Journal of Forest Economics 23 (2016) 4–26

Contents lists available at ScienceDirect

Journal of Forest Economics

journal homepage: www.elsevier.com/locate/jfe

Carbon mitigation potential of the French forest sector under threat of combined physical and market impacts due to climate change☆

Antonello Lobianco[a,*], Sylvain Caurla[b], Philippe Delacote[b,c], Ahmed Barkaoui[b]

[a] AgroParisTech, ENGREF, Laboratoire d'Économie Forestière, 54000 Nancy, France
[b] INRA, UMR 356, Laboratoire d'Économie Forestière, 54000 Nancy, France
[c] Chaire d'Économie du Climat, Paris, France

ARTICLE INFO

Article history:
Received 6 March 2015
Accepted 17 December 2015
Available online 14 January 2016

JEL classification:
Q23
Q54
L73

Keywords:
Forest sector
Carbon balance
Climate change
Bio-economic model

ABSTRACT

Objectives: (1) To quantify the contribution of the French forest-wood product chain in terms of carbon sequestration and substitution when accounting for both the physical impacts (shifts in tree growth and mortality rates) and the market impacts (increased demand of harvested wood products (HWP)) of climate change (cc) and the subsequent forest managers adaptations; (2) To assess the uncertainty of the impacts on the above carbon balance and on forest allocation; and (3) To assess the role of managers' expectations toward these future, uncertain but highly anticipated, impacts.

Methodology: We used a bio-economic model of the French Forest Sector (FFSM++) that is able to consider and integrate: (a) the effects of climate change over forest dynamics; (b) forest investment decisions (among groups of species) according to expected profitability; and (c) market effects in terms of regionalised supply, consumption and trade of HWP, depending on the forest resource stocks and international prices. By including both forest dynamics and forest products, we can evaluate the carbon balance taking the following elements into consideration: (a) carbon sequestered in live and dead biomass in the forest; (b) carbon sequestered in HWP; (c) carbon substituted when wood is used in place of fossil fuels or more energy-intensive materials; and (d) carbon released by forest operations.

☆ This article is part of a special issue entitled "Forests and climate: New insights from forest sector modeling".

* Corresponding author. Tel.: +33 627484888.
E-mail address: antonello.lobianco@agroparistech.fr (A. Lobianco).

http://dx.doi.org/10.1016/j.jfe.2015.12.003

When the model is run at constant conditions for the next century, the average carbon potential of French forests is 66.2–125.3 Mt CO_2 y^{-1}, depending on whether we consider only inventoried wood resources, HWP pools and direct energy substitution, or if we also account for the carbon stored in tree branches and roots and if we consider the more indirect, but also largely more subjective, material substitution. These values correspond to 18.3% and 34.7%, respectively, of the French 2010 emissions (361 Mt CO_2). However, when we consider both the probable increment of coniferous mortality and changes in forest growth, plus the rise in HWP demand worldwide, the average sequestration rate of the French forest decreases by 6.6–5.8% to 61.8–118.0 Mt CO_2 y^{-1}. Running partial scenarios, we can assess the relative interplay of these two factors, where the price factor increases the HWP stock while decreasing the forest stocks (where the latter effect prevails), while the physical impact of climate change reduces both, but to a lesser extent. Considering short-sighted forest managers, whose behaviour is based uniquely on the observed conditions at the time decisions are made, we obtain a limited effect of the overall carbon balance but a relatively large impact on the area allocation of broadleaved vs. coniferous species.

Introduction

Atmospheric measurements of the atmosphere show an evident and steady increase in globally averaged temperatures, with global temperatures in the first decade of the 21st century about 0.8 °C warmer than at the beginning of the 20th century (average for the period 1880–1920) and with two-thirds of the warming having occurred since 1975 (Hansen et al., 2010).

Of the various long-lived greenhouse gases (LLGHG), the atmospheric concentration of carbon dioxide alone is responsible for approximately 84% of the increase in the radiative forcing observed over the past decade and deemed to be at the root of the heating phenomenon (WMO, 2014). Fig. 1 shows a very simplified global carbon cycle, with four sinks represented: atmosphere, terrestrial biosphere, oceans and lithosphere. For each sink, the current estimated carbon storage and the current flows with the other sinks are reported.

The direct effects of human action, that is, the 7.8 $PgCy^{-1}$ emissions from cement production and fossil fuels extraction and the 1.1 $PgCy^{-1}$ emissions from net land use and land cover change (LULCC), are indicated in red. However, despite the land-use changes, the net effect of terrestrial biosphere fluxes remains as a sink (Houghton et al., 2012; Le Quéré et al., 2015).

Aside from the direct effects, the flows between the atmosphere, the terrestrial biosphere and ocean sinks depend on the relative carbon concentration between the sinks involved and, hence, from human activity. It is believed that these sinks were in a relative equilibrium before industrial era. However, due to the anthropogenic increase in atmospheric carbon concentration, these fluxes came to be positive. Oceans and the terrestrial biosphere removed 55% of the CO_2 emitted by human activity in the period 2003–2013 (WMO, 2014), and this is not without consequences. For oceans, it implies a documented acidification, and for the terrestrial biosphere a greater risk of instability, for example, in the context of forests, fires and pests. Furthermore, there is initial evidence that these sinks are starting to become saturated, and further human carbon emissions will benefit from a reduced removal feedback. Finally, aside from the saturation issue, the resulting climate change may influence the storage capacity of the terrestrial biosphere. (Ciais and Sabine, 2013; WMO, 2014).

Fig. 1 also distinguishes between two domains that are referred to as the “fast domain” and the “slow domain” in the 5th IPCC assessment report. They refer to the average turnover time of a carbon dioxide