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Conciliate Agriculture with Landscape and Biodiversity Conservation: A Role-Playing Game to Explore Trade-Offs among Ecosystem Services through Social Learning

Clémence Moreau [1], Cécile Barnaud [1,*] and Raphaël Mathevet [2,3,*]

[1] DYNAFOR, Université de Toulouse, INPT, INRA, 31320 Auzeville-Tolosan, France; clemence.moreau@inra.fr

[2] CEFE, CNRS-University Montpellier-University Paul Valéry Montpellier 3-EPHE, IRD, 34293 Montpellier CEDEX 5, France

[3] French Institute of Pondicherry, UMIFRE 21 CNRS-MAEE, 11 Saint Louis Street, Puducherry 605001, India

* Correspondence: cecile.barnaud@inra.fr (C.B.); raphael.mathevet@cefe.cnrs.fr (R.M.); Tel.: +33-5-61-28-57-68 (C.B.)

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Abstract: A key challenge in the management of ecosystem services involves weighing up the trade-offs between these ecosystem services and who benefits from them. In mountainous zones, new trade-offs between ecosystem services emerge due to shifts in farming practices and their consequences on the landscapes (land abandonment and intensification), which is a source of debate and controversy between local stakeholders. To help stakeholders tackle the challenge of decision-making around trade-offs, this study tested the use of a role-playing game based on the concept of ecosystem services to facilitate the process through social learning. The game SECOLOZ was designed in cooperation with local stakeholders to explore the impacts of three farming practices (rock removal, ploughing of meadow, and pasturing) on trade-offs among ecosystem services. The game was played with various local stakeholders in the Mont Lozère, France. We found that this experience increased awareness of interdependencies, encouraged mutual understanding, improved the ability to deal with uncertainties, and fostered the exploration of innovative methods of governance. The outcomes confirm that the ecosystem service concept can be successfully used in a role-playing game process and that it significantly contributes to social learning.

Keywords: trade-offs; ecosystem services; social learning; agroecology; participatory approaches; role-playing game

1. Introduction

Farming systems in mountainous areas are typically extensive, low-intensity systems, employing low-input farming practices that maintain open landscapes with a high level of biodiversity [1] and heritage value [2]. However, in Europe, these ecosystems have been undergoing two main changes since the Second World War [2,3] due to the mechanization of farming, the globalization of markets, and the development of the European Common Agricultural Policy (CAP): on the one hand, marginal agricultural land is being increasingly abandoned, while on the other, the most suitable land is becoming more intensively farmed, with a rise in productivity, crop specialization, and increased plot size [2–4].

These changes impact a range of ecosystem services (ESs)—the material or immaterial benefits obtained from ecosystems [5]—provided by mountain ecosystems, such as grass supply, avalanche-risk

reduction, or cultural values related to the landscape [6,7]. These ESs interact with each other, either negatively (one ES increases at the cost of another, resulting in a trade-off) or positively (several ESs benefit each other simultaneously, resulting in synergy) [8]. Several studies have analyzed the complexity of these interactions in mountain regions, using future scenarios to model the impacts of agricultural intensification and land abandonment and the resulting potential trade-offs [6,9].

From a social and constructivist perspective, ESs do not exist per se, but are socially constructed representations [10]. Thus, stakeholders' perceptions of these ESs can reflect their differing interests and values. When there are trade-offs between ESs, this can result into conflicting interests between beneficiaries of these ESs, with winners and losers [11]. An ES approach can reveal interdependencies between stakeholders that were not visible or explicit; examining the social choices underlying trade-offs among ESs [12].

Dealing with trade-offs is complex, because they can be invisible, diversely perceived, or intentionally ignored [11,13]. Social learning has been identified as a way to approach the issue of negotiating trade-offs [13]. Defined as "*a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks*" [14], social learning can help develop a broader, more systemic perspective. It can increase understanding of the diverse impacts of different ESs on different people, encourage collaboration between stakeholders, support the development of shared goals, and give rise to new practices that address trade-off dynamics [13]. Developing, testing and assessing methodologies that foster social learning in ES trade-offs is therefore highly needed.

In this study, we explored how social learning might be used to better inform choices and negotiate ES trade-offs in a mountain farming ecosystem. Various participatory tools and methodologies have been shown to foster social learning. Of these, role-playing games (RPG) have been identified as particularly valuable [15], as they increase technical and socio-institutional knowledge, improve systemic comprehension of social and ecological systems, foster socio-institutional learning and result in behavioral changes [15–22]. We hypothesized that an RPG with ES trade-offs as a focus could raise awareness through social learning and help inform choices about landscape changes. Specifically, we hypothesized that an RPG would promote four key social learning outcomes: increased mutual understanding, higher awareness of interdependencies, improved ability to deal with uncertainties, and more willingness to explore innovative methods of governance.

Numerous authors affirmed that the ES concept can encourage social learning, for example, by increasing awareness of social interdependencies [12], by adopting a systemic perspective [23], by revealing diverse perceptions of nature [24], and by supporting collective discussion [25]. Several researchers have designed RPGs based on the ES framework, either with a theoretical perspective [26] or in applied case studies focusing on wetland ecosystems [27], forests [24], or renewable energy management [28]. A study by Lamarque et al. [29] explored how stakeholders in a mountain farming system made choices regarding ES, but that study only considered farmers' individual decisions. In contrast, our study explored the interactions between farmers and other stakeholders, which is a key dimension of social choices related to trade-offs between ESs.

Our approach drew on participatory-action research and was conducted in the mountains of the Cévennes Biosphere Reserve and National Park (NP) in the south of France. We designed an RPG called SECOLOZ (SECOLOZ is an acronym for SErvice éCOsystémiques sur le mont LOZère, in English "Ecosystem Services on the Mont Lozere"), to test the hypothesis that the ES concept can help fostering social learning. It was specifically designed to address the governance challenges related to the dynamics of land abandonment and farming intensification on Mont Lozère in the Cévennes range. More precisely, we focused on three practices: pasturing, which is an extensive practice that contributes to maintain open landscapes and limit land abandonment; rock removal; and ploughing of meadows. The last two practices contribute, as drainage or land re-parcelling, to intensify the farming landscapes. We chose to focus on rock removal and ploughing of meadows because they are

good examples of social and ecological interdependencies and because they are important and often controversial issues, especially between NP managers and farmers.

In the following sections, we briefly present the conceptual framework, the case study, and the methods, before explaining how the SECOLOZ experience impacted social learning.

2. Concepts, Case Study and Methods

2.1. Conceptual Framework

In this study, we chose the conceptual framework designed by Barnaud and al [12] that uses the lens of ESs to highlight social interdependencies. We focused on the social interdependencies related to ES trade-offs and synergies between the providers of these ESs, who directly shape the ecosystem through their actions; the beneficiaries; and the intermediaries who make decisions and inform other stakeholders (Figure 1). Three types of interdependencies can be distinguished [12]: (i) between ES providers (e.g., within a collective organization of farmers who maintain open landscapes), (ii) between beneficiaries (e.g., hunters and hikers, between whom tensions may exist), and (iii) between providers and beneficiaries (e.g., between a farmer who maintains an open landscape and a tourist who enjoys it). Any changes occurring in the ecosystem can impact the balance between these ESs and create new trade-offs or synergies.

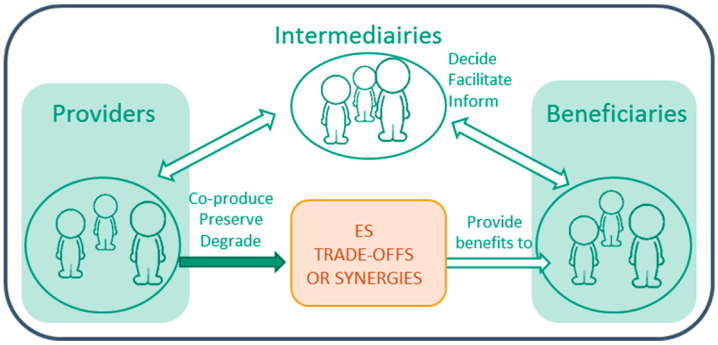

Figure 1. The conceptual framework used in this study.

In an original approach, we translated this conceptual framework into an RPG to assess its efficacy in terms of social learning and its impact on ES negotiations. Working toward this aim, we first implemented a context analysis of our case study.

2.2. Case Study and Context Analysis

Mont Lozère is a sub-Mediterranean granite mountain located in the Cévennes region of southern France. It varies in altitude from 470 to 1699 m. Its rare habitats and plant and animal species, combined with its high cultural value as a Mediterranean agro-pastoral landscape, led to the protection of the zone as an NP in 1970. In 1985, it was recognized by UNESCO as a Biosphere Reserve (under the Man and Biosphere program), and in 2011 as a UNESCO World Heritage Site [30]. The main economic sectors are tourism, farming (mainly livestock, with a transition taking place from sheep to cow production for milk and meat), and timber. The landscape is a mosaic of grasslands, heathland, meadows, and forests [31]. Granite rocks are highly present and contribute to the iconic Mont Lozere scenery, either as sparse outcrops, natural rocky masses, or human-made heaps (Figure 2).

Today, this landscape is changing due to land abandonment and spontaneous reforestation: between 1970 and 2000, the forested area has increased by 34% [32]. The open landscapes are also transforming due to changes in farming practices. Our study focused on two of these new farming practices in particular: the removal of rocks and the ploughing of meadows. The first involves removing granite rocks from the meadows to enable mechanization. The second consists of

transforming grasslands or permanent meadows into temporary pastureland through ploughing to increase productivity. Both practices are representative of a trend towards agricultural intensification, and the resulting changes have generated debate between stakeholders who have conflicting interests and perspectives.

Figure 2. Granite rocks on natural outcrops (**left**), on grassland (**middle**), and after rock removal in a meadow (**right**). Credit: J. Prudent, C. Moreau, and C. Barnaud.

Rock removal and ploughing of meadows have increased on Mont Lozère in recent years, as dairy and meat livestock farmers try to increase hay production to reach greater fodder autonomy [33]. In a context of increasing constraints on land access and economic burdens, mechanization appears necessary to these farmers; policies such as the CAP encourage also these practices [33].

In the following paragraphs, we present the main conclusions of the context analysis that we conducted.

Several stakeholders are directly or indirectly impacted by these new farming practices, especially if they are beneficiaries of one or more ESs [34]. For instance, the recent temporary pastureland increases result in higher hay production for farmers, but it also leads to a loss of biodiversity, reducing habitats of high ecological value such as permanent meadows or shrublands. Rock removal enables mechanization and thus can improve the production of hay, but this can lead to degradation of heritage landscapes and impact tourist experiences of these sceneries and the tourism operators; it can also impact the ES of erosion regulation, and thus become an issue for local elected officials. The NP is therefore concerned by the increase of these practices. In a context of a rise in reforestation due to land abandonment, NP managers seek to maintain open landscapes by maintaining agricultural activities within the NP. They consider a certain degree of rock removal and ploughing of meadows as necessary for the economic viability of farms. However, if these practices become widespread, this can alter open landscapes, their biodiversity, and aesthetic and heritage values, which the NP's purpose is to protect. Thus the NP must find trade-offs between these different objectives, which can lead to conflicting positions between its different management divisions (e.g., between agriculture and biodiversity conservation departments).

In the core zone of the NP, rock removal and ploughing of meadows are regulated by permits granted to farmers on request after an appraisal by NP managers and the NP scientific board. In the appraisal process, the potential impacts of the farming proposal on a range of stakes (e.g., the economic activity of the farm, tourism, landscape, biodiversity) are evaluated. If a permit is granted, it includes farming practice guidelines that represent a trade-off between these different issues at stake. However, the rise of rock removal and ploughing demand shows the limits of the current permit system. As permits are granted on an individual basis for a specific plot, this does not allow the anticipation of the long-term effects on the scale of the whole landscape or the irreversibility of these practices. Moreover, this system does not encourage collective discussion between farmers. For farmers, the current permit system is seen as a major constraint on their activities, while for the NP, the difficulty is to find a good balance between maintaining agriculture in the core zone of the NP while preserving biodiversity and the key features of its landscape.

Given these concerns, the stakeholders (NP managers and farmers) expressed a strong desire for collective discussions on changing agricultural practices and how they are regulated. We adopted a ComMod approach (explained below) to meet this need.

2.3. Materials and Methods

The aim of the SECOLOZ RPG was to facilitate stakeholder discussion about the landscape dynamics to explore opportunities to foster collective action by increasing awareness of social and ecological interdependencies. It was part of a broader participatory-action research project (the SECOCO project) conducted in partnership with the managers of the NP and the Biosphere Reserve. The project team decided to focus on the intensification of farming practices on Mont Lozère in agreement with the NP managers, who were facing tensions with farmers around this issue.

To design the SECOLOZ RPG, we chose a companion modelling approach (ComMod) [35], which is a participatory approach based on the co-construction and use of models. In ComMod, models, such as multi-agent systems or RPGs, are used to simulate how social and ecological systems function to facilitate collective learning and support decision-making. Based on an iterative and adaptive method that evolves with the participative process, the ComMod approach has been successfully applied in various contexts of natural resource management, from water and biodiversity, to regional planning and integrated landscape management (Etienne 2010). Following the principles of the ComMod method, we adopted an engaged posture of action research, considering ourselves, the researchers, as stakeholders involved in the local interplay.

The design and implementation of the RPG followed five steps, described in Sections 2.3.1–2.3.5

2.3.1. A Social–Ecological Context Analysis

This first step is crucial in the ComMod process: it aims to identify a problem on which collective discussion is needed and to find or create an action arena (i.e. made of impacting and impacted stakeholders). This consisted of semi-structured individual interviews conducted between July 2016 and August 2017 with 46 stakeholders from the farming, timber, tourism, environment, and hunting sectors. These interviews were recorded and transcribed. The analysis consisted in identifying the stakeholders' perception of the ESs impacted by rock removal and the ploughing of meadows. Then, we identified the providers and beneficiaries of these ESs, as well of institutions regulating trade-offs between ESs. In addition, we participated as observers at a meeting in August 2017 of the Cévennes NP scientific board, which brought together around 40 scientists and NP managers to discuss management issues around open landscapes. We briefly presented some results of this context analysis in the case study section; more details are given in another publication [34]. In the present paper, we focused on the RPG design, its use, and outcomes.

2.3.2. The Design of the RPG

The design of the SECOLOZ RPG was based on the ES conceptual framework and on the ComMod approach. The aim was to highlight social and ecological interactions via a simplified representation of farming practices, ecosystems, ESs, and stakeholders. The rules and the indicators of the SECOLOZ RPG are based on a model of the functioning of the social and ecological system, which was inspired from (i) the social–ecological context analysis; and (ii) specific structured interviewed made with scientists and experts, aiming to calibrate the game. Designing rules and indicators was really challenging because they had to be both credible and playable.

We considered four types of ecosystems corresponding to different types of land cover: open grassland, shrubland, permanent meadow, and temporary pastureland. The transition from one type of ecosystem to another is related to farming practices (e.g., rock removal, ploughing of meadows, and reopening shrubland to grazing), or ecological dynamics (e.g., forest encroachment or natural evolution of meadows). Each ecosystem provides a certain degree of ES: for instance, one plot of temporary pastureland provides two units of hay, while permanent meadow provides only one; one hen harrier

requires a habitat of 10 plots of shrubland. Some ESs are location-specific: for example, water quality is determined by the type of land cover around the spring. The ES indicators are detailed in the table in Appendix A.

We used the concept of ESs to highlight the relationships between these ecosystems and the stakeholders who shape them, through farming practices or regulation (providers, intermediaries), and who benefit from them (beneficiaries) (Figure 3).

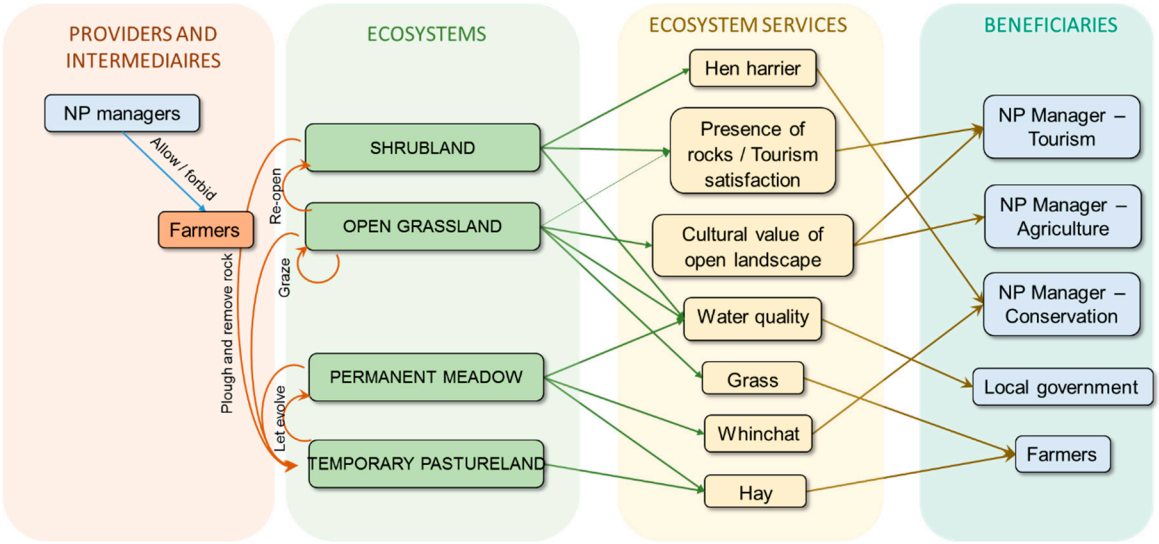

Figure 3. The conceptual model of the SECOLOZ RPG.

Based on this model, the game board represented plots with the different types of land cover belonging to four farmers (Figure 4). The players took one of seven roles. Four of these roles were livestock farmers (two meat and two dairy farmers), whose objective was to maintain or increase their herds. Farmers could change the game board through their practices. They had to pay for rock removal and reopening shrubland, and get a permit for rock removal and ploughing meadows for pastureland. The remaining three roles were NP managers: one responsible for agriculture, whose objective was to maintain agricultural activity and the cultural heritage value of open grasslands; one responsible for tourism, whose objective was to maintain granite rocks and the cultural heritage value of open grasslands; and one responsible for conservation, whose objective was to protect two emblematic birds (the hen harrier, which nests in shrubland, and the whinchat, which lives in permanent meadows). NP managers could give permits to farmers for rock removal and ploughing of meadows and could also give financial support to farmers through agri-environmental measures (AEMs). Of the seven players, a mayor was designated, who was additionally in charge of water quality. As the players have certain antagonistic objectives, the game was designed to encourage negotiation between them during the RPG and to engage discussion about points of conflict in the debriefing. The landscape dynamics (i.e., changes on the game board) illustrated trade-offs between ES and social interactions. More details are given in the table in Appendix B.

A session of the RPG consisted of three to five rounds, each with three steps: (i) a period of discussion and negotiation in which the farmers explained their projects and expressed their needs for permits and AEMs, and the NP managers discussed between themselves and with the farmers to make final decisions; (ii) a phase in which farmers implemented actions (e.g., putting cows in pastures, ploughing meadows, harvesting hay, feeding livestock, etc.), and faced various hazards (e.g., dry year, wild boar damage, etc.); and (iii) a phase in which the indicators for each ES was collectively overviewed. The period of discussion and negotiation was time-limited, which encouraged stakeholders to find an arrangement.

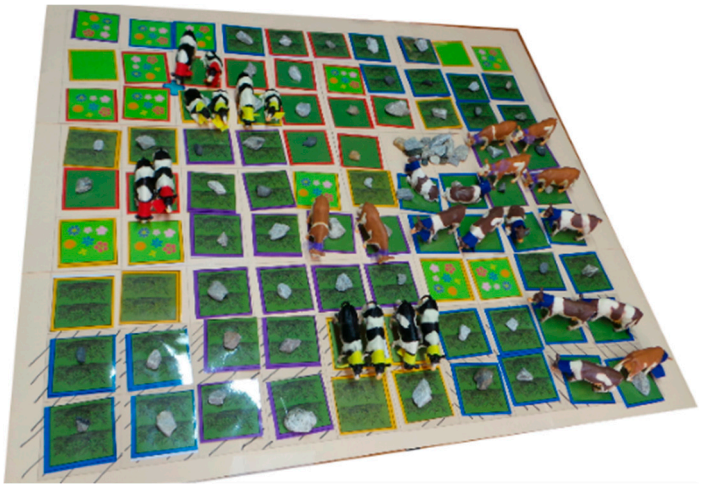

Figure 4. SECOLOZ game board.

2.3.3. The Role-Playing Sessions

Two sessions were conducted in March and April 2018, and aimed to foster social learning and bring to light different perspectives on ESs and trade-offs. Each session involved seven participants (NP managers, meat and dairy livestock farmers, municipal councilors). The total number of participants was 13 (one NP manager in charge of permits participated in both sessions). We invited farmers, NP managers, and elected officials, being careful of the balance of the different groups in each session. We also invited tourism operators, who unfortunately could not join the session. We invited first and foremost people interviewed during the semi-structured interviews, then we extended the panel to contacts given by stakeholders. Among those we invited, the rate of refusal was 55%. Generally, those agreeing to participate were stakeholders who were very concerned about the issue of rock removal and ploughing of meadows or who were used to engaging in collective decision-making. There were some social risks for all involved in the RPG sessions: making worse the latent conflict by exposing their weakness for farmers, deteriorating the local partnership for the NP managers, and having a counterproductive effect on local dynamics for researchers. Before the sessions, we reduced these social risks through frequent communication with the different stakeholders and to alleviate social tension by suggesting that players swap their roles during RPG sessions (i.e., farmers playing NP managers and vice versa).

The RPG sessions were divided into four stages: (i) a briefing and a pre-game questionnaire, (ii) the RPG itself, (iii) a debriefing, which was a collective discussion focusing on ES trade-offs: what the origin of these trade-offs in the game was and how the participants experienced them, and whether such trade-offs were encountered in reality and, if so, how they are dealt with; and (iv) the final step was a post-game questionnaire.

2.3.4. Individual Post-Session Interviews

They were conducted by phone a few days after the RPG sessions with the objective of assessing the participants' opinions about the experience and to assess the impact on learning. We followed an interview grid, which included questions about the global feeling about the RPG session and the perception of interactions between farming practices and trade-offs among ESs, of interdependencies, and of the effects of the RPG on mutual understanding. On the 14 participants, 10 answered, and 4 refused, mainly due to time constraints (the NP manager who participated in both sessions answered twice to the individual post-session interviews.).

2.3.5. The Analysis of the RPG Session

After the sessions, the content (i.e., the exchanges during the RPG sessions, the debriefings, and the post-session interviews) was integrally transcribed. We conducted the analysis with Nvivo 11 Pro software (version 11.4, QSR International, Melbourne, Australia) [36]. We structured our analysis on four hypotheses on the possible effects of the RPG on social learning that arose from literature. These hypotheses were transformed into "*parent nodes*" in the Nvivo software. For each hypothesis, we identified specific contributions of the RPG session to social learning by coding informative segments from the transcription, and aggregated them into "*child nodes*" (Table 1).

Table 1. Method for coding the RPG sessions and post-interviews.

Parents Nodes: **Main Effects of RPG on Social Learning**	**References**	**Child Nodes:** **Specific Contributions to Social Learning**
Higher awareness of interdependencies	[15,17,18]	Improving awareness of interdependencies: • Between co-producers of ESs • Between beneficiaries of ESs • Between producers, beneficiaries of ESs, and intermediaries
Increased mutual understanding	[16,37,38]	Enabling: • Expression of a need to be understood • Experiencing the constraints and challenges of others • Expressing one's own difficulties
Improved ability to deal with uncertainties	[39,40]	Identifying different kinds of uncertainties: • Lack of access to information • Knowledge gap • Ambiguity
Willingness to explore innovative methods of governance	[15,41]	Encouraging collective discussion on: • The functioning of the actual governance • The limits of the actual governance • The possibility and feasibility of alternative governance

3. Results: Effects of Role-Playing on Social Learning—Analysis of SECOLOZ RPG Sessions

In this section, we analyze the effects of the SECOLOZ experiences on the four aspects of social learning that framed our experience as explained above.

3.1. Higher Awareness of Interdependencies

Our first hypothesis was that RPG sessions could increase the participants' awareness of social interdependencies, based on other ComMod experiences [15,17,18].

Several kinds of interdependencies were made more evident during the role-playing game sessions. One involved the role of farmers as co-producers of ESs at the landscape scale. Some stakeholders, particularly the NP managers, brought out that these interdependencies are rarely taken into account in decisions regarding landscapes: "*No one takes the time to discuss with all the people exploiting the land to think about what we're doing in the valley as a whole.*" (an NP manager during the debriefing). Discussions during the sessions showed that stakeholders recognize interdependencies: for example, the NP manager responsible for conservation (played by a farmer) asked a farmer (played by an NP manager): "*If I let you reopen your shrubland for grazing, where will the harrier nest?*" Another NP manager (played by a farmer) replied: "*It will go to the neighbor's plot!*" However, the farmers (played by NP managers) played for individual gain without developing a collective strategy. This is a crucial point, as a lack of collective perspective is a real-life problem often raised by the NP managers. The game enabled NP managers to realize the constraints that prevent farmers from coming up with more collective strategies.

A second interdependency was revealed between NP managers who may have conflicting objectives as beneficiaries of ESs. For example, a farmer (played by NP manager) requested authorization to reopen shrubland to grazing. The NP manager responsible for tourism (played

by a farmer) was in favor: "*In the objective of creating open landscapes, I would like to open a maximum of plots*." However, the NP manager responsible for conservation (played by a farmer) was against: "*I don't know what will happen to the birds if that happens*." These opposing views were illustrated at another point in the game when a farmer (played by an NP manager) said to the NP managers: "*I thought you were a team, speaking in one voice?*" using irony to address the difficulty that NP managers encounter in their day-to-day work and impelled to apply multiple and sometimes contradictory goals.

A third interdependency highlighted by the sessions was the relationship between NP managers (who are both beneficiaries of ES and intermediaries) and farmers (who are producers of ESs). Through the role-playing game, the participants realized how NP managers are dependent on farmers, whose actions have a direct impact on the ecosystem. During one session, a farmer (played by an NP manager) decided to reopen shrubland to grazing, and the NP manager responsible for conservation (played by a farmer) said: "*What is this farmer doing reopening his land? We didn't give him a permit!*" The facilitator indicated that no permit was needed for this practice, making the player realize that he was dependent on farmers to achieve the objective of maintaining the habitat of hen harriers (shrubland), and that he had no regulatory tool to enforce this. Equally, the game illustrated how farmers are also dependent on NP managers. One of the most obvious examples is the financial dependency of farmers on AEMs. During the debriefing, a farmer (played by a ranger) said: "*I would like to thank the park . . . Without AEMs, I wouldn't have been able to cope . . .* " Of course, this player (an NP manager) used double-voiced discourse with the agenda of calling attention to the positive role of the park in the viability of farming activities.

Finally, the sessions highlighted the interdependencies between core stakeholders (NP managers, farmers, and elected officials), and the rest of society, which is a beneficiary of some ESs. Water quality is a good example, because this ES benefits the whole society. In both sessions, it was rapidly apparent that all players were concerned about maintaining water quality. A farmer (played by an NP manager) said, "*OK, I will leave this permanent meadow to protect water quality. That means less hay, but water is a common good!*" When water quality reached an alert level, action was taken until good quality was recovered. However, while water quality was considered a common good and raised the attention of all players, this was not the case for all ESs. Biodiversity, for example, did not engage much interest apart from the NP manager responsible for conservation.

In conclusion, the RPG raised participants' awareness, both of interdependencies that are more visible (such as those between NP managers and farmers) and those that are less obvious or rarely mentioned, for example, with the rest of society. The sessions also fostered increased awareness of the mechanisms underlying these interdependencies and facilitated discussions on their consequences.

3.2. Increased Mutual Understanding

Several authors have identified the positive role of RPGs in increasing mutual understanding, through fostering empathy between participants [37], increasing awareness of others' needs and difficulties [16], and highlighting the need for better communication and collective discussion [38].

Greater mutual understanding between the NP managers and the farmers was a primary objective of SECOLOZ due to the tensions between them and their difficulty in understanding each other's long-term strategy. To encourage this, we recommended that players swap roles: a farmer played the role of a NP manager, and vice versa.

In the analysis of the sessions, we observed three key elements that contributed to mutual understanding: making one's needs understood, experiencing the constraints and challenges of others, and expressing one's own difficulties.

The players wanted their needs to be understood. The game was judged to serve that purpose. In the post-session interviews, players felt that one of the most useful aspects of the RPG was to allow other stakeholders to better understand their constraints, objectives, and strategies. For this, swapping roles was essential: *"The fact that we exchanged roles, especially Park managers playing farmers, can change their point of view*." (a farmer, phone interview).

The sessions also enabled the stakeholders to experience the constraints and challenges of others. Some of the players experienced difficulties reaching their goals, and showed their emotions (embarrassment, stress, shame). As the game was conducted in a playful atmosphere, the players would often make fun of these difficulties. For example, a farmer (played by an NP manager) might struggle to feed his cattle and have to sell some cows. The NP managers (played by farmers) said, laughing: "*You're into the red now . . . you invested too much!*" Sometimes, the humorous tone was dropped in exchanges about the reality of such constraints: an NP manager (played by a farmer) said: "*I don't understand how we are supposed to decide on AEM allocations for one farmer or another?*", and a real-life NP manager answered, "*How do you think it is for us in real situations?*" These moments were turning points in the game. The players realized that the lack of a long-term strategy, for which they reproached each other, was partly due to constraints over which they had little or no control.

Finally, expressing one's difficulties in front of each other led to a new kind of exchange, based on the recognition of doubts and weaknesses. The RPG sessions were viewed as a safe arena, allowing participants to reveal problems and show their emotions, either using the mask of the "role" they were playing through double-voiced discourse, or more directly at the end of the sessions, during the debriefing or in the post-session interviews. For example, in a debriefing, a ranger expressed the inconsistency of certain policies implemented by the park: *"This UNESCO agro-pastoral landscape is linked to human activity . . . but it seems impossible to maintain if there is human activity. It's a paradox."* In post-session interviews, some dairy farmers expressed doubts about the viability of their production model

To conclude, the sessions resulted in increased mutual understanding as they provided a forum for participants to talk about difficulties and share doubts in a secure setting at a distance from everyday tensions. These moments of difficulty created the possibility of making links with real life. The sessions offered a unique opportunity to engage in a collective discussion about a common future.

3.3. Improved Ability to Deal with Uncertainties

Uncertainty is seen as a key issue in the management of ES trade-offs because stakeholders feel that they need a certain level of information to make relevant decisions. We believed that the RPG could open debate on how to manage uncertainty, especially uncertainties linked to cumulative and threshold effects and irreversibility. To provoke these discussions, we included uncertainties in the game: players did not have access to all the information that would allow them to anticipate the effects of their actions.

In the analysis of the sessions, we considered whether social learning could reduce uncertainties in three areas: lack of access to information, knowledge gaps due to the complexity of the systems, and ambiguities due to multiple interpretations by multiple stakeholders.

Lack of access to information refers to situations in which knowledge exists, but due to a lack of communication or organization, stakeholders do not have access to it. For example, in the game, a farmer (played by an NP manager) said: "*If you had come to me and said 'As the Park manager responsible for conservation, I need to ensure habitat for five birds by the end of the year', we could have discussed it. Instead, you just say 'yes' or 'no' to a permit we ask for, but we don't know what your objective is.*" In this example, players did not have the same level of information about biodiversity objectives. This discussion helped players realize that uncertainty here was due to poor communication, preventing concerted management of ES trade-offs.

A knowledge gap refers to a lack of scientific or empirical knowledge, which can be linked to unpredictability, i.e., the non-linear and sometimes chaotic behavior of an ecosystem [42]. For example, a farmer in the game ploughed a meadow near the spring, degrading water quality. During the debriefing, another participant said: "*You made a mistake.*" The farmer answered: "*It wasn't a mistake, I requested a permit and was granted it. I didn't have all the elements to understand that it would be a mistake.*" In this situation, in contrast to the previous example, none of the players were aware of the link between farming practices and water quality. Observing the impacts of their actions in the RPG

enabled them to understand, collectively, water quality dynamics, and thus to reduce uncertainty about this.

Ambiguity refers to "*the simultaneous presence of multiple frames of reference to understand a certain phenomenon*" [43], which leads to "*many possible interpretations of a situation*" [42]. We observed that stakeholders used the RPG to debate ambiguities using double-voiced discourse. For instance, an NP manager (played by a farmer) asked a facilitator what appeared to be a question of clarification: "*Is it necessary to plough to create a permanent meadow?*" Following the facilitator's explanation, he turned to the NP manager (playing a farmer) and said: "*You see! You have to plough! She said it!*" Indeed, in the game, transforming grassland into a meadow (for hay) involves ploughing to create temporary pastureland, which could evolve into a permanent meadow after several rounds. This exchange illustrates a fundamental debate between local stakeholders: after how many years of non-ploughing is it possible to consider that a meadow has become "natural"? In this case, all the stakeholders consider that they have a sufficient level of information, but there are differing points of view on the evidence.

Overall, the game appeared to open discussion about managing uncertainty, establishing the need to identify it, to find methods to reduce it, or to explore ways to accept and deal with it. Better organization and communication of existing information as well as improvement of mutual understanding were two solutions discussed by the participants.

3.4. Greater Willingness to Explore Innovative Methods of Governance

In the first step of the project (the analysis of the context of the Mont Lozère case study), we found that ES trade-offs were managed through permits requested by farmers and granted by the park. We replicated this system in the RPG, both to reveal the negotiations and arrangements within this system and to foster organizational learning. Organizational learning that leads to adapted methods of governance is indeed one of the potential outcomes of a ComMod approach [15]: for example, a ComMod project on spontaneous reforestation in the Cévennes resulted in the implementation of new contracts between farmers, NP managers, and forest owners [44]. We considered whether organizational learning via the RPG could promote exploration of institutional innovations.

The sessions demonstrated that negotiation is central within the permit system, enabling stakeholders to come to agreements and decide on ES trade-offs. The players often made spatial compromises at the scale of their farm, changing the location of their initial project. Sometimes they sought synergies by promoting certain farming practices that could provide several ESs at the same time. For example, one option in the game was to get an AEM to graze on shrubland. A farmer (played by a NP manager) said to an NP manager (played by a farmer): "*I don't have enough space. But if you allow my livestock to graze encroached land, I'm in.*" Therefore, the NP manager granted an AEM that enabled the farmer to graze shrubland. This example illustrates the case of agro-ecology practices as a way to increase synergies between ESs. Financial compensation (with AEMs) was one way to agree on solutions [45].

The RPG allowed the limits of the current permit system to be highlighted and discussed. An important limitation was the lack of a collective perspective. As each farmer negotiated one-on-one with NP managers, decisions were not discussed at a collective level. This meant that players may have come to a compromise at the level of a farm, but rarely at the scale of the landscape. Not taking into account cumulative effects was another consequence of the lack of a collective perspective. For example, the individual practice of rock removal cumulatively has an impact at the landscape level. As an NP manager said: "*In my district, initially rocks were just removed in plots, now they are removed from large fields. When the rocks disappear, it's not the same landscape!*" Discussions such as these revealed the difference between the impact of a practice adopted individually or at a large scale. They also highlighted their importance, since some of these practices are irreversible, so if there are land management errors, they cannot always be undone.

In the debriefing, the players, particularly the NP managers, expressed the need for more concerted management at a landscape scale and with a long-term perspective. The game appeared

to raise awareness of the limits of the current system. This indicates a willingness to explore new methods of governance; however, stakeholders also noted that developing such alternatives would require skills, resources, and time that are currently lacking.

4. Discussion

Drawing from this RPG experience, we briefly discuss two key points that are likely to improve future research programs on ESs: RPGs as tools for exploring ESs, and the role of ESs in social learning.

4.1. The Role-Playing Game, a Tool for the Implementation of the ES Concept?

The ES is a concept that has been widely discussed in scientific literature, but its implementation is still a subject of discussion for both researchers and managers of ecosystems [46–48]. Several authors suggested that the ES concept can be implemented through a participatory process, in which the concept of an ES is a "*boundary object*" because the stakeholders can give different meanings according to their background, and because it can create a common language between stakeholders [25,49].

Our approach was different. Indeed, we used the concept of ESs in the design of the RPG: identifying ESs, their indicators, and the ES trade-offs was an efficient method to design a simplified representation of the social–ecological system. However, during the RPG sessions, we decided not to explicitly evoke the concept of ESs for two reasons. First, in order to facilitate the participants' involvement and to limit the influence of differences in background between players, we tried to use an everyday vocabulary. Second, we wanted to limit the risk that the players have reluctance about the concept, which could bias their behaviors during the RPG session or their attitudes toward the research project. That is why we decided to use the word "objectives" to evoke the ESs modelled in the game: each player having one or several objectives to reach (i.e., one or several ESs to maintain or improve). The indicators of the objectives were quantified or qualified, as shown in Appendix A. The ES framework was useful to design a game that was both playable and credible.

Even if it was not explicit, the ES concept was a determinant in the RPG sessions, especially during the overview of indicators each year and during the final debriefing. During these moments, the facilitator raised awareness regarding the level of each ES. Gradually, the players understood how the board game influenced the provision of ESs and what the ES trade-offs were. They also identified the impact of these trade-offs on players' situations.

Finally, in this work, we did not consider the ES concept as a "*boundary object*" as we did not directly evoke the ES concept with players. However, we highlighted that the RPG can implement the ES concept in the sense that it creates an opportunity to explore and collectively discuss indirectly ES trade-offs. Considering this high potential, the SECOLOZ RPG has been used for pedagogical purposes with students in ecology and agronomy, with the objective to increase awareness of trade-offs between agriculture, tourism, and conservation, and to explore the potential of the RPG as a participatory tool. The repetition of the RPG sessions can also constitute a data base that could be analyzed later from a quantitative perspective [50].

4.2. Role of the ES Concept in the Social Learning Effects

Several experiences used the ES concept in the RPG, considering that this concept can contribute to social learning by three means: illustrating the feedback loop between human actions and nature [29], uncovering divergences in perspectives [24,28,29], and making the social interactions associated with ES explicit [28].

In the SECOLOZ experience, we noticed that the contribution of the ES concept varied according to the type of social learning that we identified. For example, the ES concept was an important driver of the increased awareness of interdependencies. The collective discussion about the overview of the ES indicators each year enabled eliciting four kinds of social interdependencies: (i) between beneficiaries of ESs; (ii) between providers of ESs; (iii) between providers and beneficiaries of ESs; and (iv) between intermediaries, stakeholders, and others. The ES concept also contributed to the

willingness to explore new methods of governance via two means. First, the ES concept helped uncover implicit choices: the overview of the ES indicators was an opportunity to elicit how trade-offs between ESs were managed, and who were the winners and losers of these decisions. Second, the stakeholders could engage in discussion on how the social interdependencies associated with ES trade-offs were managed in the actual system of governance. On the contrary, we noted that the ES concept did not play a strong role in the increased mutual understanding. Indeed, if we compare our results with other experiences assessing effects of RPGs on mutual understanding [18,37,38], we found comparable results, even though the concept of ESs was not used in these studies. Our study revealed that the mutual understanding was made possible using the device of the RPG, which offered: (i) the use of a model (here, the RPG) that put players in a fictive situation and encouraged them to take distance from everyday situations and tension; (ii) the exchange of roles that helped players to better experience the constraints and challenges of others; and (iii) the playful atmosphere that created a secure setting that allows stakeholders to recognize their doubts and weaknesses.

The identification of the contribution of the ES concept to social learning raises the issue of the assessment of the effects of RPGs on social learning on the middle and long term as it has been raised by other researchers [15–17].

5. Conclusions

This study sought to analyze how social learning might help to inform decision-making about ES trade-offs in a case study of a mountain farming ecosystem. Using a co-constructed RPG (SECOLOZ), the sessions showed that this approach was effective in enabling participants to collectively understand ES trade-offs. We identified four types of social learning that contributed to this outcome: the experience increased awareness of social interdependencies, encouraged mutual understanding, improved the ability to deal with uncertainties, and fostered the exploration of innovative methods of governance.

These findings show that exploring ESs through an RPG can be mutually enriching. RPGs can be used as a way to translate the concept of ESs into an operational framework, as it addresses needs such as developing common understanding and making the role of institutions more transparent. An ES framework contributes to social learning by illustrating the feedback loop between human actions and nature, uncovering divergences in social representations, and highlighting social interactions.

However, questions remain that merit further investigation. First, while the ES concept was used to design the RPG and to analyze the outcomes, it was not made explicit to participants during the sessions. In future studies, it would be interesting to expressly focus on the ES concept and discuss it with participants to get their feedback. Second, it was difficult to distinguish whether the social learning effects arose from the inclusion of the ES concept or simply the RPG itself. For example, increasing mutual understanding is a proven outcome of RPG, regardless of the concept explored. Thus, it is difficult to establish the added-value of the ES concept independently from the tool used.

To conclude, employing an RPG to discuss ESs with different stakeholders is promising and offers interesting opportunities to negotiate decisions supported by social learning. Further research could be carried out to investigate its potential further.

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Appendix A. Indicators of the SECOLOZ Role-Playing Game

Table A1. Table of indicators of the SECOLOZ role-playing game

Ecosystem Service		Beneficiaries	Indicator	Drivers of ES	Information on ES Drivers Given to Players?		Visualisation on the Game Board
					Yes	No	
Provisioning ESs	**Production of hay**	Farmers	Unit of hay	• 1 plot of permanent meadows = 2 units of hay • 1 plot of temporary pastureland = 1 unit of hay			Green cubes given to farmers after the harvest
	Production of grass	Farmers	Number of pastured grassland	• 1 suckler cow pastures 1 grassland plot • 2 dairy cows pasture 1 grassland plot			Cow pawns put on the grassland by farmers
	Drinking water	The mayor	Level of water quality (not drinkable/alarm level/drinkable)	Number of temporary meadows around the source: • ≤2: drinkable • 3: alarm level • >3: not drinkable			Score given by the facilitator each year
Cultural ES	**Heritage value of open grasslands**	NP agents responsible for Tourism and Agriculture	Number of plots of open grasslands	Number of plots of open grasslands			Number of squares on the board game
	Heritage value of rocks and tourism satisfaction	NP agent responsible for tourism	Note of tourism satisfaction (. . . /10)	Starting from a note of 10/10: • 0.5 point is removed in case of rock removal • 1 point is removed in case of rock removal around the outcrop (tourist attraction)			Score given by the facilitator each year
	Existence value of biodiversity: whinchat	NP agent responsible for conservation	Number of whinchats observed each year	• 1 whinchat for 2 adjacent plots of permanent meadows			Bird pawns put by the facilitator each year
	Existence value of biodiversity: hen harrier	NP agent responsible for conservation	Number of hen harriers observed each year	• 1 hen harrier for 10 plots of shrubland			Bird pawns put by the facilitator each year

Appendix B. Rules of the SECOLOZ Role-Playing Game

Table A2. The game board.

Type of Plot	Number in the Initial Game Board	Production of Hay or Grass
Permanent meadow	13	1 unit of hay/square
Temporary pastureland	2	2 units of hay/square
Open grassland	30	1 unit of grass/square
Shrubland	43	0 (except with pasture+ option)
Rocks (on grassland or shrubland)	65	/

Table A3. The seven roles.

FARMERS				
Name	**Initial situation**	**Objective**	**Initial level of ES**	**Needed level of ES**
Violet	8 suckler cows • Permanent meadows: 1 • Open grasslands: 6 • Shrubland: 14	Enlarge the herd to 10 cows	Hay: 1 Grass: 6	Hay: 4 Grass: 8
Blue	12 suckler cows • Permanent meadows: 2 • Open grasslands: 10 • Shrubland: 19	Maintain the herd	Hay: 2 Grass: 12	Hay: 6 Grass: 12
Red	4 dairy cows • Permanent meadows: 4 • Open grasslands: 10 • Shrubland: 2	Enlarge the herd to 8 cows	Hay: 4 Grass:2	Hay: 8 Grass: 2
Yellow	8 dairy cows • Temporary pasturelands: 2 • Permanent meadows: 6 • Open grasslands: 4 • Shrubland: 8	Maintain the herd	Hay: 10 Grass:4	Hay: 16 Grass: 4
NP AGENTS				
Name		**Objectives**	**Initial level of ES**	**Needed level of ES**
NP Agent Responsible for Agriculture		• Promote extensive agriculture • Maintain the heritage value of open grasslands	Open grasslands: 30 plots	Open grasslands: 35 plots
NP Agent Responsible for Tourism		• Maintain granite rocks and tourism satisfaction • Maintain the heritage value of open grasslands	• Open grasslands: 30 plots • Tourism satisfaction: 10/10 (65 rocks)	• Open grasslands: 35 plots • Tourism satisfaction: 8/10 (61 rocks)
NP Agent Responsible for Conservation		Conserve the species of birds	Whinchats: 4 Hen harriers: 6	Whinchats: 6 Hen harriers: 4

Table A4. Steps of the role-playing game sessions.

	STEP	EXPLANATION
1	**Previsions of the farmers' actions**	The farmers explain their projects and express their needs for permits and AEM to NP agents
2	**Granting of permits and allocation of AEMs**	The NP managers discussed between themselves and with the farmers to take final decisions
3	**Implementation of farming actions**	Farmers implement actions: • Rock removal, ploughing meadow, re-opening grassland, no-till, pasture+ • Putting cows in pasture • Harvesting hay
4	**Hazards**	Facilitator select randomly a hazard
5	**Feeding livestock**	Farmers feed their livestock They can borrow units of hay if necessary
6	**Selling/buying cows**	Farmers can sell cows if they are too indebted They can buy cows if they want to enlarge their herds.
7	**Natural dynamic of encroachment**	Grasslands which have not been pastured for two consecutive years turn into shrubland
8	**Overview of the game board**	NP agents make an overview of the number of rocks and of each type of plot on the game board
9	**Overview of the ESs indicators**	Facilitator make an overview with players of the level of ES indicators

Table A5. Players' action.

Farmers			
	Action	**Cost**	**Permits**
Rock removal	Remove rock from open grassland or shrubland	2 units of hay/plot	Yes
Ploughing	Plough a permanent meadow or a grassland without rock to obtain a temporary pastureland	Free	
Re-opening a grassland	Transform a shrubland into a grassland (removing shrub)	0.5 unit of hay/plot	No
Let evolve pastureland	Let a temporary pastureland evolve into a permanent meadow	Free	
Pasture+	Adopt more extensive practices (for dairy livestock farmers only)	2 units of hay (initial investment)	
Selling cows	Sell cows in case of significant debt	Dairy: 10 units of hay/2cows Suckler: 6 units of hay/2cows	
Buying cows	Buy cows to enlarge the herd	Dairy: 5 units of hay/2cows Suckler: 3 units of hay/2cows	
NP Agents			
Granting of permits	Allow or forbid the actions requested by farmers		
Attribution of 2 AEMs	AEM 1: "Permanent meadow"	This AEM is attributed to one plot of permanent meadow	3 units of hay
	AEM 2: "Re-opening"	This AEM helps the farmer re-open 2 plots of shrubland	3 units of hay
	AEM 3: "Pasturing on shrubland"	This AEM makes possible the pasturing on 2 plots of shrubland	3 units of hay

Table A6. Hazards.

	Hazards
Drought year	Each farmer loses 2 units of hay
Wet year	Each farmer wins 2 units of hay
Wild boar damages	Each farmer loses 1 unit of hay
UNESCO control	UNESCO controls the level of the heritage landscape value, they can decide to take off the label if the level of ESs is too low

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