, Water and Forestry, Volume 2: Forestry. World Bank, Washington DC.
- World Bank, (2013) Forest Sector Rapid Assessment, Climate Change and Low Carbon Green Growth Program draft report. World Bank Office. Bucharest.