A procedure to analyze multiple Ecosystem Services in apple orchards

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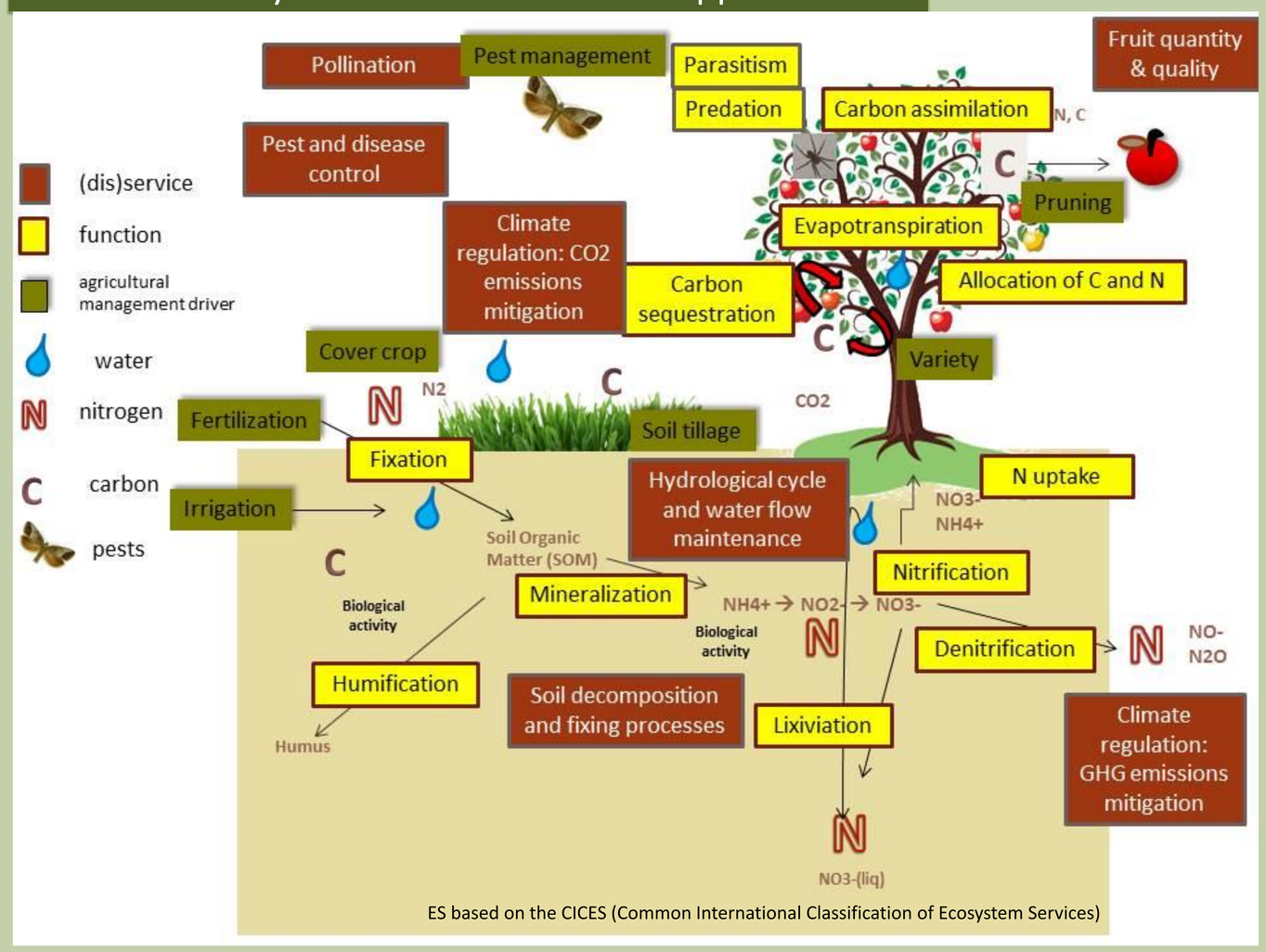
Highlights

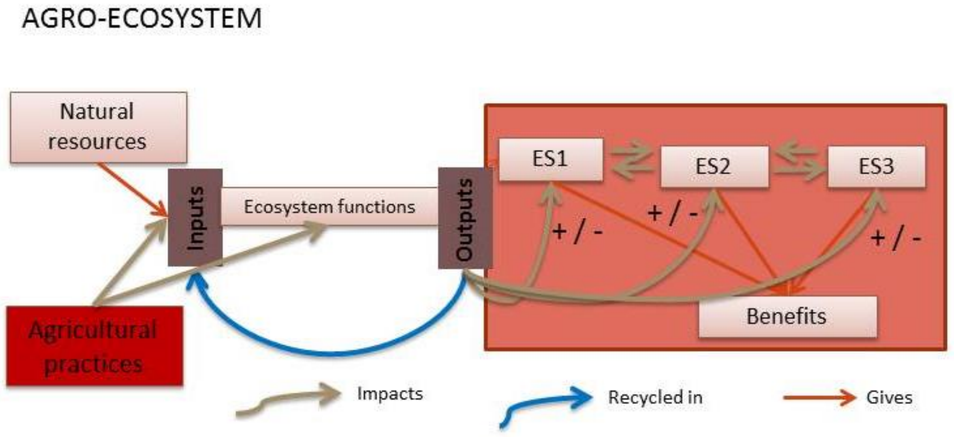
Fruit production, besides providing food to humans, can induce changes to or receive benefits from the ecosystem it relies on. These changes are induced by particular agricultural management and pedoclimatic conditions, which are used as levers to draw optimal benefits from an **agroecosystem**.

1. Five **ecosystem service (ES)** have been selected in apple orchards as an example of multiple ES analysis. Each of them depends on biochemical transformations or processes, which are defined as **ecosystem functions**. These functions are all influenced by **agricultural practices** used in this agroecosystem.
2. Agroecosystem functions present complex relations, which leads 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. Agroecosystem functions are analyzed within an apple orchard 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



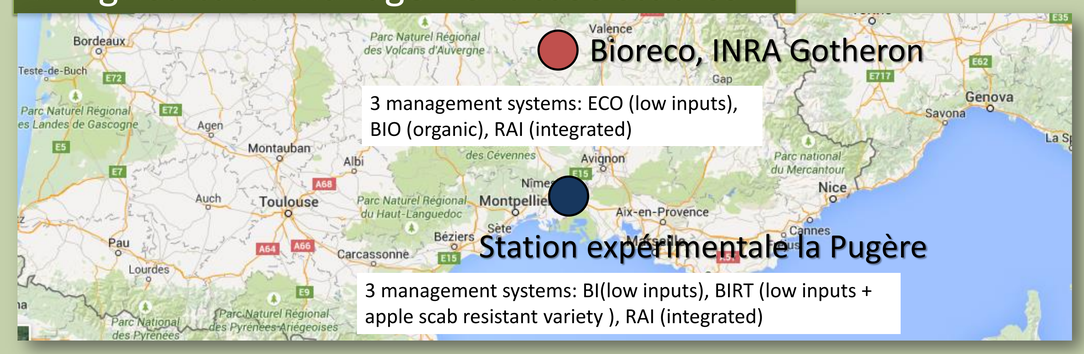
2. Design framework for ES assessment



3. Using models as tools to assess ES

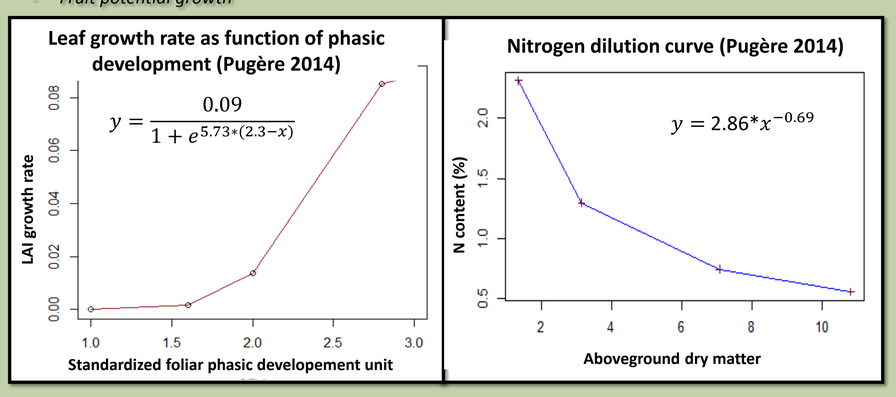
	STICS (Simulateur mulTIdiscplinaire pour les Cultures Standard)	IPSIM (Injury Profile Simulator)
What is it?	A crop model which simulates the functioning of the soil-crop system on a daily time scale, over one or several successive crop cycle(s).	A generic modelling framework which aims at predicting a crop injury profile as a function of cropping practices, abiotic and biotic environment.
Ecosystem services involved	Fruit production, GHG emissions mitigation, soil decompostion and ixing processes	Pest and disease regulation (codling moth, apple scab and rosy apple aphid)
Parameterization method	Measures on 2 experimental sites in south-eastern France Bibliographic 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 weight, fruit mean weight, N2O emissions, leached nitrogen, humified carbon	Injury severity caused by pests on apple orchards

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 indicators*

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

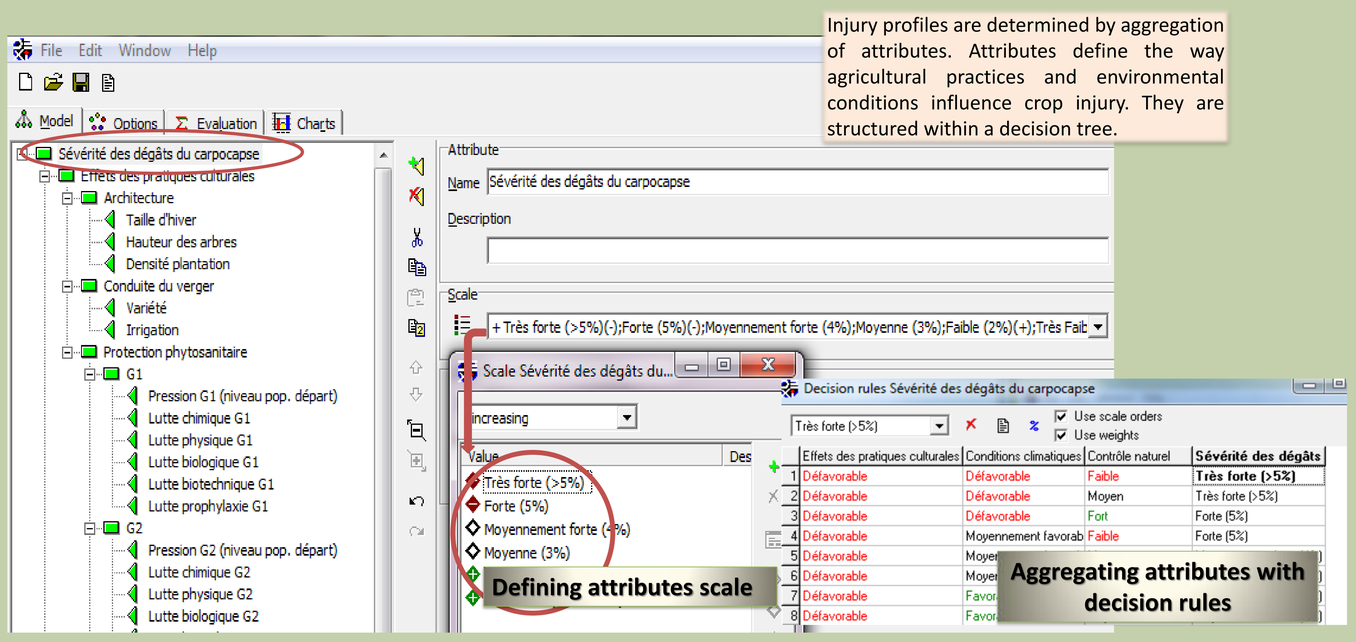


STICS

Specific apple tree physiology parameters were found using experimental data on 2 case studies.
These experimental data are also used to assess the model goodness-of-fit.

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.



Conclusions

- The conceptual scheme linking resources, functions, ES 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 pressure, 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 ES.
- The use of models makes it possible to simulate a large panel of possible scenarios to evaluate these relations.

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