



Cognitive and managerial challenges for the design of sustainable social-ecological systems

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Cognitive and managerial challenges for the design of sustainable social-ecological systems

Elsa Berthet and Marine Agogu 



Conference on Complex Systems
Satellite session: Imagination and Climate Change
October, 1st 2015 – Arizona State University

Introduction



Folke et al. 2011
Westley et al. 2011

- SES trajectories are often locked in unsustainable pathways
- A need to enhance our ability to envision innovative SES
- A new stake for science:
 - not only inform decision
 - but also contribute to design capacity building
- How can science meet this challenge?
 - Focus on ecology

Outline

1. Formal distinction between modeling and design reasoning
2. Case study: from modeling to designing an agro-ecosystem
3. Principles of a “generative” ecology
4. Implications on the role of ecology in SES governance

1. Formal distinction between modeling and design reasoning

Modeling

- Inputs:
 - X_i is an object considered as:
 - Existing
 - Partly unknown
 - Observable
 - $K(X_i)$: initial knowledge on X_i
- Output:
 - Increased knowledge on X_i :
 $K'(X_i) > K(X_i)$
- *The aim is not to produce new X*

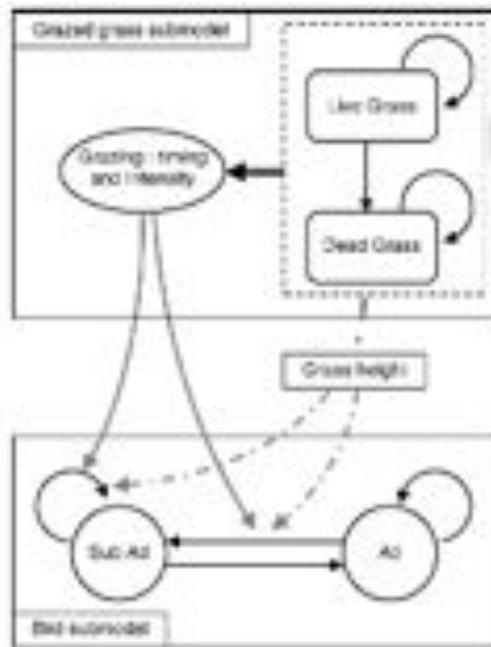
Design

- Inputs:
 - X_x is an object considered as:
 - Not existing
 - Partly unknown
 - Not observable
 - Desirable: desirable property $P(X_x)$
 - $K(X_x)$: initial knowledge on X_x
- Outputs:
 - X_D exists, and $[X_D, P(X_D)]$ true
 - X_D is a combination of expansions of X_x
 - $K'(X_x) > K(X_x)$
- *The aim is to create both knowledge and objects*

Illustration

Modeling

- Let X_i be a landscape of wet grasslands



Output:
Knowledge on bird population dynamics as a function of livestock grazing

Sabatier et al. 2010

Hatchuel & Weil 2009

Design

- Let X_i be an intensive cereal agro-ecosystem
- We want it to be a “harmonious place to live” (P_J)
- $[X_i, P_J(X_i)]$ untrue; $[X_x, P_J(X_x)]$ unknown



Expansions of X_x

Recreate landscape heterogeneity?



Foster other activities?

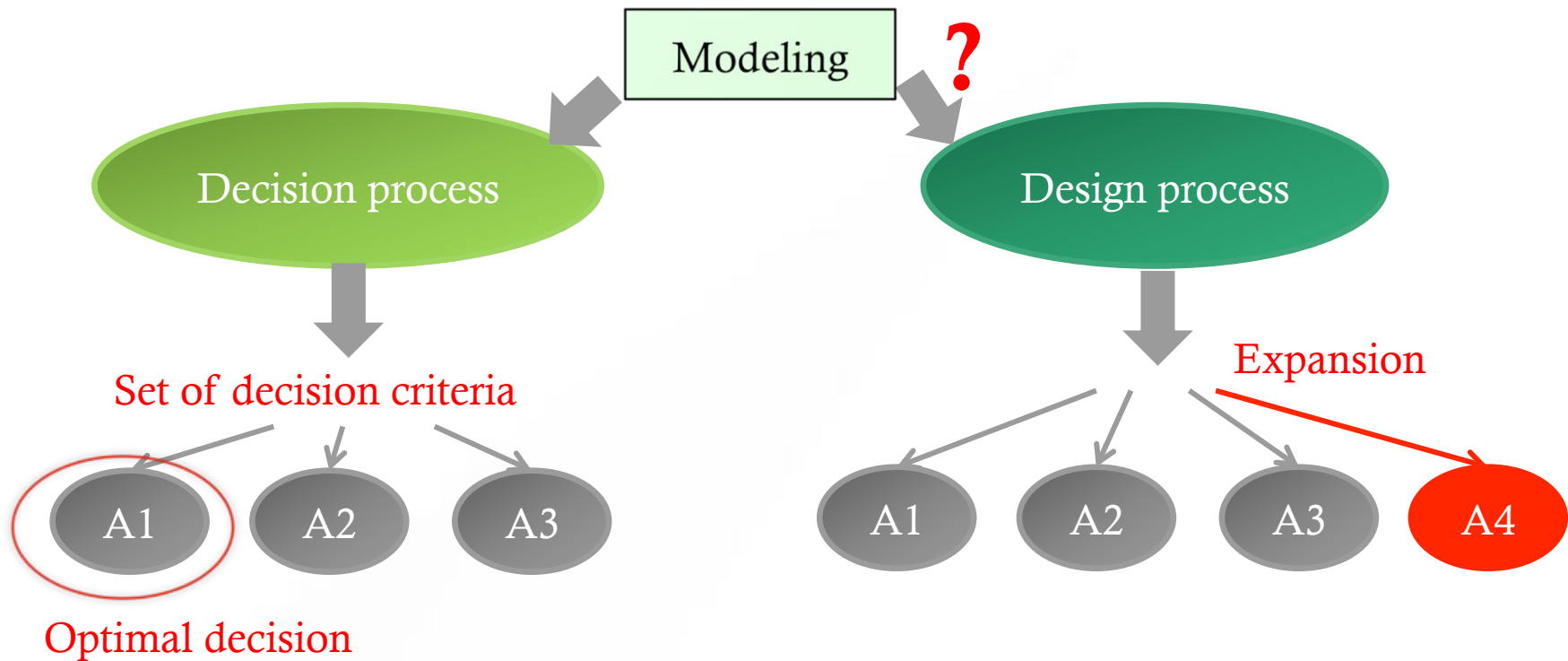


Develop organic farming?



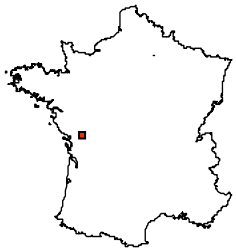
Toward a new role for modeling

Hatchuel 2002



Under what conditions can modeling support an innovative design process?

2. Case study: from modeling to designing an agro-ecosystem



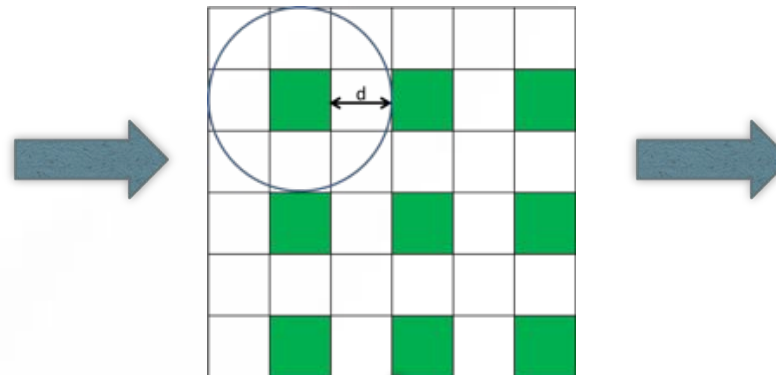
- Intensive cereal agro-ecosystem
- Biodiversity loss and water quality degradation
- Long term research program in ecology



X_i : agro-ecosystem



$K'(X_i)$

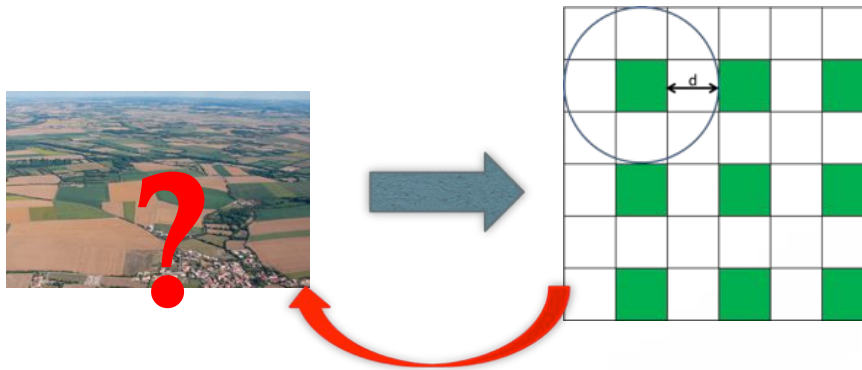


$D^*(d_i)$

- Maintain >10%
grasslands

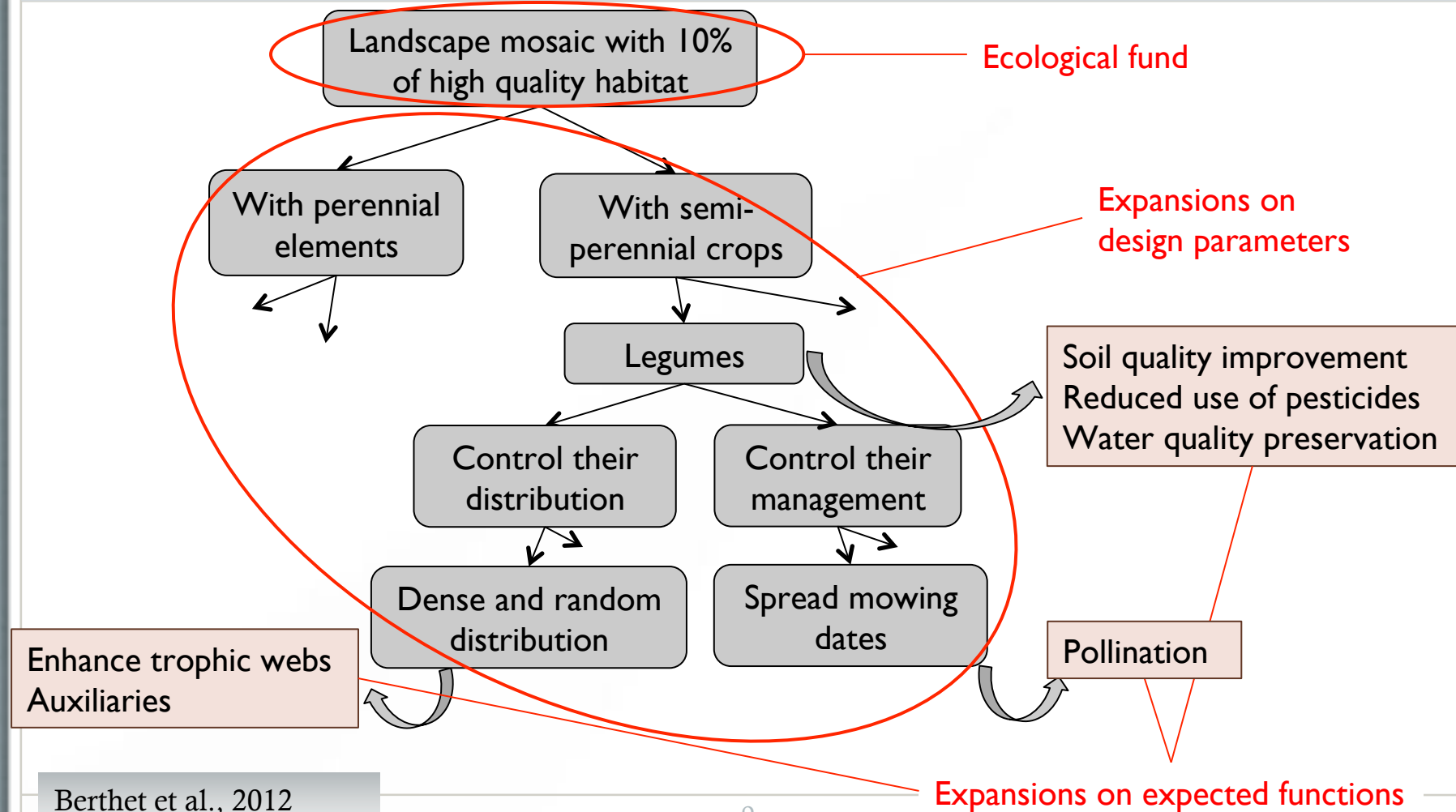


Using ecology's modeling to initiate design



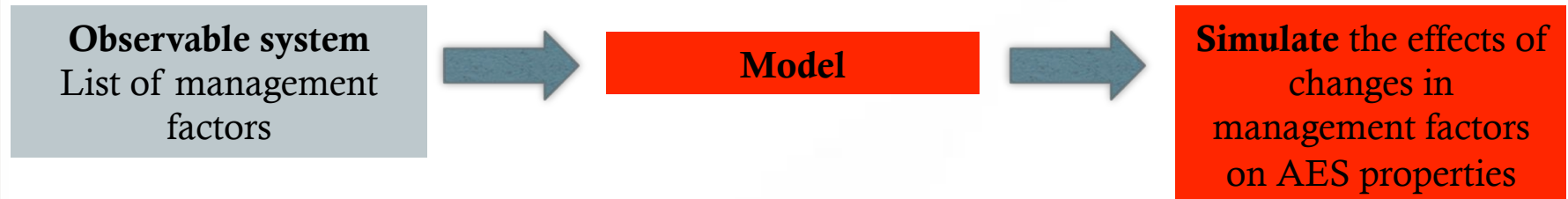
- X_x : a desirable agro-ecosystem
 - $K'(X_x)$ is the landscape mosaic
 - P_j : the desirable property “with 10% of high quality habitat”
 - P_j is necessary but not sufficient to design an acceptable X_x
- $\Rightarrow [X_x, P_j(X_x)]$ is the departure point of a design process: “ecological fund”
- \Rightarrow New properties $P_j(X_x)$ can be imagined, by various stakeholders

Expansions explored during a collective design workshop

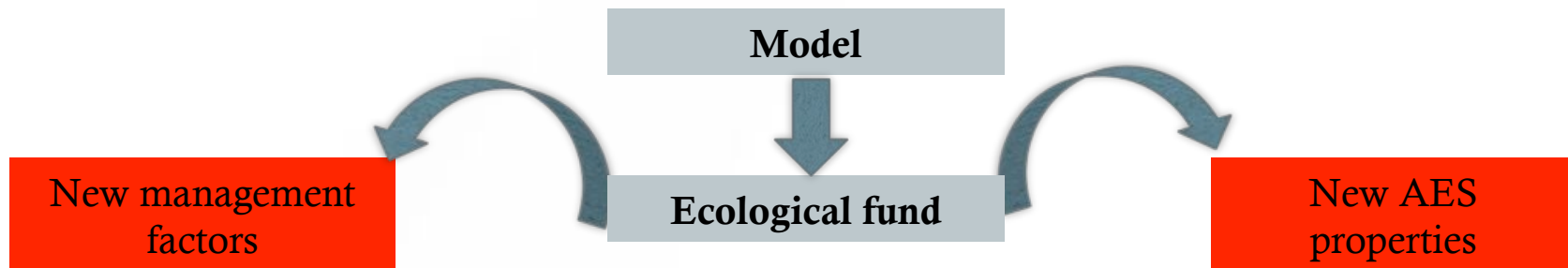


3. Principles of a “generative” ecology

Classic AES modeling



Ecology-based AES design



**Ecology is not used to provide an expertise in a decision process,
but to open new design spaces**

4. Implications on the role of ecology in SES governance

a) Role of ecology in existing governance models

- **Instruments based on the concept of ecosystem services**

- Let X_i be an existing ecosystem
- Let P_j be an desirable property of the ecosystem
 - (e.g.: “reduce pesticides to preserve heritage species)
- $[X_i, P_j]$ is constraining

⇒ Design of incentivizing or coercive instruments



- Ecology is called upon to identify P_j and support the design of regulation/market instruments
- Problems:
 - Ecology is seen as a constraint
 - High costs, conflicts...

Boyd & Banzhaf 2007
Swinton et al. 2007

a) Role of ecology in existing governance models

- **Self-governance of common pool resources**

- Let X_i be an existing resource system (e.g. fisheries)
- Let P_J be an existing property of this system that the community wants to preserve
 - (e.g.: “sustainably provides fish”)
- $[X_i, P_J]$ exists but is threatened

⇒ Design of self-governance rules and norms



- Ecology is called upon to support the design of solutions to maintain $[X_i, P_J]$
- Problem: the CPR model is very specific; it does not hold for AES

b) A new role for ecology: support SES collective design

- Social ecological systems are not stocks to preserve (X_i), but ecological funds to design (X_x)
 - They can be assigned other properties than the initial targeted ones
 - Ecological fund: not a common good, but a “common unknown”
 - Collective action is facilitated by the open dimensions to explore
 - This exploration can be carried out by various stakeholders
- A crucial role for ecology:
 - Qualify the ecological fund and the basic specifications [X_x , $P_j(X_x)$]
 - Open collaborative design spaces, to explore new $P_j(X_x)$
- Toward more democracy in both governance processes and research

Conclusion and perspectives

- Developing a generative ecology: a first step for SES innovative design
- However, managerial challenges:
 - Whom should be involved, and how?
 - Which design tools and methods?
 - How to adapt local governance?
 - Facilitators and new collaboration spaces at a territorial scale
 - New policy instruments
 - Not only incentivizing or coercive
 - but that foster local exploration processes and collaboration



Thank you!



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