

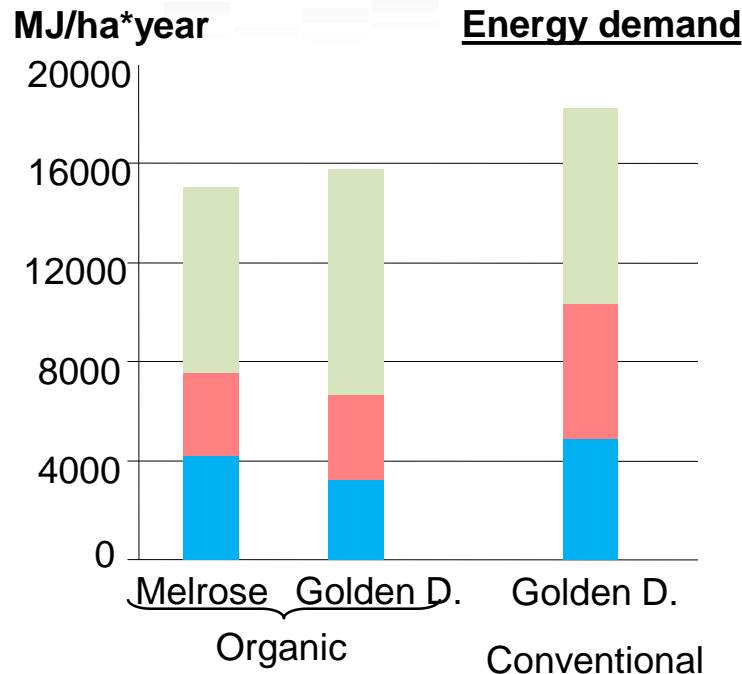
Using of the LCA methodological framework in perennial crops: Comparison of two contrasted European apple orchards

Aude Alaphilippe
Joachim Boissy
Sylvaine Simon
Caroline Godard



Example of LCA results for perennial crops

What is usually done



- ❖ **Full productive year(s)**
 - No non-productive year
 - Compare production systems
 - Goal: identify hotspots
 - Produce reference values
- ❖ **FU: one FU**
 - mass or area-related unit



From Alaphilippe et al., 2013 in ASDE

Orchard complexity

Different stages along its lifetime



Structure and training
(Tree density, irrigation,...)

Cultural practices
(Tree training, plant protection, harvest...)

Nursery

Destruction

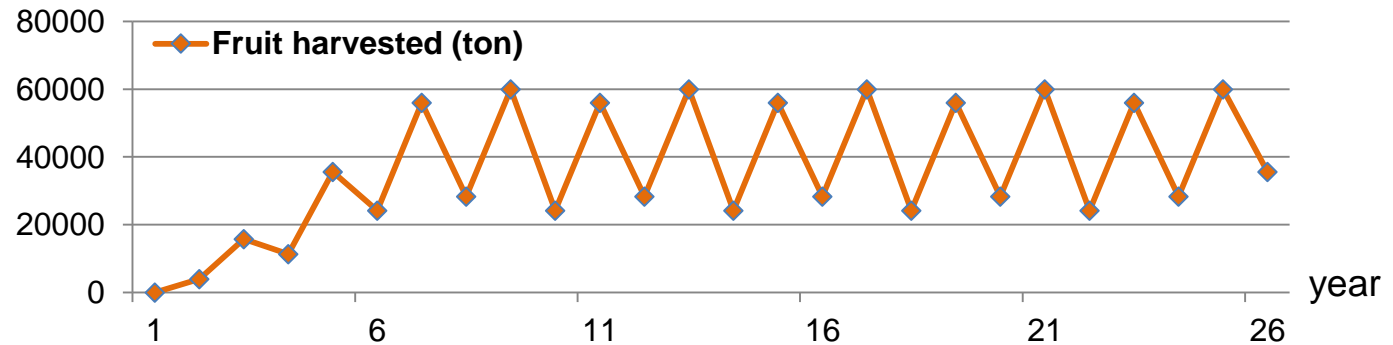
Planting

Young orchard -

Productive orchard

Time

Production dynamic



How to cope with the orchard whole life?

New proposed recommendations for perennial crops



Bessou C et al. (2013) **LCA applied to perennial cropping systems: a review focused on the farm stage**. Int J Life Cycle Assess.

Cerutti AK et al. (2011) **A review of studies applying environmental impact assessment methods on fruit production systems**. J Environ Manag.

List of recommendations

- ❖ **Modelling of each orchard stage, unproductive stages (i.e., nursery, orchard creation, establishment and destruction) and the productive stage**
- ❖ **Functional units (FU) :**
 - **mass-based FU** : 1 ton of apples for the cumulated yield over the whole orchard lifetime
 - **area-related FU** : 1 ha.year of land used to produce apples over the whole orchard lifetime
- ❖ **Direct field emissions:** from **pesticides** and **fertilizers**, using models

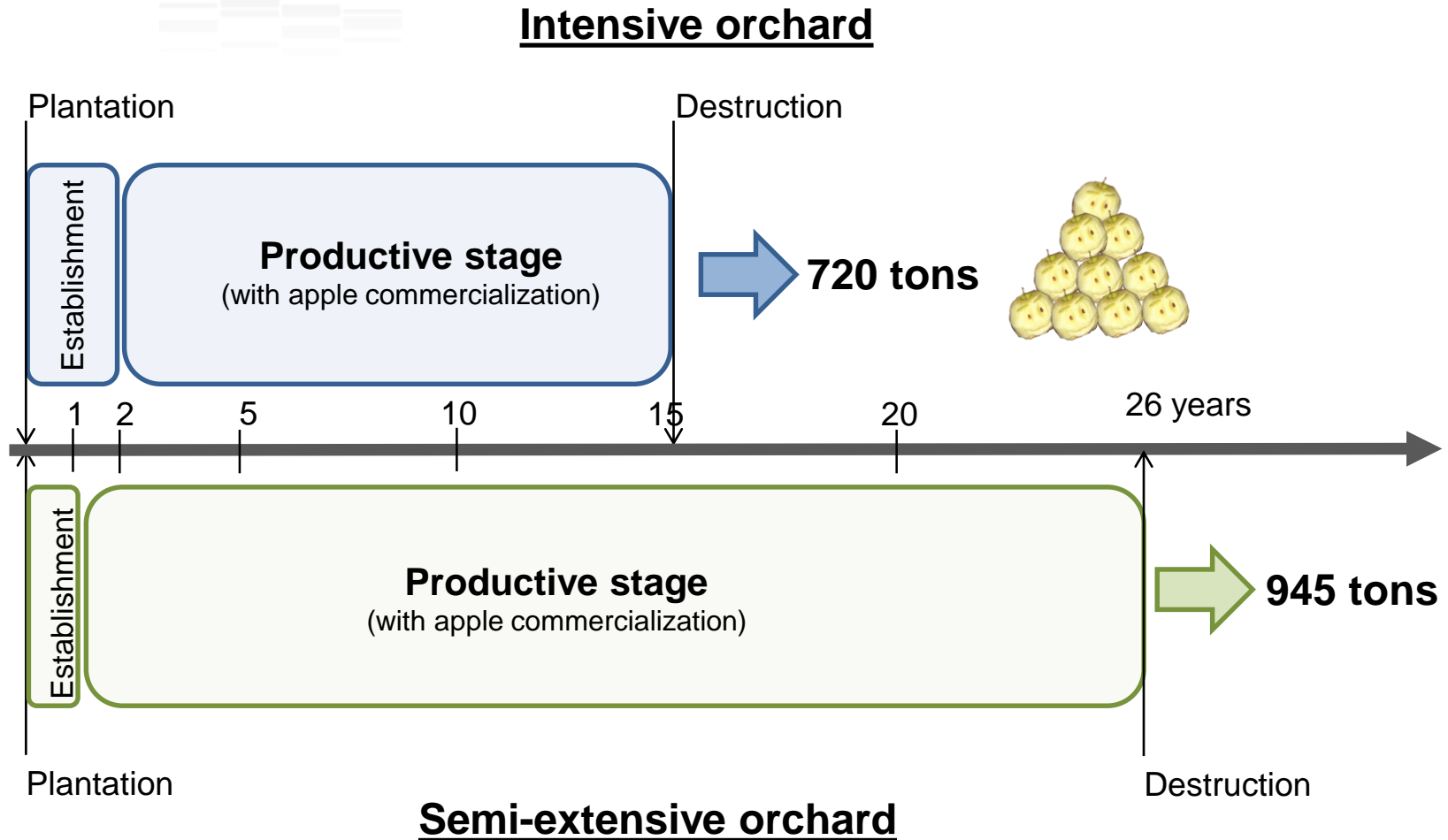
What we did and why



- ✓ To choose 2 contrasted case studies
 - ➔ to test the recommendations & methodological framework
- ✓ To analyze the results
- ✓ To discuss the proposed recommendations & methodological framework

Orchard description

Selection of two contrasted orchards



Orchard description

System definition



	North
Farming system	Intensive
Cultivar	Jonagold
Tree density (/ha)	2500
Lifespan (years)	15
Irrigation	No
N fertilizer (kg N/ha)	114
Active ingredient (kg /ha)	74
Average yield (t /ha)	55.4

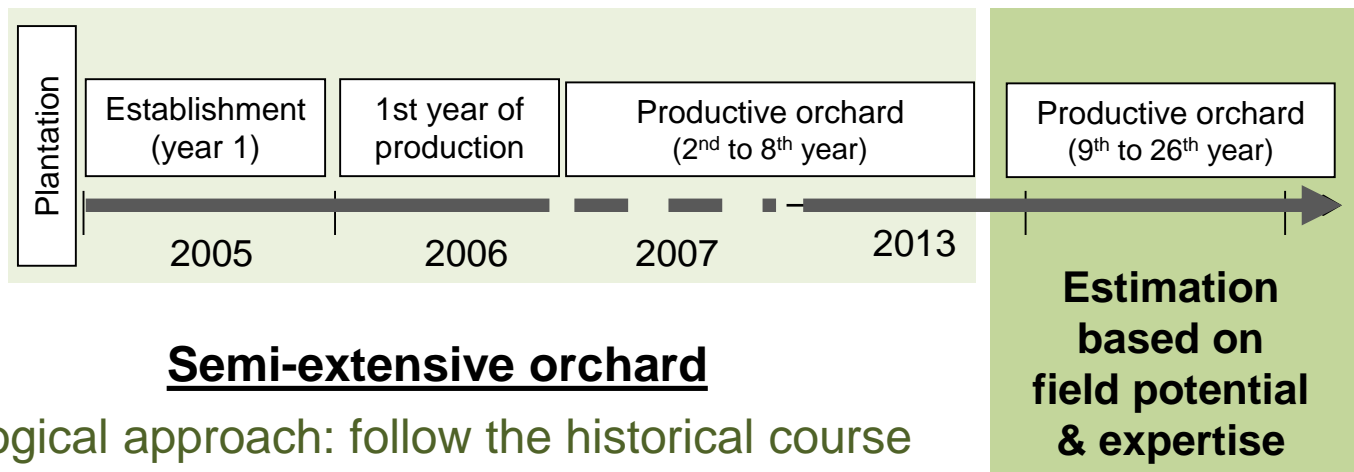
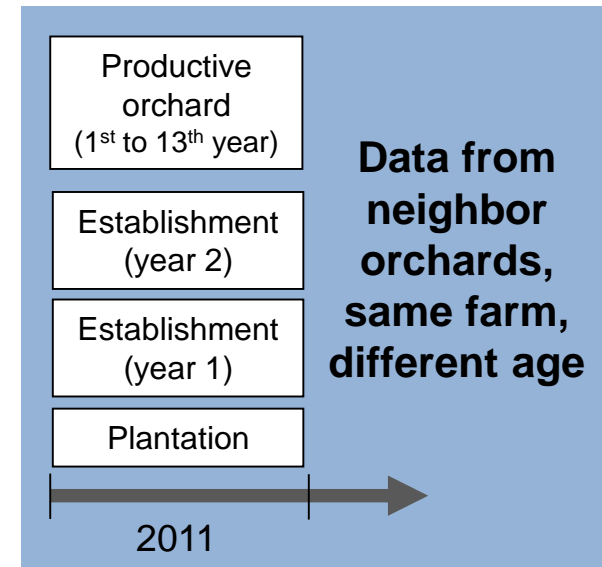
Modelling approach

Modular and chronological approaches

Intensive orchard

→ modular approach: ≠ stage in 1 single year

- ✓ Data from on-farm surveys
 - ✓ Data consistency ensured by the geographical origin (north/south and same farm)
- Modelling approach based on the data availability



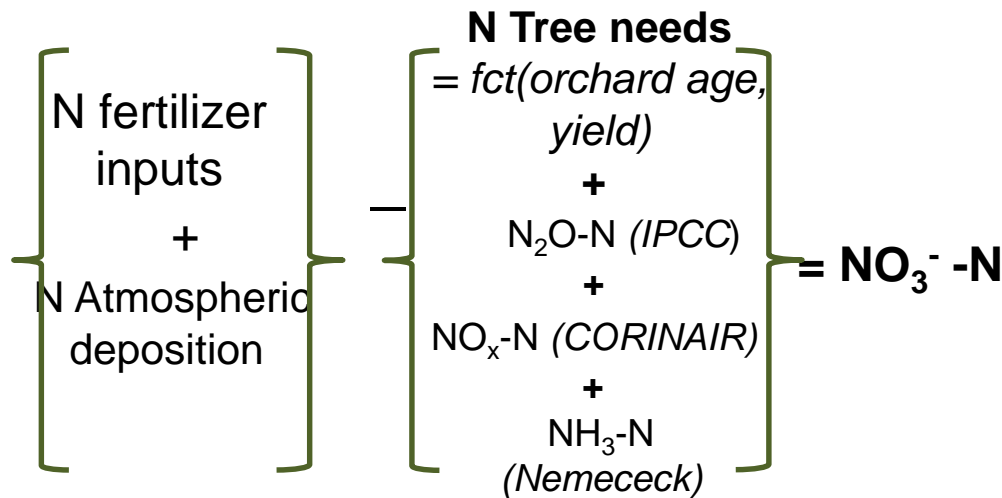
Semi-extensive orchard

→ chronological approach: follow the historical course

LCA inventory

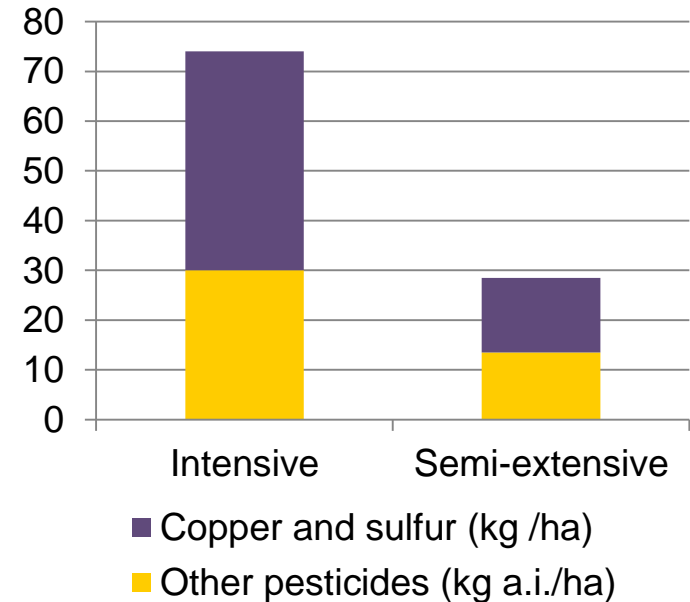
Models for field emissions

Fertilization



- ❖ **No model use but a 'N balance'** based on tree needs for each orchard stage
- ❖ N tree **needs estimated** according to the **apple yield** and the **orchard age**

Pesticides



- ❖ **Pest-LCI 2.0.5** to assess organic pesticide fluxes
- ❖ **Sulfur and Copper in-field fluxes not inventoried** despite great importance

LCA results: impact assessment

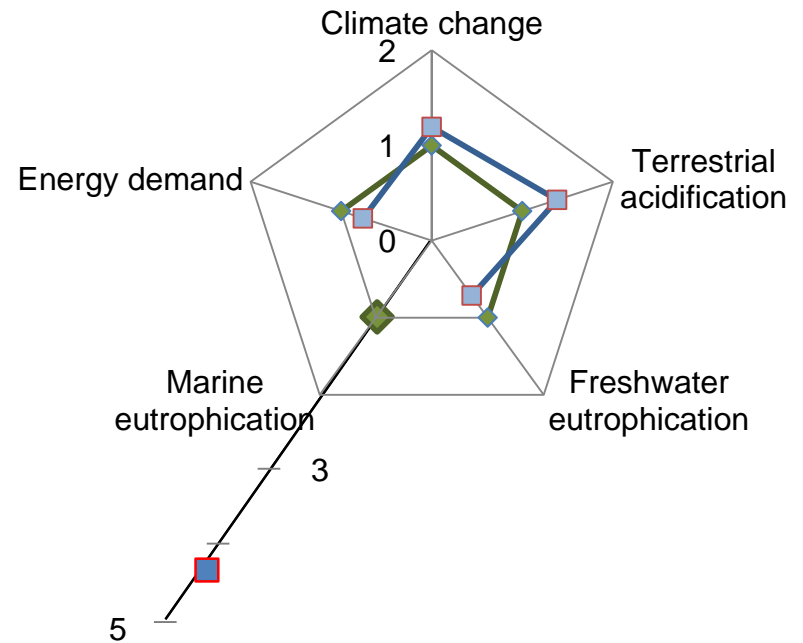
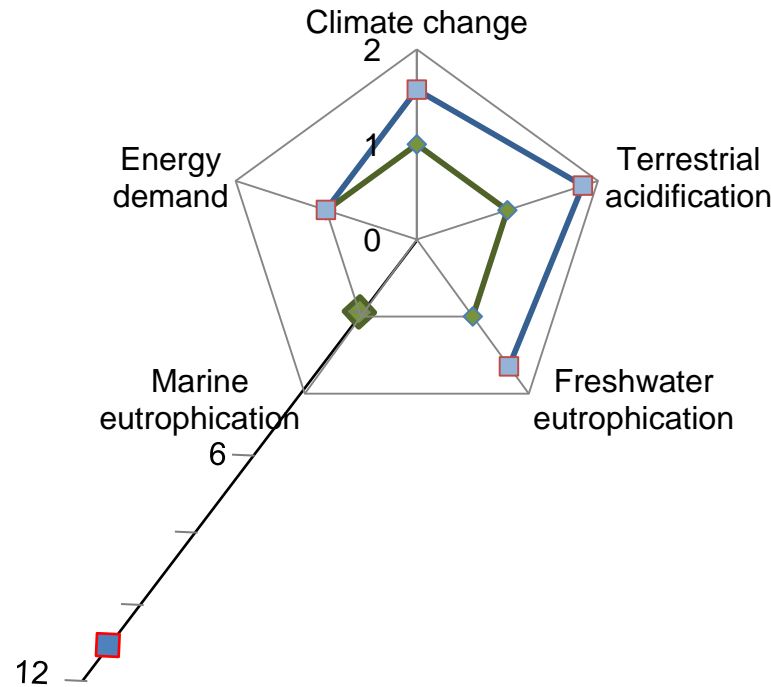
Comparison of the global impact of the two orchards

ha⁻¹ year⁻¹

—◆— SE

—■— I

ton⁻¹



❖ Intensive orchard was a little bit more impacting

- Differences less important with the mass-based FU

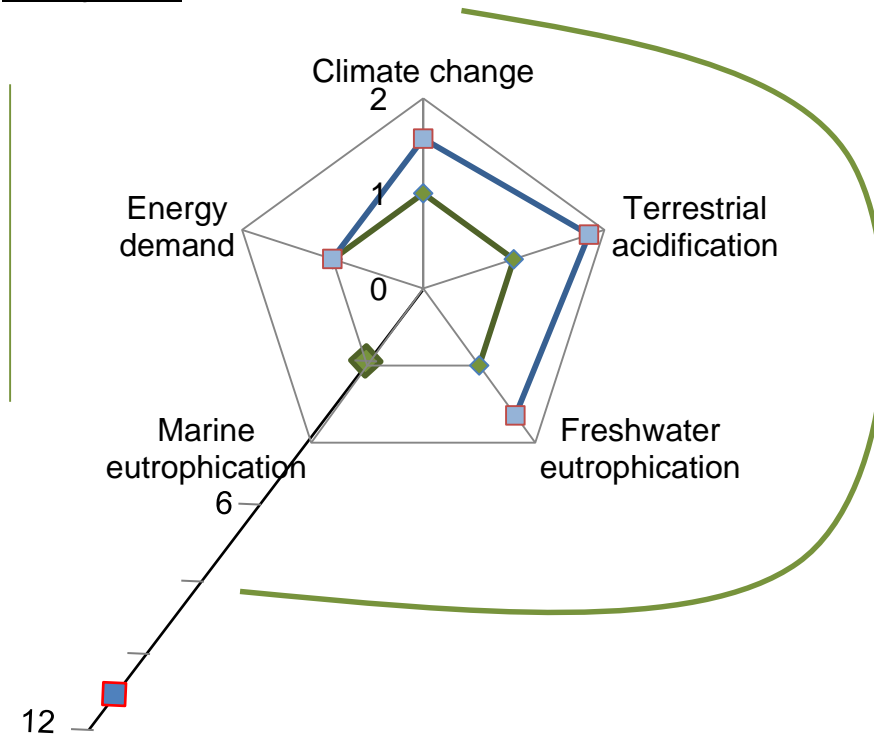
➔ Importance of using different FU

LCA results: impact assessment

Hotspots for the two orchard types.

ha⁻¹ year⁻¹

◆ SE ■ I



SE orchard:
machinery and
infrastructures
(plantation &
irrigation)

Intensive orchard:
fertilization

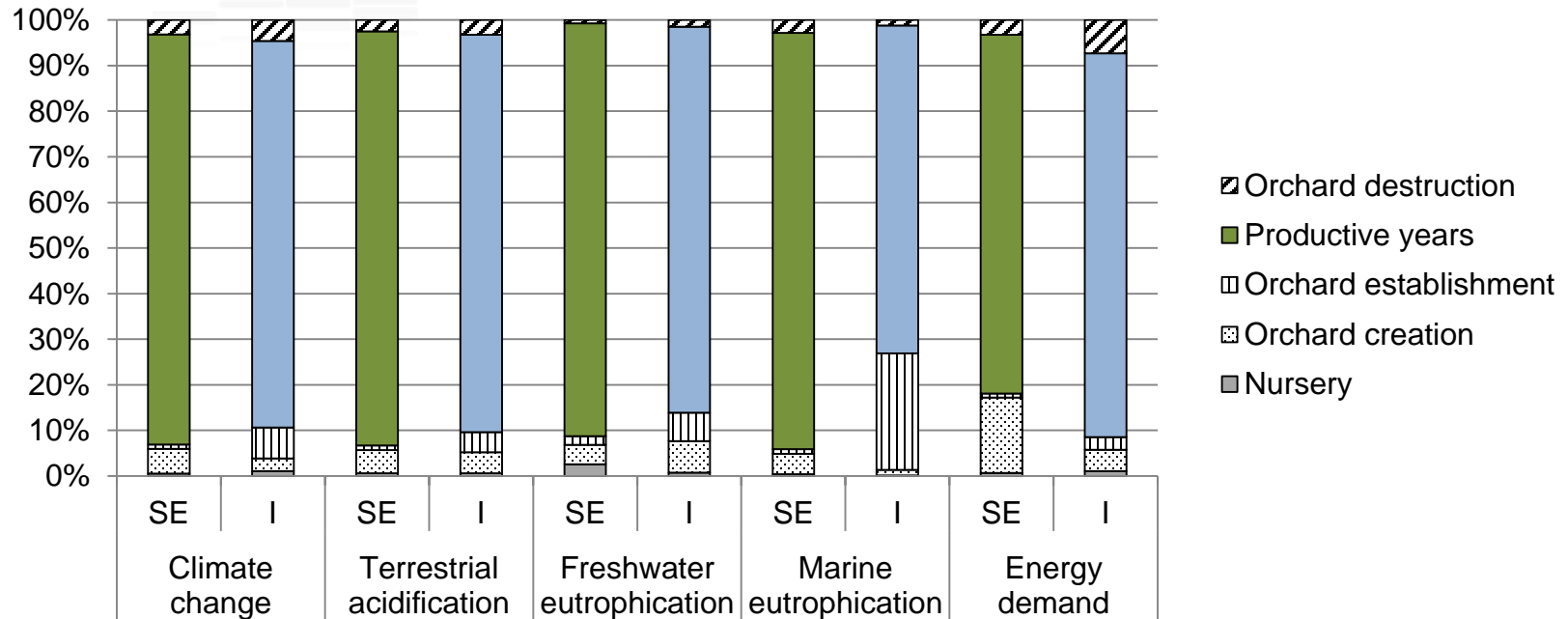
Semi-extensive orchard:
fertilization & pesticides
production & application

- ❖ Importance of field emissions
- ❖ Weight of the non-productive stages

- ➔ Importance of emissions modelling
- ➔ Importance of non-productive stages

LCA results: relative contribution of each stages

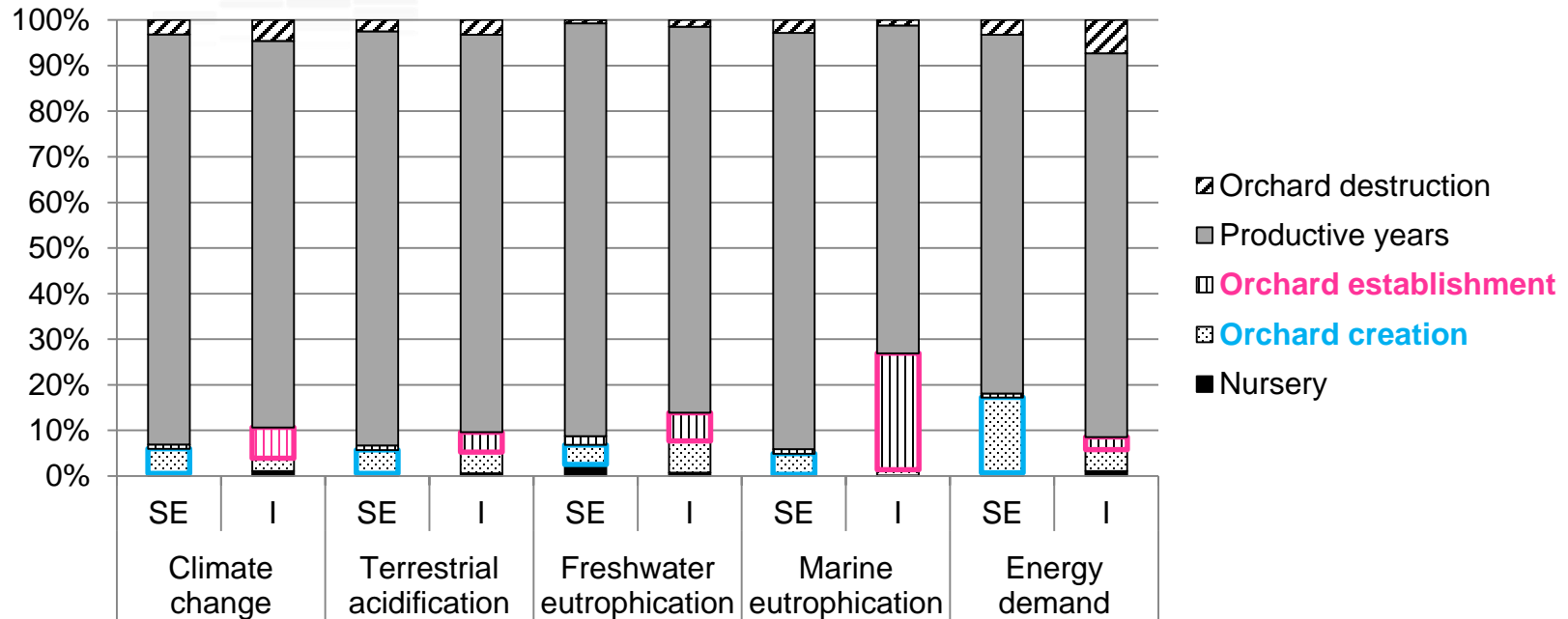
Importance of non-productive stages



❖ **Productive stages = hotspot (72 to 82 % of the impact category)**

LCA results: relative contribution of each stages

Importance of non-productive stages



- ❖ Productive stages = hotspot (72 to 82 % of the impact category)
- ❖ **Lower contribution of the non-productive stages in the semi-extensive orchard,**
 - intensive orchard: 'orchard establishment' = main contributor
 - semi-extensive orchard: 'orchard creation' = main contributor
- ❖ **Nursery < 1% - 2.2%>**

Conclusion



- ❖ **Importance of the overall recommendations made in the 2 reviews:**
 - Importance of considering different FU (mass- & area-related)
 - Direct field emissions have to be considered
BUT more knowledge on modelling are requested
 - Importance of non-productive stages in this comparison

- ❖ **BUT, aside from marine eutrophication and cumulative energy, the weight of the unproductive stages in all impact categories was only slightly changed**

Perspectives



- ❖ **Our work outlines that these recommendations are relevant to assess global environmental impacts in orchards**

- ❖ **However, with the goal of comparison no need to calculate the nursery stage, we recommend:**
 - To privilege an accurate representation of the field stages, including the orchard establishment and the orchard creation
 - To create a specific inventory for the nursery stage

- ❖ **Pesticide and fertilization emission modeling has to be developed**



Thank you and to continue the discussion



Aude.alaphilippe@paca.inra.fr

j.boissy@agro-transfert-rt.org

c.godard@agro-transfert-rt.org