A practical framework to analyse the functioning of socio-ecological systems in the European Alps

Isabelle Boulangeat, Ecosystems and Societies in Mountain Lab (LESSEM), Irstea, Grenoble

Context

Alpine ecosystems are usually involved into economic activities (**tourism** and/or **agriculture**) while they host a specific and vulnerable **biodiversity**, and a low density of inhabitants. Current socio-ecological systemic approaches are yet limited in their ability to identify measurable properties which are involved in determining the dynamic and resilience of the system.

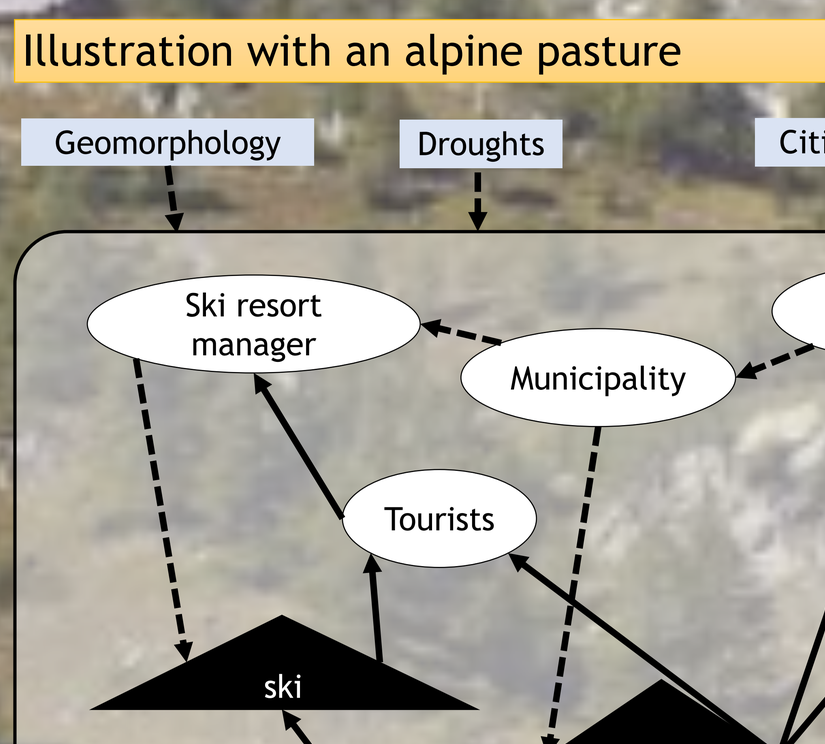
Objective

To propose a structured vision of the functioning of (alpine) Socio-Ecological Systems, for comparative analyses and to build simulation models

Strong innovations of the framework

1. Makes no human/non human dichotomy but habitat/inhabitant
2. Based on resource + practice = effective service
3. Scalable in space (size of habitat unit)
4. Reconciliates ecological system and actor system entries
5. Uses the power of object-oriented structuration

The Habitat-User-Manager-Network (HUMAN) Framework



Activity linking the 3 types of nodes

May be spatial (S): co-presence of users and habitats
May involve biomass extraction (B)

- Provision services: (S) and (B)
- Cultural services: (S) but not (B)
- Regulation services: neither (S) nor (B)

Flow (material, financial, or cognitive)

Management constraint/rule

Habitat	**Users**	**Managers**
+Effect()=PotentialResource()	+Effect()=Use()	+Effect()=ManagePractice()
+area, structure, species composition and diversity, geomorphology, …	+human or not, trophic position, local or migratory, efficacity, behaviour, …	+political or economical, local or not,…

A habitat

- is a spatial unit
- is relatively homogeneous
- includes the biodiversity (species populations) that is limited to the spatial unit

Illustration with an alpine pasture

From the functioning to the resilience

Resilience of what ?
What makes the identity of the system ? A combination of node properties, a network structure, and link properties. E.g. Alpine pasture = enough grass biomass + presence of cattle in the summer
► determines which properties are important to follow/measure? E.g. grassland productivity, cattle load

Resilience to what?
Changes in the context (i.e. environment) of the system. E.g. climate warming, droughts, European politics on agriculture
► determines which context-dependence is important to include? E.g. response to climate, European subsidies

How to measure resilience?
How to measure a change in structure and functioning? Diversity and connectivity metrics within the HUMAN framework E.g. connectivity of habitats, number of modules of users and managers, number of activities
► determines which state variables are essential to monitor? A combination of node properties, network structure metrics, and link properties E.g. number of tourists, presence of wetlands, cattle type, human population density, use of forests

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