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Using Foresight to Gain a Local Perspective on the Future of Ecosystem Services in a Mountain Protected Area in Peru

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Ecosystem services in the mountainous Salinas and Aguada Blanca National Reserve in Peru are under pressure, and perspectives on possible solutions depend on the different stakeholders' understanding of these services and their interests in them. We describe the application of the foresight approach to integrate various stakeholders' perspectives on the future of ecosystem services in the reserve. Ultimately, the purpose of this approach is to achieve an inclusive and viable plan for conservation and management of existing resources. The participatory analysis provided local people's perceptions of bofedal *(wetland) and* tolar *(shrubland) ecosystem services, as well as their assessment of likely scenarios for the future. We identified 2 important factors in the hypotheses the local people provided: extreme events such as water scarcity and drought, and participation of the private sector in water distribution. Participants estimated that water storage and fuel for cooking were likely to have the strongest effects on current and future ecosystem services. Based on this, we jointly developed hypotheses using a stepwise approach and used software to calculate probabilities in a systematic way and produce a series of scenarios. The likelihood of these scenarios was also assessed by groups of stakeholders, yielding 5 scenarios for consideration in designing management plans. Future scenarios are highly dependent on proper management of the* bofedal. *We conclude that foresight helps to involve local people better in the process of developing viable strategies for the future of the reserve and for the conservation of the natural resources that it harbors.*

Keywords: *Andes; protected areas; participation; conservation; foresight; ecosystem services; Peru.*

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Introduction

Foresight, often dealt with in futures studies, is playing an increasingly important role in planning processes and studies related to potential future scenarios (Mojica 2010). As an approach, foresight explores individual and institutional opinions in a structured and participatory way and is particularly useful when decisions need to be taken to achieve sustainable development (Medina and Ortegón 2006). Futures studies have been carried out in territorial planning, business development, and public policies. As a result, it has improved strategic planning (MP 2005; Miklos 2007; Godet 2010). Foresight has similarities with scenario planning, but the approaches have different origins: The first was developed for enterprise management and industry, while the second has been used more frequently in social studies and ecological research.

In Peru, futures studies and participatory foresight have achieved recognition from the government and from the scientific community in the last 10 years. For example, the National Institute of Natural Resources of Peru (INRENA 2008) used foresight to describe the use of Peru's natural resources and its ecosystem services until 2030, and the National Center for Strategic Planning (CEPLAN 2014) includes scientific studies about mountain ecosystems in the National Foresight Congress every year.

Scenarios for the future of ecosystem services

Ecosystems provide various services—provisioning, regulatory, supporting, and cultural—that are essential to meet human needs, such as mitigation of flood impacts (Costanza et al 1997; de Groot et al 2002; Millennium Ecosystem Assessment [MA] 2003; Toth et al 2005). However, ecosystems are rarely managed in a sustainable

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way. González et al (2007: 65) noted that "15 of the 24 ecosystem services (62%) are degrading." Moreover, public access to ecosystem services is not equally distributed, with wealthy societies having greater access to, and reliance on, more ecosystem services than less wealthy societies (Coomes et al 2004; González et al 2007).

The MA proposed the development of future scenarios for ecosystem services and their relationships to wellbeing (Cumming et al 2005). Those scenarios would tailor predictions of outcomes to prevailing assumptions about the subjects and drivers of change (Intergovernmental Panel on Climate Change [IPCC] 2013), such as human and environmental factors that directly or indirectly cause ecosystem shifts (Carpenter et al 2006; Nelson et al 2006). The MA defined 4 scenarios for 2050: (1) global orchestration, which "…depicts a worldwide connected society in which global markets are well developed"; (2) order from strength, which "…represents a regionalized and fragmented world concerned with security and protection"; (3) adapting mosaic, which "…depicts a fragmented world resulting from discredited global institutions"; and (4) technogarden, which "…depicts a globally connected world relying strongly on technology and on highly managed and often-engineered ecosystems to deliver needed goods and services" (MA 2005: 225). While these 4 global scenarios are very useful to show the need for action, they do not take into account local and regional specificities. These need to be examined separately, ideally with the people who live in the areas assessed.

Futures studies and protected areas

Protected areas (PAs) are important for the sustainable management of ecosystems (Zamora 2010). However, disregarding the interests and perceptions of local people who live in or near the PAs can lead to conflicts (West et al 2006); therefore, since the 1990s, local residents' roles and voices in conservation have been increasingly taken into account to improve conservation strategies (Berkes 1993; Pimbert and Pretty 1997; Phillips 2003; Brown et al 2004), with the aim of enabling local residents to contribute to shaping conservation and management processes (Kerstan 1995; Carter 1996; Nemarundwe and Richards 2002).

The sustainability of ecosystem services requires consensus between decision-makers and local people. The development of scenarios can promote the creation of a collective vision, generate knowledge, and foster cooperation (Wollenberg et al 2000; Brown et al 2001). At the same time, the perceptions and needs of rural indigenous communities are methodologically difficult to identify, so specific efforts are needed to collect them (Scott 1999).

A form of foresight implemented in the Doñana National Park in Spain (Palomo et al 2011: 1) found that "participatory scenario planning can create different visions of the future of the system addressing its uncertainty and the main ecosystem services trade-offs and can propose consensual management strategies to determine a path toward a desirable future." Participatory scenario projects elsewhere have used methods to assign value to ecosystem goods and services; for example, Raymond et al (2009) revealed that ecosystem values varied from regional to local scales in Australia and contributed multiple management and planning possibilities for conservation. Maltby et al (2013) found out that analyzing scenarios of wetland management and agricultural use using a foresight approach with all stakeholders involved was more likely to alleviate water management conflicts in British PAs. Reed et al (2009) concluded that, in the upland zones of PAs, competing national scenarios of agriculture versus cattle-grazing intensification can emerge from changes in global demands for food and energy and are effectively tackled using participatory scenario methods.

The need for participatory approaches in mountain areas

Foresight studies and other participatory approaches are crucial to understand the uncertainty and complexity of mountain ecosystems. These studies are useful in many ways—for example, for integrated planning and decision-making (that involves local communities) in a context of rapid landscape change at different spatial scales (Castella et al 2005; Peringer et al 2013). In recent years, mountain ecosystems have undergone major structural and functional shifts, partly originating from increased human use and impacts (Soliva et al 2008). For example, in the Andes, the growing populations of major cities rely completely on the services provided by local and regional ecosystems (Mathez-Stiefel et al 2017). High-elevation sites are the world's largest sources of freshwater, and foresight and other participatory methods can contribute substantially to resolving conflicts between stakeholders and developing management alternatives (Paerregaard 2013), as well as incorporating the knowledge of local people in water management (Vera Delgado and Vincent 2013).

Purpose of this study

Considering these insights on the benefits of using participatory approaches for assessing the options that may be available in the future for managing natural resources, this study used a foresight approach for participatory development of scenarios for the use of ecosystem services in the Salinas and Aguada Blanca National Reserve (RNSAB), a mountainous PA in Peru, over the next 20 years. Foresight was used to develop these scenarios jointly with local stakeholders—with a focus on *bofedal* (wetlands) and *tolar* (shrub-dominated) ecosystems, which have undergone substantial degradation—as part of ongoing efforts to update the reserve's management plan

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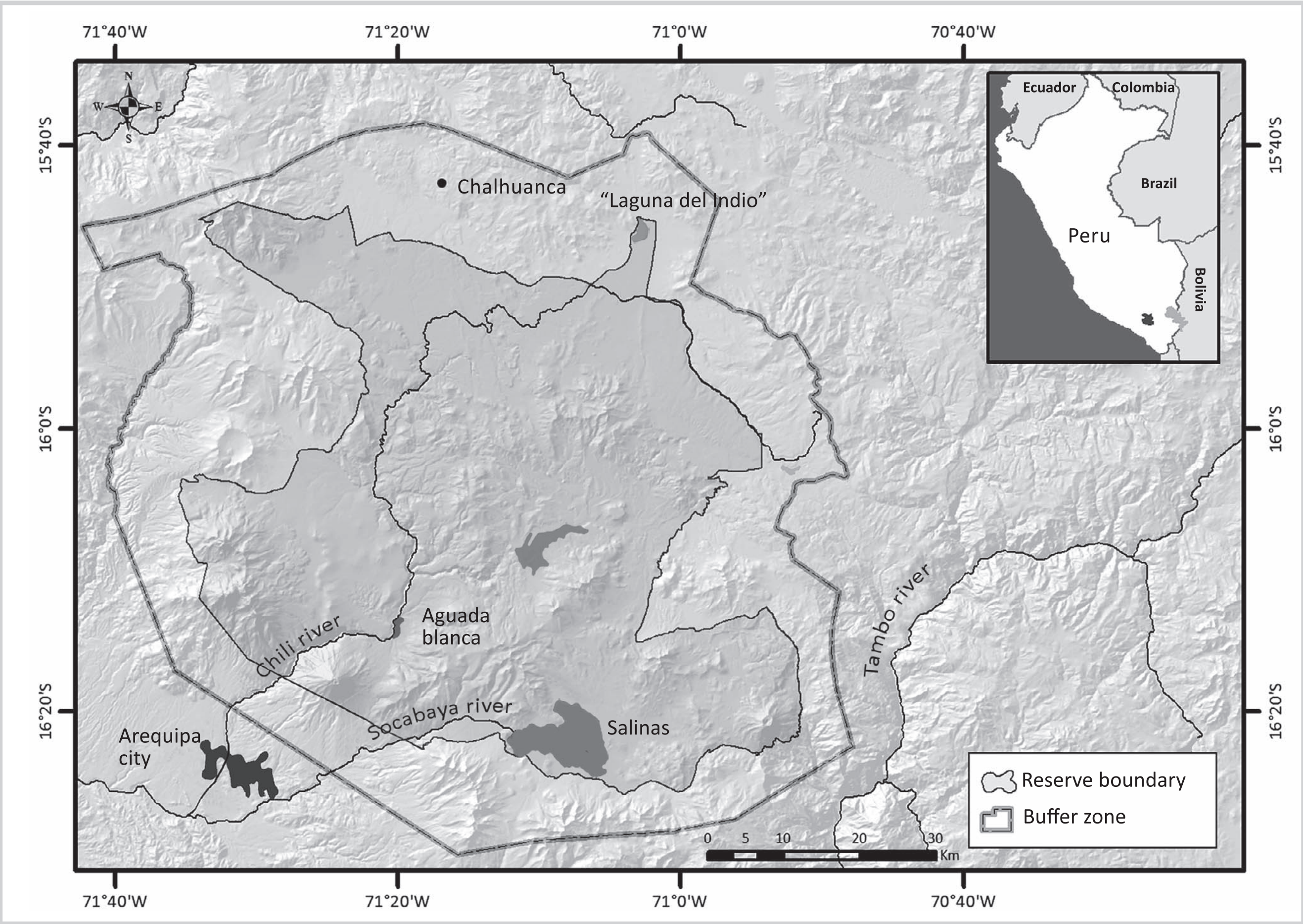
FIGURE 1 Location of the study area. (Map by Fernando Regal)



and resolve conflicts between the local population and external users of the ecosystem services.

Methods

Study area

The RNSAB (15°45′05″S to 16°22′55″S; 71°34′00″W to 70°54′40″W) covers 366,936 ha (Figure 1), with elevations ranging between 3500 and 6075 m above sea level. Average temperature and precipitation vary between 2 and 8°C and 200 and 600 mm annually, respectively. The reserve hosts diverse ecosystems, including desert scrubland (16%), *pajonal* or high-Andean grassland (69%), *tolar* (10%), *bofedal* (2%), *yaretal* (high-Andean low shrubs, 2%), and *queñual* (high-Andean low forest, 1%) (Talavera et al 2010). The RNSAB also harbors more than 20 lakes, most of them seasonal. The most important are Laguna Salinas and Laguna del Indio; they are the largest in the reserve and are permanent.

Human settlements are small and highly dispersed in the central area of the reserve. There are 18 villages in the reserve, totaling >6500 inhabitants and ranging in size up to ~650 inhabitants in Çhalhuanca, and 9 villages in the buffer zone (National Institute of Statistics [INEI] 2007). The main economic activity is alpaca breeding, which provides wool and meat for local sale (Centre for the Study and Promotion of Development [DESCO] 2003). This activity was introduced in the 16th century by the Collaguas (Robinson 2003), the largest ethnic group in the reserve.

The RNSAB was created in 1975 with the goals of halting ecosystem degradation, alleviating poverty among alpaca breeders, and encouraging the sustainable use of natural resources (INRENA 2011), following Peru's national categories (Solano 2009). From its onset, the RNSAB was managed by DESCO, a nongovernmental organization, and regulated by the National Service of Protected Natural Areas (SERNANP).

Substantial progress has been made in integrating local people in the planning of the reserve. For example, local stakeholders participated in the update of the reserve's management plan from 2006 to 2016. However, conflicts about ecosystem services still exist, including the following:

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- Water access—4 dams regulate the flow of the Chili and Yura Rivers, and there is increasing demand for water in Arequipa City, which mostly depends on Laguna del Indio, a 488 ha reservoir built during the Spanish colonial era (Caballero et al 2010). There is conflict between the local population and Arequipa's inhabitants.
- *Bofedal* ecosystem services—These are used to graze livestock (mainly alpaca) but are also important breeding habitats for multiple bird species. The conflict here is between the users of wetlands (farmers) and enterprises that use the land for dam constructions (Machaca, Lizárraga et al 2010).
- *Tolar* ecosystem services—In particular, firewood is used for cooking by >60% of the local rural population (INEI 2007), and for traditional bread making in Arequipa City. The conflict here is due to competition for firewood between both user groups.

The foresight approach

Foresight analysis is carried out in 6 steps (Godet 2007); in this paper, we describe the process that was followed to conduct the first 5 steps:

1. Define the "study system" (ie the focus of the analysis): In our case, this led to *a selection of ecosystems*. We selected the *bofedal* and *tolar* ecosystems (Figure 2) based on their significance according to INRENA (2011) and Ibáñez and La Torre-Cuadros (2017). The *bofedal* was designated a Ramsar Site in 2003. It provides a wealth of ecosystem services that are currently under conflict. The *tolar* is the main source of firewood, a major resource for local communities. The *bofedal* is part of the high-Andean wetlands and characterized by mass growth of *Distichia muscoides*. This plant occurs in basin headwaters and riparian habitats. The *tolar* consists of low shrubs (*Parastrephia*, *Lepidophyllum*, and *Baccharis* spp.) and is typical of the dry mountain *puna*, a high cold dry plateau in the Andes.
2. Jointly analyze the variables in the study system: This led to *identification of ecosystem services*. Using snowball selection, we invited 20 experts to list the ecosystem services that they believed were provided by the *bofedal* and *tolar*. We then applied Smith's salience index to their lists. This index scores the importance of items on a list according to the frequency with which they are mentioned and their average rank when all lists are combined (Smith 1993; Biedenweg and Monroe 2013). These salience index-weighted ecosystem services (19 *bofedal* ecosystem services and 18 *tolar* ecosystem services) were then rated through the pebble distribution method (van Heist et al 2015)—a simple diagnostic scoring procedure that clarifies the priorities of the participants. As a result, we selected 7 of the 19 identified *bofedal* ecosystem services, and 7 of the 18 identified *tolar* ecosystem services for further analyses (Table 1; for further details, see Ibáñez and La Torre-Cuadros 2017).
3. Jointly understand the dynamics of the system and its environment, using *structural analysis*. Structural analysis uses a matrix to identify the most relevant variables of a set of variables based on the relationships between them. In this case, we treated the ecosystem services as variables. The relationships were identified in 10 working groups consisting of 45 local leaders involved in the management of the RNSAB. We selected these leaders given their degree of involvement in the reserve, knowledge of related conflicts, and residency in the reserve.

   Binary (1 = true, 0 = false) relationships between ecosystem services were provided by the local people and entered by one of the researchers in a 7 × 7 data matrix, in which the ecosystem services were displayed in a column and in a row, leaving 49 cells to be filled with the number 1 or 0. By adding the 7 numbers in every column, we obtained scores for *motricity* (ie the intensity with which a variable changes ecosystem services); by adding the 7 numbers in the rows, we obtained scores for *dependence* (the intensity with which a variable is affected by ecosystem services) (Guzmán et al 2005; Popper and Medina 2008). The 7 results in the rows and 7 results in the columns provided 14 numbers, which we added to get a total matrix value. The percentage was then calculated by dividing each of the 14 results by the total matrix value and multiplying it by 100. The maximum number possible for a column or row was 7, which we translated as 100% motricity and dependence, respectively. The 2 services that had the highest motricity—water storage (in the *bofedal*) and fuel for cooking (from the *tolar*)—were selected for building hypotheses.
4. Jointly construct hypotheses for the future using *morphological analysis* and scenarios for the future using *cross-impact systems and matrices*. We formulated hypotheses for the 2 selected ecosystem services (water storage and fuel for cooking) using morphological analysis as modified by Godet (2006) and Toro (2003); morphological analysis helps to organize information in a relevant and useful way for developing hypotheses.

   The hypotheses were developed in 2 workshops—the first with 31 participants (7 from SERNANP, 8 from DESCO, and 16 park rangers), and the second with 45 participants (4 from SERNANP, 6 from DESCO, and 35 local leaders). The local leaders, 23 men and 12 women, were from Chalhuanca village, the most populous community in the reserve. Altogether, 6 hypotheses were chosen as a result of these 2 workshops (Table 2; for details on how to achieve more reliable results regarding probability of hypotheses, see also Porter et al 2004; Loveridge et al 2010).

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FIGURE 2 The *bofedal* (wetland, top) and *tolar* (shrubland, bottom) ecosystems. (Photos by Alexis Ibáñez Blancas)

The *cross-impact systems and matrices* method developed by Godet (1983) was used for creating likely scenarios based on the 6 hypotheses. We implemented it through the Systèmes et Matrices d'Impacts Croisés (SMIC) program PROB-EXPERT version 5.0. This program is based on the analysis of a probability function. This function generates hypothesis-based algorithms and probabilities of combined scenarios

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TABLE 1 Key services provided by *bofedal* and *tolar* ecosystems.

Code	*Bofedal*	Code	*Tolar*
B1	Water for human consumption	T1	Food for livestock
B2	Food for alpacas	T2	Pollination of other plants
B3	Water storage	T3	Control of soil erosion
B4	Counteracting the effect of drought	T4	Aquifer recharge in rainy season
B5	Water for aquaculture production	T5	Fuel for cooking
B6	Water for irrigation	T6	Medicines
B7	Space for recreation and play	T7	Protection of pastures against sudden changes in the weather

(Godet 2007; Coates et al 2010). We used the standard probability score (Godet 1983), along with positive and negative conditional probabilities (Toro 2003). In the latter, the probability of a scenario happening in the future (probability of occurrence of a scenario) is conditional on other scenarios occurring or not occurring. The result of running the program led to 64 scenarios.

5. Conduct joint validation of the scenarios through a *survey*. The scenarios needed to be tested for their likelihood. This is generally done with a panel of experts. We defined this panel as a group of people who had sufficient knowledge to assess the probability of potential scenarios based on their involvement and leadership in, and knowledge of, the use of ecosystem services. We selected a total of 90 experts (the same group who validated the survey in the first round): 65 Chalhuanca leaders (44 men and 21 women), 8 Chalhuanca school teachers (following DESCO's advice), 4 SERNANP members, 6 DESCO members, and 7 RNSAB staff. They were given a survey to assess the likelihood of each scenario; those who were not available on the day of the workshop answered the survey by email.

Ethics

The work was carried out with the authorization of SERNANP, which was under contract with DESCO. The participation of all participants was voluntary; we informed them about the entire set of activities to be undertaken.

Results

Through the comparison and ranking exercises, the local stakeholders in Chalhuanca identified 14 ecosystem services, 7 for *bofedal* and 7 for *tolar* (Table 1). The joint structural analysis showed that 2 ecosystem services—water storage and cooking fuel—scored the highest motricity and dependence for *bofedal* and *tolar* ecosystems, respectively (Figure 3). Consequently, they were used to define 11 hypotheses regarding the future development of these ecosystem services, of which 6 were selected by the participants as reflecting the possible trend of development (Table 2). The combinations of hypotheses led to 64 scenarios, 5 of which were assessed as likely by the workshop participants, adding up to 50% probability

TABLE 2 Final hypotheses.

Hypothesis number	Description
1	Private sector participation in the management of RNSAB's water resources increases in number and in area of dams in response to decreased rainfall.
2	The number of conflicts among irrigation users increases due to water scarcity and drought.
3	Reduction in *bofedal* area triggers increased water demand for Arequipa City and nearby towns, which in turn increases ecosystem impacts (eg on bird and plant diversity).
4	Use of gas as the main fuel for cities and bakeries in Arequipa reduces impacts on *tolar* ecosystem.
5	Decrease in rainfall and increase in the length of drought periods decrease *tolar* extent within RNSAB.
6	Cattle are excluded from *tolar* by fencing, leading to ecosystem conservation.

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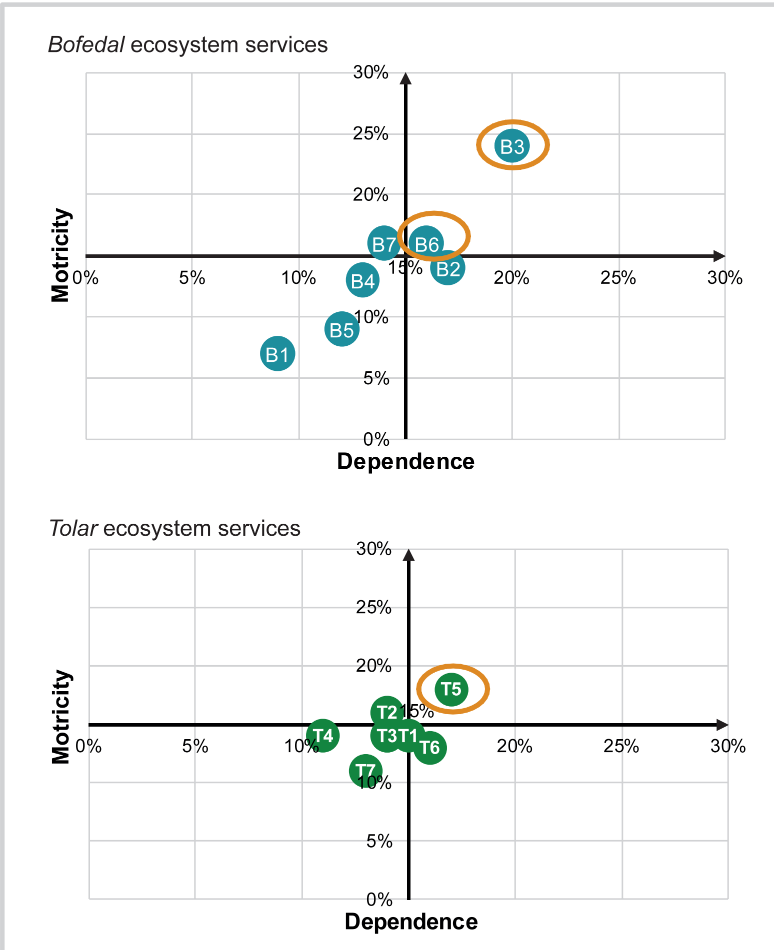
FIGURE 3 Motricity and dependency scores for *bofedal* (B1–B7) and *tolar* (T1–T7) ecosystem services listed in Table 1.



of occurrence together. This was defined as the threshold for further assessing the scenarios.

The 5 scenarios are summarized in Table 3. Four of them (scenarios 1, 2, 5, and 33) predicted conflicts over water and *bofedal* deterioration and can be considered pessimistic. A more optimistic scenario (number 64) focused on biodiversity management. Under this scenario, water management in the *bofedal* is done locally, irrigation conflicts are solved, and the ecosystem persists and continues to support birds and plants. Moreover, the *tolar* ecosystem also persists; in this ecosystem, livestock use is not controlled, and exploitation for energy purposes continues.

Figure 4 shows different participants' views on the likelihood of these scenarios occurring, using the cross-impact systems and matrices program. According to the entire group participating in the assessment (90 persons), the optimistic scenario had a probability of occurrence of 26%; however, for the 3 groups of conservation experts (SERNANP, DESCO, and RNSAB staff), this scenario had a probability of occurrence of only 15%. Scenario 1 (pessimistic) had a probability of occurrence of 15% as rated by the whole group and 10% as assessed by the conservation experts (SERNAMP, DESCO, and RNSAB staff). In both cases, the experts involved in the management of the reserve were generally more pessimistic than the whole group of 90 persons.

Discussion

Future scenarios for ecosystem services

This participatory study anticipated a major role for private management in future ecosystem-service scenarios for the mountain wetlands it investigated (hypothesis 1; see also Palomo et al 2011). Previous efforts to establish communication with stakeholders about water resources had failed. We contend that a strong alliance among users of irrigation infrastructure, as initiated by the foresight process, could promote the sustainability of the reserve and mitigate the effects of water scarcity and drought and their associated uncertainties (see also Peterson et al 2003). The full group of participants (90 persons) who

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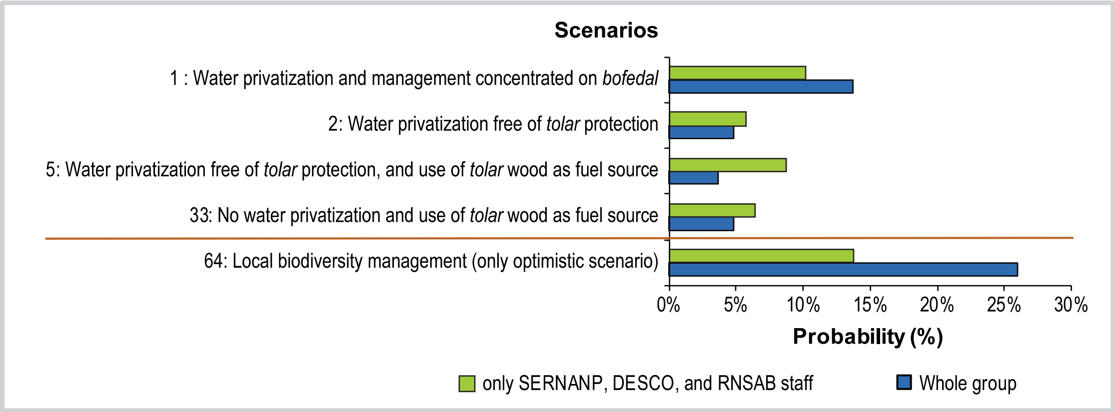
TABLE 3 Scenarios for the year 2030 for the Salinas and Aguada Blanca National Reserve.

Scenario number	Title of scenario	Description of scenario
64	Local biodiversity management	Water-management conflicts are resolved; management occurs at local scales; ecosystems are conserved.
1	Water privatization and management concentrated on *bofedal*	Rainfall shortages and drought persist. Water is privatized. Conflicts between irrigation users grow in number and intensity in response to water shortages. *Bofedal* area is reduced; *tolar* area is reduced by drought. *Tolar* exploitation is reduced as areas are fenced and gas replaces wood as the main fuel.
2	Water privatization free of *tolar* protection	Water is privatized. Conflicts between irrigation users grow in number and intensity in response to water shortages. *Bofedal* area is reduced; *tolar* area is reduced in response to drought. *Tolar* exploitation is reduced as gas replaces wood as the main fuel.
5	Water privatization free of *tolar* protection, and use of *tolar* wood as fuel source	Water is privatized. Conflicts between irrigation users grow in number and intensity in response to water shortages. *Tolar* area is reduced in response to drought. *Tolar* areas are fenced to keep cattle out and control overuse. There are no conditions to stop using *tolar* wood.
33	No water privatization and use of *tolar* wood as fuel source	Water is not privatized. Conflicts between irrigation users grow in number and intensity in response to water shortages. There is a moderate decrease in *tolar* exploitation as gas replaces wood as the main fuel. *Tolar* areas are fenced to keep cattle out.

assessed the likelihood of scenarios showed concern about water conflicts and water availability. The formulation of the hypotheses and ensuing scenarios shows that this is because of the proximity of rural households to Arequipa City. In formulating the hypotheses, they also expressed their hope that the participation of the private sector in scenarios 1, 2, and 5 would be useful, because they believed that the private sector could help to keep water available for human consumption. Discrepancies between the perceptions of the whole group of 90 participants and the perceptions of the smaller group of conservation experts regarding the likelihood of the scenarios indicate that the understanding of ecosystem services is based on direct exploitation at local scales for the former, but on scientific information, often available only at regional or global scales, for the latter (Alessa et al 2003; La Torre-Cuadros and Arnillas 2014).

In the definition of scenario 5, hypothesis 4 was not included because participants said that a change in fuel habits and improvement of bread-making technology were unlikely. If fuelwood continues to be extracted, and no other form of energy is used to replace it, one should expect that the *tolar* ecosystem would eventually disappear. However, participants thought that this was unlikely because of the effectiveness of fencing, included in the definition of the scenario. Indeed, many local residents mentioned that *tolar* ecosystem services can be protected by fencing to prevent livestock access and wood

FIGURE 4 Probability of scenario occurrence as perceived by the whole group consulted and by the group consisting only of conservation experts.



extraction for domestic use or bread baking. Fencing has indeed assisted the recovery of disturbed *tolar* early in the creation of the reserve.

Overall, in the opinion of the participants, steps to improve the RNSAB's current situation by 2030 should include input from external parties (Arequipa's population, the water enterprises, and other water users) into water management and irrigation planning and conflict-solving outcomes, and foresight into ongoing habitat loss for birds and reduction of *tolar* area. Similar conclusions were reached by Maltby et al (2013) for mountainous areas in England.

Predictions for ecosystem services over the next 20 years

Efforts to improve current schemes of water and wetland management in *tolar* and *bofedal* ecosystems could benefit from the Collaguas' ancestral knowledge about water storage and harvest mediated by communal work (Santa Cruz et al 2008; Machaca, Montesinos, et al 2010). Those efforts must take into account that different stakeholders have different priorities. For example, irrigation organizations embolden increased water demands, alpaca breeders want the *bofedal* intact, and the SERNANP focuses on conserving the ecosystems.

In a context of water scarcity, conflicts over irrigation in grazing areas, water allocation to agriculture, and low capacity for negotiating could exacerbate future conflicts in the RNSAB, as illustrated by Gentes (2006) and Isch (2006) for Ecuador. The *tolar* faces multiple impacts from drought and rain scarcity and reduction in area due to the increase of firewood use. Changes in energy sources (eg gas replacing firewood) and transformation of traditional bread ovens to electric ones might diminish those impacts. However, the way in which those factors will play out is unknown, partly because local residents may not worry so much about water and space as such, but more about their economic, cultural, and societal challenges (as found for Australia by Raymond et al 2009). Likewise, studies in similar areas have shown the fragility of mountain pastures (eg on the Manu reserve in Peru in the study by Bustamante and Dantas 2007).

Our foresight analysis indicates that by 2030, water supply is likely to be the main driver of change in *bofedal* ecosystem services (for a global perspective, see Nelson et al 2006). The payments for environmental services approach, under which local actors are paid a stipend for their contribution to the maintenance of ecosystem services (Le Velly and Dutilly 2016), is one attractive option for promoting the conservation of ecosystem services. Loyola (2007) has argued that such an approach should mitigate future conflicts over water usage in Arequipa City. Further, we expect a reduction in the current area of the *bofedal* and in its sheltering function for migratory birds if the magnitude of current irrigation conflicts persists (hypothesis 3). Overall, shifts in ecosystem services could substantially modify the structure and functional dynamics of the reserve.

Main lessons learned

We lack knowledge about the intellectual and cultural codes (see Van Oudenhoven and Haider 2012) by which local people draw connections between different variables. For example, we encountered problems in translating the concept of *influence* into the Quechua language. Differences in the perceptions of future scenarios between experts and stakeholders remain poorly understood (Malinga et al 2013). The foresight method allowed us to incorporate the perceptions and values of the local people in the characterization of the key variables and the ecosystems services of the *tolar* and *bofedal*. These results enriched the vision of the RNSAB management plan; a similar process was described by Palomo et al (2011) for Spain and by Raymond et al (2009) for Australia.

Our analyses have contributed to the definition of management strategies for the RNSAB, accounting for drought and rain scarcity and water use for the 2016–2021 management plan. Wetland reduction, due to drought and rain scarcity, and increasing conflicts among irrigation users are bound to influence the future of the other ecosystem services (Bohensky et al 2006; Martinez-Harms et al 2015) and the conservation strategies of the RNSAB, a situation that would affect its Ramsar Site category.

Finally, we expect this analysis to be replicated elsewhere, since resource investment is low and analytical methods are straightforward to apply, even with indigenous populations having low levels of formal education.

Conclusions

Based on the predominant ecosystem services of the RNSAB's *tolar* and *bofedal* ecosystems, we worked with local actors to construct several management scenarios. Our scenarios predict that *bofedal* and *tolar* services will wane due to external factors (eg regulation of and private participation in water management), conflicts over access to services, and climate-change impacts. *Tolar* ecosystem services are more threatened than those of the *bofedal*. This study demonstrates that foresight analysis can help to incorporate the perceptions of local communities in resource planning and management, with cascading positive effects on biodiversity within reserves and the success of conservation measures. Within such a framework, local residents are given a leading role in managing natural resources (eg water) in a sustainable fashion.

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