Accounting for socio-economic drivers in climate change analysis with the French Forest Sector Model 2.0

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Objectives

Given the importance of anthropogenic determinants in forest growth within Europe, the objective of this work is to link the evidence arising from biological models of climatically-induced variations in forest ecosystems with socio-economic determinants, where the expected returns of forest investments represent the main drivers.
Hence first an adequate spatial scale is adopted to facilitate models linkage and then a management module is introduced to account for expected climatically-induced variations in forest investments.
With both climate and economic drivers considered we can try to: understand the impact of forward-looking vs conservative forest management; forecast the impact of climate change on forest profitability, depending on forest managers strategies; forecast the long-term evolution of the French land-use, comparing forests and agriculture profitability.

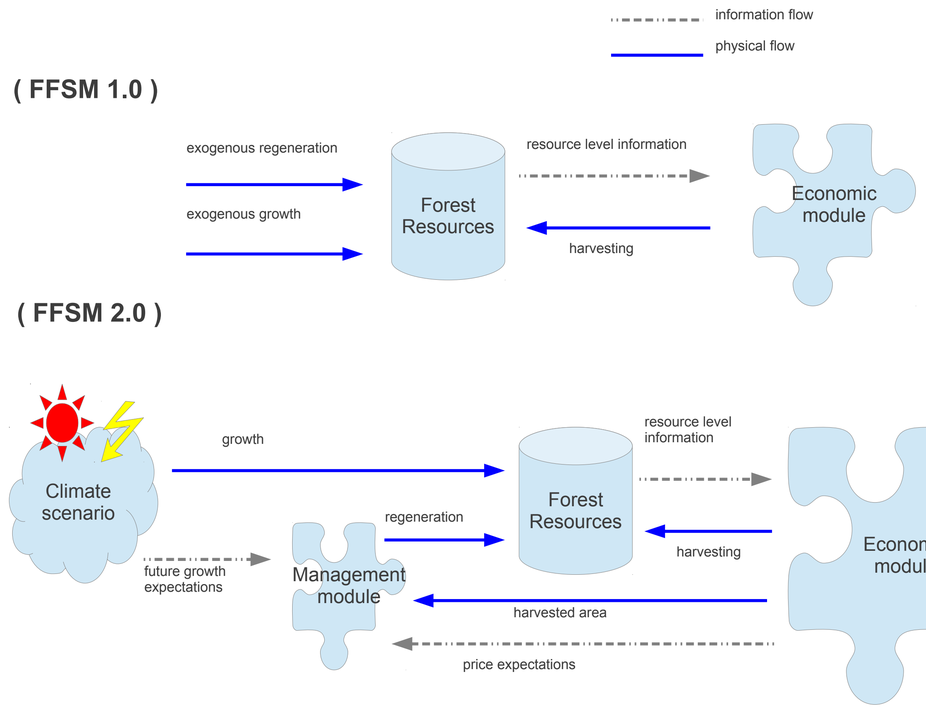
Implementation

FFSM 2.0 is composed of tree modules: the ***market module*** (KM) is a partial equilibrium model that determines wood market prices, demand, supply and trade, the ***resource module*** (RM) simulates the forest dynamics, and the ***management module*** (GM) determines investments in a specific forest type.
While a regional scale is reasonably adequate for KM, it is not for RM and GM: hence an high-scale, GIS based approach has been implemented for RM and GM where climatically-induced variations produced from the (exogenous) biological models can be accounted at a pixel level.
The GM module endogenises forest wood regeneration (depending on harvesting levels), incorporates forest managers expectations and finally determines model forest investments (replanting).
The unmanaged forest area is treated according to a probability of presence (of forest species) derived from the biological models.

Development status

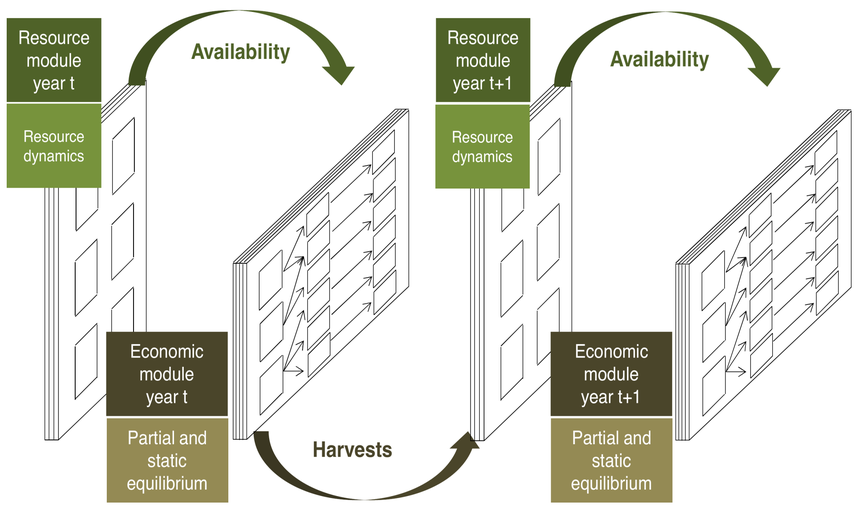
FFSM 2.0 is currently under validation. Exercises have been performed in order to empirically validate the new C++ coded model (FFSM 2.0) in comparison against its GAMS-coded predecessor (FFSM 1.0 - this is a well established model that has already been used in several exercises of political economy simulations) and the effects on the model of considering endogenous regeneration rather than fixed (exogenous) regeneration.
More extensive validation exercises are on the way.

At a glance



Module	Spatial Levels	Var Input	Var Output
Market	Countries, regions	$Inv_{r,pp,t}$, $Price_{wrd,pp,t}$	$Supply_{r,pp,t}$, $Price_{r,pp,t}$
Resource	Counties, regions, pixels	$Supply_{r,pp,t}$, $RegArea_{px,ft,t}$	$Inv_{px,pp,t+1}$, $HArea_{px,ft,t}$
Management	Countries, regions, pixels	$Price_{r,pp,t}$, $HArea_{px,ft,t}$	$RegArea_{px,ft,t}$

Model dynamic



$$V_{dc,t} = (1-1/tp_{dc}-mort_{dc}-hr_{dc,t})*V_{dc,t-1}+(1/tp_{dc-1})*beta_{dc}*V_{dc-1,t-1}$$

Forest investments and regeneration

- Expected returns from a given forest type depend from both market price of related wood products and biological parameters;
- converted to annualised valued ;
- each possible combination is multiplied by a weighting factor of the actual harvested for that specific combination to the total harvested for the forest type (only final harvested considered).

$$expReturns_{px,ft,t} = \sum_{dc}\sum_{pp} \frac{PW_{r,pp,t} * vHa_{px,ft,dc,t} * ponCoeff_{px,ft,dc,pp,t}}{(1+r)^{(cumTp_{px,dc,t}-1)}+(1+r)^{(cumTp_{px,dc,t}-2)}+\ldots+(1+r)^{(cumTp_{px,dc,t}-cumTp_{px,dc,t})}}$$

$$ponCoeff_{px,ft,dc,pp,t} = \frac{hv_{px,ft,dc,pp,t} * finHrFlag_{ft,dc}}{\sum_{dc}\sum_{pp} hv_{px,ft,dc,pp,t} * finHrFlag_{ft,dc}}$$

- Each year an harvested area for each f.t. is computed from the harvested volumes (in turn derived from market demand)

$$harvestedArea_{px,ft,dc,t} = hV_{px,ft,dc=finharv,t} / vHa_{px,ft,dc,t}$$

- The regeneration area for each forest type is equal to the unmanaged share of the harvested area of its own type ;
- the managed share of the total harvested area is allocated as the regeneration area of the forest type having the highest expected return ($\mathring{ft}$).

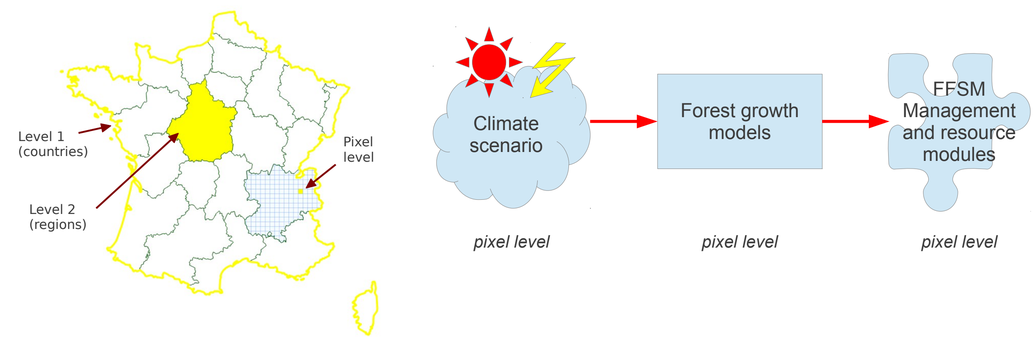
$$regArea_{px,ft,t} = \sum_{dc} harvestedArea_{px,ft,dc,t}*(1-mr)$$
$$regArea_{px,\mathring{ft},t} \mathrel{+}= \sum_{ft}\sum_{dc} harvestedArea_{px,ft,dc,t}*mr$$

- A time leg exists between harvesting/regeneration and availability of wood resources

$$vReg_{px,ft,t} = regArea_{px,ft,\tau} * vHa_{px,ft,dc15,\tau}$$
$$\tau = t-tp_{px,ft,dc0,t}$$

Spatial Representation

- Decoupling the spatial scale of the market module (regional) from those of the resource and management modules (pixel)
  - regional scale reasonably adequate for the market module
- Consistency within ORACLE projects:



FFSM references

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equation indices

t	time	[2005-2100]
c	country	{France}
r	region	[22 administrative regions in France]
px	pixel	
sp	forest species group	{Broadleaves, Coniferous}
mt	forest management type	{High forests, Mixed forests, Coppers}
ft	forest type (including management: *sp* × *mt*, e.g. *coppers broadleaved* or *high forest coniferous*)	
dc	diameter class	{0, 15, 25, 35, 45, 55, 65, 75, 85, 95, 150}
pp	primary product (that is, deriving directly from forest resources)	{Hardwood Roundwood, Softwood Roundwood, Pulpwood and Fuelwood}
tp	transformed products	{Fuelwood, Hardwood Sawnwood, Softwood Sawnwood, Plywood, Pulpwood, Pannels}
prd	products (pp ∪ tp)	

further information

http://www7.nancy.inra.fr/lef/recherches/ffsm

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