

Sustainable Management of Crop Health

Xavier Reboud & Olivier Le Gall

@FutureIPM, Riva del Garda IT, 19-21 March 2013



Sustainable management of crop health

- Why “sustainable management of crop health”?
 - Rather than the pest, the focus is the crop
 - Rather than disease, the target is health
- What does it take?
 - Ambitious: it is not “old soup” but high tech
 - Both technical & organizational innovation
 - Both bio-ecological & socio-economical sciences
 - Science is a key but not the only one

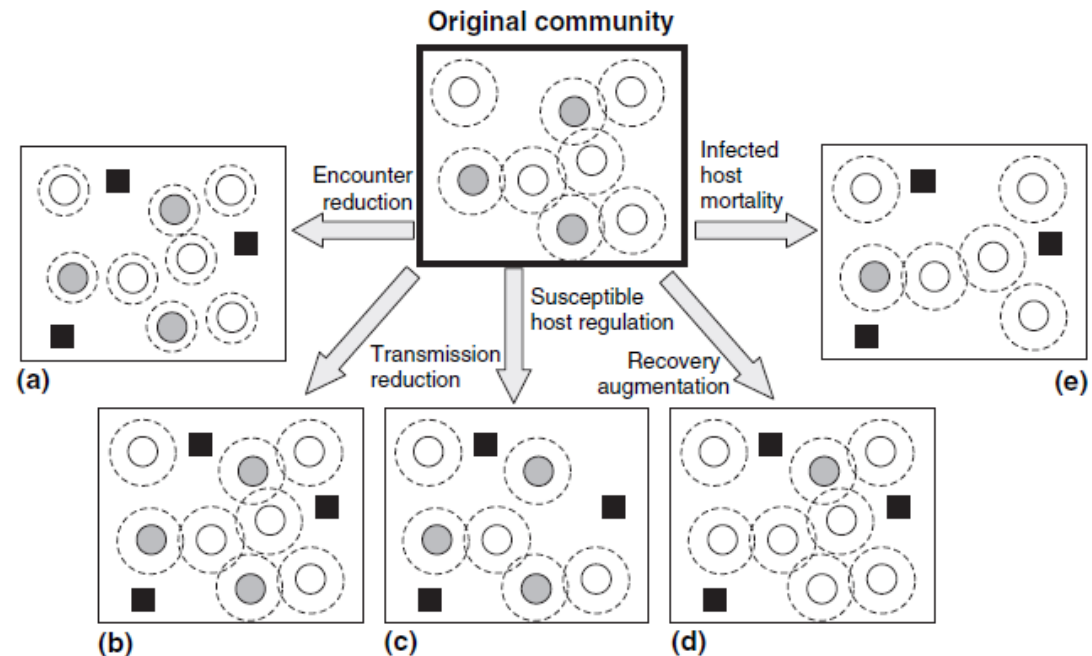
Sustainable management of crop health

- Two examples worth being further explored
 - Biodiversity / plant disease relationships
 - Pesticide resistance and evolution of virulence : a same story ?

Biodiversity / plant disease relationships

- Biological diversity (species and genetic):
 - rate of encounter between susceptible and infectious individuals
 - probability of transmission given an encounter
 - density of susceptible individuals
 - recovery rate
 - death rate of infected individuals

Keesing et al. (2006) *Ecol. Lett.* 9 : 485-489

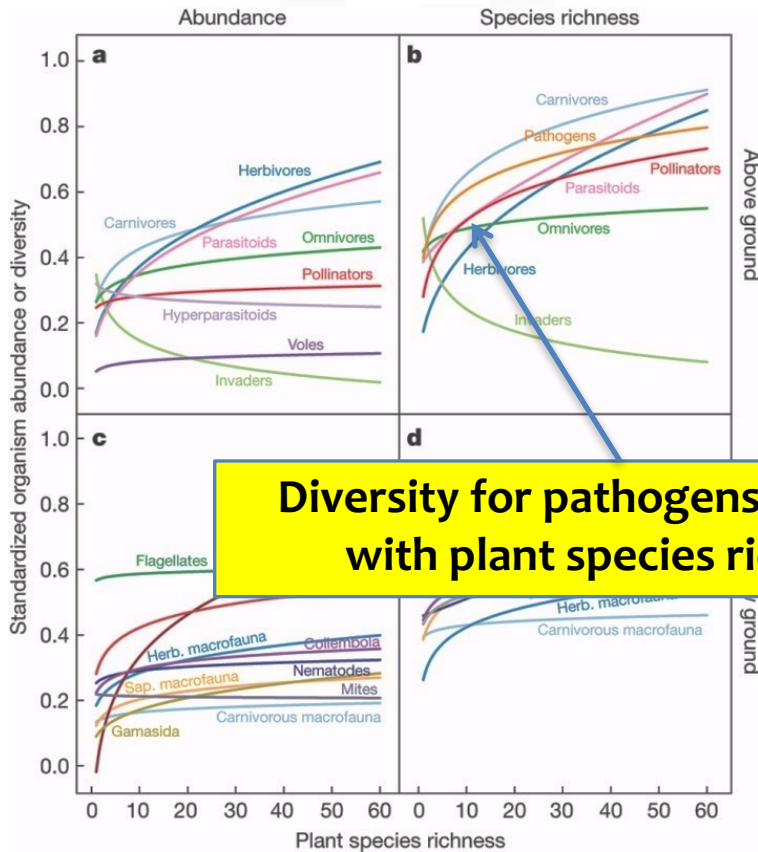


→ Listing principles that could apply to many IPM systems !

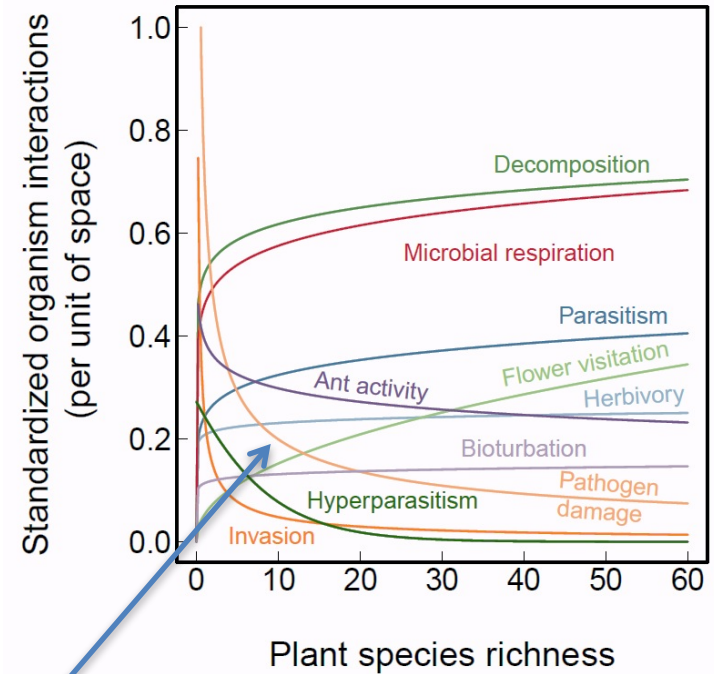
Effects of plant diversity on other organisms



Effects on organismic interactions



Diversity for pathogens increases with plant species richness



But pathogen damage sharply drops

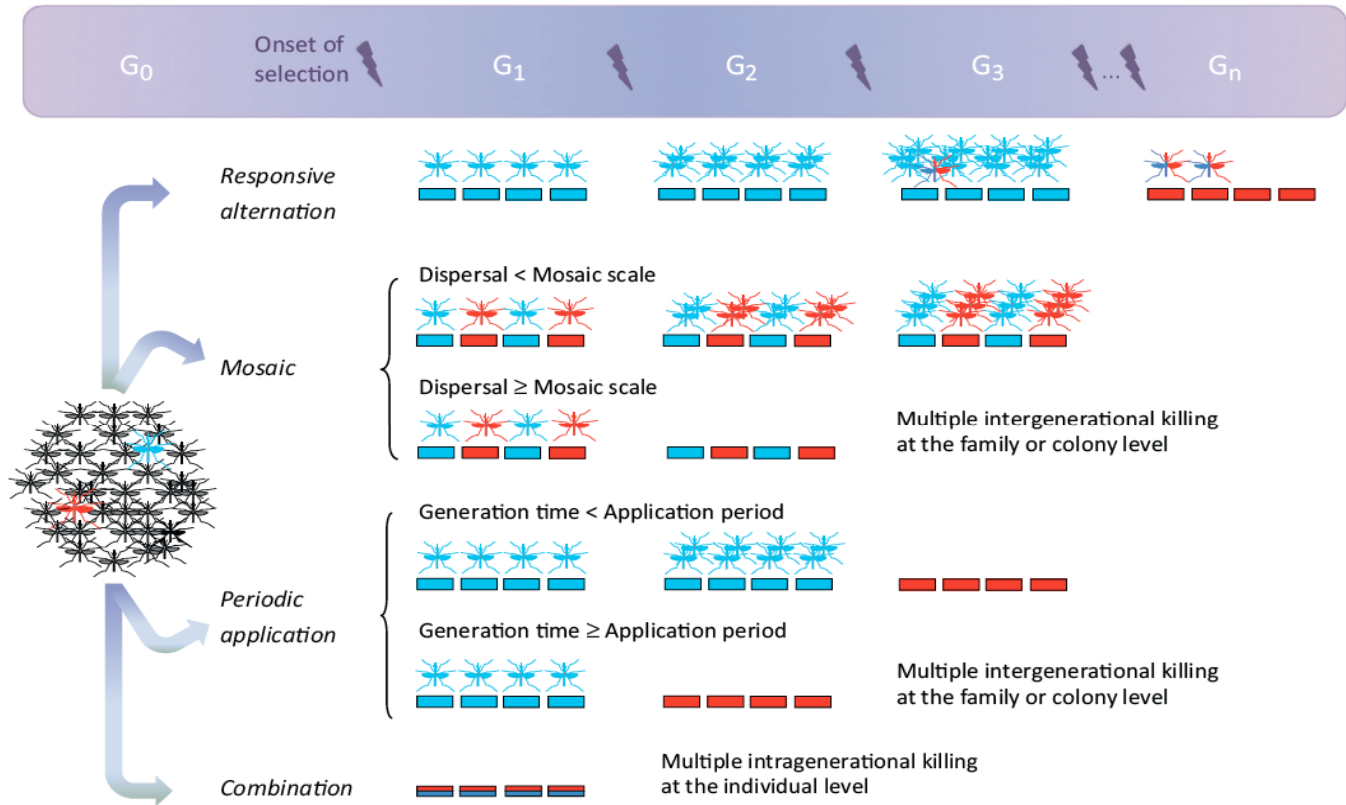
Pesticide resistance and evolution of virulence : a same story ?

Review

Trends in Ecology & Evolution February 2013, Vol. 28, No. 2

Heterogeneity of selection and the evolution of resistance

REX Consortium^{*,†}



TRENDS in Ecology & Evolution

Similarity between case studies ?

PESTICIDE RESISTANCE

Deployment Strategies to delay pesticide resistance evolution

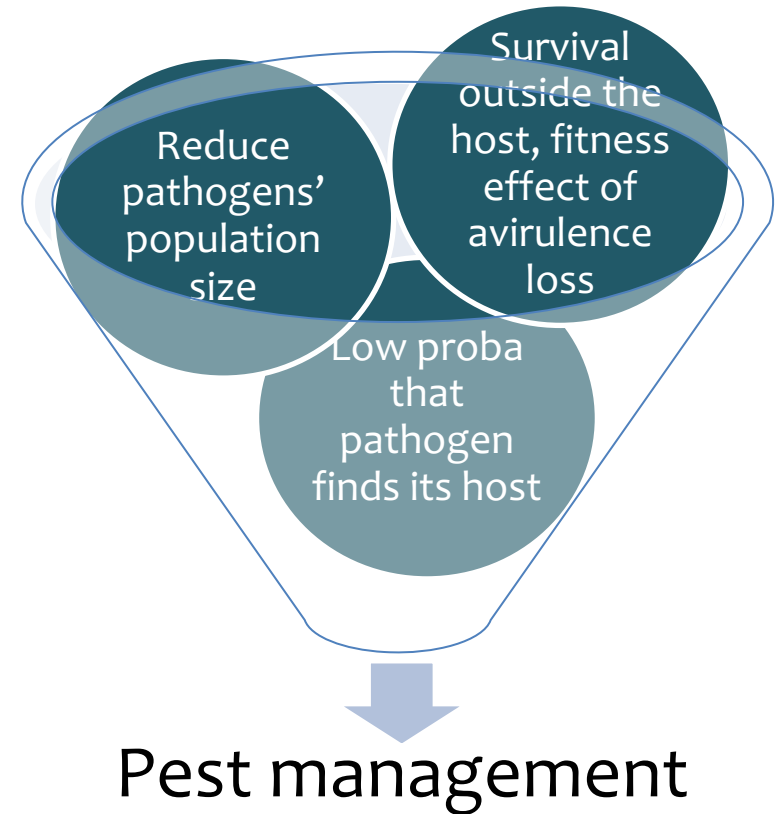
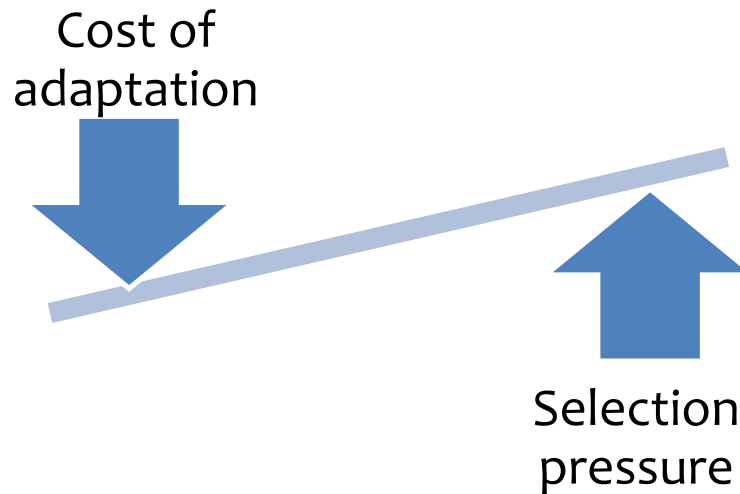
- Sequential use of pesticide
- Pesticide rotation over time
- Mixture of pesticides
- Combine a single site to a multisite active matter
- Landscape spray design as mosaic

EVOLUTION OF VIRULENCE

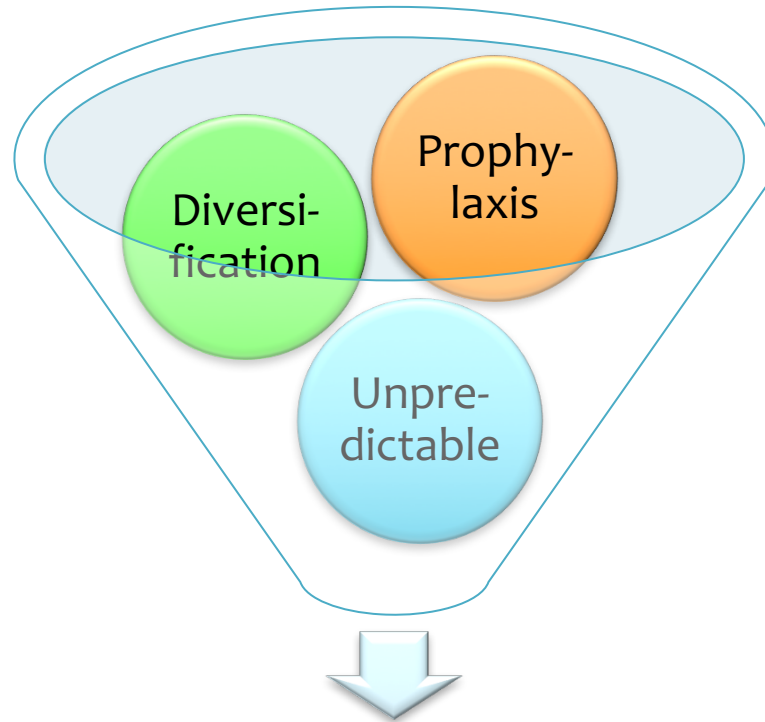
Deployment Strategies for quantitative resistance durability (from C Mundt)

- Single gene at a time
- Gene rotation
- Pyramids
- Mixtures / combining major and minor genes
- Landscape design

Speed and extent of pesticide resistance evolution

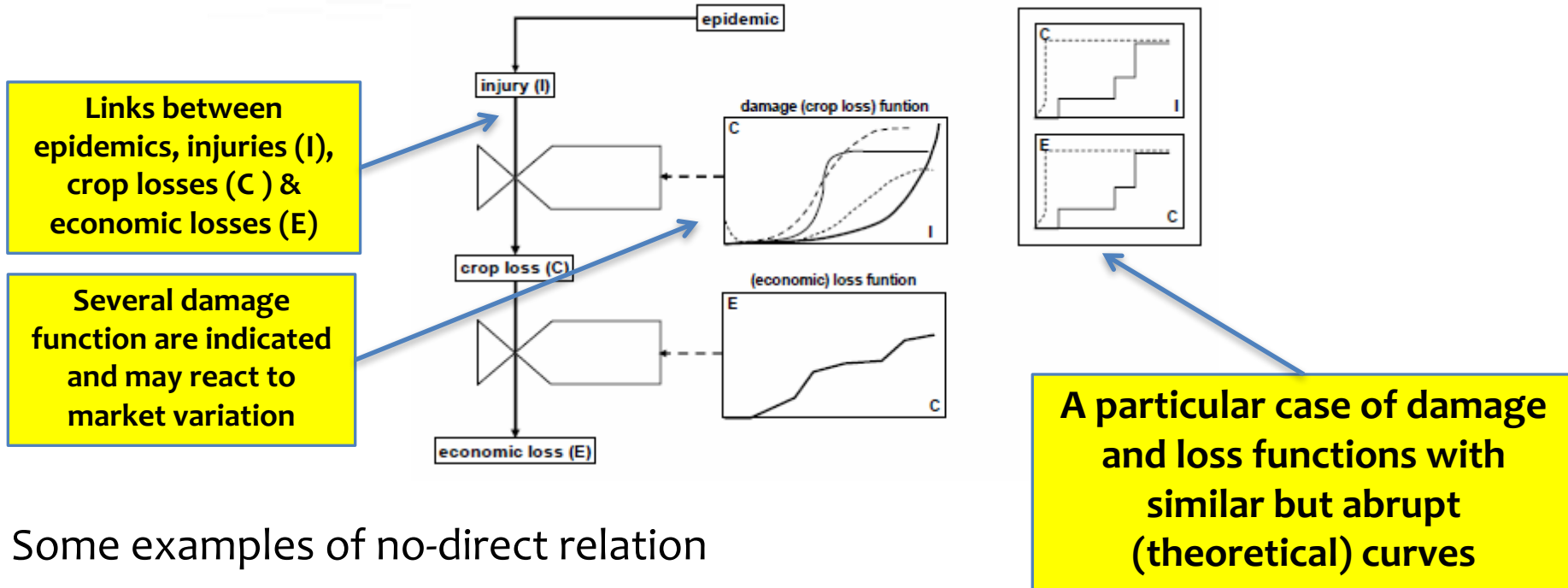


Both examples pinpoint the combination of approaches and methods



Cumulative contributions to crop health

Consequences of pests on crop losses



Some examples of no-direct relation

- Risks of mycotoxin production
- Decreased value of fresh product because of its visual appearance

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→ **How to translate this into research challenges?**

Research challenges for a SMaCH

- Genericity: the more one wishes to integrate and use local resources...
 - ... the more one needs to extract genericity from specificities
 - Refer to concepts (Ex.: life history traits, ecosystem services, tragedy of the commons, etc.)
 - ... the more one gets closer to the user's need for expertise
 - Build tools (Ex. Information centers, diagnostic tools, databases, etc.)

Di@gnoPlant: expertise in the user's palm



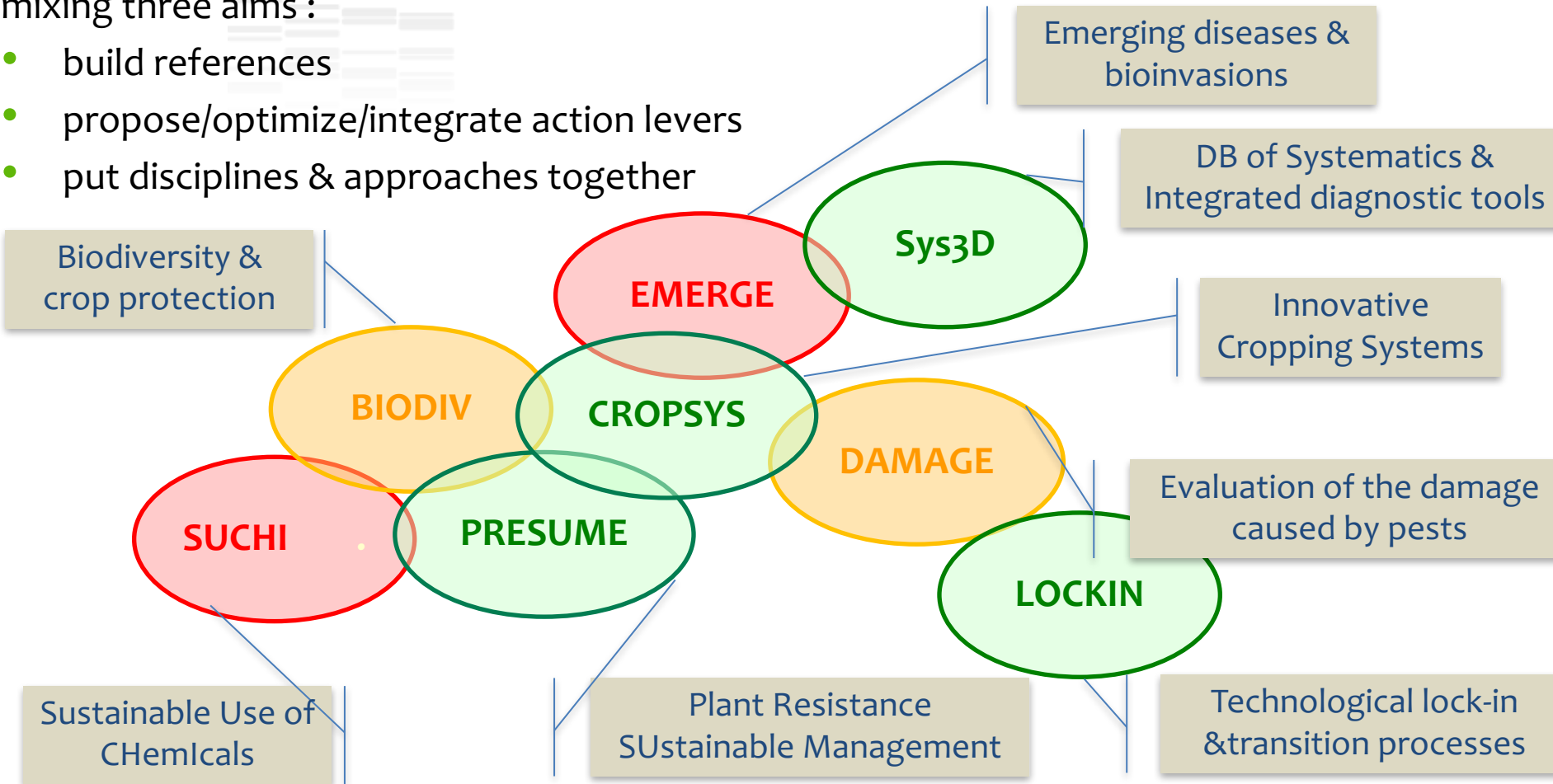
Research challenges for a SMaCH

- Genericity
- Integration
 - Working scales: space / time / organization
 - A continuous process: Description / Efficiency / Substitution / Re-design
 - Approaches: Systemic / Analytic
 - Disciplines: bio-ecology / socio-economy
- Partnership
 - Between researchers (national / international)
 - Between various types of partners (incl. stakeholders)
- Agility
 - Required to manage crop health sustainably in a changing world
 - Tomorrow's solutions may not be today's solutions

SMaCH at INRA: a bunch of coordinated key-actions

mixing three aims :

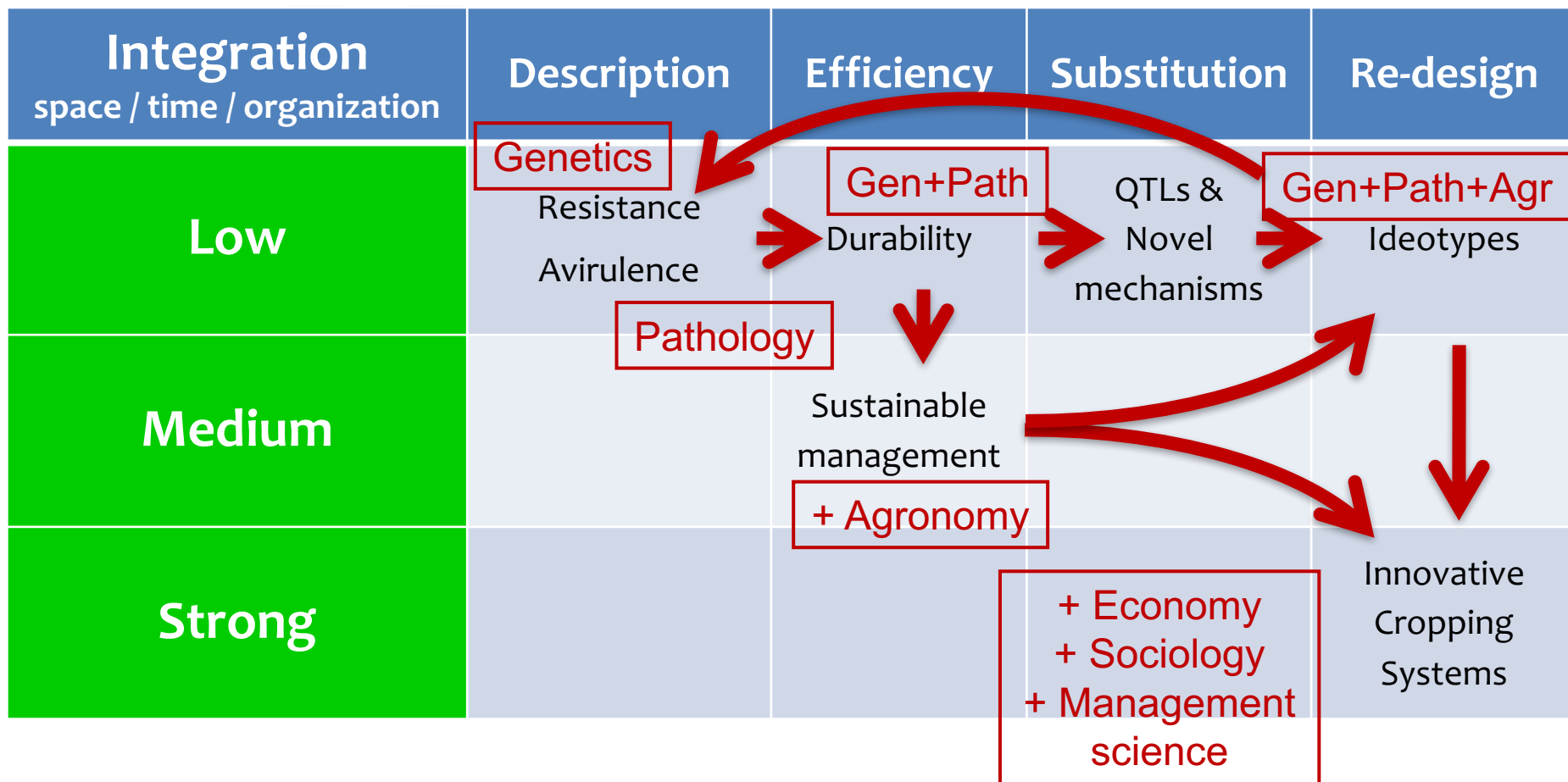
- build references
- propose/optimize/integrate action levers
- put disciplines & approaches together



Ex. sust. management of plant resistance

- The notion of “Durability” has shifted
 - Gene / individual >>> agro-ecosystem
 - Genetics / Pathology >>> add Ecology, Modeling, Agronomy, Economics, Management Sciences, etc.
- Aims of research
 - Exploit data from host/pest molecular talk & resistance mechanisms
 - Identify candidate sources of durable resistance
 - Elaborate and validate management strategies
 - Explore the socio-economic impacts and technological lock-ins

Ex. sust. management of plant resistance



Ex. sust. management of plant resistance

- The notion of “Durability” has shifted
- Aims of research
- Raises feedback questions: ex. to plant breeders
 - Pyramiding of resistance sources
 - Reconsidering traits that enable innovative cropping systems
 - Ex. Competitiveness against weeds, incl. resistance to late sowing
 - Engineering diversity
 - Within varieties, incl. at “silent” loci
 - Propensity to be used as mixtures

Ex. sust. management of plant resistance

- Implementation of this policy by INRA:
 - Reallocation of teams and opening of new positions
 - Modeling for the sustainable management of fungicides and resistant varieties in agriculture
 - Durability of wheat resistance to fungal diseases
 - Granting of fellowships
 - Modeling the phytosanitary risk region-wide: a help for the choice of varieties
 - Support of collaborative research projects
 - GEDUNEM : Varietal and technical innovations for the sustainable and integrated management of root-knot nematodes in protected vegetable cropping systems
 - K-MASSTEC: Knowledge-driven design of management strategies for stem canker specific resistance genes
 - TAKECONTROL: Deployment strategies of plant quantitative resistance to take control of plant pathogen evolution
 - ARAMIS: Apple partial Resistance durability Assessed through Metabolic pathways and pathogen adaptation to Selective pressures
 - The international conference “Plant Resistance Sustainability” (Oct. 2012)
 - <https://colloque4.inra.fr/prs2012>

A living arena for partnerships to reach ambitious goals (national / international)

- To share expertise, know-how and facilities



A living arena for partnerships to reach ambitious goals (national / international)

- To share expertise, know-how and facilities
- Endure
 - <http://www.endure-network.eu>
 - Coordination of research on crop protection
 - Platform for research projects (ex. FP7 PURE)
 - Scientific support to the implementation of policies relevant to crop protection
 - FP6 Network of Excellence (2006-2010) then self-supported European Research Group



A living arena for partnerships to reach ambitious goals (national / international)

- To share expertise, know-how and facilities
- Endure
 - <http://www.endure-network.eu>
- Candidate Era-Net C-IPM
 - 31 partners in 21 countries
 - Working Objectives
 - To consolidate a common knowledge base on IPM solutions and experiences
 - To develop a research and development agenda on IPM solutions (including those for minor uses) and on reducing dependency on pesticides
 - To build and improve/foster transnational activities from existing national and transnational initiatives
 - To organize and fund joint transnational calls
 - To ensure a better translation of existing scientific knowledge into ready-to-use innovations



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 - Working Objectives
 - A strategic agenda
 - Develop relevant and science-based indicators
 - Optimize pest monitoring systems and decision support
 - Design cropping systems that prevent or minimize pest pressure
 - Diversify direct control methods
 - Manage pest evolution
 - Consider social aspects, economics and assessment
 - Facilitate extension for IPM



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