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IBMA
Slovenian Parliement

Pathways towards a pesticide-free agriculture in Europe

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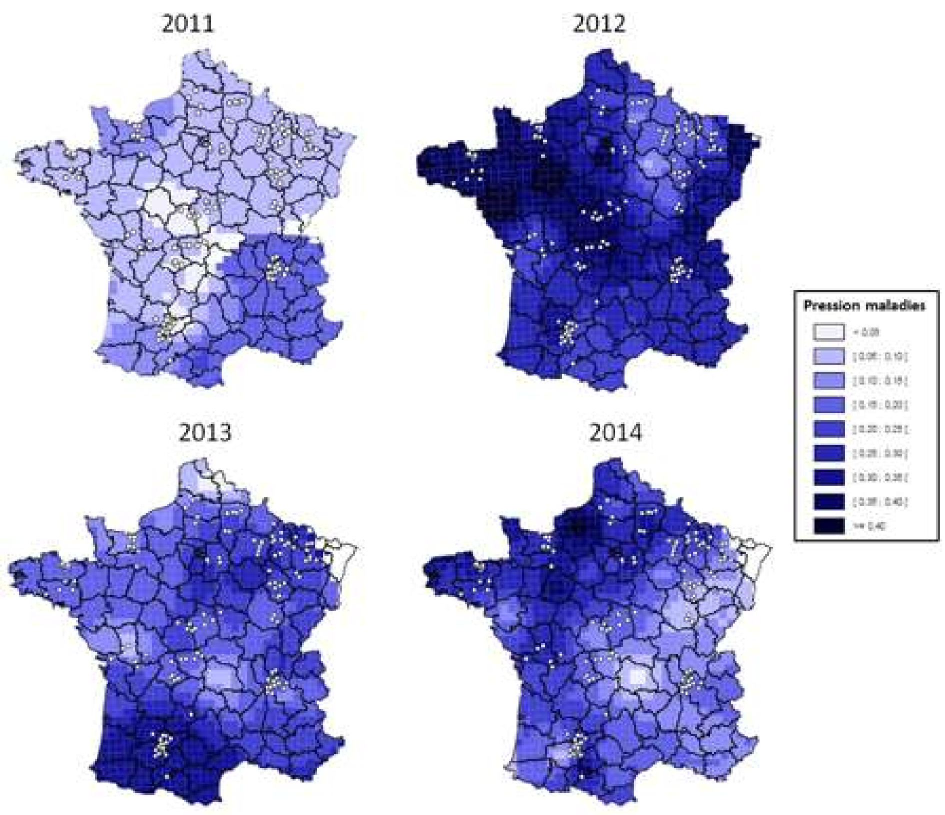
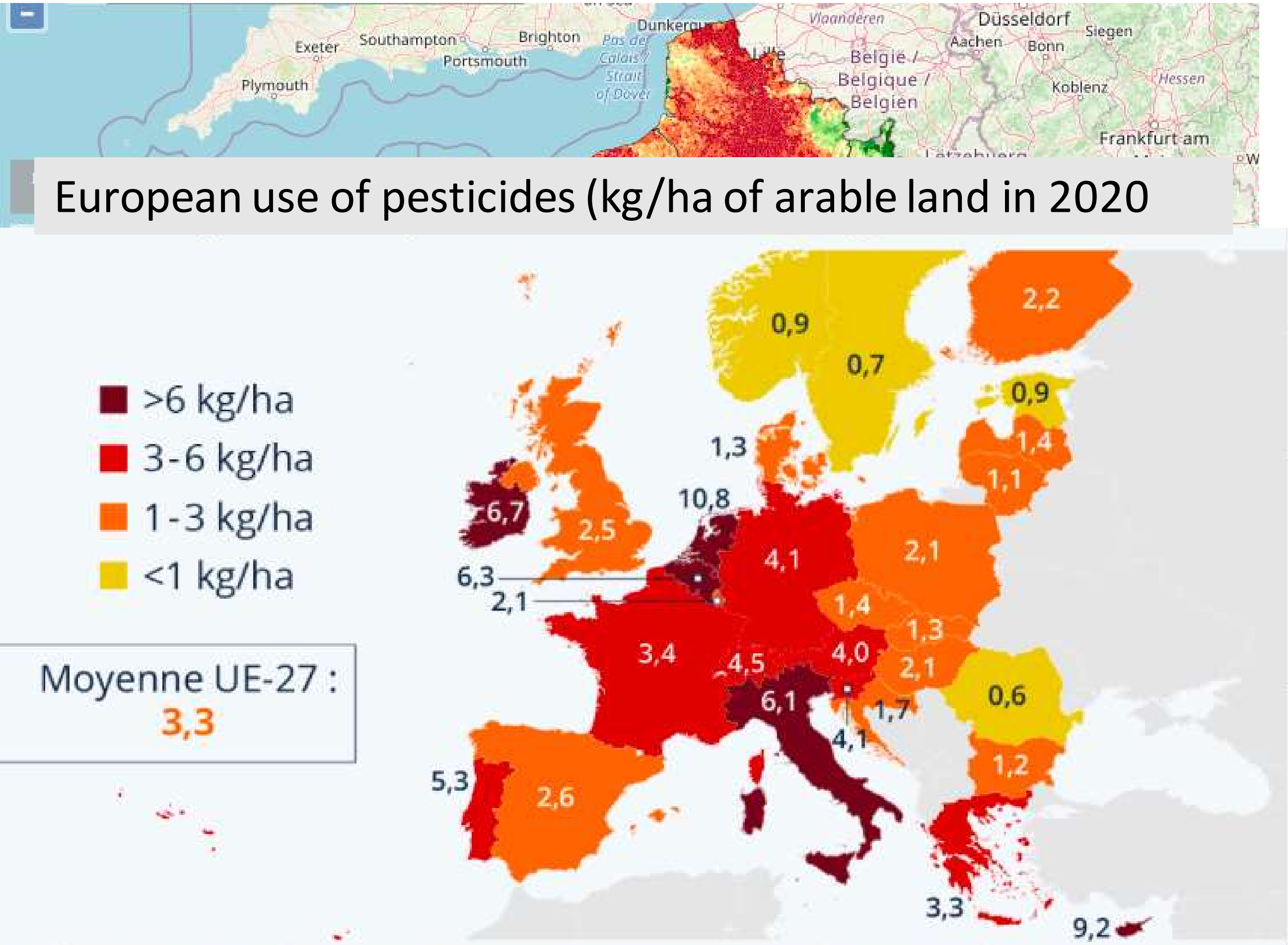
Crop protection is compulsory to ensure safe and affordable food to all



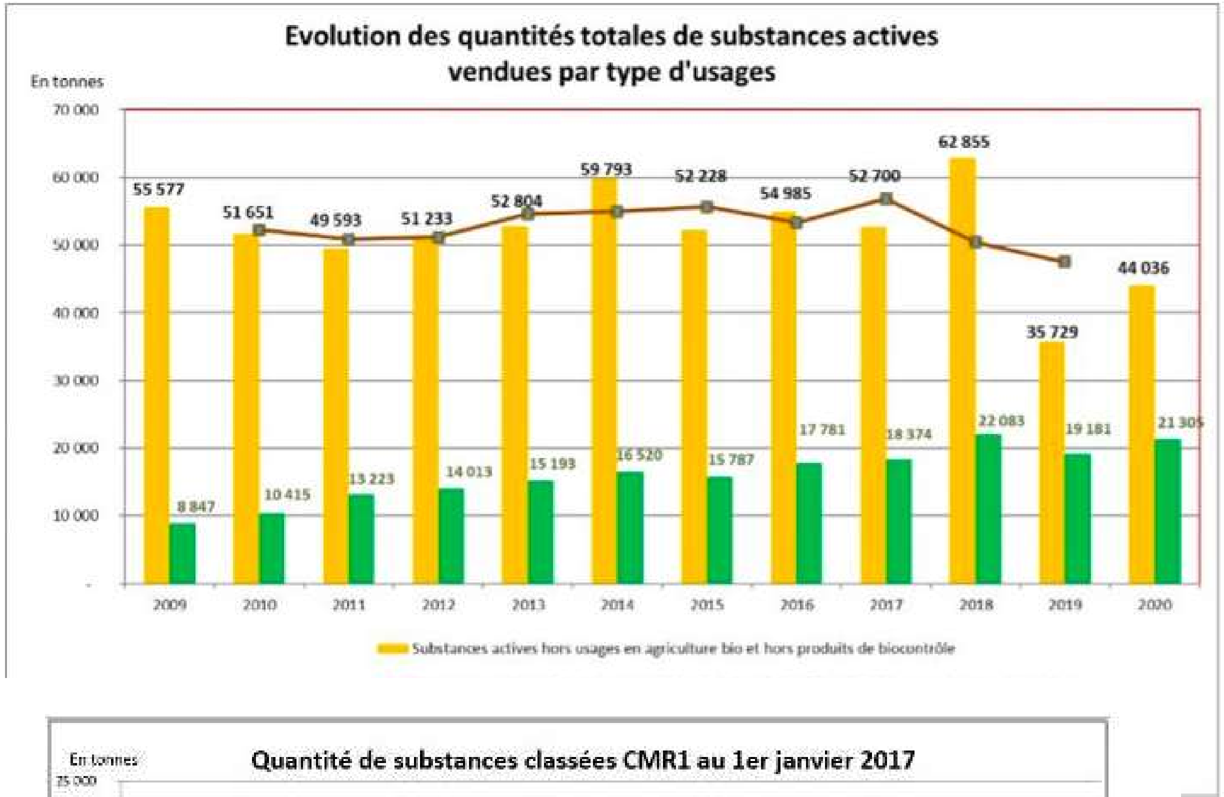
Yield losses due to foliar diseases in bread wheat in absence of any protection
Urruty et al, 2016

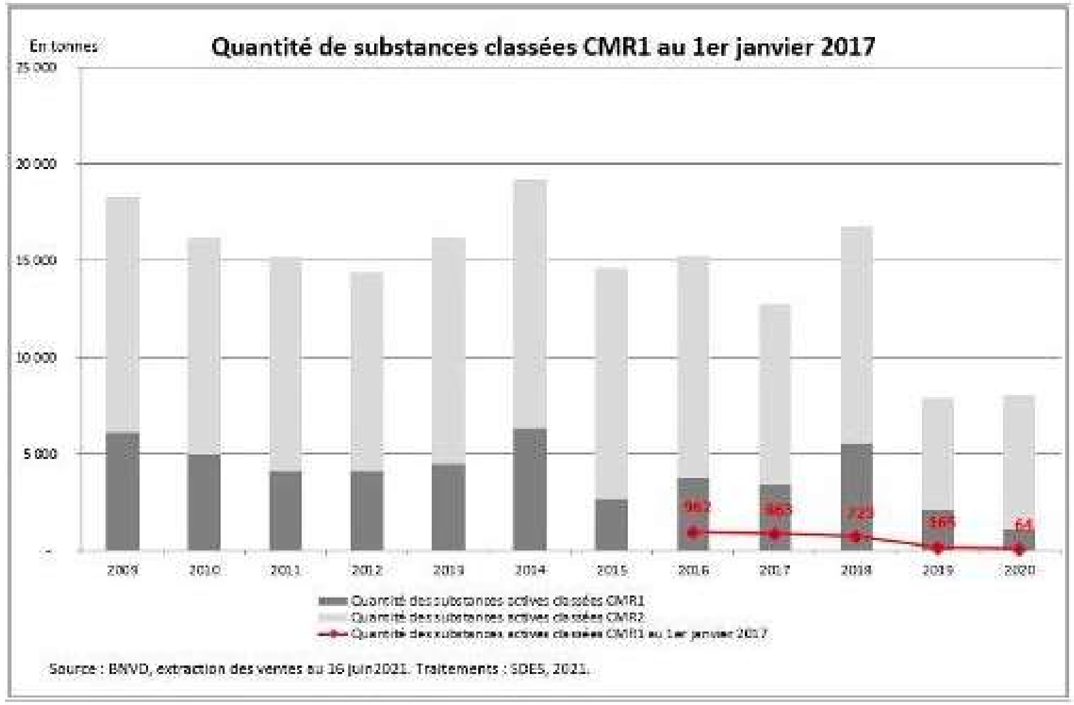
- In absence of protection, losses may be high, are variable among sites and years and not predictable

Crop protection is achieved today with massive use of chemical pesticides…

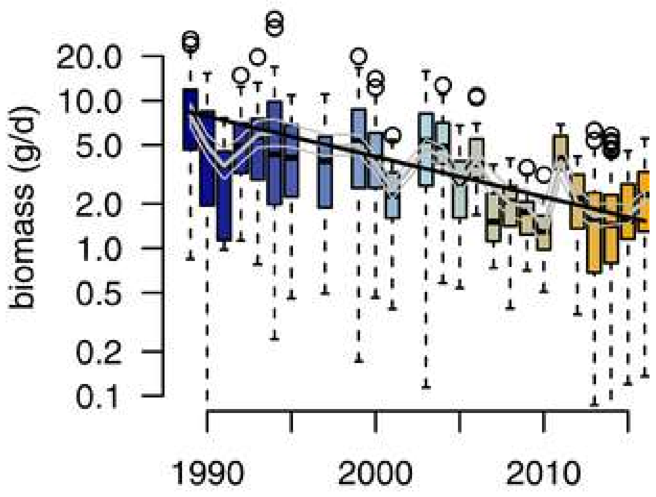


Sélection : pays de l'UE et Suisse, Royaume-Uni, Norvège. Données arrondies.
Source : FAO

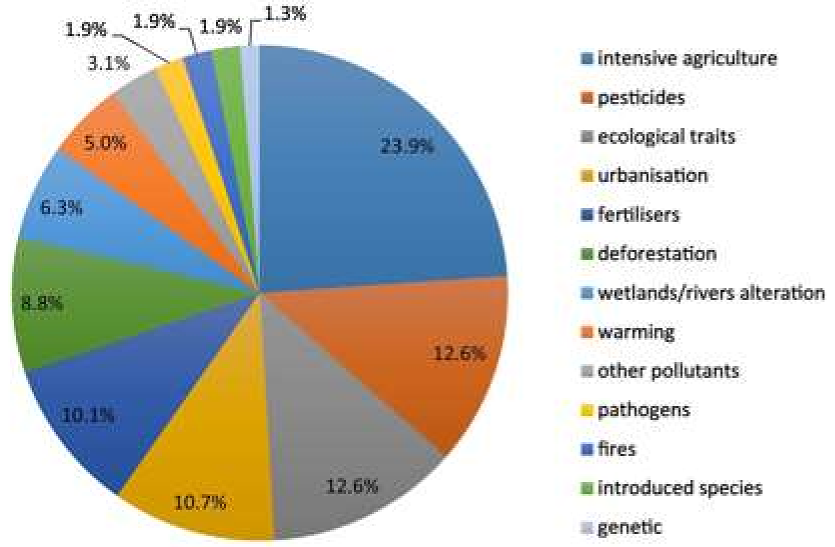




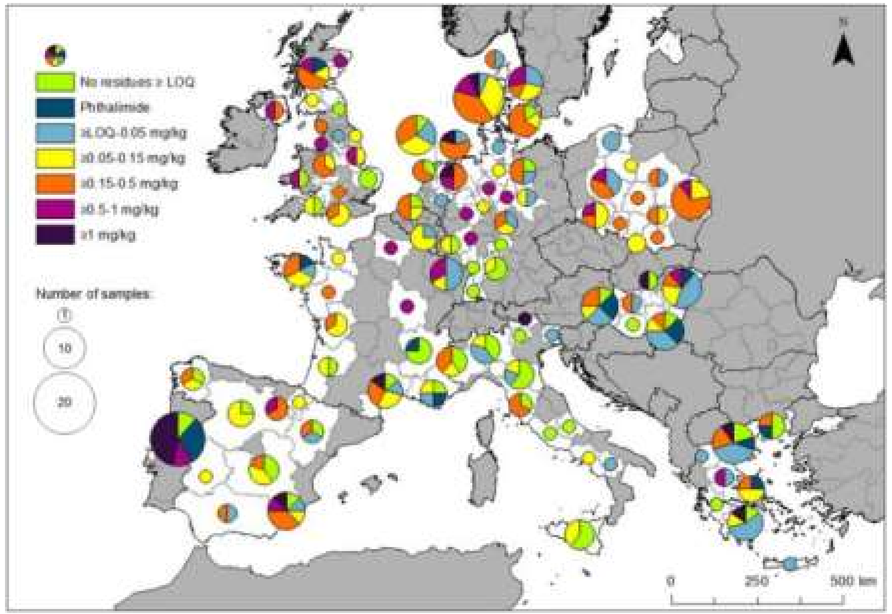
…generating an unsustainable pressure on environment and biodiversity, pesticides being a cornerstone of cropping systems



Hallmann CA et al. (2017) PLOS ONE 12(10): e0185809.
https://doi.org/10.1371/journal.pone.0185809



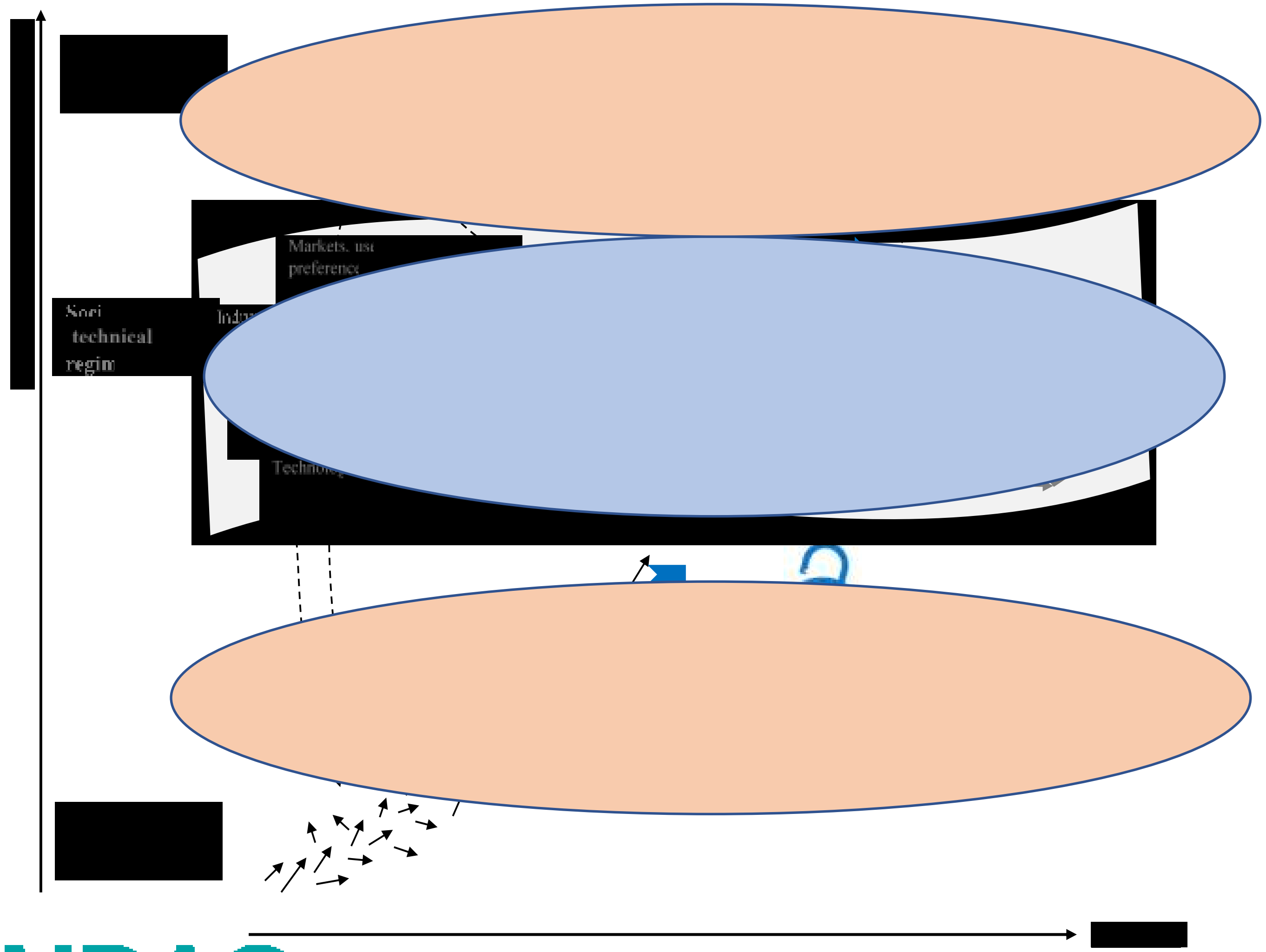
Sanchez-Bayo F et Wyckhuys KAG, 2019, Biological Conservation



Distribution of total pesticide contents in EU agricultural topsoils (according to Silva, 2019)

A worldwide review of soil contamination by pesticides has been recently proposed by Sabzevari and Hofman (2022, Science of the Total Environment, 812, 152344)

Crop protection is a typical lock-in situation

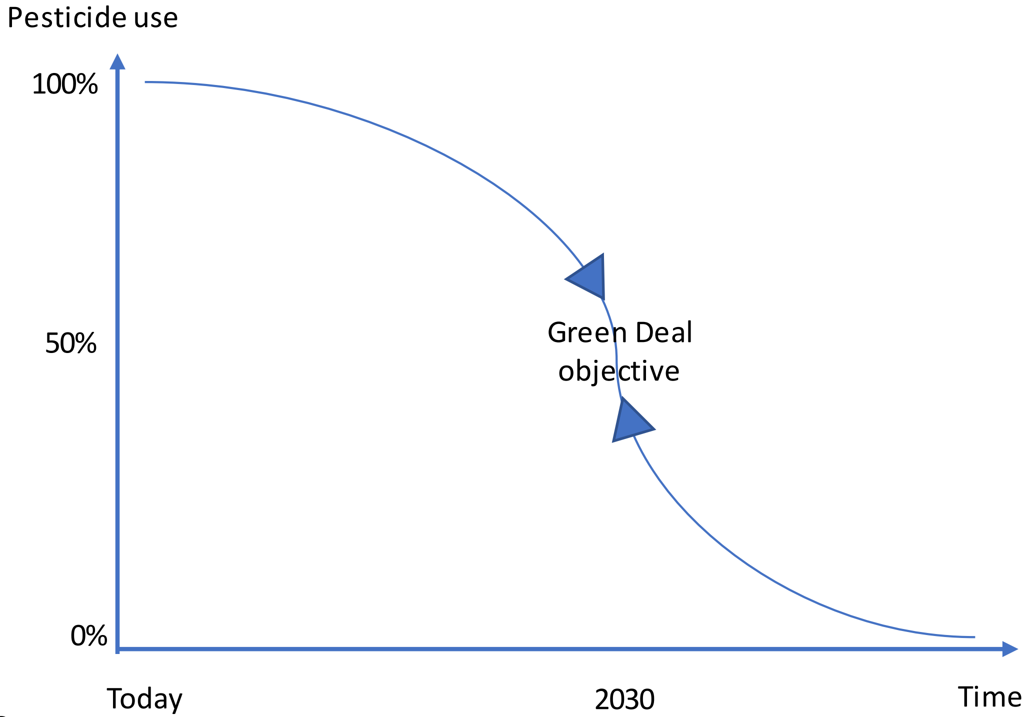


How to achieve the Green Deal objectives?

- Incremental innovations into the existing cropping systems (E and S according to Hill and Mc Rae)

OR

- Disruptive innovations based upon paradigm shifts (S and R according to Hill and Mc Rae)



(adapted from Ollivier et al., 2018 (Ecology and Society) who adapted from Geels, 2002 (Research Policy))

Options for future sustainable crop protection

- Avoiding an *a priori* attitude that a trade-off between production and environment has to be accepted

- Levers already exist (genetics, biocontrol) but are not sufficient for a 0-pesticide agriculture
- What are the possible knowledge and innovation breakthroughs, in the coming decade *(under the hypothesis of absence of limitations due to regulations and societal acceptance)* ?

- *A EU proposition for a revised version of the* ***Directive*** *2009/128 (Sustainable Use of pesticides) was released on 22 June 2022. Towards a* ***Regulation***

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The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services (R)

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According to a synthesis of 98 meta-analyses, gathering 6160 original studies (Tamburini et al, 2020, Science Advances **6** : eaba1715): **Increasing diversity of practices and of crops massively increases environmental services while preserving production**

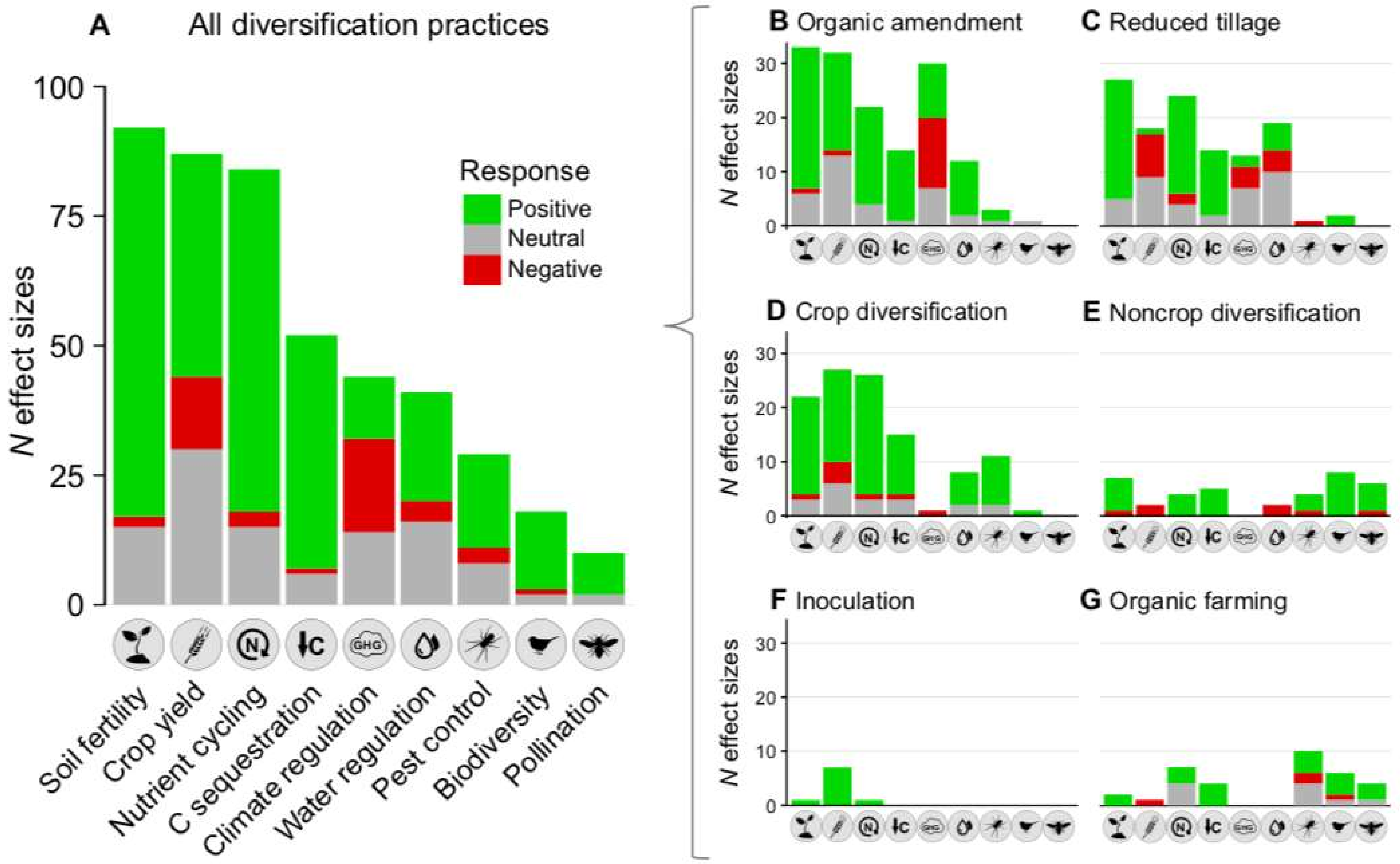


Fig. 1. Vote count reveals that agricultural diversification practices generally have a positive impact on biodiversity and ecosystem services. Number of reported effect sizes with a significant positive (green), negative (red), or neutral (gray) response to agricultural diversification, overall (**A**) and to each category of diversification practice separately (**B** to **G**). The systematic review comprises 456 effect sizes from 98 meta-analyses based on 6167 original studies (fig. S1). Diversification practice and ecosystem service categories were based on classifications following (*8, 9*) and (*13, 14, 27*), respectively (tables S1 and S2).

Fully consolidated by the paper of Beillouin et al, 2021: **Positive but variable effects of crop diversification on biodiversity and ecosystem services**. *Global Change Biology*

In practice

New species and new swards to produce ecosystem services

- New species
  - Crops for new food and non food demands: meeting dietary transitions
  - Crops adapted to climate change
  - Cover crops and intercrops to preserve environment (e.g. soil conservation) and/or to produce renewable biomass (methane) : Towards multi-services intercrops
  - Species for living mulchs

- New cropping systems
  - Growing mixtures of species, with different functional traits

  - Relay-cropping (crop n+1 sown long before the harvest of crop n (LER >>1). *Here soybean sown in winter wheat*

  - Agroforestry

The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics (S and R)

- Drilling multi-species swards

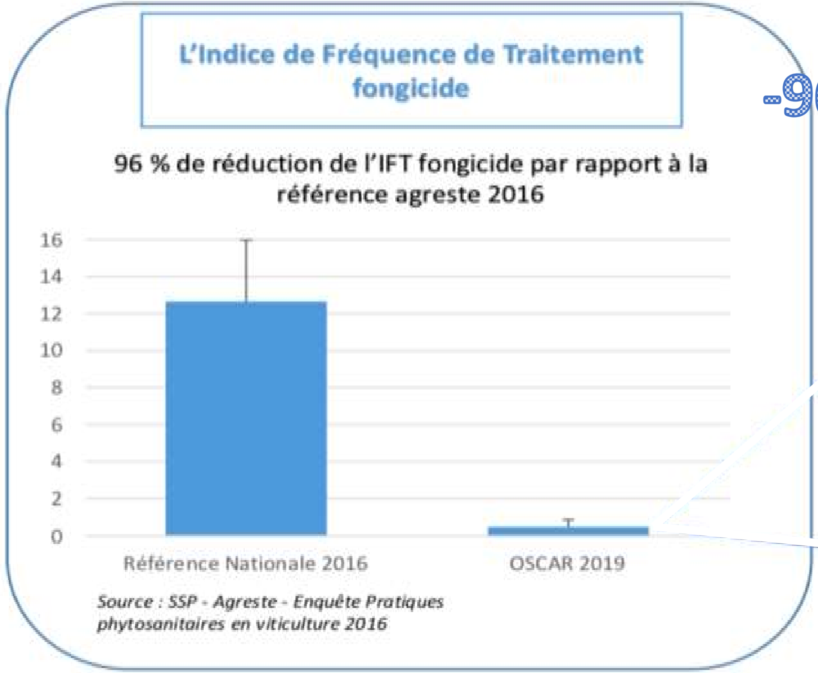
- Leading to reconception of agronomic practices

- Efficient alternative for weed control

The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties (S)

Oustanding successes already exist such as in grape, with resistance to downy and powdery mildews



-96% FTI in farm conditions !

How to make this true **for all species**?

- Genetic resources
- High throughput phenotyping infrastructures
- Breeding technologies
  - *Genomic selection (that requires full length sequences)*
  - *New Breeding technologies and genome editing*

The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology (R)

- Insect behavior is highly driven by odors in the environment: presence of volatile organic compounds
  - Sexual confusion (pheromons)
  - Detection of host plants
    - Tagetes and protection against flies (in gardens)
    - Mixtures of rapeseed and annual forage legumes to control cabbage-stem flea beetle *Psylliodes chrysocephalus*
  - Attracting predators against aphids/pests (Verheggen et al, 2020)

- Emergence of the concept of odorscape
  - For screening substances or plant species
  - For setting new survey systems (trapping odors of pests)
  - Creating new agricultural landscapes with odor gradients?

The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology
- Microbiota, including endophytes: a key role for plant protection and plant nutrition (R)

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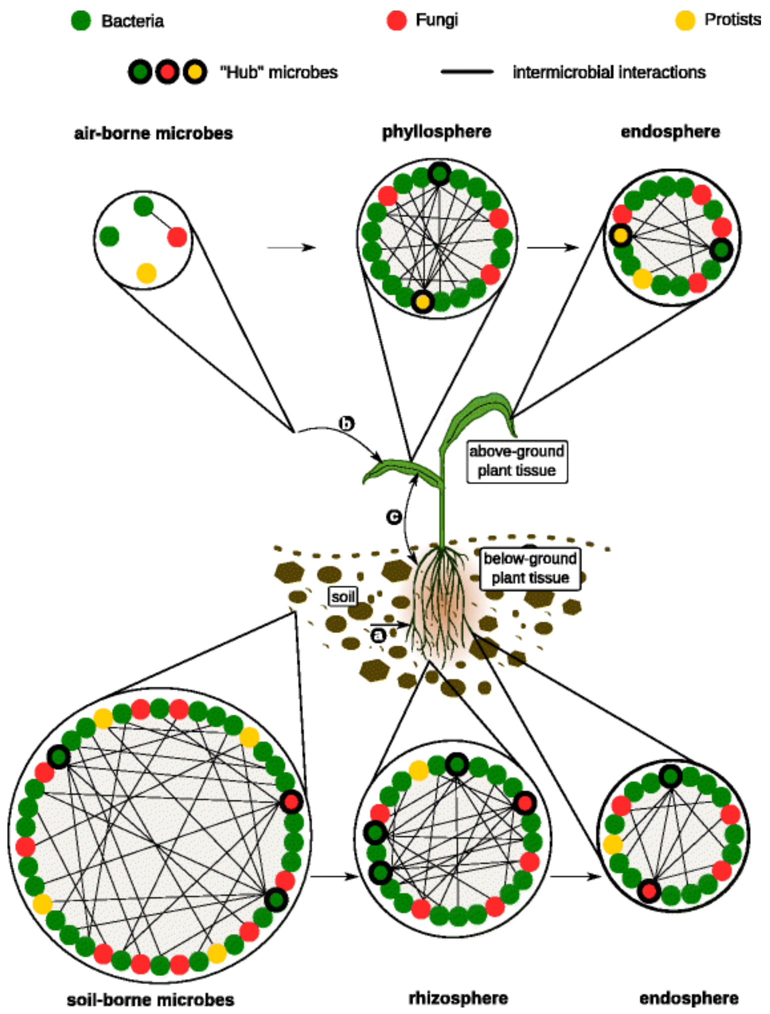
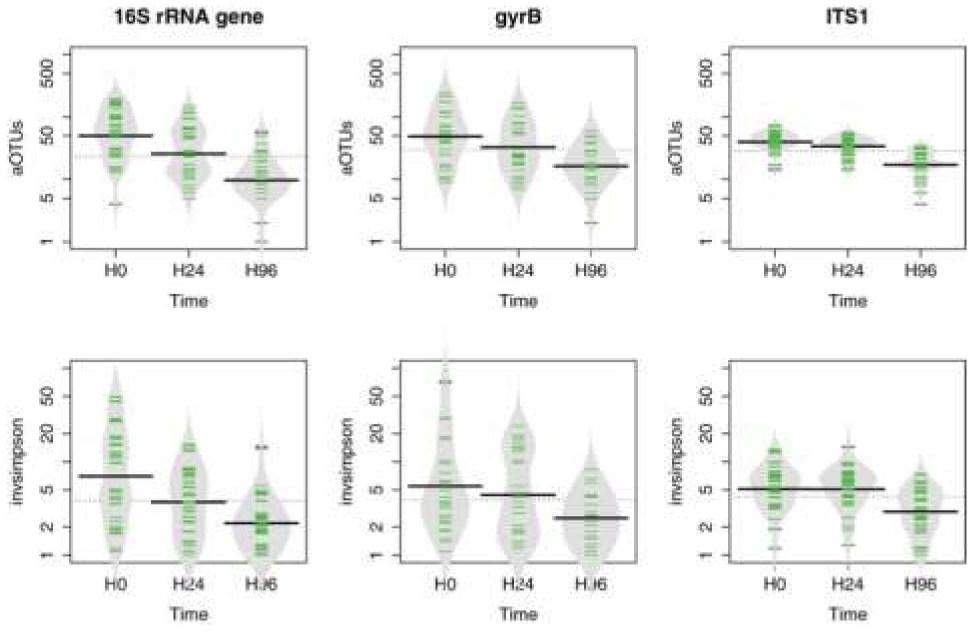


Hassani et al, 2018, Microbiome 6, Art 58

Complexity of microbial networks in the various plant compartments.



Matthieu Barret et al. Appl. Environ. Microbiol. 2015

Horizontal transmission through seeds and screening during seedling emergence

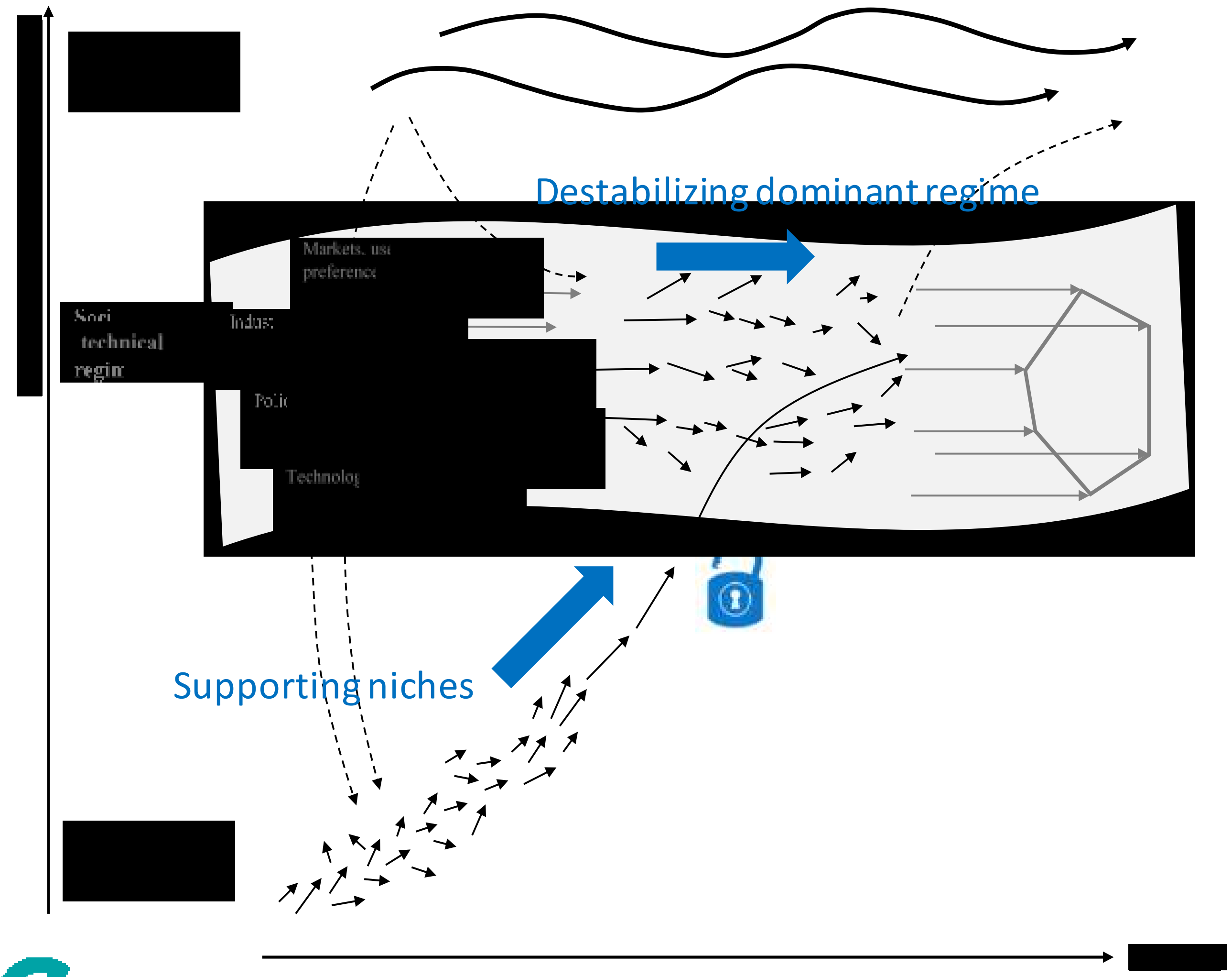
Challenges

- Towards the concept of holobiont
- Screening plant microbiota and understanding the functions
- Defining complex and stable microbiota communities
- Applying them to seeds and fields
- *Adapting the regulations*

The knowledge and innovation breakthroughs in the coming decade

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology
- Microbiota, including endophytes: a key role for plant protection and plant nutrition
- In social sciences, unlocking the sociotechnic systems (R)

How to unlock locked-in systems?



Forcing changes of the socio-technic landscape: public policies including CAP, regulations, listening societal demands

How to go beyond?

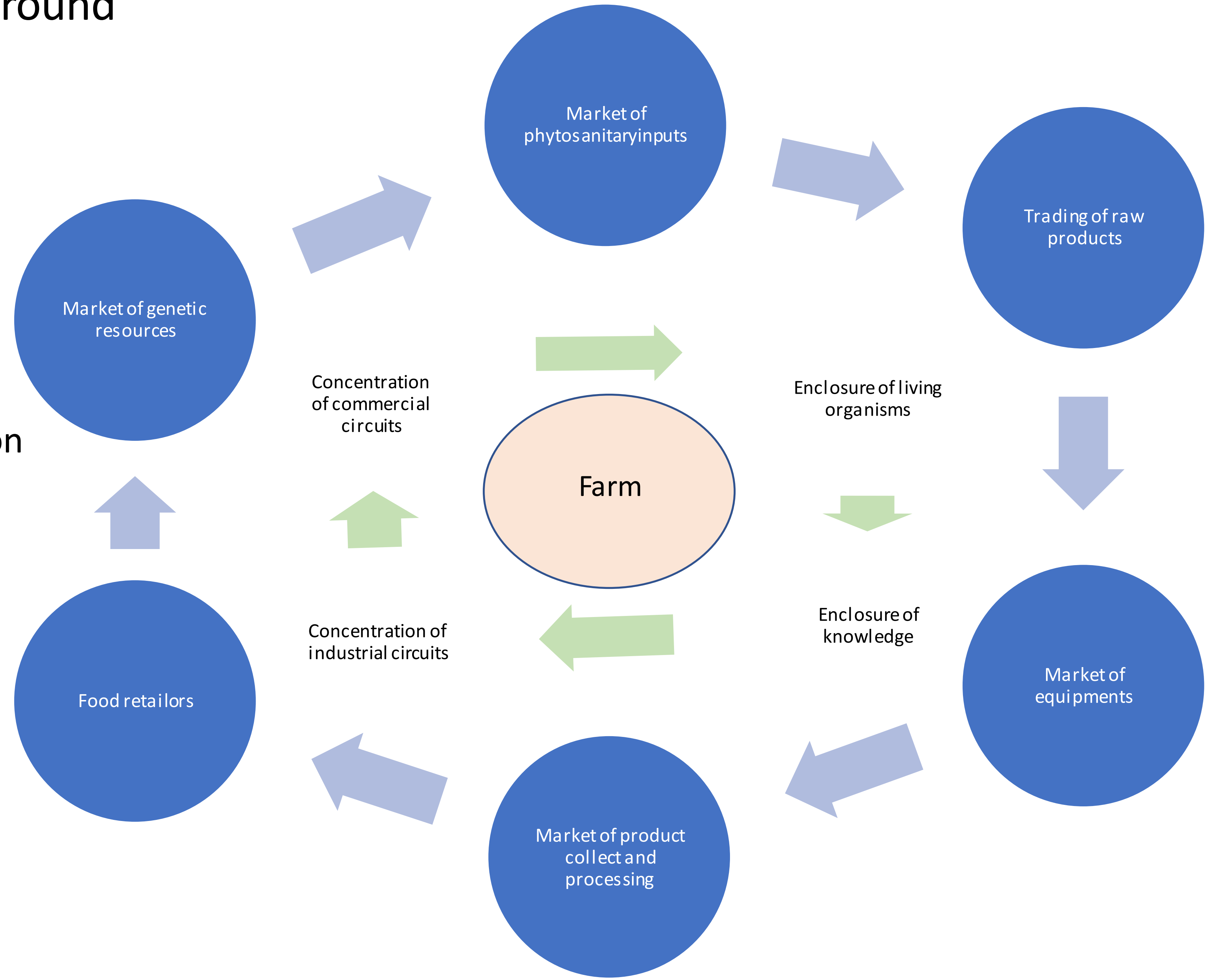
- Setting non prescriptive extreme scenarios: 0-pesticides (*PPR, European Research Alliance)*
- Participatory approaches and living labs: involving new players (Klerkx et al, 2020)

Supporting rupture innovation. R&I is essential

(adapted from Ollivier et al., 2018 (Ecology and Society) who adapted from Geels, 2002 (Research Policy))

Strong socio-technic lock-in around farms (Geels, 2002)

Adapted from Valiorgue (2020)



Two major issues to foster transition

- The enclosure patterns
- The weight of specific investments


Thank you for your attention …