Multiple ecosystem services analysis in apple orchard

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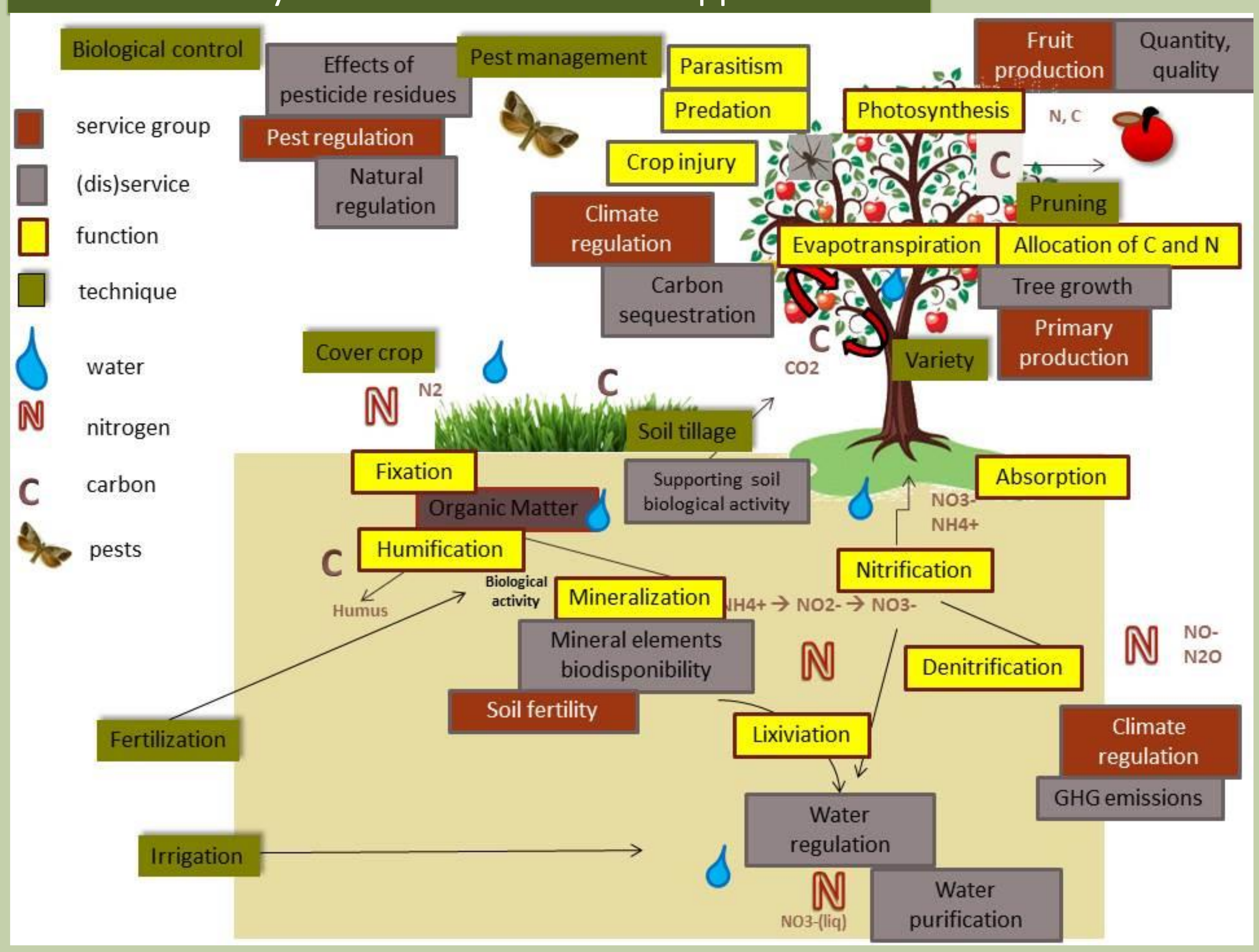
Highlights

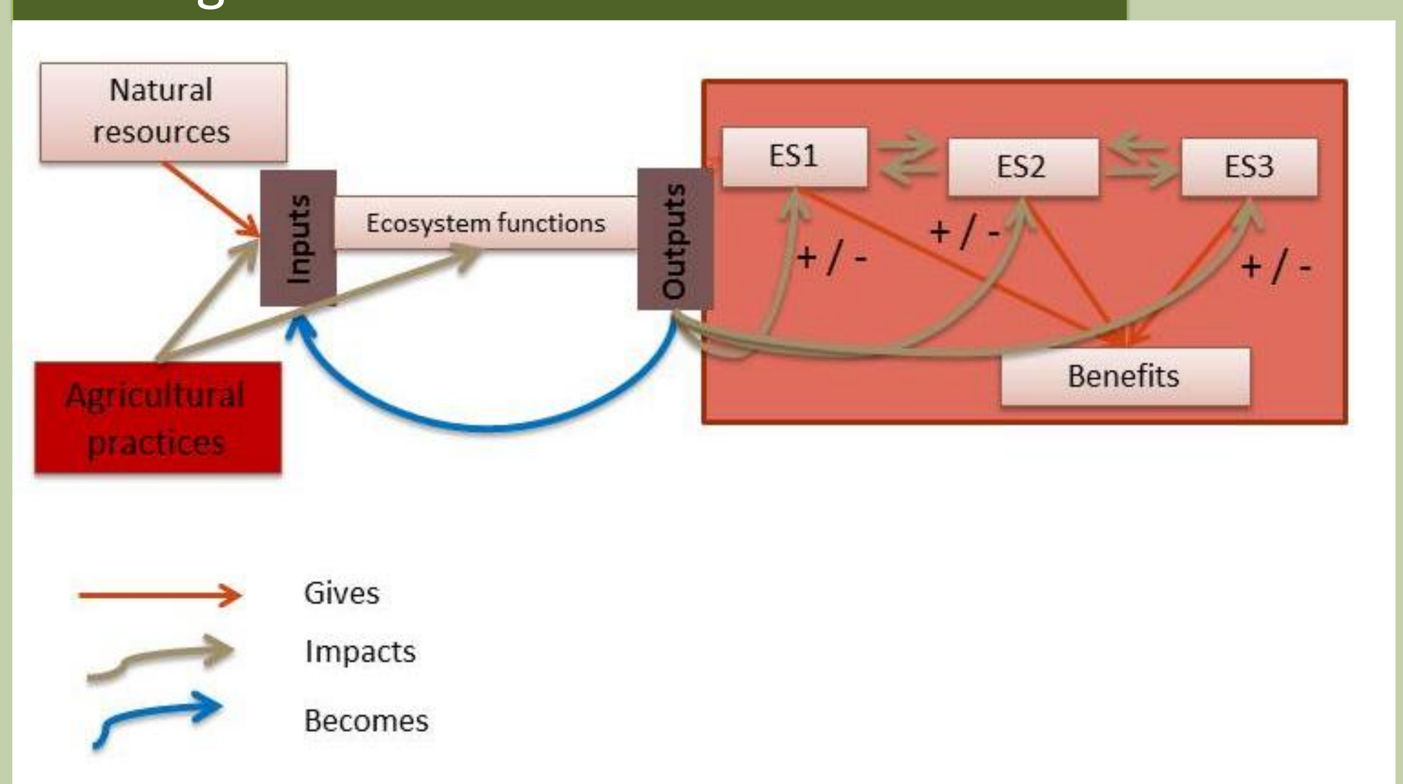
Fruit production, besides providing food to humans, can induce changes to or receive benefits from the ecosystem it relies on. These changes are induced by particular agricultural management and pedoclimatic conditions, used as levers to draw optimal benefits from an **agroecosystem**.

1. Five **ecosystem service (ES) groups** have been selected as an example of multiple ES analysis, declining in particular **ecosystem services or disservices**. Each of them depend on biochemical transformations or processes, which are defined as **ecosystem functions**. These functions are all influenced by **agricultural practices** used in this agroecosystem.
2. These entities present complex relations within agroecosystems, leading to **tradeoffs** and **synergies** between ES. The design framework for ES assessment considers the idea of cascade services (Haines-Young & Potschin, 2009) while taking into account the non-linearity of these relations.
3. These entities are analyzed within an apple orchard agroecosystem using two **simulation models** which outputs can be used as **ES indicators**.
4. These models are **parameterized** on apple orchard using experimental data on two specific sites in south-eastern France.

1. Studied ecosystem services within an apple orchard



2. Design framework for ES assessment



3. Using models as tools to assess ES

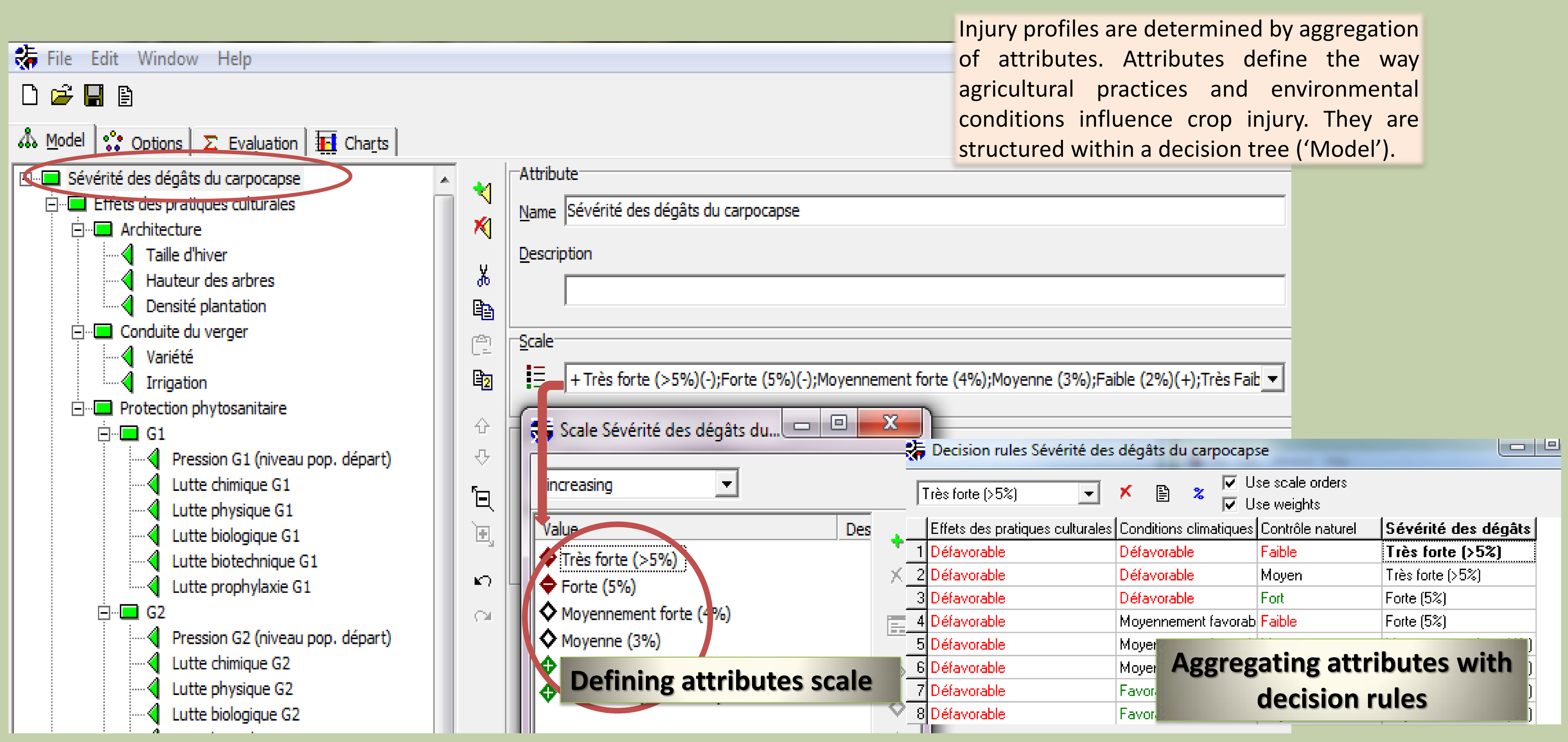
	STICS (Simulateur mulTIdiscplinaire pour les Cultures Standard)	IPSIM (Injury Profile Simulator)
What is it?	A crop model which simulates the behaviour of the soil-crop system on a daily time scale, over one or several successive crop cycle(s).	A generic modelling framework which aims at predicting a crop injury profile as a function of cropping practices? abiotic and biotic environment.
Ecosystem services involved	Fruit production, carbon sequestration, GHG mitigation, soil fertility, primary production	Pest regulation on codling moth, apple scab and rosy apple aphid.
Parameterization method	Parametization of plant physiology: • Measures on 2 experimental sites in south-eastern France • Bibliographic data • Estimated data	Bibliographic data • Individual experts statements • Workshop with 8 experts on the link between agricultural management and injury severity
Inputs	Climate data , soil data, Agricultural practices	Agricultural practices, environmental conditions (biotic and abiotic)
Outputs or ES indicators	Soil nitrogen balance, water stress, soil organic carbon content, yield, aboveground dry matter, fruit mean weight, NO- and N2O emissions, leached nitrogen	Injury severity caused by pests on apple orchards

STICS

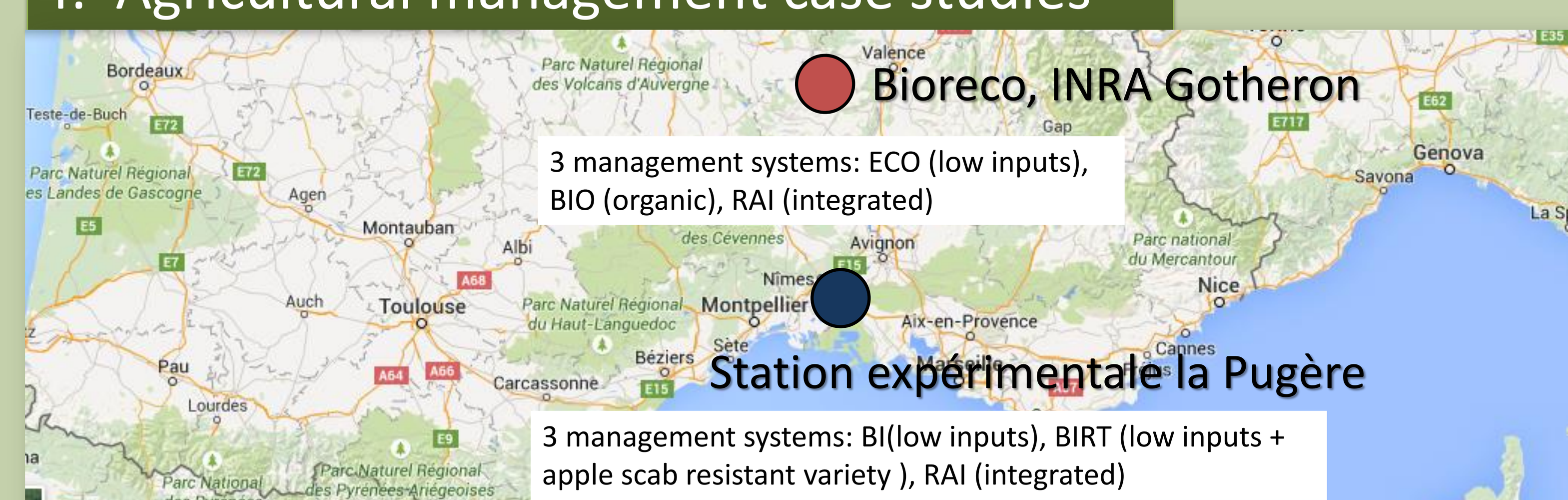
Specific apple tree physiology parameters were found using experimental data on 2 case studies. These experimental data are also used to compare them with model output.

IPSIM

Injury profiles are determined by aggregation of attributes. Attributes define the way agricultural practices and environmental conditions influence crop injury. They are structured within a decision tree ('Model').



4. Agricultural management case studies

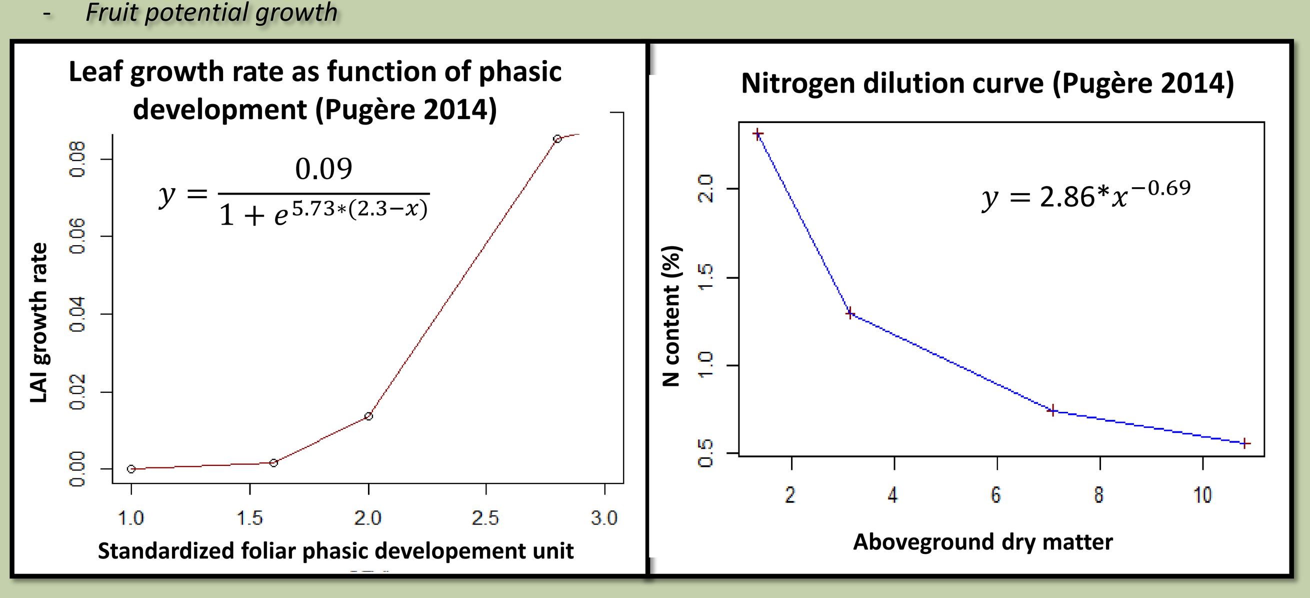


Selective data

- *Soil analysis (mineral/organic nitrogen and carbon)*
- *Aerial biomass (shoot growth, foliar surface, allometric relations (diameter / weight) , fruit weight at harvest)*
- *Fruit quality*

Dynamic data

- *Leaf growth rate as a function of phasic development*
- *Nitrogen dilution curve*
- *Fruit potential growth*



Conclusions

- The conceptual scheme linking resources, functions, benefits and agricultural management within an apple orchard shows the complexity of ecosystem services relations.
- In order to analyse these relations, two models were chosen, related to the studied ES. STICS for soil-plant continuum, takes into consideration the agricultural practices as well as detailed pedoclimatic conditions in order to simulate nitrogen, carbon and water cycles. IPSIM deals with pest regulation considering pest pression, treatment frequency and agricultural practices.
- Models outputs together with directly measured data can be used as ES indicators to evaluate the impact of agricultural management and pedoclimatic conditions on synergies and trade-offs relations between them.
- The use of models may offer a large panel of possible scenarios to evaluate these relations.

References

Aubertot, J.-N., & Robin, M.-H. (2013). Injury Profile SIMulator, a qualitative aggregative modelling framework to predict crop injury profile as a function of cropping practices, and the abiotic and biotic environment. I. Conceptual bases. PloS One, 8(9)

Brisson, N., Launay, M., Mary, B., & Beaudoin, N. (2008). Conceptual basis, formalisations and parameterization of the STICS crop model. (E. QUAE, Ed.).

Haines-Young, R., & Potschin, M. (2009). Methodologies for defining and assessing ecosystem services. Final Report, JNCC, Project Code C08-0170-0062.