Introduction

Agriculture covers 38% of the Earth’s land area (Foley et al. 2011). From 1960 to 2000, global food production increased 2.5 times, relying on increasing application of fertilizers, pesticides, and irrigation. Should this trend continue, 10^9 hectares of natural ecosystems would be converted to agriculture by 2050 (Tilman et al. 2001). This might have strong ecological effects such as habitat destruction, deregulation of biogeochemical cycles and large-scale pollution.

In order to alter such an unsustainable trajectory, there is a need to envision innovative agro-ecosystems (AESs), taking into account both their ecological and production stakes. A new challenge for science is thus not only to produce knowledge to inform decision-making, but also contribute to stakeholders’ design capacity building. This is particularly true for ecology that is often considered as constraining by farmers. What if ecological modeling was a crucial input for AES innovative design?

Drawing on the analysis of three research programs in ecology, we aim to identify the principles of a ‘generative’ ecology, i.e. a science that facilitates innovative design processes.

Methods

We selected three case studies in France, where research programs in ecology:

- deal with contrasted AESs in terms of soil and climate conditions, land uses and ecological stakes
- mobilize different research methods and theories.

Wet grasslands:
- Effects of livestock grazing on bird reproduction
- Viability theory

Subalpine grasslands:
- Effects of grassland management changes on plant functional diversity and ecosystem services
- Functional traits

Cereal plain:
- Effects of agricultural intensification on insect and bird diversity
- Metapopulation theory

Data collection:
Analysis of 30 research papers and additional literature
Interviews and iterative exchanges with the researchers in charge of these programs (May-October 2015)

Results (1)

1) Generic description of the three research programs

The ecologists elaborated conceptual models of the AESs, identifying:

- Management factors that have an effect on AES state and dynamics
- Indicators to assess AES properties
- Intermediary variables to account for the effect of changes in management factors on the AES.

AES modeling

| List of known management factors | Intermediary variables | Expected AES properties and values |

A major objective of modeling is to identify the most explicatory intermediary variables. These are key to build an interface between agricultural practices and ecological processes.

In the three cases studied, the models were used to run simulations and elaborate scenarios, in order to inform decision.

Results (2)

2) Leveraging modeling for innovative design

Ex.: Case of the cereal plain

Landscape mosaic with high and low quality habitats

“The landscape mosaic should comprise >10% of grasslands”

Design process

Optimization process

“With perennial elements”

Effects of agricultural intensification on insect and bird diversity

Optimization process

“With semi-perennial crops”

Landscape mosaic with 10% of high quality habitat

Ecological fund

Exploration of new AES management factors

With perennial elements

With semi-perennial crops

Legumes

Soil quality

Water quality

Control their management

Control their distribution

Explore new AES properties

Nutritional dates

Bird survival

Dense and random distribution

“New AES properties and values”

New management factors

Intermediary variables

Perspectives and follow-up research

An AES design approach raises various governance challenges: How to set up the design collectives? Which methods and tools could enhance their design capacity? Which policy instruments could foster design processes?

The next part of my postdoctoral program tackles these challenges. I will compare two case studies in Quebec and one France, where collective initiatives were set up to reconcile agriculture and the environment. This research aims to highlight innovative modes of management and governance, while accounting for the difficulties in terms of innovativeness and actor coordination.

Conclusion

This case analysis highlights a key principle for a ‘generative ecology’: use intermediary variables to explore new AES management factors and properties. Such a perspective contributes to seeing ecology not only as expertise in decision-making processes, but also as key knowledge to open design opportunities.

References


Hatchuel, A. et al. 2013


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