Exploring chemical pesticide free cropping systems in Europe in 2050

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Session 6.4 Multi-scale scenario design for European agriculture and food systems to frame future diversification contexts

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Context and aims of this foresight study

A foresight study to develop **scenarios of chemical pesticide-free agriculture in Europe in 2050**, aiming at answering two questions:

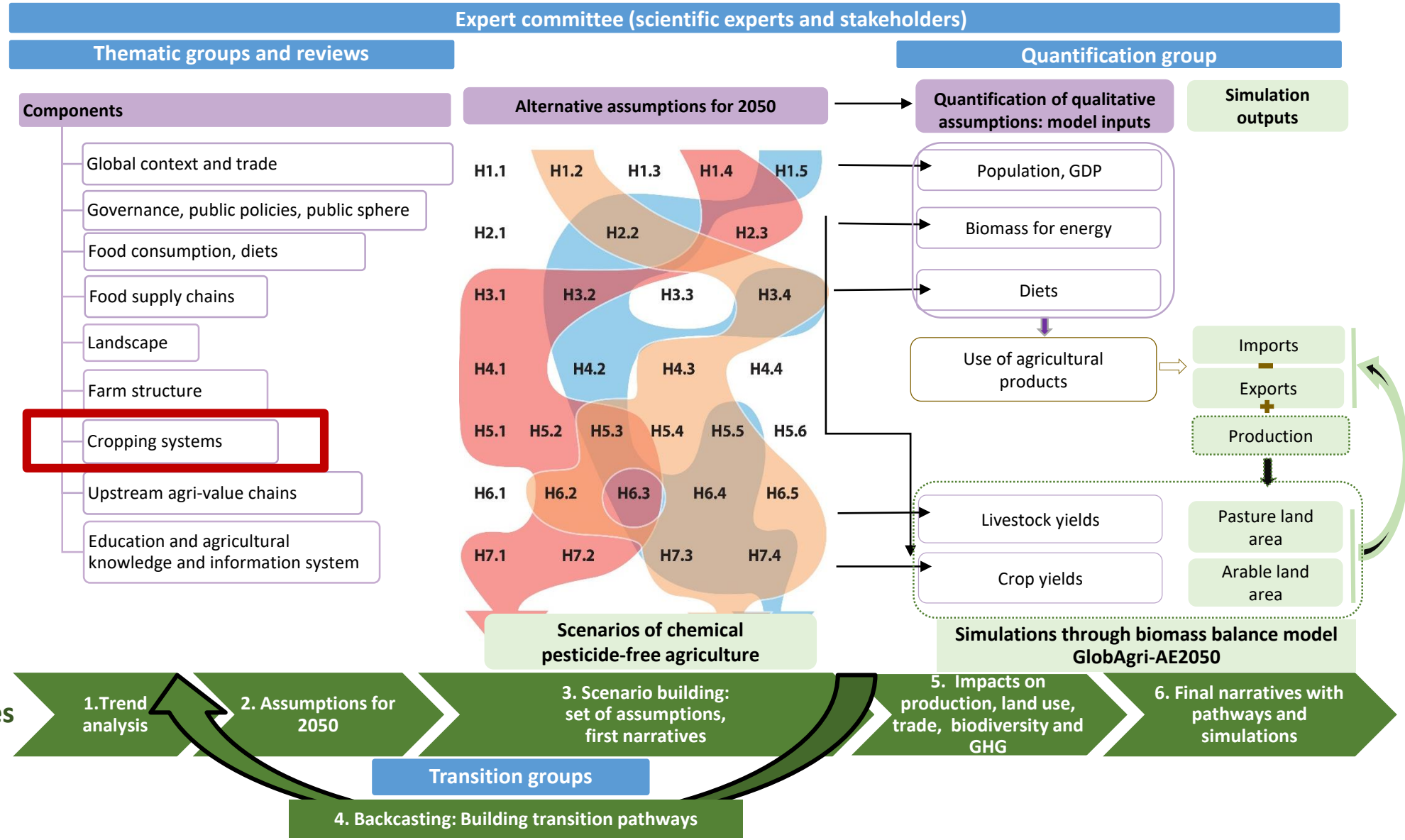
- What could be the different forms of a **chemical pesticide-free agriculture** in 2050?
- What could be the different **pathways towards such chemical pesticide-free agricultures**?

- Included in the French national priority research programme (PPR), **Growing and protecting crops differently**, led by INRAE, launched by the French Government
- Linked to the **European Research Alliance** "Towards Chemical Pesticide-free Agriculture“

Objectives

- Build **scenarios** describing what could be **European agriculture without chemical pesticides**
- Identify **transition pathways** for each scenario
- **Assess through modelling and simulations the different scenarios** (impacts on production, land use, trade, GHG, biodiversity)

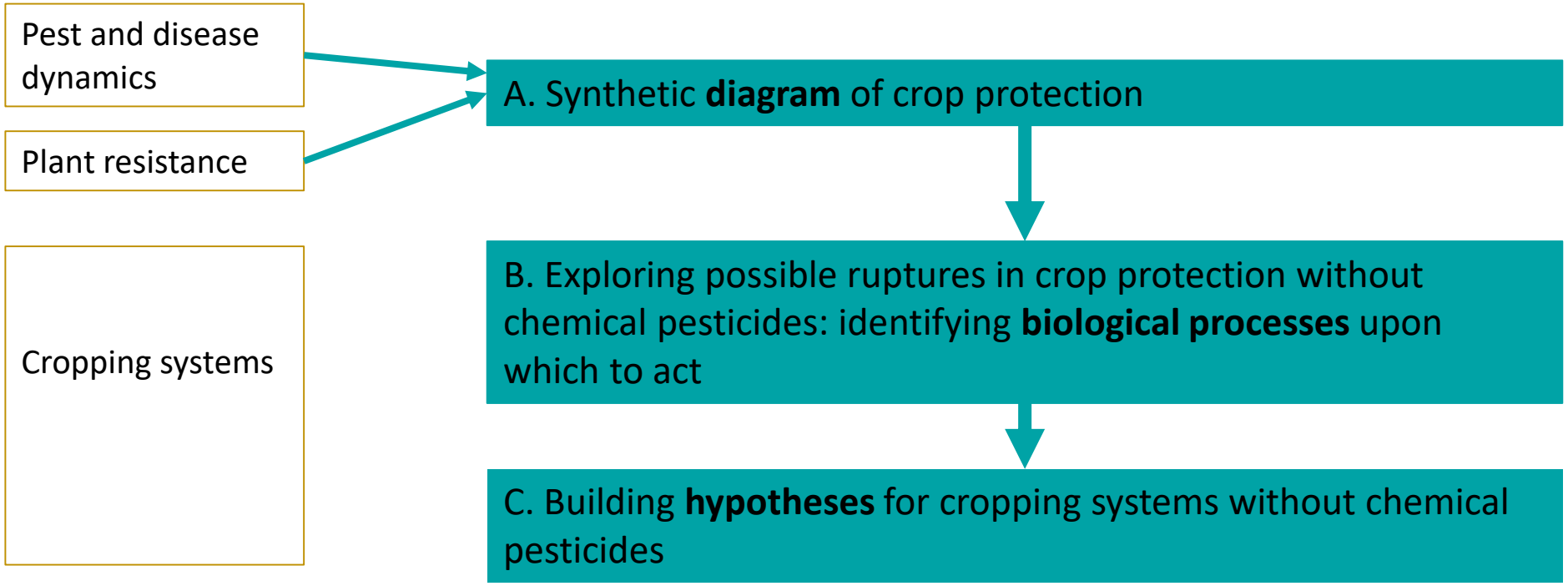
General method for building scenarios of chemical pesticide-free agriculture in Europe in 2050



Method for building rupture hypotheses for **cropping systems** without chemical pesticides

Four interdisciplinary workshops with scientific experts (2020-2021):

- Reducing pest pressure
- Strengthening plant resistance
- Hypotheses for cropping systems without chemical pesticides (2 workshops)



Mobilising the theory of innovation through withdrawal as a heuristic tool for foresight exploration

Simplified presentation of the theory of innovation through withdrawal based on the case study of agricultural **techniques without ploughing or no-tillage** (Goulet and Vinck, 2012)

1. Creation of centrifugal associations

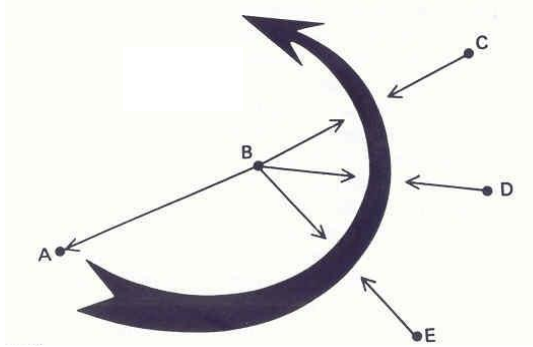
- What is the problem with the entity that has been withdrawn?
- Ploughing encourages soil erosion and represents a cost.

2. Strengthening links by making pre-existing entities visible

- Are any pre-existing but non-visible entities made visible by the withdrawal?
- Making soils and their biological activity visible.

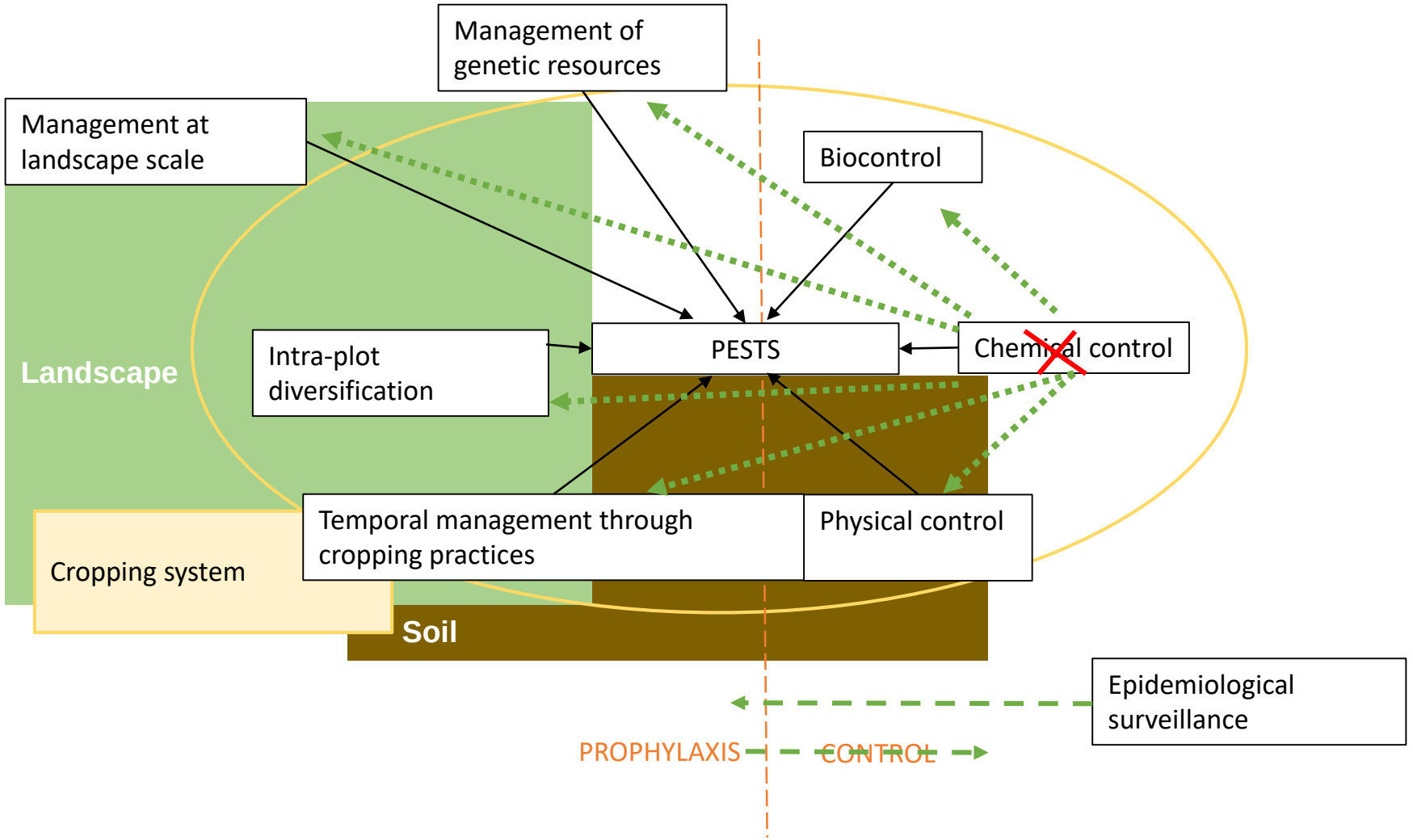
3. Association of new entities

- Detachment and dissociation from a technical act is possible thanks to the introduction of new technical objects: seed drills and herbicides for no-till

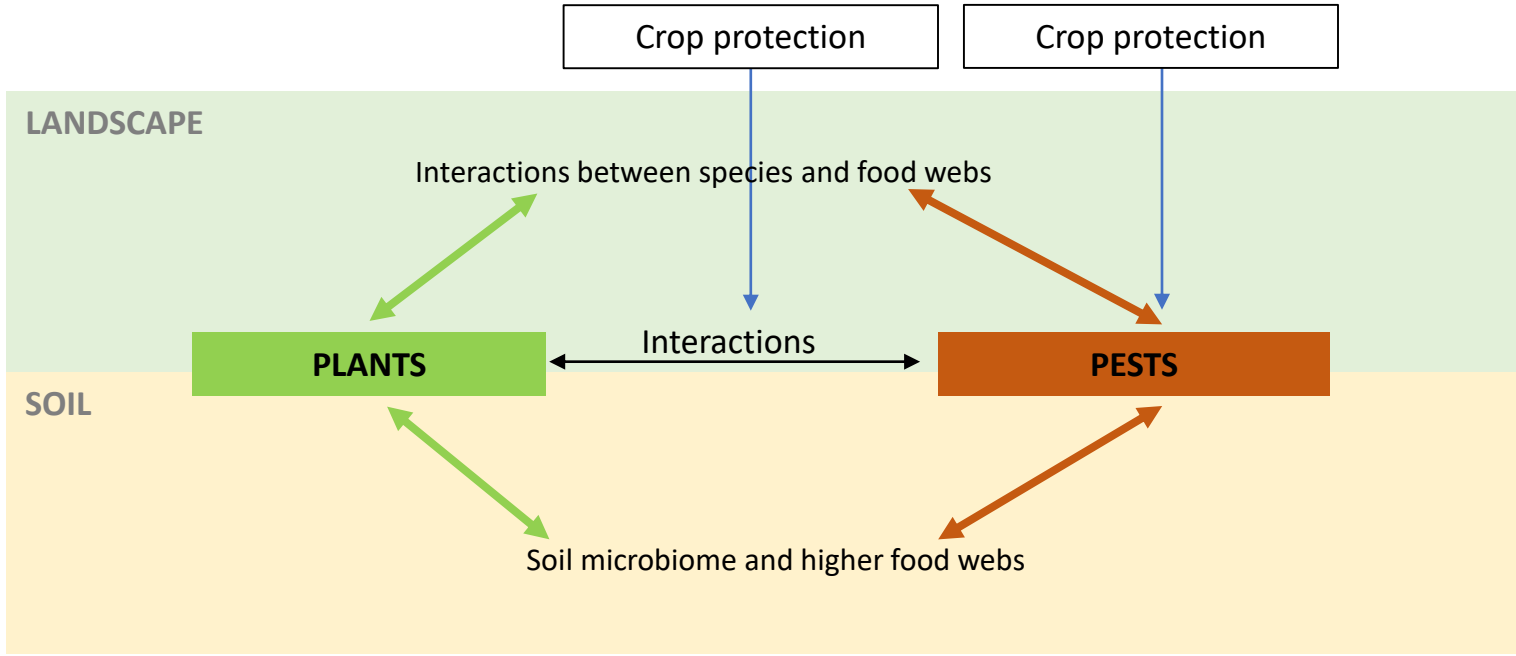


A momentum of uncertainty about the categorisation of entities in interaction

Thinking crop protection strategies as a withdrawal of chemical pesticides

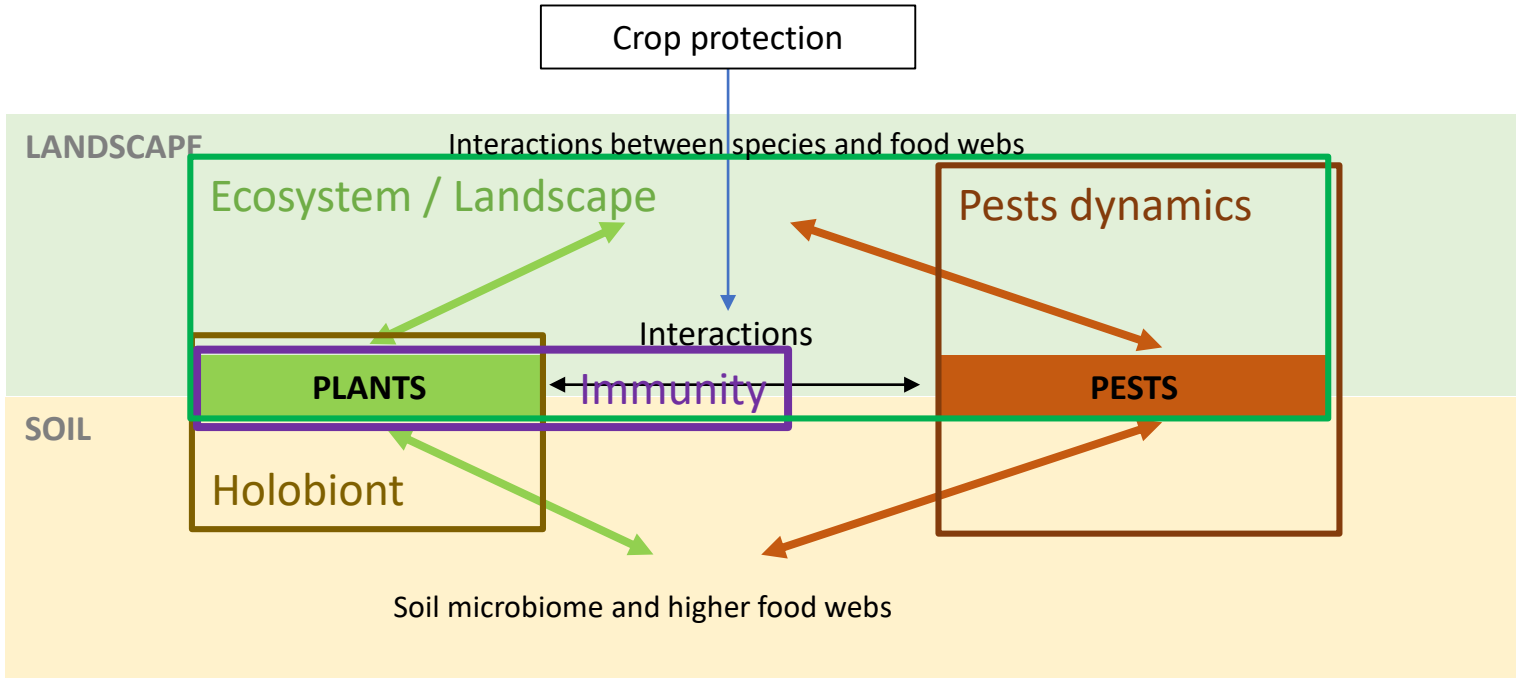


Exploring possible ruptures in crop protection without chemical pesticides in 2050



- By varying the **boundaries of the system** and the **definition of objects/entities in interaction** in the cropping system, we identified **biological processes** that could support ruptures for a pesticide-free crop protection.

Exploring possible ruptures in crop protection without chemical pesticides in 2050: identifying the biological processes upon which to act



HOLBIONT: The term “holobiont”, first introduced in 1991 by Lynn Margulis, refers to a host and its associated communities of microorganisms (also referred to as the microbiota which corresponds to the collection of microorganisms in interaction with their host and ranging from mutualistic to parasitic interactions).

Four hypotheses for cropping systems without chemical pesticides (1)

➢ Designing **diversified landscapes** adapted to local contexts and their evolution

- Managing pests through **biological regulations** by increasing **biodiversity** and **agrobiodiversity** from the landscape to the field level and over space and time
- **Diversification** through building stable matrix of **semi-natural habitats** and **mosaic of crops** (diversification of cropping systems, crop management practices, small fields)
- Considering landscapes as **interfaces between agro-ecosystems and actors**: adaptive governance, coordination and recognition of the multifunctionality of agriculture

➢ Managing the **holobiont** by strengthening host-**microbiota** interactions

- Strengthening the **adaptability of the holobiont** (the plant ability to recruit microorganisms in the face of disturbances) and the **functions of microbiota** (« core » microbiota) to improve plant resistance to pests (through increasing diversity of microbes)
- Developing **diagnostic tools for microbiota** (building proxies to assess soil health, understanding reservoirs of microbial diversity)
- **Managing the holobiont** by **modulating the biodiversity of the existing microbiome** in a **systemic, integrative and historical strategy**
  VS **Designing the holobiont** (**reconfiguring the microbiome** with inoculations of microorganisms, **modifying the plant** through plant breeding)

Four hypotheses for cropping systems without chemical pesticides (2)

➢ Strengthening the **immune** defences of cultivated plants

- Directly stimulating the immune system of plants by **plant defence stimulators** and **bio-stimulants** (plus allelochemical component)
- Modifying the immune system of cultivated plants by **genetic control**
- **Indirectly stimulating the immune defences** of cultivated plants through interactions with microbiota, other crops (diversification) and plant services

➢ Supervising the **health of the environment** and its regulations at large scale and in the long term

- Maximising the levers of observations for being able to **monitor biological regulations and the quality of environmental health**, **detect anomalies** as early as possible and **anticipate** upcoming problems
- **Modelling of biological mechanisms** and providing the capacity to **anticipate at different time horizons**
- **Supervising the health of the environment** as a component of prophylaxis (new sector of services, public good, data sharing)

Conclusion: different means of diversification for chemical pesticide-free agriculture

- In our scenarios, diversification appears as a way to **strengthen biological regulations to control pests and diseases**, through biodiversity
- **Various forms of diversification** could be mobilised for scenarios of chemical pesticide-free agriculture:
  - of crops at the **intra-field** level (intercrops, mixtures of varieties and populations)
  - of crops at the **inter-field** level and over time (mosaic of crops, long rotations)
  - at the **landscape** level (**semi-natural habitats and their interfaces with fields)**
  - within **soils** (microorganisms)
  - also an indirect role of plant diversification to reinforce plant immunity and microbiota
- **Monitoring** is necessary to anticipate pest and disease and could take different forms depending on the diversification strategy
- Diversification has **multiple meanings** as it describes **different processes**.
- Some remarks on building scenarios with diversification:
  - Diversification is not an objective *per se*. **How diversification can help to reach specific aims** of the foresight study (such as building a pesticide-free agriculture)?
  - A need to **take into account some conceptual changes** in scenario building: holobiont, plant immunity, landscape and environmental health
  - A need to study not only cropping systems, but **transition pathways** including the whole **food value chains** and people **values**, **public policies** and **markets** (that will be the next steps of this foresight study)

More information: https://www6.inrae.fr/cultiver-proteger-autrement_eng/Studies-tools/2050-Foresight-Study
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