

Synthesis of the governance workshop on the South American Locust

Tucumán, Argentina, February 26 and 27, 2020

Clara Therville, John M. Anderies, Hector E. Medina, Rick Overson, Eduardo V. Trumper,
Arianne Cease,

Introduction

As transboundary migratory pests, locusts present a complex societal challenge that requires coupled natural-human systems, interdisciplinary and coordinated approaches. We contribute to the development of such sustainable pathways for locust management within a project led by Arianne Cease and funded by the Foundation for Food and Agriculture Research (FFAR). This project explores connections between land-use practices, governance structures and locust outbreaks, and identifies and addresses barriers to sustainable locust management. The project is based on work conducted across four case studies (Figure 1): the South American locust (*Schistocerca cancellata* Serville, 1838), the desert locust (*Schistocerca gregaria*), the Australian plague locust (*Chortoicetes terminifera*) and the Senegalese grasshopper (*Oedaleus senegalensis*).

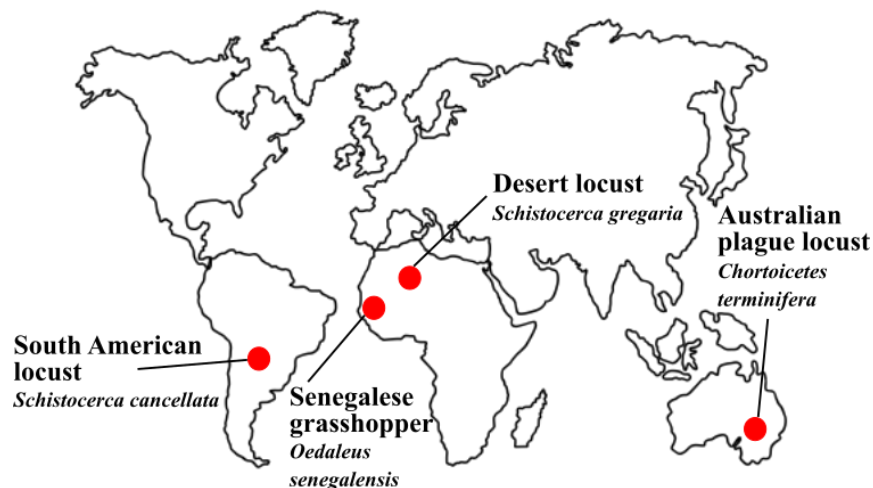


Figure 1: Four case studies included in the FFAR project: the South American locust, the desert locust, the Australian plague locust and the Senegalese grasshopper.

This project is based on a strong collaboration with stakeholders to increase capacity to institutionalize knowledge and integrate research and management by working across regions, sectors, and disciplines. It leverages the Global Locust Initiative Network, which is an international network that strengthens global partnerships and connects stakeholders to increase our worldwide capacity to address locust challenges sustainably.

This workshop supports the second objective of the project that focuses on governance and institutional barriers to sustainable locust management. While ecological conditions are known for largely determining the origin of locust outbreaks, the sustainability of locust management systems can be seriously constrained by social, financial, economic and organizational factors (Lockwood et al. 2001). Locusts represent a governance jigsaw because of i) the spatial expansion of the phenomenon and ii) the intermittent, uncertain and low-frequency of outbreaks. In particular, two challenges reported in the literature can be raised. First, one of the main challenges is the coordination issues raised by locusts, among multiple actors organized at multiple levels, from local to international. According to Berkes (2002), a failure to recognize cross-scale linkages, or 'cross-scale institutional pathologies', is a central reason for some unsuccessful interventions in resource systems. This is also referred to as the archetypal scale challenge of the mismatch when the authority or jurisdiction of the management institution is not coterminous with the problem or the resource (Cash et al. 2006). This is especially true for locusts whose scale of presence is highly variable. Second, many authors have described an organizational 'vicious cycle' linked to the discontinuities induced by locust phase polyphenism, and so to the cyclic nature of locusts outbreaks which is threatening the long-term efficiency of a preventive strategy (Doré and Barbier 2015; Gay et al. 2019; Lecoq 1991): locusts decrease, attention decreases, budget decreases, locust crisis, attention reactivation, budget upgrade... This is particularly true in the case of the desert locust, where this cycle was identified as one of the reasons that explained the 1987–1988 plague. As a consequence, according to Lecoq (2005), ecological research '*is no longer the key limiting factor with respect to plague control*'. Along with other authors (Zhang et al. 2018), he has called for the stronger inclusion of social sciences into the study of locusts, especially regarding stakeholders' strategies and governance issues.

In such conditions, how should an operational governance structure against a transboundary intermittent plague be maintained? How to govern such an unruly nature, govern the ungovernable? A workshop conducted in Tucumán, Argentina, on February 26 and 27, 2020, tackles this challenge and identifies institutional barriers to sustainable management of the South American Locust, or SAL, from the local level to the scale of the southern cone. This species has historically represented the biggest agricultural problem in Argentina from the late 1800s to the first half of the 20th century. After a recession of 60 years during the second half of the 20th century, notable upsurges have been observed since 2015 (Medina et al. 2017). Along with South American partners, and particularly SENASA and INTA, our objectives were to: 1) draw a stakeholder map indicating the institutions currently operating in locust management and research in the case of the SAL; 2) identify the strengths and weaknesses of the existing institutional structure; 3) Describe a long-term vision for the management of the SAL. We paid a particular attention to cross-scale interactions and to the potential expression of a SAL governance cycle.

Methodology

1. Participants

During a day and a half, the workshop brought together 38 participants from 5 countries: Argentina (n = 33), Bolivia (2), Paraguay (1), Uruguay (1) and USA (1). Argentina was particularly well represented, with participants working at the provincial level within ten different provinces (Buenos Aires, Catamarca, Chaco, Cordoba, Jujuy, Salta, La Rioja, Sante Fe, Santiago del Estero, Tucuman) as well as at the national level. Five different types of actors were represented: 16 representatives of the national plant protection organizations (including 14 from SENASA, Argentina; 1 from SENASAG, Bolivia; 1 from SENAVE, Paraguay); 9 from research (7 from INTA, Argentina; 1 from Bolivia; 1 from the USA); 8 from Argentinian provinces, mostly from the ministry of agriculture and the associated agricultural departments at the provincial level; 4 farmers also representing producers associations intervening at the provincial or national levels; 1 from IICA, the Inter-American Institute for Cooperation in Agriculture. The important representation of Argentina, and particularly of SENASA and INTA can be explained both by the historical involvement of these structures in the SAL management, by their involvement in the organization of the workshop and by its geographical implementation. Limited funding did not allow more people from neighbouring countries to participate. Since participants were Spanish-speakers and the organizing team was composed of English-speakers, two translators were hired and helped for an instantaneous translation using earpieces.

2. Methodology

The objective of the workshop was to identify institutional barriers to sustainable locust management in the case of the SAL. We used a participative methodology freely inspired by the 21st Century Town Meeting model (Lukensmeyer and Brigham 2005). This model aims to promote the sharing of diverse points of view and ensure fair and productive dialogue in which individual voices are equal. The workshop dedicated ample time for extensive small-group discussion, balanced by time for large group synthesis and recommendations (Figure 2). Four small groups were composed of 9 persons reflecting the participants' diversity, with one person in charge of facilitating discussions. Participants were invited to discuss three themes: 1) Analysis of the current situation characterized by regular outbreaks of *S. cancellata* since 2015;



Figure 2: Workshop organization, between A) small-group discussions and B) large group synthesis. Photocredit: R. Overson.

2) Characterization of the governance structure through a participative social mapping exercise (Identification of the actors and institutions currently operating in locust management and research in the case of the SAL; reflection on the influence of the identified actors; characterization of the links and of the collaboration between these actors); 3) Identification of the main strengths, opportunities for improvement and threats of this governance structure. The ideas generated during the discussions were written on post-it notes and instantly transmitted to lead facilitators, who identified the strongest themes and reported back just after the discussion had ended. This timely reporting allows for iterative, in-depth discussions. Ideas generated on post-it notes were systematically collected and analyzed using the R-Cran software. Social maps produced by the four groups were discussed collectively during the workshop, and merged in a second time to produce a single social network analysis. Large group discussions were recorded, transcribed and used for a qualitative post-hoc theme analysis. Results presented here mostly come from the workshop, but were completed by a literature review and by interviews with key informants.

Results

1. The current situation

The workshop began by painting the picture of the current situation regarding the management of the SAL. While the species has been almost absent for 60 years in the southern cone, participants were asked to explain the emergence of the current situation characterized by regular outbreaks since 2015 (Medina et al. 2017). The 39 ideas that emerged were grouped into 14 categories, among which 7 are quoted more than once, and 4 more than four times (see Figure 3): climate change (n = 8), lack of long-term and continuous state policies (6), changes in land-uses especially due to changes in the productive matrix (6) and lack of knowledge and information (4).

Two main categories of explanations of the current situation are thus emerging, and were equally quoted by the participants (n = 15): environmental changes that favour locusts outbreaks such as climate change or changing land-uses, and those expressing institutional weaknesses such as the lack of long-term policies. Other explanations were quoted just once,

such as the difficulty to implement control in national parks considered as a haven for the plague, the adaptation of locusts, the lack of transparency or the lack of capacity to give quick responses.

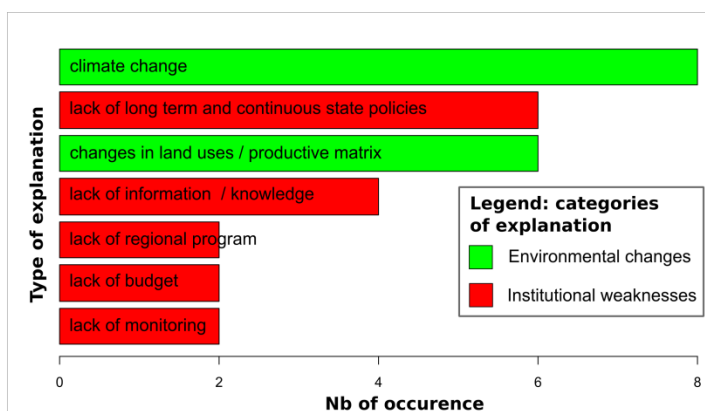


Figure 3: Identification by the participants of the main elements that explain the current situation characterized by regular outbreaks of *S. cancellata*. Only the categories quoted more than twice are represented.

2. The governance structure

In a second stage, participants were asked to characterize the governance structure of the SAL management, and particularly the actors and their interactions.

1. Actors represented in the governance structure

First, the participants were asked to identify the main actors involved in the governance system of the SAL (Figure 4). They also had to specify the corresponding level of governance, either local, provincial, national or international. 73 post-it notes emerged from the small-group discussions, representing 35 different types of actors within which 18 were quoted more than once, in particular: producers associations and cooperatives (n = 6), ministry of agricultural production (5), IICA (4), INTA (4), municipalities (4), SENASA (4) and national universities (4). A few coordination infrastructures were also identified as actors, such as the regional plan for locust management, crisis committees or inter-institutional committees.

The level of action of these 35 actors was determined by the participants: 36% at the national level, 31% at the provincial level, 18% at the local level and 15% at the international level. Certain types of actors intervene at multiple levels, such as the producers associations or the press, acting both at the local, provincial and national levels. Also, one actor, such as SENASA or INTA, can be associated both with the national and with the provincial level because of the presence of decentralized offices.

These actors can also be categorized by the type of role they play in the management of the SAL or by their sectoral interest. The identified actors are particularly interested in research (9 different actors identified), agriculture (7) and plant protection (6). More marginally, the environmental sector, the army or railway were also cited. Interestingly, only one of these actors is specifically dedicated to locusts: the Global Locust Initiative (GLI) at the international level. It should also be noted that actors from other countries than Argentina, especially Bolivia and Paraguay, were only marginally quoted by the participants. This can be explained by their under-representation during the workshop, but also potentially by their only recent involvement in building back capacity to manage locusts since 2017.

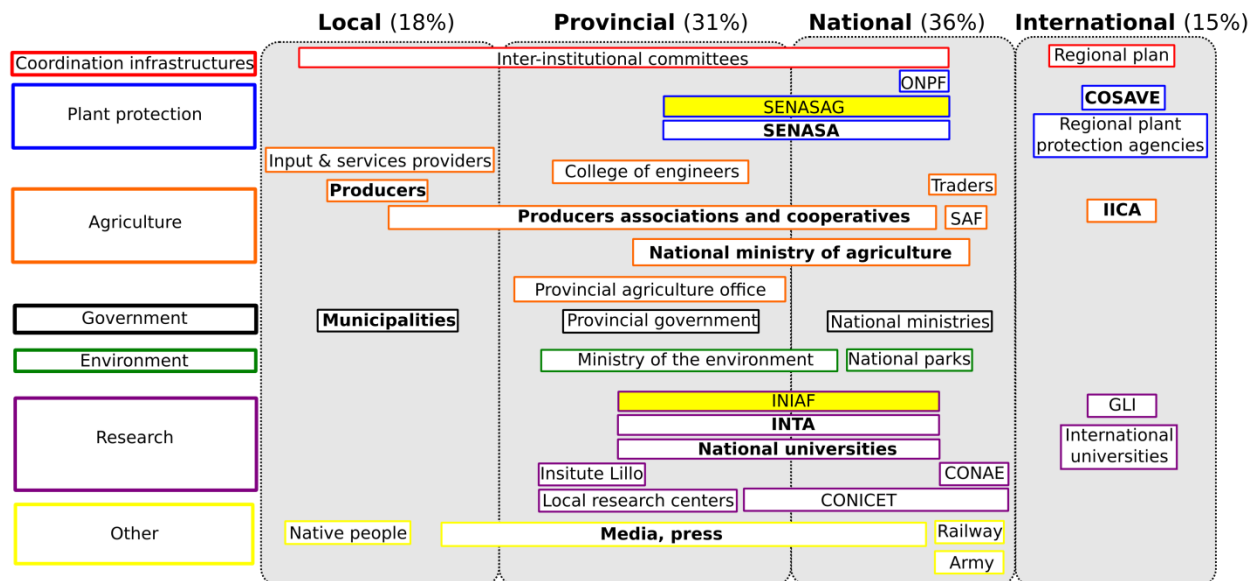


Figure 4: Institutional map representing the actors involved in the governance system of the SAL management. Actors are positioned on the map depending on their level of action and on their main interest, identified in the boxes on the left. The size of these boxes are proportional to the number of actors identified in each category. The percentage of actors identified in each level of action is indicated at the top of the Figure. Actors highlighted in bold are the ones who were more quoted by the participants (3 times or more). Actors highlighted in yellow are from other countries than Argentina, either Bolivia or Paraguay.

2. Influence of the actors

In a second step, participants had to individually identify the actors i) who have an important influence today in the governance system and ii) who should have a stronger influence.

Regarding actors that currently have a strong influence, the participants quoted 107 actors in total, for a mean of 3 actors quoted per participant. These actors were first sorted into 22 categories, and then into 13 among which the most quoted were: Senasa ($n = 25$), the provincial government (17), producers (12), producers associations (11) and research centers (10). Some actors were first cited here while they were not identified in the previous stage, such as people in general (1), SENAVE (1) or the private sector (3). Also, some coordination infrastructures were identified for the first time here such as the national plan for locust control or crisis committees.

For the actors who should have a stronger influence, the participants quoted 66 actors, for a mean of 2 actors quoted per participant. These actors were first sorted in 26 categories, and then in 18 categories among which the more quoted were: research centers ($n = 17$) and INTA in particular (8), producers (13), environmental stakeholders such as the ministry of the environment, national parks or environmentalist associations (8). Again, some actors were first identified here, such as environmental associations (1), legislators (2) or meteorological services (1).

The main actors are represented in Figure 5 in a current influence vs. expected influence matrix. This matrix allows differentiation of actors who, according to the participants, currently play their role effectively (high current influence, low expected influence) such as SENASA or provincial

governments to a lesser extent, from those who should play a greater role and are thus positioned to the left of the 1:1 line. Among these actors, we can differentiate those who already play an important role but could play a greater one such as producers or researchers, and those that are not playing an important role but that should be further integrated into the governance system such as environmental stakeholders.

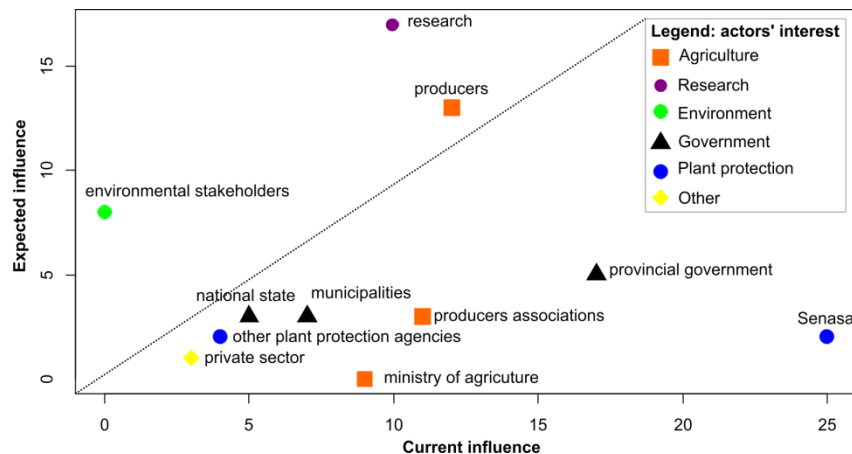
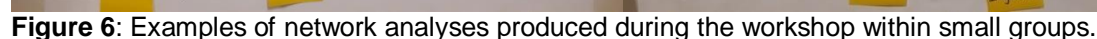


Figure 5: Observed - expected influence matrix for actors involved in the management of the SA locust. Only the actors quoted at least three times either in terms of current or expected influence are represented on the figure. Actors identified to the left of the 1:1 line are those who should play a greater role.

In a third step, participants were asked to characterize the interaction between the actors of the governance system. Each of the small groups participatively drew this social network from a basis of 23 actors and 2 infrastructures (regional plan and crisis committees) selected from the previous exercise and identified on sticky notes. Each small group was allowed to use these actors or not, add others if they found it useful, and move the notes on the board as they wanted to facilitate the network mapping exercise. The characterization of the links was quite free, even if some examples were given by the organizing team before the beginning of the exercise such as: specify if the interaction is uni- or bidirectional, precise if the interaction is strong or weak, or identify the type of interaction (coordination, sharing information, sharing financial or material resources). Each group came up with a map presented afterwards to the whole assembly. These four maps were organized in different ways, either reflecting a radiating or rather circular organization (Figure 6).

The four maps were analyzed a posteriori. The analysis included the identification of i) the actors or infrastructures suppressed or added by the participants; ii) the effective interactions between the actors, iii) the weak interactions. Classical network analyses were implemented such as density of the network, centrality or betweenness played by actors within the network. A particular attention was paid to the commonalities and differences between the four maps, but the results presented here concern a global analysis of the four maps altogether. The governance network resulting from the merger of the 4 small groups maps is represented in Figure 7.



First, we characterized the existing governance network based on the existing and functional edges identified by the participants (Figure 7). For the whole group, 3 actors were added by the participants during the mapping exercise: the ministry of economy and its provincial representative by group 1, and legislative bodies by group 4. Between 24 and 33 interactions were drawn on each map, for a median of 29. A total of 72 different interactions have been identified, among which only 17% have been cited by three groups at least, and only 3 have been cited by the four small groups: between SENASA and i) GLI, ii) other ONPF and iii) producers associations. 61% of the interactions were identified within one group only. This network presents a density of 0.19 and is dominated by a radial structure around SENASA which is part of 32% of the cited interaction, indicated by a high degree of eigenvector centrality and betweenness. It also indicates a central role played by stakeholders able to act at several levels, such as SENASA, producers associations, INTA or crisis committees. According to a post-hoc test after Kruskal-Wallis, actors at the national level play a less significant role in the network than these multiple levels actors ($p.value = 0.005$). The international level seems to be at the margin of the network, its involvement depending almost only on SENASA. Within this merged network, interactions are almost equally vertical (between governance levels), horizontal (within one governance level) or undefined because of involving actors acting at several levels, such as crisis committees or producers associations.

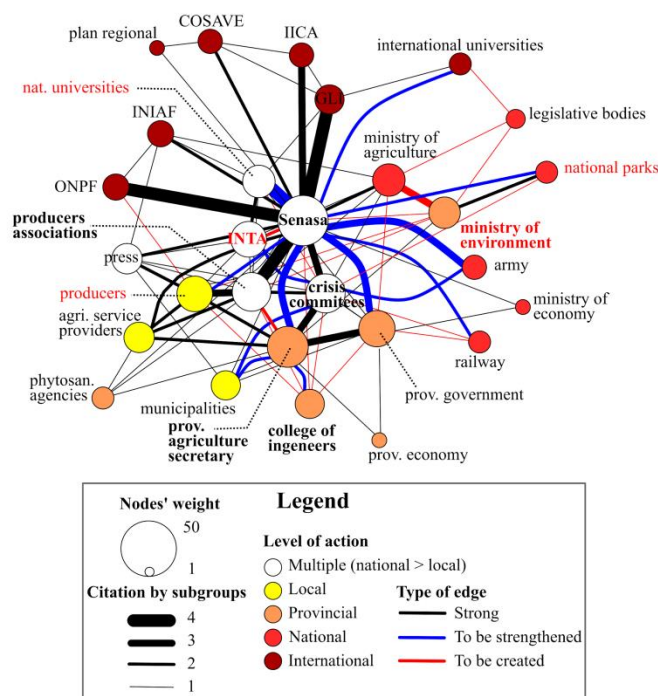


Figure 7: Governance network involved in the management of the SAL. The represented networks are built from the fusion of the 4 small groups networks. The size of the node indicates the summing up of the edge weights of the adjacent edges for each node. The color of the node indicates the level of action of the actors. The size of the edges indicates the number of groups that cited this edge. The color of the edges indicates its strength. Actors highlighted in bold are those that were the more quoted, while actors highlighted in red are those that should have a greater influence.

b) Missing governance network

Secondly, we synthesized the weak edges identified by participants in the governance network (Figure 7). A total of 30 different types of weak edges were identified, between 5 and 11 within each small group for a median of 9,5. 26 edges

were cited only by one group (86%), whereas 4 were cited by 2 groups or more: between ministry of environment and ministry of agriculture (3), between military and SENASA (2), between INTA CONAE and Senasa (2) and between college of engineering and provincial agriculture secretary (2). Senasa is part of more than 30% of the 30 identified missing edges (cited 11 times), followed by crisis committees (6), colegio de ingenioes (5), ministry of environment (5) and producers (4). Within the merged network, interactions are mostly equally vertical (12) or undefined (11), whereas horizontal edges – between actors at the same hierarchical level - are less represented (7). This missing network presents a density of 0.08 and is organized, as the governance network, around SENASA and crisis committees. This missing network highlights the importance of inter-ministerial coordination, especially between agriculture and environment, as well as the need to reinforce the involvement of national actors such as railway, army or legislative bodies into the governance system.

3. Strengths, weaknesses and challenges

Lastly, the participants were asked to identify in small-groups the main i) strengths, ii) opportunities for improvement and iii) threats for the SAL long-term management. Therresults are presentedbelow.

1. Strengths

24 ideas emerged from the small group discussions focusing mostly on coordination, infrastructure production, accumulated knowledge and people commitment. The main strength cited is the 'inter-institutional work' between 'committed institutions' that has been done (n = 4),

especially under the 'leadership and coordination of SENASA'. One participant mentioned the importance of the coordination within 'the governance triangle composed by SENASA, provincial governments and producers'. This strength is supported by the reinforcement of coordination infrastructures such as the 'regional plan' for the SAL management at the international scale, the 'national locust program' at the Argentinian scale and the 'continuity of crisis committees'. It is also strongly supported by an improved ability to communicate and share information, especially with the use of communication media such as cell phone applications. Infrastructures supporting the control and the management of the pest on the field were also mentioned, especially the 'monitoring system' used for detection of locusts on the field, and the 'pest management protocol'. Consequently, more and more 'knowledge' and 'expertise' have been accumulated: knowledge of the plagues and of the territory, but also competencies of the committees and of the staff on the field thanks to training sessions. 'Human resources', their skills and their commitment is a great strength in the fight against locusts. The 'involvement of international organization' has also been of great help to ensure this knowledge production. All of these elements contributed to the 'recognition of the locust problem', the 'budget and infrastructure organization' and to the definition of 'assumed commitments'.

2. Opportunities for improvement

31 ideas emerged from the small group discussions, mainly focusing on financial and research needs, coordination and communication, and the strengthening of infrastructures. The main opportunity for improvement cited is the need for a 'higher budget' (n = 6) in a context where funding is described as 'scarce'. According to one of the groups, an opportunity could be to use green funds in order to develop alternative control methods. The participants also highlighted the needs in terms of research (5), either at the regional and national scale or through the elaboration of international research projects. They insisted on applied research, especially on the biology and control of locusts. A third issue is to 'improve governance' (5), particularly the involvement and participation of the private sector including producers, of research centers such as INTA or of other agencies such as environmental stakeholders. In relation to coordination and governance, participants insisted on the lack of information dissemination (4), and thus on the need to ameliorate information processing and communication among actors, for example through a proper information management system. Even if the development of infrastructures was mentioned as strength, it was also identified as an opportunity for improvement (3), especially regarding the regional plan or the need for a strategic and collective plan design. In the same vein, participants are calling upon the development of shared work methodologies and protocols, new control methods, the use of technology and a collective work on legislation, especially on environmental restrictions.

3. Challenges

Last, the participants identified 21 ideas regarding future challenges. The first one mentioned is the 'lack of resources' (5), especially funding, and the bureaucracy related to their acquisition. This is also associated with the lack of a strong state policy (3), its unenforceability and a weak judicial system (2), and its discontinuity through time. This discontinuity is in part related to the cycle of the plague (3): in particular, recession times induce a loss of interest, coordination and

memory. It thus threatens the possibility to maintain long-term actions. Also, the participants were sensitive to the remaining challenge in terms of coordination, relationships and understanding between actors (3), in particular with environmental stakeholders (3) and an expected increasing pressure from the society regarding the consideration of the environment. Last, the participants mentioned the possible further geographical expansion of locusts as a possible threat (2), or the emergence of other pests that could lead to a plant health emergency.

Discussion

Inputs and limits of a participative methodology

This workshop represented a great occasion to gather people involved in the management of the SAL while questioning governance issues which was not an usual exercise for the participants. Reflection about governance was qualified as a 'new issue', and the workshop was qualified as very 'positive' and 'productive'. It helped formalize thinking about relationships between many actors, governance and rules. According to one of the participant:

"The workshop gave us the opportunity to think about something that we live every day, which is the relationships between stakeholders. That has to be a solution for a given problem. The more complex the problem, the more stakeholders involved, the more complex are the relationships. We live that everyday but we never think about that. We never formalize that."

It also highlighted the need to reflect on responsibility distribution across several governance levels which appeared as a delicate exercise: *"What is clear is that each of us has a role to play. Until we don't have a clear role, a governance structure that shows us who has to do what, it will be complicated. We need to think about what our role is (...) No matter who the minister is, the minister may change, but the task is clear and it brings stability."*

The workshop highlighted some commonalities between the participants points of view. For example, the social network analysis helped to identify the central role played by SENASA or crisis committees, or at the contrary, the need for stronger relationships with environmental stakeholders. It also revealed important discrepancies since most of the identified edges were cited only once, with a high variability among small-groups in the presented networks. However, we can consider that an analysis conducted on the merged elements produced in small groups is a way to tackle the representation of the governance system at the whole group scale.

If the workshop was for sure a place for learning and sharing, it also presented some limitations. For the organizers, the first one would be the under-representation of the international level, especially of Bolivia and Paraguay representatives. While many participants insisted on the fact that *'the fight against the plague must be regional and with greater integration'*, the whole exercise is clearly weakened by an under-representation of this international level. For the participants, some frustration emerged from the lack of time to conduct such discussions: *'We find it hard to do this in a short time because we all contributed with our own point of view, so there would be discussion'*. This is especially true considering the spatial expansion of the locust problem and the differences in interactions depending on the considered locations, for

example between different provinces or countries. Last, some of the participants would have liked spending more time in training and learning from the governance experts.

The SAL as an archetypal example of a vicious cycle?

Results from the workshop confirmed the presence of a ‘vicious cycle’ evoked in introduction and that has been described in the case of the desert locust. Participants strongly insisted on the lack of long-term strong state policies. This discontinuity through time was associated with the cycle of the plague: recession times induce a loss of interest, coordination and memory. The specificity here is the extremely long period of almost 60 years that separates the two last plagues. And indeed, for years and before 2015, the management of the SAL was described as a successful example of implementation of a long-term and efficient preventive control strategy (Hunter and Cosenzo 1990; Medina et al. 2017; Zhang et al. 2018).

The resurgence of the plagues in 2015 can be explained both by environmental changes and institutional weaknesses identified by the participants, thus corroborating the analysis produced by Medina et al. (2017). On one hand, a climatic favourability, referred to as ‘climate change’ by the participants, had three main consequences: an increasing locust growth rate, a third generation leading to an exponential population growth and an expansion of the suitable reproduction sites. This process was favoured by landscape changes induced by modifications in the productive matrix. The most clear change was the expansion of the “agriculture frontier” in Argentina (meaning more and more Monte and specially Chaco woodland being cleared and replaced by agricultural crops). On the other hand, the adopted preventive strategy presented two main weaknesses. First, the monitoring was restricted to Catamarca and La Rioja provinces, *‘but was minimal elsewhere because the locust populations had diminished’* (Medina et al. 2017). While the knowledge of locusts’ dynamics was enhanced at the scale of these provinces, it has been reduced at a larger scale thus enhancing the vulnerability to potential resurgences. Second, this strategy requires a continued diligence and is sensitive to variations in available human and financial means. Red flags were already raised in 1990 by Hunter and Cosenzo: *‘continued diligence is required, however, because in 1988, when no band control was undertaken because of budget restraints, an unusually large and expensive campaign against adults was required’*. According to one of the participants: *“Another big issue is the lack of federal resources and the lack of continuous work when the plague is not seen”*. Without any outbreaks for years, we can speculate that infrastructures and capital that were accumulated in the 1950s, either human, social, financial or material, slowly decreased. In particular, the reduction of experienced field scouts or locusts experts retiring with a low transmission of knowledge was observed here as it was in the case of the desert locust (Roy 2001). As a consequence, when the upsurge emerged in 2015, the combination of both environmental changes and institutional weaknesses led to a situation where the area requiring monitoring and control was *‘too large to be covered by the available scouting personnel’*, and where available human means were insufficient regarding the rapidity of the required response: *‘When the first swarm was found in July 2015, Argentina relied on a handful of the most experienced field officers from Catamarca and La Rioja provinces to train newer colleagues. As such, in Argentina the response was limited in its efficacy because of the time necessary to train individuals and the reactive nature of the response’* (Medina et al. 2017). The loss of memory and capacities

also impacted research and practical ways of implementing control: *'There were no locust experts, we didn't know what chemicals to use, how we should use them...'*.

Reorganizing SAL management in a crisis situation

As a consequence, when the workshop was held, actors involved in the SAL control were swept away in a crisis situation, trapped in reactive responses, with a limited capital that they had to rebuild along the way. Because of the extremely long period without any major crisis but with slow and hardly noticeable changes, the needed reorganization concerned several aspects: updating the knowledge regarding locusts and their dynamic, the methods of control and the concerned actors that may have changed in 60 years.

Results from the workshop indicate that the participants feel that they are at a halfway point in this reconstruction. In particular, what was referred to as the 'governance triangle' composed of SENASA, provinces and producers have been strongly reinforced in the last 5 years: *"Without the work of the producers and SENASA in conjunction with the provinces, efficiency would have been very poor"*. Participants indicate that they have been able to 'create personal empathy', to 'work efficiently', to learn, complement and trust one another: *'We have seen a great evolution, we've learned a lot along the way'*. However, all of the participants are not so unanimous regarding trust and good relationships, and one of them indicated the 'lack of transparency' as a potential threat: *'Sometimes, we're not told what is actually happening. Where is democracy? It's a big issue and it's also linked to governance'*.

This observed improvement mostly relies on personal commitment and *'good interpersonal relationships'*, raising the question of its continuity through time: *'It is important to achieve continuity and strengthen it (...) we have good international relationships (...) we should also build interpersonal relationships (...) My fear is that during recession times, we might lose some of these relationships. We need to think about a permanent system in recession times.'* This raises the question of the institutionalization of these interactions, so they are not only informal, based on interpersonal interactions, and more robust to changes of particular individuals in the network. According to one of the participants, *'we need more institutionalization'* which involves a longer process however. This is particularly true when difficult decisions have to be made in a short time within a complex governance structure: *'we need an early warning system, but governance, as discussed here, is a complex system with so many stakeholders. At some point in time, someone has to take a decision, to take action. (...) we need to work on this and be the owners of this process'*. This institutionalization process is ongoing: it is organized around key coordination infrastructures such as emergency protocols and crisis committees that are already well represented, or the regional plan for the SAL management which seems to be more on the track than fully effective at the moment of the study.

Another challenge resides in the reconstruction of knowledge and individual capacities, thus requiring both research and training of field scouts. In particular, the call for research was clearly made during the workshop to strengthen an early system alert despite the lack of resources to properly work: *we need more scientific work in the country, we need more resources for scientists (...) we need an early alert system that really works'*. Indeed, the present forecasting system assisting in anticipating upsurges, swarm dispersion, etc., albeit implemented, could be improved based on field scouting, meteorological monitoring or ecological modelling.

Thinking of a two stages governance structure

As evocated earlier, the observed situation during the workshop corresponds to a crisis situation, when the objective would be to *'get out of this situation, do early control to avoid peaks'*.

For one of the participants, *'the key to work with locusts in the long term is to go back to preventive management, and it is based on early monitoring and control so we don't have another crisis (...) We need preventive management, not reactive and palliative'*. Indeed, governance changes in time of crisis. Actors, infrastructures, interactions, scales and timings are not the same, as illustrated below:

"Some agencies such as INTA, universities, CONICET, scientific organizations and SENASA have to work on this issue continuously, they shouldn't interrupt that work. The ecology of the pest must be well known to be able to prepare for the future. And there are other actors in this chain who should work specifically when there is an outbreak: farmers, farmers associations, crisis committees, provincial agencies. They have to act directly when there is a problem, and other organizations especially research organizations should be working on this issue continuously."

So one of the main issues tackled during the workshop was to identify who should be in the governance structure during crisis and between crisis. Some actors are specifically mobilized in a time of crisis, such as the army in the case of Bolivia for occasionally providing material so not all costs are borne by a single community. The same observation can be made for some coordination infrastructures such as crisis committees that create an arena for discussion during crisis but that wouldn't even exist during recession times. However, even with these punctually involved actors and infrastructures, responsibility, roles and interactions should be anticipated, clarified and maintained during recession times so they effectively work when a crisis emerges. On the contrary, some actors should be permanently involved into the system. In particular, the participants mentioned research and provinces: *'Managing the crisis may be difficult but it is easier when you are in a crisis. But you have to identify the stakeholders who we should work with using a permanent, continuous communication, inside provinces and between provinces'*. As a consequence, one of the limits of the social mapping exercise was to unclearly separate situations of crisis from situations of recession, and participants recognized that *'we should separate if possible, a crisis from continuous surveillance'*. A complementary work to do would be to draw two maps, in time of crisis and in time of recession, and identify the processes allowing to switch from one to the other.

In terms of interactions between actors and with locusts, monitoring, communication and information sharing to maintain awareness and continuity are key and were mentioned several times: *'provincial agencies working in the territory have to keep this awareness'*. In this sense, discussions emerged among the participants regarding tools such as cell phone apps. Indeed, information flows have also to be anticipated and facilitated through shared procedures and tools. A participant wonders: *'Wouldn't it be best to have those cycles defined in advance, in that part of the cycle, who should receive information, who should send information, I'm asking because when there is a crisis, everybody gets frightened (...) So information flow faces issues'*. A remaining challenge relies in the harmonization of the tools used across space, to avoid loss of information or disruption in information flows, which is key for an effective preventive strategy as well as for rapid responses in emergency situations:

'Sharing information not only in Argentina but also in Paraguay and Bolivia. We are starting to share information, for example regarding monitoring procedures and techniques. Nonetheless, we still have to standardize and harmonize monitoring criteria. So that's part of that flow of information, the information is on WhatsApp but other agencies don't have access to that information. These agencies (...) need a database to be able to work on it'

Dealing with the spatial mismatch

In the reorganization of the system, one of the main challenges will be to deal with a variety of governance levels concerned about locusts, from local to international. This is extremely challenging, in particular in a context of emergency where reactivity is needed and with such a high spatial uncertainty where you don't know where locusts will be tomorrow, so you don't know with whom you will have to collaborate. Also, the strategy may vary through spatial units since the relations with the different actors involved in the network differs depending on the province or the country, as suggested by one of the small groups when commenting on the mapping exercise: *'we have dotted lines in some cases, joining producers and ONPFs (Organización Nacional de Protección Fitosanitaria: SENASA, SENASAG, SENAVE in Argentina, Bolivia and Paraguay, respectively), and depending on the country, on the scenario, it may be thinner'*.

At the local level, the issue is to implement long-term monitoring and be able to control locusts in diverse contexts, thus questioning the role played by actors present on the field or involved in land-use access such as producers, municipalities or national parks. Indeed, since the last plague in the 1950s, these actors as well as their roles have evolved: more land is in the hands of ranchers or agricultural producers, environmental awareness has raised and participative decision-making is promoted. These actors who were probably poorly involved in locust management before, now need to be fully integrated. One of the consequences is the explosion of the number of people with whom actors involved in locust control have to work with, in particular producers and municipalities. For example, *'some producers are very involved and informed, but others really lack a lot of information. And those producers are the ones who go against our work, at the time of working, at the time of fighting pests. That's why we have to focus on those producers who do not understand how the pest should be managed and everyone has to be informed whether their fields are affected or not. And some farmers sometimes say locusts are not affecting their land, so they don't care'*. The role of producers was emphasized as rulers on their land but also as a potential allies in the fight against locusts, which was referred to as 'private-public partnerships': *'we realized that the producers should be involved and control locusts in their fields. Agencies should be present in areas where there are less producers or on state lands'*. However, changing this role also implies to care about the available means producers have to ensure it, and on the solidarities that can be strengthened: *"The role of the federal government is also of great importance as it is a public pest that small producers find difficult to combat due to lack of means"*.

Another major change is the raising of environmental concerns, supported for example by environmental groups, municipalities or national parks. For example, *'some municipalities have standards and say that we cannot use pesticides'*, it was a *'challenge to control in a touristic area [where] an environmental group did not understand the issue (...) It took us 10 days to get the green lights to conduct the control (...) We have to meet all the stakeholders and work with*

them, but environmental groups are the key'. Mostly, the environmental sector was presented as an hindrance to the implementation of control. Participants called here for top-down approach and legislative help to support pest management, especially through the inclusion of the ministry of environment and through a better inter-ministerial coordination with the ministry of agriculture: *'Regarding the legislative aspect, I will add that we should be authorized to act in provincial and national parks. (...) We have huge national parks of thousands of hectares and they're just across the swarms of locusts'*. Other examples across the world, in Australia in particular, rather tried to promote exemplarity in locust control by developing the use of biopesticides and being proactive and anticipative towards environmental regulations and environmental stakeholders interests.

Last, even if the international level was poorly represented during the workshop, issues of harmonization and coordination between Argentina, Bolivia and Paraguay were mentioned. Argentina was presented as the regional expert, a model *'that worked the best in the region and that needs to be shared with Bolivia and Paraguay'*, especially regarding its experience in private-public partnerships. However, this *'slow going of regional coordination'* encounters *'obstacles coming from institutional instabilities stemming from administrative and/or political reasons'*, such as switching people in administrations. Participants mentioned the need to move on from *'blaming one another'* to *'put the three countries together'*, in particular through the regional plan.

Conclusion

After 60 years of silence, actors involved in the management of the SAL are in the middle of a storm, reorganizing a system that slowly disintegrated for political disturbances and lack of signal from locusts during years. The short-term issue is to re-accumulate the necessary capital and adapt the needed knowledge and network to the new context of the 21st century to be able to get out of the crisis. A major challenge here is to face the spatial uncertainty induced by locusts' dynamic, to promote coordination among multiple governance levels with their own history, interests and constraints, and to manage the tension between the need for fast reactive responses and long term processes involved in building trust and coordinating infrastructures between actors. A medium-term challenge would be to strengthen this emerging governance structure by institutionalizing it. And a long-term challenge is the one faced all over the world by all locust management systems, which is being able to get out of the vicious cycle and maintain a long-term efficient preventive system, despite the reduced frequency of locusts outbreaks, and despite major societal or political changes such as wars or insecurity, which is actually going on in Africa with the desert locust.

Acknowledgements

This study was realized through a FFAR funding and was part of the GLI. The authors are particularly grateful to SENASA and INTA, and Hector E. Medina and Eduardo V. Trumper in particular, for their invaluable assistance in the organization of this workshop. We are also grateful to all the participants and to the two translators who facilitated discussions among Spanish and English-speakers.

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List of acronym

CONAE: Comisión Nacional de Actividades Espaciales; National Commission on Space Activities

CONICET: Consejo Nacional de Investigaciones Científicas y Técnicas; National Scientific and Technical Research Council

COSAVE: Comité Regional de Sanidad Vegetal del Cono Sur; Southern Cone Regional Plant Health Committee

EEAOC: Estación Experimental Agroindustrial Obispo Colombres; Obispo Colombres Agroindustrial Experimental Station

FFAR: Foundation for Food and Agriculture Research

GLI: Global Locust Initiative

IICA: Instituto Interamericano de Cooperación para la Agricultura; Inter-American Institute for Agricultural Cooperation

INIAF: Instituto Nacional de Innovación Agropecuaria y Forestal; National Institute for Agricultural and Forestry Innovation, Bolivia

INTA: Instituto Nacional de Tecnología Agropecuaria; National Agricultural Technology Institute, Argentina

ONPF: Organización Nacional de Protección Fitosanitaria; National Plant Protection Organization

SAF: Subsecretaría de Agricultura Familiar; Under secretary for Familial Agriculture, Argentina

SAL: South American Locust

SENASA: Servicio Nacional de Sanidad y Calidad Agroalimentaria; Argentinian National Food Safety and Quality Service

SENASAG: Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria; Bolivian National Agricultural Health and Food Safety Service

SENAVE: Servicio Nacional de Calidad y Sanidad Vegetal y de Semillas; Paraguayan National Food Safety and Quality Service