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- 1 Climate change and its warning signs (increasing droughts) have stimulated awareness of the risk of radical transformations in vulnerable areas such as alpine pastures under the combined effects of the climate and changes to pastoral practices. Given this context of unprecedented uncertainty, how might an observation system be designed so that it brings together the different actors concerned and fosters collective learning? In this article, we show how the Sentinel Alpine Pastures programme strives to take into account the different requirements. The aim is to build a programme to monitor and understand the processes at stake together with their determining factors and encourage collective learning as part of an adaptive management approach (Pahl-Wostl, 2009). We describe how this programme came into being and how the wish to involve actors led to the design and implementation of field information collection protocols and to methods for capitalizing on the lessons learnt. In the discussion part, we outline thinking about the scientific positioning of the system and the new forms of governance generated by it.

Emergence of the Sentinel Alpine Pastures programme

Alpine pastures: an area of production and exceptional biodiversity threatened by climate crises

- 2 Alpine pastures are highly rich in terms of biodiversity (Körner, 1999) and cultural heritage (Jourdain-Annequin and Duclos, 2006). They simultaneously fulfil economic, social and environmental functions. They allow livestock farmers to find low-cost fodder resources during the summer period, which is often a critical time for valley grazing or Mediterranean areas. When the farmers do not herd their own animals on the alpine pastures, they have more time to focus on other tasks, notably on haymaking operations. Thus, alpine pastures also provide a break in working patterns: farmers who send their animals to be kept by a herdsman up on the alpine pastures are freed of the daily task of tending to them. Alpine pastures are increasingly being managed by collective structures such as pastoral associations. They do not operate as isolated systems. They are the hinge pin of many livestock farming systems in the French Alps and the Provence area: roughly one quarter of herds of cattle and three-quarters of flocks of sheep graze the alpine pastures¹. According to the livestock farmers themselves, the alpine pasture is “an extension and continuity of the farm”.
- 3 Fashioned by centuries of pastoral activities, alpine pastures have undergone multiple transformations. However, the climate crisis caused by the series of repeated droughts in the southern French Alps between 2003 and 2005 (Nettier *et al.*, 2010) had a substantial impact on alpine grazing and worried the officers of the Ecrins National Park. The officers reported changes to pastoral practices with over-grazing in certain areas. They feared that alpine plant life would be deteriorated. The Park therefore took the initiative of organizing a consultation process on alpine pasture management methods. This was debated during a meeting of its Agriculture Commission in November 2005. The discussions led to a consensus: alpine pastures should be recognized at once as an area with shared challenges in terms of the announced consequences of climate change, involving the co-responsibility of livestock farmers and Park staff, and as an ideal place for cooperation-based observation and

intervention (Della-Vedova and Legeard, 2012). This posture forms the basis of the design and implementation of the Ecrins Sentinel Alpine Pastures network launched in 2008/09.

Sentinel Alpine Pastures: an innovative programme for the collective management of climate challenges

- 4 The increasing frequency and intensity of climatic events, notably episodes of drought in the Alps (Calanca, 2007), is a tangible sign of climate change manifestations according to the Intergovernmental Panel on Climate Change (IPCC), which is expecting to see these amplified over the coming decades (IPCC, 2012). In this context, alpine ecosystems appear to be especially vulnerable. The consequences may be a considerable loss of biodiversity and modifications to the landscape caused directly by the climate (Engler *et al.*, 2011) and owing to modifications to practices in response to climate change. The ultimate goal of the Sentinel Alpine Pastures programme is to anticipate the impact of climate events and changes to pastoral practices in order to preserve (or restore) sustainable management of these areas. Our focus is thus on modes of adaptation to different events as part of a long-term approach to the complex dynamics of climate change in an effort to devise anticipation strategies (Nettier *et al.*, 2010).
- 5 In its current phase, the programme is purposefully limited to taking into account climate events that can be anticipated for any given season and which can be shared with livestock farmers and herdsmen. In the field, the programme involves recording several sets of data with the aim of producing knowledge and building up technical references about the intertwining dynamics and processes linked to the climate, the local environments, pastoral practices and livestock farming systems. The idea of taking into account the functional link between the alpine pasture and the farm within the alpine pasture-farm system (Nettier *et al.*, 2013) is one of the original aspects of the programme.
- 6 However, the Sentinel Alpine Pastures programme is not only about collecting data. Its value comes from the collective dynamics it aims to impel.

The need for collective learning

- 7 Climate change is not the only factor of uncertainty facing livestock farmers. The 2014/2015 Common Agricultural Policy (CAP) reform, the increasing costs of animal feed and energy, disturbance caused by the presence of wolves and the employment conditions of alpine pasture herdsmen are affecting the decisions of farmers, who also have their own life projects and aspirations in terms of working conditions and job conceptions.
- 8 Of course, livestock farming systems and their associated practices are generally designed to take unexpected events into account. However, the increasing incidence of such events combined with other factors has created new conditions. Farmers and herdsmen must therefore plan to act in a situation of heightened uncertainty (Lémery *et al.*, 2005; Ancey *et al.*, 2013). This situation has also captured the interest of agricultural advisors, managers of natural areas and researchers. Although existing scientific and agro-environmental models are already frequently and substantially

adapted to tie in with mountain situations, they are out of sync with the new context and the obligation to take on board unparalleled dynamics and changes. This loss of bearings is unsettling from an epistemological point of view: with scientific knowledge no longer benefiting from a defined framework, close collaboration between the actors concerned is more than ever necessary (Callon *et al.*, 2001). The conventional modes of capitalizing on science and providing advice also need to be reviewed. Because they have to do something about the situation, farmers and herdsmen have become producers of knowledge, seeking answers to their questions, notably with regard to their changing environment. They are also now keen to share their perceptions. This need for collective learning in relation to an emerging problem is at the core of the Sentinel Alpine Pastures network design. Indeed, the programme aims to provide a forum for dialogue and sharing.

Implementation of the programme in the Ecrins Park

The monitoring system

- 9 The monitoring system was developed with the help of scientific partners from the Zone-Atelier Alpes². The research subjects are monitored according to different timeframes and different spatial scales using simple, robust and reproducible protocols: meteorological factors are used to characterize the climatic seasons on the alpine pastures and farms; vegetation is considered in terms of its biodiversity and as a pastoral resource; the level of herbaceous biomass available for the animals on the alpine pastures is taken into account and, according to longer timeframes, the evolution of diversity and the specific composition of plants; pastoral management is assessed at the end of the summer grazing period; farmers' and herdsmen's observations and perceptions over the course of the year or season are recorded; and, finally, the link between the alpine pasture and the farm is studied in depth (figure 1).

Figure 1. THE SENTINEL ALPINE PASTURES PROGRAMME

Research subjects (IN **BOLD**) AND INFORMATION COLLECTION **PROTOCOLS** (IN *ITALICS*)

- 10 The ambition is also to be able to perceive warning signals based on the changes noted in the sample of pairs {alpine pasture x farm} making up the network. It is in this sense that the qualifier “sentinel” is used to refer to livestock farming health approaches (sentinel ewe in epidemiology).
- 11 In the Ecrins, the pairs {alpine pasture x farm} were chosen to cover a range of diverse environments, alpine pasture configurations and user farming systems (sheep/cattle, local/transhumant livestock farmers), and according to the keenness of farmers to sign up for the long term and how motivated they are to address the problem of climate change. Previous alpine pasture knowledge was an additional argument: environmental challenges identified by the Park, pastoral assessments performed by specialist services, flora readings along the transect lines set up sometimes as long as twenty years ago to monitor plant dynamics, and research work carried out on specific alpine pastures.

An alpine pasture-farm system approach to assess adaptation possibilities

- 12 Each sentinel alpine pasture undergoes a pastoral assessment (Bonet *et al.*, 2006). This involves studying its configuration to identify the areas and sectors of grazing, the suitability of the plant species, the recommended pasture management and multiple-use requirements (hiking paths, forestry operations, etc.). With each summer grazing season, the herdsman fill in a grazing log book (numbers, dates and grazing circuits), explain their practices on the alpine pasture and make a note of any key seasonal facts. An interview with the herdsman takes place at the end of the season. The aim is to

understand the reasons for their practices, notably in relation to the year's weather conditions and their perception of the pastoral resource.

- 13 Annual interviews with the livestock farmers aim to identify their coping methods in the driest seasons, and to understand how much room for manoeuvre they have in relation to their production systems and objectives. In this way, we are able to back up the “livestock farming system” approach (Dedieu and Ingrand, 2010) with an analysis of the spatial organization of the farming activity, from a more agronomic and geographic point of view, in order to assess the role played by the alpine pasture in the livestock farming system and the contribution of the different areas used (alpine pastures, rangelands, grasslands, hay meadows) to animal feeding and fodder autonomy. One basic approach to work organization aims to identify the influence of this factor on herd (or flock) and area management methods.

Involving actors to produce knowledge

- 14 As part of a participatory research approach, the farmers and herdsmen produce knowledge by performing measurements and sharing their observations and approach to their practices. One of the scientific challenges of this programme is really to compare the “field observations [of the actors]” with “field measurements” to help understand and interpret the different processes at work.
- 15 To take into account the considerable local variations in mountain rainfall, which can only be measured via the network of Météo France weather stations, the alpine huts have been fitted with rain gauges. These are read by the herdsmen during the summer grazing season. Furthermore, the herdsmen note other events in a log book (presence of old snow in the August grazing areas, sudden snow falls during the summer grazing period, etc.). Their observations are notably compared with the measurements of alpine pasture snow clearance dynamics based on satellite data (Bigot *et al.*, 2010).
- 16 The herdsmen's observations concerning grass growing and animal behaviour are compared with plant-related measurements. The LECA alpine ecology laboratory has been able to develop a fast method for estimating the biomass produced based on plant cover height measurements (Lavorel *et al.*, 2008). LECA trains technicians in the field and monitors feedback over the course of the season.
- 17 Studying farmers' and herdsmen's practices (or concrete coping methods) (Landais and Deffontaines, 1988, 1990; Meuret, 2010) is another means of involving them and getting them to participate in the production of knowledge. With their help, we aim to identify the reasons for their practices (Darré and Hubert, 1993). These practices also reflect the way farmers conceive what should be done. In other terms, these practices are social constructs, broadly impregnated with local culture (Darré *et al.*, 2004).

Sharing observations in the field: inspections performed at the end of the summer grazing period

- 18 One of the key tools for monitoring pastoral management is the end-of-summer-grazing-period inspection performed jointly by a pastoral systems specialist, a Park officer and the farmer or herdsman concerned. The inspection is carried out according to a transect repeated every year and crossing the main areas of use. The aim of this inspection is to assess the consumption level of the pastoral resource at the end of the

summer grazing period based on visual indicators and rating tables according to plant types and for different pastoral management methods (Garde, 1996).

- 19 The inspection is thus an ideal opportunity for sharing and assessing the impact of pastoral practices: based on joint observations in the field using simple marking grids that can be applied to most of the environments, the different actors are in a better position to perceive the effects of practices in the medium term and together think about ways to improve these practices if necessary.

Work collectives bringing together different professions

- 20 This cross-disciplinary approach is based on collectives of farmers and herdsmen, agricultural technicians, pastoral systems specialists, researchers (agronomists, ecologists and climatologists) and protected area managers. The protocols were designed and validated by the whole collective and thus take into account everybody's concerns. Knowledge is also exchanged and co-built through meetings at different times and in various places where actors come together. These are less formalized, at least initially. As well as meetings in the field (for biomass measurements, during end-of-grazing-period inspections or meetings with the herdsmen or farmers), actor-researcher working groups analyse the information collected and interpret the relations between weather conditions and vegetation, between vegetation and pastoral practices, and between alpine pasture management and farm management.

Fostering exchange and debate

- 21 The observations and results obtained are collated during an annual day of discussions with the farmers and herdsmen. This day is also used as an opportunity to present an alpine pasture and the farm(s) monitored with the farmers and herdsmen concerned. A theme is chosen collectively for debate. For example, the opportunity to take lambs up to the alpine pasture was debated in one discussion: the production of late lambs sold once they come down from the alpine pasture is already a traditional practice on some sentinel alpine pastures but recent changes (i.e. lambs being taken up) have been identified on other alpine pastures. The discussion focused on the technical conditions required for this type of alpine pasture production, but also on downstream sector strategies, CAP application conditions, and the need for collective local structures (slaughterhouses, cutting rooms, etc.). Thinking was extended to cover the notion of "alpine economy" (selling local products but also land maintenance and an authentic image).

Discussion

The value of "hybrid forums"

- 22 The above illustration of the themes debated during discussion days (i.e. taking lambs up to the alpine pastures) shows how, based on a technical question relating to alpine pasture management methods, thinking is extended and work on a new alpine economy is initiated or public action is called for. This echoes Callon *et al.* (2001) who

underline the value of “hybrid forums” as open spaces where sociotechnical controversies can be developed and raise unexpected questions.

- 23 In relation to the different “translation” phases (Callon *et al.*, 2001), we feel that the sentinel alpine pastures scheme carries with it the concern to involve a large population (farmers, herdsman, technicians, protected area managers, etc.) in the first two phases: they take part in formulating problems and participate in the research collective. The third phase, referred to as the “return to the world at large”, has not yet been reached (since the results and references have not been acquired). This phase raises the question of alliances and the ability of the work collectives set up to interest (in reference to Callon’s notion of *intéressement*) other influential stakeholders. The production of a film describing the programme in 2013 is a step in this direction.

Scientific positioning

- 24 Sentinel Alpine Pastures is a partnership-based action-research scheme that reflects the current movement to promote integrated management of natural resources (Sayer and Campbell, 2002). If transposed and adapted to livestock farming systems (Dedieu and Ingrand, 2010) several of the concepts of this research movement, such as socioecological system flexibility and resilience (Walker *et al.*, 2004), provide an interesting reading for the analysis of how the monitored alpine pastures and farms work and how to address their adaptation possibilities.
- 25 Research operations that are part of this movement are often used with the aim of providing collective guidance with decision-making processes (collectif ComMod, 2005). The scientific productions are thus above all methodologies, with the researcher mainly being there to provide tools and dynamic impetus rather than acting as the leader. With the Sentinel Alpine Pastures programme, the aim is also to produce knowledge about how complex systems work. Co-building with actors is seen as a means of modelling such systems. Another objective is to find methods for coping with uncertainties and managing these collectively (ComMod collective, 2005). The researchers here are full actors of the programme, sharing questions with the other actors and providing their knowledge and tools in exactly the same way.
- 26 In this context where situations of uncertainty have to be managed, the farmers and herdsman engaged in action to cope with unexpected events are producers of knowledge. They therefore play an essential role within the collectives. The collective learning that takes place is based on an analysis of the farmers’ and herdsman’s practices, the way they act and have an impact on the alpine environments and the animals as they interact with events. Such learning could lead to formalized “eco-knowledge” (Moneyron, 2003).

Protected areas: ideal places for such collectives?

- 27 The context of climate change and the increase in climate-related hazards (exogenous causes of alpine pasture and protected natural area management) can thus be seen as a driving force for joint work on the management of these complex and ever-changing areas.
- 28 The November 2005 conclusions of the Ecrins Park Agriculture Commission may appear “revolutionary”. They perhaps reflect local actors’ dismay faced with the announced

consequences of climate change. They are also undoubtedly the fruit of the agricultural partnership and support work that the Park has been carrying out for 40 years (subsidies provided for livestock farming buildings and machinery, the drawing up of reference frameworks with respect to alpine vegetation fodder potential and pastoral assessment methods with the help of the INRA, the Cemagref and the Cerpam, the implementing of an agro-environmental measure in 1994, etc.). They are also part of a process to elicit greater contribution to local area problems from those involved in pastoralism (Legéard, 1998; Caraguel, 2006).

- 29 Yet, these alliances are still fragile and the notions of areas with shared challenges and of co-responsibility promoted in the Ecrins may prove to be tricky – if not dangerous – in other contexts where the partnership between protected area managers and farmers and herdsmen is not as solid, reflecting reciprocal mistrust and even power struggles. This was the case recently in the Vanoise Park where the Commons unanimously refused a draft charter and farmers protested against the presence of wolves in the Maurienne. Similarly in the Mercantour Park, the substantial impact of wolves on alpine livestock farming has led to much tension (Garde, 2013).
- 30 Experience shows, however, that collectives tend to turn to structured “park” type areas when it comes to implementing and managing such schemes. This is because the vision proposed is long term and the project involves scientific monitoring as well as local actors. At the same time, the Sentinel Alpine Pastures scheme is an opportunity for national parks to work on eco-system functionalities, without being limited to the monitoring of heritage species, and to contribute to a long-term socioecological approach (Lavorel *et al.*, 2013).

Map 1. Alpine pastures and farms in the Sentinel Alpine Pastures network

N.B. The blocks of plots and places used by the farms are represented by their centroids. Each farm is represented by a colour.

- 31 Since its beginnings in the Ecrins, the Sentinel Alpine Pastures network has been extended to the Vanoise, Vercors and Chartreuse Parks (map 1). Other similar initiatives are seeing the light of day in the Lubéron and Ventoux areas. This broad spin-off effect reflects the programme's potential for innovation and widespread adoption. The Ecrins example nevertheless underlines the difficulty of learning to share a joint culture and how this requires long-term collaboration. This collaboration was first forged around pastoral techniques before more recently being applied to local area issues.
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NOTES

1. Source: 1996/97 pastoral survey and 2000 agricultural census.
 2. The Zone-Atelier Alpes (*joint dynamics of alpine ecosystems, their use and the climate*) has been accredited by the CNRS as part of the Observation and Experimentation Systems long-term initiative for Research and Development.
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ABSTRACTS

The Ecrins National Park organized a meeting of its Agriculture Commission to discuss repeated droughts and fears arising from the impact of alpine farming practices on high altitude environments. The alpine pasture was pronounced an area of shared challenges in terms of climate change, involving the co-responsibility of livestock farmers and the Park. It was also seen as an ideal area for observation and intervention based on cooperation. The ideas put forward led to the creation of the Sentinel Alpine Pastures programme.

The ultimate aim of this programme is to anticipate the impact of climate events in order to ensure sustainable alpine pasture management. Studying modes of adaptation to events is part of a long-term approach to address the complex dynamics of climate change. We show how this approach, the information collection protocols and the data capitalization methods implemented aim to meet the requirements stemming from this current issue: involvement of all actors (livestock farmers and herdsmen, farming technicians, pastoral systems specialists, researchers and managers of protected areas), collective learning based on shared observations, and integration of an alpine pasture farms system. The programme works as a tool providing help with analysis and decision-making in relation to processes involving the climate, the environment, pastoral practices and livestock farming systems. The work collectives implementing it are also paving the way for new forms of governance in terms of the relations between pastoralism and local area stakeholders.

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Mots-clés: alpine pasture, biodiversity, climate change, pastoral practice, alpine pasture-farm system, adaptive management

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