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# Social-Ecological Systems: towards a global approach of biodiversity observation in a Regional natural park of alpine territory

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## Abstract

Regional natural parks (PNR) in France were created to protect and enhance the open rural inhabited spaces. PNR are organized around a collaborative project of sustainable development and are marked by complex human-nature relations where integrated management and conservation planning requires cross disciplinary approach. It is impossible to understand nature without society and *vice versa*. The Baronnies Provencales PNR project takes part in the preservation of an Alpine ecological continuum. In the context of climate change we consider adaptive capacities (of nature and human) are favored by a co-constructed observation process of the state and evolution of socio-ecological systems (SES). From conceptual and methodological tools of landscape ecology, we could have a vision about the spatial organization of different components in this territory and understand the interactions between the ecological landscapes organization and structure of biodiversity. By coupling environmental and socioeconomical diagnosis, SES delineations and characterizations could be identified. By the proposed method of territorial study we aims to prove the interest of territories to consider a holistic social, ecological and economical approach based on SES. In making the understanding and the spatial characterization of SES the core of this research, we characterize socio-ecological interdependencies and we tend towards a global approach to biodiversity.

## Keywords

Socio-ecological systems, global change, biodiversity, sustainable development, adaptation capacity, observatory

## Introduction

The concept of biodiversity initiated between 1986 and 1988 (WILSON 1988) from the contraction of biological diversity was revisited with a social, anthropocentric perspective in the context of sustainable development during the global summit in Rio de Janeiro. The ecological vision of sustainable development (PASSET 1979; CATO 2009) presents the economy as a subset of the sphere of humanity-society, which is itself a subset of the biosphere. As explained by BARBAULT (2011) biodiversity goes through the three circles of sustainable development, linking the economic sphere to the biosphere while including human affairs. This new concept of biodiversity implicates a transversal approach for biodiversity management planning and ownership of related issues involved, including a global vision of the socio-environment. Objectives of biodiversity conservation can no longer be thought by separating biodiversity and society. Systems to be explored are less ecosystems than coupled human-environment systems, also called social-ecological systems (SES) (BERKES et al. 2003). SES are integrated, complex and adaptive systems, associating nature and human society and structured in two sub-systems being: ecological systems and social systems (LIU et al. 2007). This approach considers human as an active component and integrates human-nature interactions.

Regional natural parks (PNR) are in fragile balance territories, with rich but threatened natural and cultural heritage. PNR's specificity relies not only on the complementarities of its objectives of protection and development, but also on the voluntary commitment of all the partners (municipalities, region(s), department(s) and State), to apply the contract that is the Charter of the Park. A PNR contributes to research programs and mission to introduce new procedures and methods of actions that can be taken in any other territory. Challenges of PNR are to promote adaptation planning meeting the challenges of global change and the implementation of an ecological transition to foster good practices. These territories are at the heart of complex human-nature relations, which require the consideration of the socio-ecological dimension of biodiversity. Integrated management planning and biodiversity conservation within PNR requires a cross disciplinary approach and the narrow interweaving between nature and the human societies leads us to consider PNR as SES.

In this prospective study we look at the Baronnies Provencales territory, wishing to be certified as a PNR by 2014. This project of 2,350 km² has nearly 40,000 inhabitants, is spread over 130 communes between two regions: 2/3 in Rhône-Alpes and 1/3 Provence-Alpes-Côtes-d'Azur. This PNR project can be seen as the "missing link" of an alpine ecological continuum of protected areas recognized for their heritage value. In this territory, we seek to

explore biodiversity issues through sustainable development logic. Here, we discuss the extent to which a global approach to biodiversity can provide relevant information in order to develop a sustainable management of territories. SES become the core object of our cognitive interest for sustainable development and for an appropriation of biodiversity issues. We hypothesize adaptation capacities (of the environment and humans) within alpine territories - a protected area subject to local and global changes and where the heterogeneity and disparity of natural and human situations dominate, are encouraged by a co-constructed process of observation of the state and dynamics of socio-ecological systems.

## Method

To conduct a territorial analysis of SES, knowledge in five areas is needed (BOURGERON et al. 2001a; 2009): (1) characterization of biological component(s); (2) characterization of physical components; (3) characterization of biological-physical interactions; (4) characterization of socioeconomic components and (5) characterization of SES as a whole, including coupling of component and system properties, such as disturbance and resilience.

The method described below has been divided into four steps.

STEP 1 - Database construction

The implementation of a socio-environmental coupled scenario has to deal with heterogeneous quantitative and qualitative biophysical and socio-economical data generated to study human-environment interactions. Information integration to identify SES can be very challenging and involves integrating information across domains (e.g. geomorphology and human values), different sources (e.g. scientific survey and administrative survey), different formats (e.g. qualitative and quantitative survey), and covering the whole study area (SLOCOMBE 2001; BOURGERON et al. 2009). Knowledge about the territory is acquired via the analysis and interpretation of hierarchical database and maps describing environmental component (topography and landform, soil, climate and land cover) and human component (socio-economic census and socio-demographic census). If necessary, the data sources are transformed and georeferenced to make them useful in GIS. For the typology at the first scale level, grid cells are used as spatial unit, defining the grain of the characterization. The variables are integrated to the grid cells by GIS overlay of the data sets and all variables are transposed in continue attributes. For example three types of land cover in one grid cell will be expressed as the dominant surface one in the grid cell.

STEP 2 –Ecological landscape patterns and interactions with biodiversity

From conceptual and methodological tools of landscape ecology (BUREL & BAUDRY 1999), we will highlight patterns and representative identity of the territory. This will show the relationship between the spatial organization of ecosystems/habitats and ecological mechanisms, that underlying the dynamic of biodiversity and ecosystem functioning.

Three studies are conducted on biodiversity to determine: biodiversity hotspots and vulnerable areas (method from VIMAL 2010), life history traits and interactions between biodiversity organization and ecological landscape patterns. In spite of several tools and data sources, data on biodiversity are difficult to collect from naturalist organizations which are protecting their intellectual property and fear of making known the geographical position of threatened species. Thus, biodiversity data are often heterogeneous and do not cover the whole territory. Currently, it is not possible to make statistical analyzes with much accuracy because considerable uncertainty remains about the true absence of species. To overcome this problem we will study plant association and species communities.

STEP 3 – Representation of the systems and socio-ecological units

Multivariate analysis (to define the variables acting on the system) and a hierarchical classification (using CAMIN) will be conducted on the environmental and socioeconomical variables in order to characterize environmental and socioeconomical systems. Then, this diagnosis will be applied to the total database to determine socioecological units.

STEP 4 - Socio-environmental coupled scenario for strategic scenario planning

Scenario planning is conducted at the last stages of this study and determines the various implication and tradeoffs of various possible environmental and land use scenarios. Multi-agent systems have features especially suited to integrate social and environmental components under different forms of organization levels (BOURGERON et al. 2009). For this study, Cormas platform will be use to model the interactions dynamics within and between SES and identify resilience and adaptation capacity of SES. The diagnostic approach from OSTROM (2007, 2009) based on resource systems will enable us to analyze interaction and outcomes of resource systems within linked SES. The framework proposed by PAETZOLD et al. (2010) to assess ecological quality based on ecosystem services will show the overlap between social expectations, and the sustainable provision. In order to take such an approach we need to integrate explicitly human needs and expectations in the assessment of ecosystems.

## Prospective Results and Discussion

Towards a socio-ecological approach of biodiversity

Since the preservation of biodiversity and associated ecosystem services are playing an increasingly important role in society and politics, real scientific debates develop on the social and economical dimensions of biodiversity conservation (CZECH 2000, MANGEL et al. 1996). The design of territorial projects requires a first phase of knowledge following certain rules and having to be extended in the long-term. It will be possible to meet societal demands for integrated management and spatial planning by the global understanding of biodiversity and human-environment interactions.

The first two steps from the method are necessary to better understand the different components within the PNR. In a territory of alpine and Mediterranean influences, in the context of global change, we plan the environment structure to be pronounced and landscape to be in mosaic. After the integration of biological, physical, land use and socio-economical data in a database framework, a correlation relationship would be made among ecological landscape patterns and biological patterns. Here, we hypothesis that landscape units will correspond to functional units.

Socio-environmental adaptation to global change

We consider ecosystems adaptation should go through the conservation of biodiversity and socio-ecosystems by seeking a territorial equity and minimizing processes of inequality, leading to territorial intelligence. Should this happen through the development of an ecology that considers different scales of time and space, functions and dynamics of ecosystems and anthroposystems, including their socio-economical, territorial and legal status? On the basis of this knowledge would it be possible to better meet societal challenges of sustainable development?

The long-term vision places the territory within environmental gradients and ecological transitions allowing changes in species range. By forward-looking vision with a long term society project, we could anticipate risks, changing landscapes and activities, evaluate impacts on the ecological connectivity (interconnected landscape) and support the ability of each of us to act with responsible manner. Understanding the nature and the extent of combined ecosystems and sociosystems vulnerabilities in rural areas is essential in a changing climate, economic and social situation, which is becoming increasingly difficult. Thus, this study will contribute to respond to priority questions relating to the maintenance and restoration of an ecological continuum in the European Alps. (WALZER et al. 2013). Ecologists and biologists can study the imbalances of ecosystems, social scientists those of societies. Making it difficult to manage and anticipate the consequences of their management. How to study the consequences of the vulnerabilities of the two subsystems, social and ecological? We project that the observation and understanding of socio-environmental coupled scenarios promote an adaptive management of the territory. The resilience, the potential of compensation and the interactions (homogeneity and diversity) between SES will be analyzed while running a multi-agent base model. In this context of global change, the territory of Baronnies Provencales must adapt, and the economical development will relies on resources being primarily the agriculture, forest exploitation and tourism. The main issue for PNR is to provide information on the status and evolution of the territory and to promote good practices. It is therefore interesting to see if the socio-economical vulnerability covers ecological vulnerability and if the ecological vulnerability may be a limiting factor for socio-economical development. The study of SES by the resources units will forecast the internal and external dynamics in the SES, determine ecological services and indicate the paths to achieve a sustainable SES (OSTROM 2007, 2009). The interaction between supply and demand from the model proposed by PAETZOLD et al. (2010) will demonstrate if the supply of ecological environment can support the socio-economical demand.

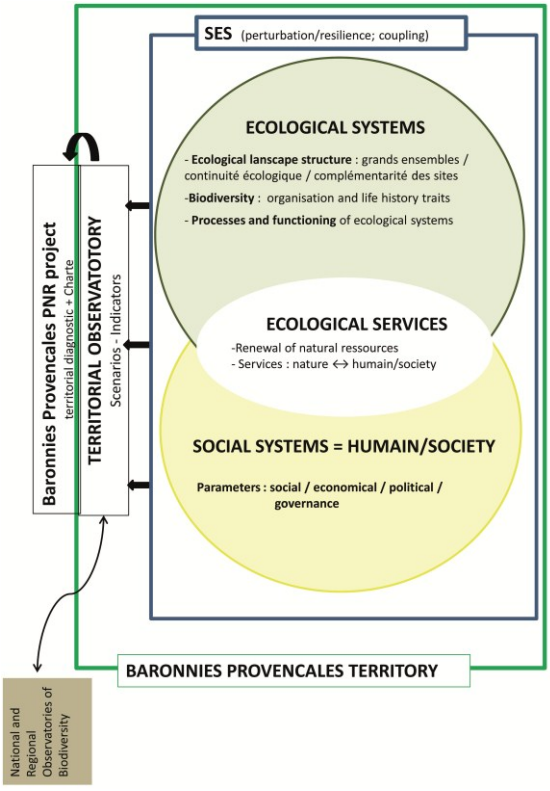


Figure 1: Synthetic scheme of the interrelated context areas related to SES to address within a Regional Natural Park.

A territorial observation tool to develop the link between science and society

To integrate and compare data from various sources over the long term and to study SES, we will implement a territorial observatory within the Baronnies Provencales PNR. This tool aims to help sustainable local

development, fosters adaptation capacities and meets the current challenges related to local and global change. The question arises about the appropriateness of a tool "observatory" looking at SES and integrating social and environmental aspect: How to account for the characteristic (and evolution) of ecological and social systems in the observatory? How to address global environmental issues locally and to highlight the global dimension of local issues?

The Observatory is seen as a tool acting as a catalyst of development project, for an adaptive management of socio-ecological systems. Observatory tool has the capacity to transform territorial practices in development and conservation projects. An appropriation of this tool by public policies as well as the society could promote a better approach of biodiversity issues facing global and local change.

For implementing a relevant observation tool we have to:

- Define the relevant spatial unit, time steps and recurrences to observe changes in ecological and social systems.
- Reveal conditions for better coordination between processes located at different time steps: renewal / biodiversity conservation, public policy, technical decisions.
- Establish gateways (conceptual and instrumental) between the approaches and descriptive categories relevant to the action.
- Develop efficient sets of indicators (compositions, structures, functions and evolution) to observe changes in ecological and social systems.

## Conclusion

In this study we focus on the social and environmental observation of biodiversity for territorial management planning and to design the construction of an observatory tool addressing the territorial issues. In making the understanding and the spatial characterization of SES the core of this research, we characterize socio-ecological interdependencies and we tend towards a global approach to biodiversity. By this method of territorial study we want to prove the interest for territories to consider a holistic social, ecological and economical approach to biodiversity based on SES. Observation of SES dynamics is particularly important for territories at bioclimatic intersections as they will undergo accelerated changes of biodiversity and of their economy. Given the mission of PNR as to be laboratories for the study of territories capacity to adapt to global change, this work within the Baronnies Provencales presents a more general interest for other territories.

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