N° 4/2012 – MAY 2013

RESEARCH IN ECONOMICS AND RURAL SOCIOLOGY

FFSM: a French forest-wood sector model which takes forestry issues into account in the fight against climate change

Within the framework of policies aiming to reduce greenhouse gas emissions, France now relies largely on energy substitution. This results in the implementation of projects involving fuelwood or heat production from biomass. On the other hand, due to the very partial consideration of in-situ sequestration in the international climate policies ensuing from the Kyoto treaty, State action hitherto has not relied on measures favouring forest carbon sequestration. Some researchers from the Nancy Laboratory of Forest Economics developed the French Forest Sector Model (FFSM), a bio-economic model of the French forest-wood sector, used for simulations of climate policies and impact analysis. The first results of the FFSM model show that: (i) an ambitious policy of substitution may cause tensions on resources and wood industry markets; (2) a sequestration policy presents a better carbon balance through to 2020 than a substitution policy; (iii) the implementation of a generalized carbon tax would have a globally positive effect on the French forest-wood sector.

According to the simulations of the Intergovernmental Panel on Climate Change (IPCC), there would seem to be significant potential for mitigation of greenhouse gas emissions (GGE) on the global level in the decades to come. By modifying certain forest management practices, land use, harvesting and harvested-wood use, the forest sector could avoid a volume of emissions corresponding to 3% to 14% of current global emissions (taking all sources together). This mitigation potential involves two physical levers: substitution and sequestration (see box 1).

Although the environmental impacts of fuelwood policies (accounting greenhouse gas emissions, consequences on forest resource development) have already been assessed, however, the economic consequences on the sector, in particular, the competitive effects and consequences on producers' profits are largely absent from the scientific literature (Delacote *et* Lecocq, 2011. It was therefore important to assess the consequences of these policies in the sector, both from an environmental and economic point of view. Although only fuelwood policies are currently implemented, we want the consequences of two alternative policies to be assessed: a policy relying on sequestration in the forest and a policy relying on substitution via an inter-sector carbon tax, contrary to current policies.

To answer both levels of questions, the French forest sector modelling team of the Laboratoire d'Economie Forestière de Nancy (LEF) built a regionalized bio-economic model of the French fuelwood sector: FFSM for *French Forest Sector Model*. This model represents the whole French forest and wood sector by disaggregating the representation of the resources and the economy on the level of each French administrative region (see box 2).

Environmental and economic consequences of wood-fuel policies

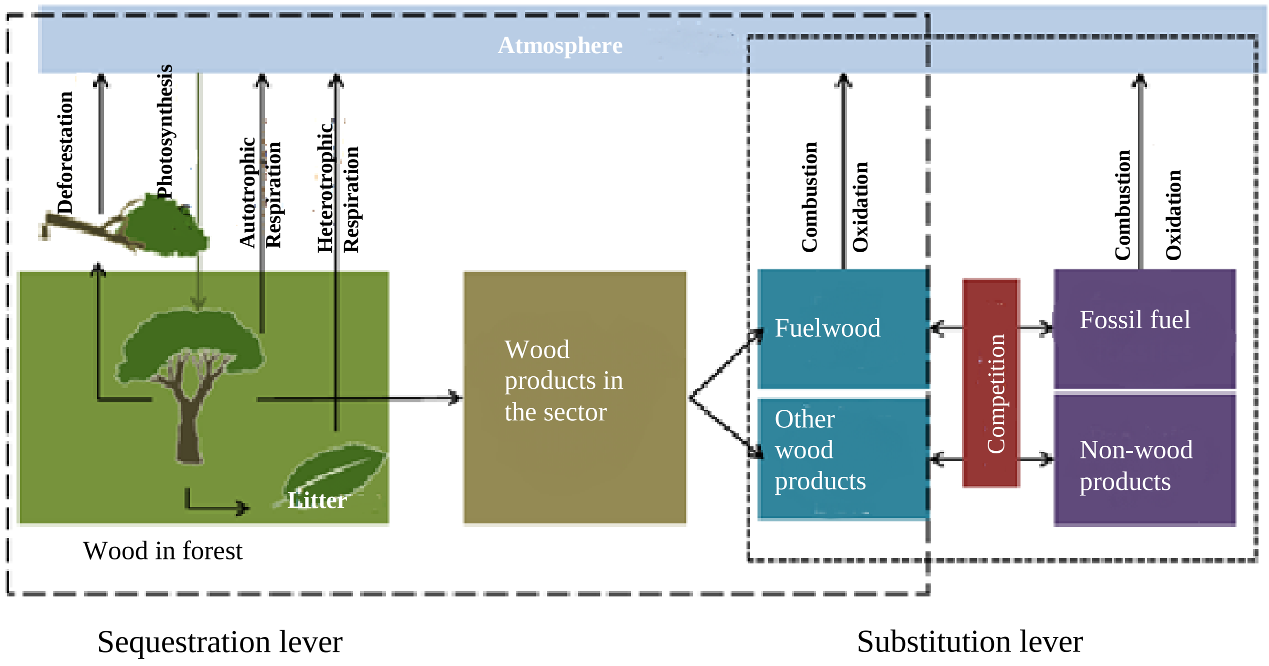
European Directive 2009/28/EC increased the objective for the incorporation of renewable energy into the French energy mix to 23% by 2020. In this context, several programmes have been implemented to boost the fuelwood sector. The objectives of these programmes are to structure the sector by handing out subsidies for individuals to change their heating systems; by developing collective boiler houses, heating networks and supply sectors or by implementing heat and electricity cogeneration projects.

Frame 1: Substitution and sequestration, the two physical levers of GHG emission mitigation

Sequestration: management of forest areas influences the amount of carbon sequestrated in the forest biomass. Forest densification, afforestation, reforestation and reductions to deforestation allow an increase in net carbon sequestration in forest ecosystems. Furthermore, carbon sequestration in long-life-cycle wood products, wood structural frames for instance, delays carbon release into the atmosphere (sequestration lever in figure 1).

Substitution: emissions linked to wood-product consumption are generally lower than those created by consumption of non-wood substitute products. Wood-fuel product consumption (substitution for fossil energies) and wood-product consumption (substitution for products coming from other sectors for building, insulation, packing or furniture) consequently allow a reduction in fossil energy emissions (substitution lever in n figure 1).

Figure 1: Simplified diagram of carbon flows between the atmosphere reservoir, earth reservoir and fossil reservoir. Here are the two mitigation levers in the wood-forest sector.



Frame 2: The FFSM model (French Forest Sector Model)

FFSM (figure 2) is the first model representing the French wood-forest sector (Caurla *et al.*, 2011) and a disaggregated economic module with three sector levels in a specific and exhaustive way.

The resource module is recursive-dynamic and captures the development of the national and regional forestry resource disaggregated into 132 field case-studies: breakdown per diameter class, region, type of forest population and deciduous or resinous species. It also calculates the results of emissions for the whole sector, taking the substitution effects between products in the sector into account.

The economic module is resolved in static partial equilibrium (figures 2 and 3) The resolution in partial equilibrium implies that the retro-action effects between forest-wood sector and the rest of the French economy are not taken into account, an acceptable assumption due to the low proportion represented by the forest-wood sector in the French economy (less than 1% of PIB). In the end, international prices are considered as exogenous in this model.

The module conducts an annual simulation of the price/quantity equilibria of national markets for three raw wood products and nine processed wood products (see figure 3), from which the calculations of the producers' and consumers' aggregated surpluses can be deduced. It also enables assessment of trade volumes between French regions and between France and the rest of the world. Domestic trade between regions is modelled via a "Samuelson 1952" spatial representation (see Caurla *et al.*, 2010) while international trade is based on the Armington theory of imperfect substitutability (1969) (see Sauquet *et al.*, 2011). The use of two different methodologies makes it possible to show the various levels of substitutability between products. Woods from France and abroad are less substitutable than French woods among themselves, because of variations between species, consumption habits and transaction costs.

FFSM allows the simulation of public policy implementation and assessment of their impacts against (i) environmental criteria, such as the evolution in the forest resources and carbon results; and (ii) economic criteria such as the equilibria of national markets and the balance of trade. The time horizon taken for simulations is 2020.

Figure 2: FFSM economic module represents 3 sector levels and 9 wood products

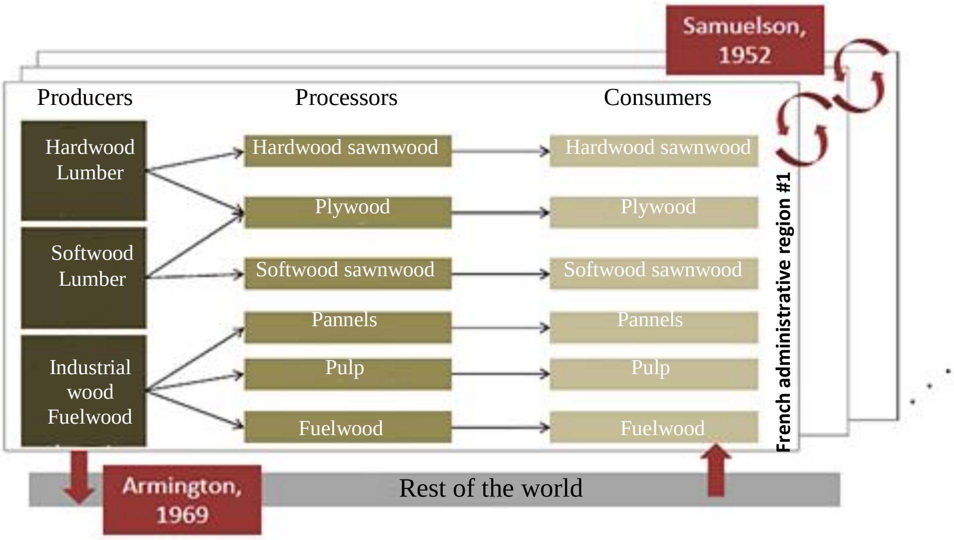
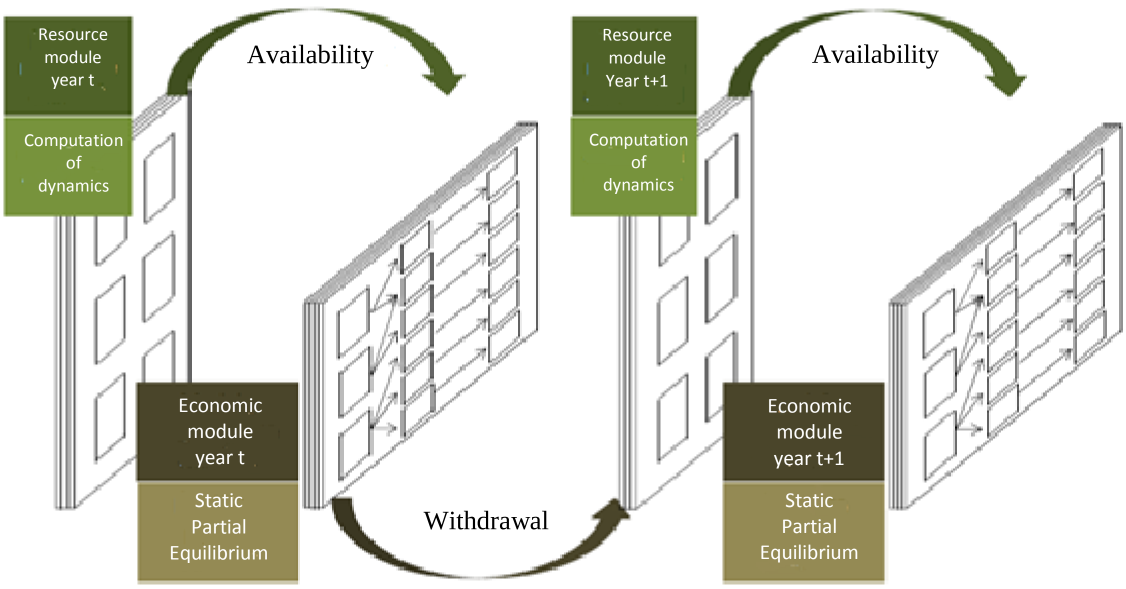


Figure 3: Modular and Recursive Dynamics



These programmes have been given a mixed reception within the forestry community. Some appreciate the creation of a real energy sector, a potential source of employment and a reduction in the French trade deficit in wood products. Others fear competition with the pulp sector (wood-pulp and chipboard) competing for the same type of raw-wood products as fuelwood. In a context of uncertainty as to the availability of additional wood, others fear potential tensions in forestry resources. To attempt to shed light on this debate, we translated the national objectives into additional consumption of fuelwood to calibrate the FFSM Model and simulate the impact of three policies: a consumption subsidy, a production subsidy and fixed public demand. These policies represent the various types of measures implemented by the State.

The first result concerns the tension level induced by these policies on forestry resources. This level depends on the policy considered, but also on the level of theoretical additional availability. At national level, some recent studies (see Caurla *et al.* 2009) estimated that there is a gross additional availability of about 40 to 50 million m^3 of standing wood in the forests. By taking away those resources that are technically difficult to exploit or that can be exploited but at higher prices than the current market price, the additional resource of industrial and fuel wood (BIBE) which is the first raw material of forest wood-fuel products, would be 12 million m^3. The 2011 national forest inventory (see Caurla *et al.* 2009) recently revised this availability downwards, arguing than the uncertainties surrounding the supply behaviour of small forest owners had not been taken into account by most of the studies. In order to take this uncertainty as to additional availability into account, we considered two assumptions: a high availability assumption corresponding to the estimations of the available studies, and a low availability assumption based on an absence of supply from small forest owners and corresponding to an initial additional availability of 6 million m^3 per year in France as a whole.

In the low resource availability hypothesis, whatever the policy that is applied, the simulation results lead to strains on resources (that is to say a reduction in the available resources by 0.4% to 0.85%) by 2020. On the other hand, in the high availability hypothesis, only the production subsidy policy leads to tension on resources by 2020 (the estimated fall is about 0.14). In addition to showing the differences between the policies, this result shows how important it is to mobilize all forest owners for the production of wood-fuel, small owners included, in order to avoid over-exploitation of resources in national and municipal forests or in big private properties.

In economic terms, the simulation results show that the production subsidy reduces the trade balance deficit and avoids competition phenomena with the pulp sector. The consumption subsidy and fixed demand, meanwhile, are much less costly for the State but induce increased competition with the pulp sector. None of these three policies is optimal both from the point of view of tensions on resources, intra-sector competition, the trade deficit and global cost.

We simulated several options with the FFSM in order to find one which would both reduce the trade deficit and preserve the competitiveness of the pulp sector, while reducing the total cost for public finances and reducing negative impacts on resources. The results show that upstream incentives (such as production subsidies) should be combined with downstream incentives (fixed public demand).

Comparison of the environmental and economic impacts of a policy of energy substitution and a policy of carbon sequestration in the forest

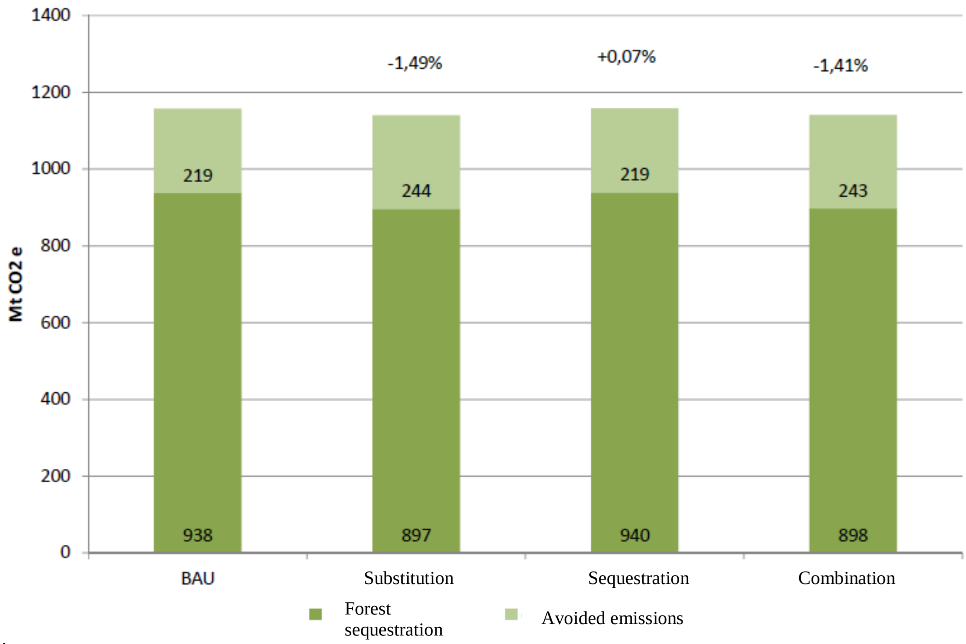
As the choice of the lever of action in national forest climate strategy is not without its consequences, we compared the results of a forest sequestration subsidy and a wood-fuel consumption subsidy, in environmental and economic terms.

Economically, our results show that in the short term (2020) a subsidy for energy substitution is much more costly (about 50 times more) for the State than a sequestration policy. The substitution policy that we simulated comes with a significant windfall effect. The fuelwood consumers who would have consumed fuelwood anyway, in the absence of such a policy, are therefore subsidized. We also show that the substitution policy is more easily acceptable, politically speaking, insofar as it allows an increase in consumer and producer surpluses. Conversely, a sequestration policy raises the producer surplus but reduces the consumer surplus.

As far as the environment is concerned, our results show that a sequestration subsidy induces a more favourable result on emissions than an energy substitution subsidy (figure 4).

Figure 4: **Sequestered carbon in the forest and emissions avoided (in millions of tons equivalent CO2) in the sector in 2020 in the three scenarios.**

(Variations according to the baseline scenario without policy)



Source: authors' calculation

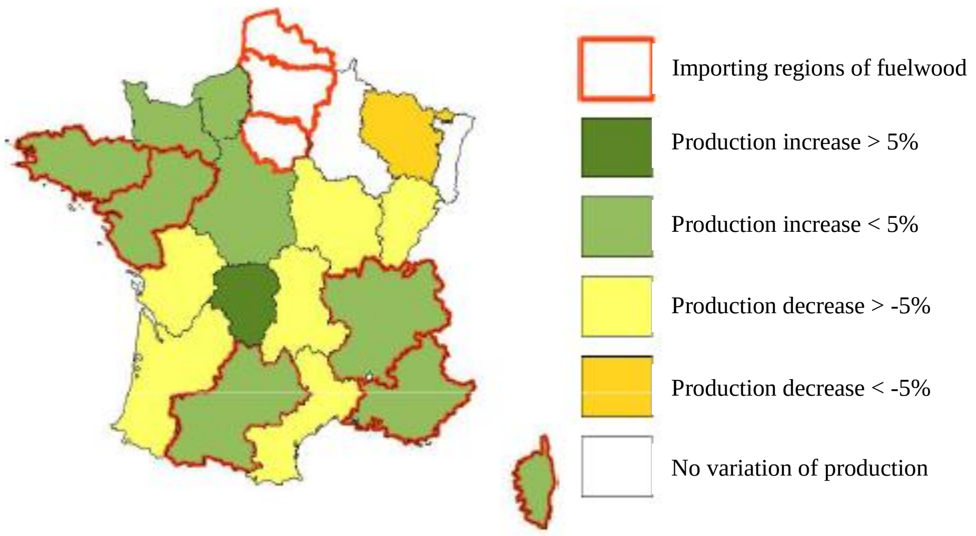
However, we believe that due to two effects, our results could be different over the long term. From an economic point of view, we considered that the GHG emission mitigation costs linked to sequestration projects decrease in the short term, as they increase less quickly than carbon storage. This can be explained by the fact that there is a large forest resource surplus compared to supply. In this way, preserving a tree at time T for carbon sequestration at time t+1+1, has almost no influence on the available stock and therefore on the level of supply. However, these costs could rise if a longer time horizon were considered. In the long term, with the preserved trees accumulating and available stock reducing progressively, the supply function could become more convex and costs to producers should increase. Taking the effects of density into account on growth parameters, on mortality as the stand becomes more dense and on the upturn in growth when the stand thins, could also modify the results in the long term.

Expected impacts of an inter-sector carbon tax on the fuelwood sector

We simulated the adoption of an inter-sector carbon tax and assessed its impact on the forest-wood sector, taking an initial carbon value of €17 per ton CO2 in 2010, with a €2 rise per ton CO2 each year. To do so, we modified the demand function of the FFSM model to include competitiveness between wood products and non-wood substitutes. The tax was inserted in the harvesting, processing and transport costs.

Most wood products emit less carbon than their non-wood substitutes during the production and transport processes. The simulation results show de facto that at national level, implementation of a carbon tax benefits the wood sector, generating a production rise for most wood products. However, it is a small rise for most of the products concerned (less than 6% compared to a scenario without tax). Moreover, the FFSM model results show that it is not systematically the case at regional level, even when wood-product production increases nationally (figure 5 for fuelwood case).

Figure 5: **Regional variations in wood-fuel production in 2020 after tax implementation (€17 / tCO2 in 2010 with a €2 increase per year) compared to a baseline scenario without tax.**



The tax increases transport costs and induces a relocation of production and modifications in inter-regional trade. For instance, regions that were importing initially tend to see their imports go down (especially if imports were coming from distant regions) and their production increase. Conversely, exporting regions tend to see their production reduced when their exports were destined for remote regions.

Research prospects: towards FFSM 2.0

A new FFSM version is being developed, with four priority points: completion of the validation model; modelling of investment in the forests and the sector; better consideration of the forest management choices in the long term and a finer representation of the physical flows within the sector, notably in the biomass field.

On this basis, version 2.0 of the model should allow the Laboratory of Forest Economics to attempt medium or long-term studies (2050/2100) in order to examine climate change adaptation policies in the forestry sector in particular. The mission of the LEF is to analyse the economic impact of climate change on the fuelwood sector and assess adaptation strategies.

More largely, FFSM version 2.0 is intended to become an assessment tool for public policies relating to forestry. According to requirements, developments for questions of biodiversity, industrial policy or even transport can be envisaged.

Sylvain Caurla INRA, UMR0356 Economie Forestière, F-54000 Nancy
Sylvain.Caurla@nancy.inra.fr
Philippe Delacote (corresponding author) INRA, UMR0356 Economie Forestière, F-54000 Nancy
Philippe.Delacote@nancy.inra.fr

Further information

Caurla S., Lecocq F., Delacote P., Barkaoui A. (2010). The French Forest Sector Model version 1.0. Presentation and theoretical foundations. *Cahier du LEF* n°2010-03, Nancy, 41 p.
Caurla S., Delacote P., Lecocq F., Barkaoui A. (2009). Fuelwood Consumption, Uncertainty over Resources and Public Policies: What Impacts on the French Forest Sector? *Cahier du LEF* n°2009-03, Nancy, 24 p.
Delacote P., Lecocq F. (2011). Fuelwood, Timber and Climate: Insights from forest sector modeling. An introduction. *Journal of Forest Economics*, 17(2), 107-109.
Lecocq F., Caurla S., Delacote P., Barkaoui A., Sauquet A. (2011). Paying for forest carbon or stimulating fuelwood demand? Insights from the French Forest Sector Model. *Journal of Forest Economics*, 17(2), 157-168.
Sauquet A., Caurla S., Lecocq F., Delacote P., Barkaoui A., Garcia S. (2011). Estimating Armington elasticities for sawnwood and application to the French Forest Sector Model. *Resource and Energy Economics*, 33(4), 771-781.
Wernsdörfer H., Colin A., Bontemps J-D., Chevalier H., Pignard G., Caurla S., Leban, J-M., Hervé J-C., Fournier M. (2011). Large scale dynamics of a heterogeneous forest resource are jointly driven by geographically varying growth conditions, tree species composition and stand structure. *Annals of Forest Sciences*, 69(7), 829-844.

Published by the INRA Department of Social Sciences, Agriculture and Food, Rural Development and Environment
Publishing unit: Editorial Director: Bertrand Schmitt– Editor: Sophie Drogué (Chief Editor),
Translation and composition: Ariel Gille