JOB OFFER

PhD position: Accounting for land use dynamics in the calculation of carbon substitution by wood products

The French National Research Institute for Agriculture, Food, and the Environment (INRAE) is a public research establishment. It is a community of 12,000 people with more than 200 research units and 42 experimental units located throughout France. The institute is among the world leaders in agricultural and food sciences, in plant and animal sciences, and is ranked 11th in the world in ecology and environment. INRAE's main goal is to be a key player in the transitions necessary to address major global challenges. In the face of the increase in population, climate change, scarcity of resources and decline in biodiversity, the institute develops solutions for multiperformance agriculture, high quality food and sustainable management of resources and ecosystems.

WORK ENVIRONMENT & MISSIONS

General scientific context

The principle of carbon substitution is to replace a *substitutable* product with a *substitute* product that provides the same service for human activities but whose life cycle emits less greenhouse gases (GHGs). In particular, carbon substitution by wood products is a significant contributor to mitigation strategies based on forest socio-ecosystems[1].

Carbon substitution is usually quantified in tons of CO_2 equivalent or in tons of carbon and is calculated as the difference in carbon emissions of a substituted reference pathway *without an additional wood consumption* with those of a replacement alternative pathway *with an additional wood consumption.* The substitution is positive when the alternative pathway emits less GHGs than the reference pathway and negative in the opposite case. To do so, current methods involve performing Life Cycle Assessment (LCA) for both pathways in a cradle-to-grave perspective, and comparing them. LCA is a standardized method used to assess the environmental impacts of a product or a service according to both lifecycle and multicriteria perspectives[2,3], allowing the identification of pollution transfers between life cycle stages and impact categories.

In practice, substitution is often quantified through the use of so-called substitution coefficients or displacement factors[4]. Displacement factors (DF, usually in $MtCO_2$ or MtC per ton of wood or m^3 of wood) reflect the change in GHG emissions from using a unit of wood instead of another material to provide a good or service. In other words, they represent the efficiency, in terms of GHG emissions reduction, of using an additional unit of wood product for the same purpose. For a given product, the literature shows a broad range of values for DF, even when the scenarios compared are similar. For example, wood used for construction in Switzerland avoids the emission of 1.3 tCO_2/m^3 in one study[5] but only 0.5 tCO_2/m^3 in another[6]. A meta-analysis of this literature shows that the DF for medium and long-lived wood products range from - 2.3 to 15 tC avoided per tC in wood products[4]. Such information may be used in operational assessments and the development of policy goals and scenarios (e.g. National Low Carbon Strategy), which makes the quantification of DFs a critical issue.

Research Project

Research hypothesis:
The variability observed in the value of DF comes from discrepancies in the definition of the boundaries of both pathways, which leads to differences in how emissions related to resource extraction, manufacturing processes, product use and end-of-life destination for wood and non-wood products are accounted for. In particular, if, within a given territory, demand cannot be met from local production, products will likely be imported from elsewhere, a phenomenon known as leakage[7]. For example, forest conservation policies in Finland and China increased wood harvest in Russia to support Finnish and Chinese wood consumption[8]. Leakage can also be indirect when stricter forest conservation policies affect sectors other than forestry, e.g., switching of economic activity from forestry to pit mining as a response to logging restrictions. Our research hypothesis is that considering such leakage effects, in particular when they result in land use changes abroad, can significantly affect the substitution values of wood products.

Methods to implement: To test this hypothesis and its implications on the substitution and the DFs of wood products, the project will rely on the development and coupling of two existing models: FFSM and NLU. The French Forest Sector Model (FFSM)[9] is currently the only bio-economic model of the French forest sector. The model's current version only takes into account land-use dynamics across several types of forest, but considers total forest area to be constant and therefore does not endogenously capture interactions with other land uses (e.g. agriculture). To address this limitation and account for land uses changes between forests and other land uses, we aim at coupling the FFSM to a global land-use model (Nexus Land Use, NLU[11]) . This model coupling will make it possible to simulate the consequences of an additional harvest of wood at the extensive margin, i.e. the impact of an additional harvest on the dynamics of the forest area, and its consequences on the type of land use in France and abroad. This procedure will make it possible to account for the leakages in terms of land use changes abroad and, eventually, in terms of greenhouse gases emissions. These leakages will then be incorporated in the calculation of the substitution through a partnership with Life Cycle Assessment specialists.

REFERENCES

1. Gustavsson, L. *et al.* Using biomass for climate change mitigation and oil use reduction. *Energy Policy* **35**, 5671–5691 (2007).
2. ISO. 14040-Environmental Management-Life Cycle Assessment-Principles and Framework. (2006).
3. ISO. 14044: Environmental Management - Life Cycle Assessment - Requirements and Guidelines. (2006).
4. Sathre, R. & O'Connor, J. Meta-analysis of greenhouse gas displacement factors of wood product substitution. *Environmental Science & Policy* **13**, 104–114 (2010).
5. Werner, F., Taverna, R., Hofer, P. & Richter, K. Carbon pool and substitution effects of an increased use of wood in buildings in Switzerland: first estimates. *Ann. For. Sci.* **62**, 889–902 (2005).
6. Suter, F., Steubing, B. & Hellweg, S. Life Cycle Impacts and Benefits of Wood along the Value Chain: The Case of Switzerland: Life Cycle Impacts and Benefits of Wood. *Journal of Industrial Ecology* **21**, 874–886 (2017).
7. Ostwald, M. & Henders, S. Making two parallel land-use sector debates meet: Carbon leakage and indirect land-use change. *Land Use Policy* **36**, 533–542 (2014).
8. Mayer, A. L. ECOLOGY: Enhanced: Importing Timber, Exporting Ecological Impact. *Science* **308**, 359–360 (2005).
9. Caurla, S., Delacote, P., Lecocq, F. & Barkaoui, A. Stimulating fuelwood consumption through public policies: An assessment of economic and resource impacts based on the French Forest Sector Model. *Energy Policy* **63**, 338–347 (2013).
10. Lobianco, A., Delacote, P., Caurla, S. & Barkaoui, A. The importance of introducing spatial heterogeneity in bio-economic forest models: Insights gleaned from FFSM++. *Ecological Modelling* **309–310**, 82–92 (2015).
11. Souty, F. *et al.* The Nexus Land-Use model version 1.0, an approach articulating biophysical potentials and economic dynamics to model competition for land-use. *Geosci. Model Dev.* **5**, 1297–1322 (2012).

PRACTICAL INFORMATIONS

Training & Skills

- Degree required: Master of Science or Engineering with relevant background in environmental economics, environmental sciences or forestry.
- Strong appetence for modelling approaches and inter-disciplinary research.
- Prior experience with large-scale modelling (environmental sciences or economics) and knowledge of programming softwares (R, Python, C++, etc.) are appreciated.
- Capacity to work in English is required. Knowledge of the French language appreciated.

Supervision, environment & life quality :

- The thesis is a collaboration between CIRED (Paris) and BETA (Nancy). The International Research Center on Environment and Development (CIRED) is dedicated to the study of the relations between economic regulation and the relations between human activities and the natural and constructed biophysical environment. The research conducted at the Bureau d'Economie Théorique et Appliquée (BETA) is oriented by the desire to articulate the theoretical aspects and applications of research in economics and management.
- The candidate will be co-supervised by Thierry Brunelle and Miguel Rivière at CIRED (Paris) and Antonello Lobianco and Sylvain Caurla at BETA (Nancy). The thesis director will be Sylvain Caurla (BETA).
- The thesis is funded by the Labex ARBRE and the metaprogramme CLIMAE (INRAE).
- The thesis is part of the research project STREISAND co-funded by ADEME, the French national agency for ecological transition. Thus, the thesis will benefit from the brainstorming and the bibliographical review carried out by the consortium of the project.

↘ Working conditions

Location:

UMR BETA, Nancy, France, http://www.beta-umr7522.fr/

and/or

UMR CIRED, Nogent-sur-Marne, France, http://www.centre-cired.fr/fr/

Time period : 3-year doctoral position, starting in October 2021

↘ How to apply

Applications and inquiries should be sent to:

Sylvain Caurla, researcher
(sylvain.caurla@inrae.fr) 03 83 39 68 96

✖ Application deadline: May 31st 2021

Please submit your application as a single PDF file. This file should contain a 1-page cover letter describing your motivation to apply, a CV including relevant degrees and publications and the contact information of a current or former supervisor.