Bioleft: A collaborative, open source seed breeding initiative for sustainable agriculture

Anabel Marin, Patrick van Zwanenberg and Almendra Cremaschi

1. Introduction

In this chapter we discuss the research and engagement process that led to the development of Bioleft, a multi-actor 'transformation laboratory' that develops and prototypes institutional and technical tools to create and support an alternative, open and collaborative, innovation and distribution system for seeds. Originating as an experimental research and action project involving two social scientists, Bioleft has now become an initiative driven by a trans-disciplinary team of more than twenty people in both Argentina and Mexico, including social and natural scientists, agronomists, agricultural extension workers, farmer-breeders, and representatives of farming associations and a small seed firm. Our approach, as with the other initiatives reported on in this volume, has been based on ideas of co-design and the transdisciplinary production of knowledge and action (Kates, 2001, Miller and Wyborn 2018, Marin et al 2016). Consequently, although originating in a research setting, Bioleft has now evolved to become an initiative co-owned by a diverse group of people that happens to include academic researchers. It increasingly bears more resemblance to an emerging non-government organization or social enterprise than a research project.

Bioleft grew out of concerns about the direction of change within the Argentinean agricultural sector, which has become dominated by high external input, intensive, large scale commodity crop production for export (Phelinas and Choumert 2017). We focused on seeds, a key input that shapes the possibilities and configuration of agricultural systems. Global seed markets have become highly concentrated over the last 30 years, in response to the emergence of new business models made possible by genomics-based technologies and, the worldwide diffusion of strict intellectual property rights, especially patents and patent-like restrictions over seed material. Just three giant multinational (MNC) agro-chemical firms now dominate the global seed market (MacDonald, 2019). Those firms focus their breeding efforts on important commercial seed markets, and on commercially significant production constraints (Fess et al 2011). Other production constraints, minor crops, marginal agro-ecological environments, niche markets such as for agro-ecological production, and the needs of small farmers are increasingly neglected (Smale et al 2009; Osman et al 2008; Falcon and Fowler 2002). This is likely to result in an acceleration in the long-term decline of crop diversity, unsuitable seed varieties (for many farmers), and a much narrower variety of agricultural systems and practices that the seed sector is able to support (FAO, 2019; Hubbard, 2009). Market concentration also results in the loss of domestic technological capabilities in seed breeding in some countries, and therefore of agricultural autonomy and control over food sovereignty (Marin et al 2015; Brieva et al, 2008; Perelmuter, 2008).

The global transformation of the seed industry has impacted Argentina in a significant way. Independent domestic firms and the public sector, with a long tradition of breeding, are responsible for an increasingly smaller proportion of seed breeding, undermining the provision of diversity (Marin et al 2015; Perelmuter, 2008). Domestic firms and the public

sector also find it more difficult to deliver their varieties to farmers given that marketing and distribution channels are increasingly dominated by the MNC agrochemical firms. As a consequence, the seed requirements of family farmers are unmet, whilst producers working in sectors, such as agroecological or organic production, informally try and develop suitable varieties within their own networks (see Bioleft.org for testimonies). Argentina nevertheless retains domestic capabilities in breeding. Some firms that were not acquired by the large agro-chemical MNCs during the 1990s and 2000s have been very successful and the public sector, despite significant budget cuts, still possesses plant breeders engaged in producing important innovations (Marin et al 2015, van Zwanenberg et al 2018). A key objective for Bioleft has been to try and connect those existing dispersed capabilities and create new ones by taking advantage of new technological and social opportunities to develop and support an alternative seed innovation system.

2. Towards more sustainable seed innovation and agriculture systems: our framework

Our approach to developing Bioleft was inspired in part by the socio-technical transition literature which puts 'system innovation' at the center of processes of transformation (Smith et al 2010; Köhler et al 2019). This interdisciplinary body of literature gives a prominent role in transformation processes to experimentation with novel socio-technical practices that develop in 'niches'; spaces that are protected, at least temporarily, from competition with well established ways of producing and using the goods and services that experimentation is seeking to provide indifferent ways. The argument is that niche-based activities provide a source of diversity - of ideas, knowledge, and practice - which established, mainstream socio-technical systems, such as those concerned with the development, production, use and governance of seeds, may draw on to solve problems, or which may themselves get translated into new emergent socio-technical systems. (Smith 2007; Geels and Schot, 2007)

The literature argues that the temporary protection provided by niche spaces (for example in the form of subsidies), allows the costs and performance of novel technologies and practices to be improved, as well as space and time to build networks, and to try and modify the unfavourable selection environments that tend to favour incremental innovation over system transformation (Kemp et al. 1998). For example, niche-based actors may try to construct new markets for their ideas, influence user preferences, lobby for supporting regulations, persuade financiers to back their new technologies, or represent their novel practices as solutions to wider cultural and political changes that are causing problems for mainstream regime activities. As Geels and Schot (2007) put it, niche entrepreneurs are 'creating the technology and its environment in the same process'.

Within this framework Bioleft can be considered as a laboratory for experimenting with and developing alternative niche-like practices, knowledge and technology to support more sustainable seed innovation and agricultural systems. Transitions frameworks helped us to appreciate that our activities need to go beyond just designing, testing and improving alternative approaches to seed breeding. We have needed, for example, to try and obtain temporary protection for our experimental practices as we were learning how they can work effectively, in our case in the forms of external financial support beyond the original research project, and individuals committed to sharing their time and energy in order to experiment with us. Transition perspectives also helped us to appreciate the importance of building networks with people, not only from the worlds of plant breeding and agricultural extension, but also from government departments of science and technology and

agriculture. Likewise, we have sought to develop wider awareness about why we think an alternative seed breeding initiative is important, and of connecting with other like-minded initiatives in the area of sustainable agriculture. We have also been seeking to build alliances with open source seed initiatives in other countries which share the objectives and approach we have been experimenting with, which is important in terms of learning and gaining influence within mainstream seed innovation systems at both local and international levels. The following sections of this chapter outline in more detail how we have approached trying to collectively define a shared vision and approach, and enrol diverse people in Bioleft.

3. Our methodological approach

In developing Bioleft we drew, as with the other initiatives covered in this volume, on ideas about transformation labs (T-Lab). These emphasise the importance of social interaction between diverse participants in order to learn about sustainability challenges, identify innovative solutions, and then to put some of those ideas into experimental practice. A diverse range of participants help ensure that a range of different perspectives, experiences and knowledge can be brought to bear on understanding problems and potential solutions.

This approach was inspirational for us because it encourages researchers to become involved in action, and to do so by working with other stakeholders. T-Lab ideas also helped us to think about the centrality of social as well as technological innovation in transformative change, and about social innovation in a structured way. This literature draws attention to the importance of techniques to encourage transdisciplinary learning about complex systems and the problems they generate, and to test the potential of different ideas for achieving system change.

A specific method we used, in conjunction with T-Labs, was Q-method, which is an approach to systematically study subjective viewpoints on a topic (Eden et al. 2005). With Q-method a small, nonrepresentative but diverse group of people are asked to rank a series of statements about a topic. In principle, the statements are selected by the researcher so as to encompass everything that has been said or written about the topic in question. The ranking is performed by each participant who sorts the set of statements from those that they most agree with to those they least agree with (and in doing so the participant explains the rationale for their ranking to the researcher). The method then looks for patterns among rankings and reduces individual rankings to a few clusters, which represent broadly shared ways of thinking about the topic. Among other things, the technique can help identify themes or issues that are critical to differentiating between different views, as well as those about which there is consensus across different perspectives (Barry and Proops 1999).

We ran a pilot Q study in order to inform the remit and running of our first T-Lab event, a co-design workshop. The idea was to map a range of different views about the sustainability problems associated with the current industrial structure and governance of seed systems. The exercise covered perspectives on the relationships between intellectual property rules and seed market concentration on questions of access, innovation and biological and rural socio-economic diversity. We interviewed eleven people for our pilot study, including plant breeders from both private and public sectors, seed firm representatives, academics and civil servants.

4. Key moments in the T-lab process

In this section, we identify some key moments or milestones in the T-lab process. **An early key moment**, prior to our first T-Lab event, was a decision about the planned remit of that event We decided to focus on challenges faced by the agricultural sector associated with increasing seed market concentration and to propose an open source breeding system for seeds as a way to address some of these challenges. The aim of our T-Lab event would be to explore the viability of this novel idea with a range of stakeholders involved in the development, use and governance of seeds.

A second key moment, again prior to our first T-lab event, followed the completion and analysis of our pilot Q-study. We had expected those findings to help us plan the event but they prompted us to alter its remit . It was clear that many of the participants we interviewed believed that seed intellectual property rights were not a significant cause of problems such as loss of agricultural biodiversity and domestic technological sovereignty. Other factors were seen as more immediately relevant. Consequently, we decided there would be little purpose focusing on discussion about whether and how an open source breeding system for seeds would be a way to address sustainability challenges if our stakeholders did not think that intellectual property rules were fundamentally problematic. We therefore broadened the remit of our planned workshop to focus more generally on exploring an unrestricted range of possible solutions.

A third key moment was the first day-long T-Lab even itself, held in March, 2017. For this 'co-design' event, nineteen people participated, including representatives from Via Campesina, peri-urban agro-ecological producers, seed breeders from the public and private sector, government officials, academics, specialists in intellectual property law, a representative of the multinational seed industry, journalists, trade associations, and a member of Congress´s agriculture committee. We learnt through this experience that, despite being very enriching to work with this large and diverse group of actors, who held very different perspectives about challenges in the agricultural and the seed sectors in Argentina and their possible solutions, it was also very difficult to collectively identify and pursue a concrete social innovation that addressed some of those challenges.

We began the event with a presentation of our pilot Q study findings, a brief video produced by the research team, which illustrated a range of effects associated with market concentration and property rights regimes in the seed sector, and a panel discussion. The participants were then split into small groups and asked to try and arrive at a consensus about the most important sustainability challenges associated with the structure and governance of the seed system. The groups collectively identified eight challenges, not all of which were necessarily directly related to the seed sector, nor were they all problems that social innovations could necessarily address . As organizers we chose three of those problems for group discussion in the afternoon, on the grounds that it might be possible to begin to address them through social innovations. These concerned an absence of agricultural diversity; a lack of recognition and support for informal seed improvement; and weak protection and support for domestic seed technological development.

At a subsequent plenary session, discussion focused on the idea of creating a network of actors working on or interested in participative breeding. This proposal was supported by university-based plant breeders, scientists from the public sector research service, and rural NGOs and social movements present at the workshop. The suggestion was that such a network could be used to experiment with a range of initiatives linked to improving support for participative breeding, as summarised in Box 1.

Box 1: First T-lab workshop

The T-lab was organised around two guiding questions:

1. What are the most relevant challenges faced by the agricultural and seed sector in Argentina, as a result of increased seed market concentration?
2. What interventions could address and begin to resolve those challenges?

Several actions were proposed, oriented to support participatory seed breeding:
1. To map participatory crop improvement initiatives at global and national level in order to learn from existing practices and explore networking opportunities.
2. To develop capabilities and good practices in participatory crop improvement, based on a broad conception of the agriculture production system.
3. To obtain certification for the outputs of participative breeding;
4. To create a market for the products of such seeds, when used in practices such as agro-ecological and fair trade production;
5. To create an open-source license or pledge for germplasm produced through participative breeding.

Following this event, we pursued some of the ideas proposed , initially trying (but failing) to raise funding to support an agro-ecological NGO to develop a seed library and to organise training in participatory breeding.

We continued, thereafter, to organise a number of meetings with small groups of stakeholders in order to explore how we might support some of the proposed solutions identified at the first T-lab. A central - and formidable - challenge involved thinking about which kinds of initiatives or interventions were most likely to make people sufficiently enthusiastic to actively participate, in the absence of funding. Eventually, we decided - our **fourth key moment** in the T-Lab process.- to focus on our original idea, also discussed and supported at the co-design T-lab, namely the creation of an open source seed license.

A key rationale for that decision was the enthusiasm expressed by a group of plant breeders from the Faculty of Agronomy at the University of Buenos Aires, after a presentation to the group about the open source ideas we were exploring. We recognised at that time one important issue that was crucial for our work thereafter.

We realised that single T-Lab events, such as workshops, were not sufficient to advance and push our practical idea (nor was it easy to persuade busy people to give up an entire day or two for a workshop). We therefore started a T-Lab *process* in 2018, which included discrete short meetings and presentations with different kinds of stakeholders and possible partners to discuss ideas and enroll people. Our objective was to create a core team and extended network to develop and prototype tools to support an open source license. We were particularly interested at this stage in enrolling breeders and farmers working with alternative forms of agriculture.

This new way of working resulted in a **fifth key moment**, which was to develop a digital platform in parallel with open source licenses, with the aim that both could support an embryonic open source seed innovation system . The initial rational for a digital platform was as a means to document and register informal seed varieties that were already being used, improved and exchanged by family farmers and others, in order tocollect evidence that could be used in any future attempts of biopiracy (e.g. a firm using IPRs to restrict the use of a seed variety that is already widely used but undocumented). Experience from other

countries that have avoided piracy of native varieties suggested that evidence of past use of seeds was an effective tool. We subsequently realised that to the extent that a digital platform could be used to enable the exchange of information between breeders and farmers, it could also be a tool to support participatory breeding. We began to co-develop the idea of digital 'field books' for registering and exchanging data on seed performance. The co-development of these fieldbooks, that need to include variables that can be practically collected by farmers and that are also useful for breeding, and which have to be adapted to the requirements of each crop, is a challenging task. Addressing that challenge is the **sixth key moment of the ongoing T-Lab** through which Bioleft is being developed.

5. Impact, outcomes and pathways

Bioleft is contributing to new pathways of seed development and therefore, indirectly, also to alternative pathways of development for the agricultural sector, such as those based on agroecological or other low input practices. Well adapted seeds are key to improving the productivity and viability of these alternative approaches to practising agriculture. Such alternatives, despite being the systems typically utilised by many family farmers (FAO 2018; IAASTD 2009) and widely recognised as crucial for diminishing agriculture's impact on biodiversity loss, air and water pollution, occupational health and carbon emissions (IPBES 2019) are ill-served by the mainstream seed sector.

To support the creation of those new pathways Bioleft has developed and is improving two tangible outputs: a set of material transfer agreements inspired by Open Source ideas, and a digital platform. The first of these aims to guarantee the unhindered circulation of germplasm and its embodied knowledge for future breeding purposes. The second aims to connect users and providers of seeds, and to create information about seed characteristics and performance that can be used to support collaborative breeding. A third expected and important tangible output of Bioleft that we are developing through the diffusion of the digital platform and the enrollment of actors who are interested in using it, is a data set of information about users and seed performance that will be a very valuable asset to support decentralised breeding. This will require policies for the governance of this data which Bioleft is also co-designing with stakeholders.

New seed varieties, registered under open source principals and released for collective improvement are also tangible outputs of Bioleft. In 2018, Bioleft registered its first seed , named *Ubuntu,* a salt tolerant variety of melilotus (a forage crop) bred for agro-ecological production systems by a Professor of Plant Genetics at the University of Buenos Aires and a member of Bioleft's core team. That variety was transferred, in small quantities, to representatives of the Federation of Organizations for Family Farming, and the Organization of Indigenous Nations and Peoples of Argentina.

Subsequently, between 2019 and 2020, twenty additional seed varieties were released with a Bioleft license: a maize variety , another fodder crop, and 18 varieties of tomato. The latter were from a University of Buenos Aires project that had recovered old tomato varieties from the first two thirds of the 20th century. 160 of those recovered tomato varieties were multiplied and 18 selected during a public tasting experiment. Seeds from these varieties were then transferred to 300 producers using Bioleft's open source material transfer agreement.

Most of those varieties have been bred or selected to work well with low input agricultural practices. To illustrate the potential impact of these seeds we can use the example of the

maize variety released through Bioleft, a Candelaria, bred at the National Institute for Agricultural Research. Since Candelaria has been bred to work without herbicides it can be co-planted with pumpkin and peas which increases productivity per hectare (in kg of food) by an average of 190% compared to hybrid maize grown as a monoculture (Gomiero, Pimentel & Paoletti, 2011).

We have also achieved two less overtly material outcomes. One is a transdisciplinary core team of people and a larger community beyond that core team that is willing to contribute to the idea of developing collaborative approaches to seed innovation for more sustainable agricultural systems. The other outcome is the development of new knowledge and skills in three important areas: (a) participatory and co-design methods for social innovations aimed at transformation processes; (b) the design and use of legal tools for open innovation and (c) collaborative breeding processes. In relation to the last of these, beyond the knowledge gained from day to day work developing Bioleft, two PhD students are also researching processes of collaborative breeding as part of their doctorates on aspects of Bioleft. One focuses on knowledge conflicts between scientists and farmers in respect to collaboration in participatory breeding processes, and the second on the challenges of expanding from participatory evaluation of seed varieties to more integrated forms of participatory breeding.

6. Re-framing sustainability challenges

Processes of reframing the way in which people think about and approach seed and agricultural sustainability problems and solutions, have been important for our developing initiative. This has occurred both within the process leading up to the creation of Bioleft, and then subsequently as we have experimented with new seed breeding practices.

For example, in the early stages of creating the initiative, it was clear that most people critical of existing seed system practices were focused on immediate problems with proposed changes to the national seed law that were seeking to strengthen domestic intellectual property rights over seeds. Those problems were largely related to issues of price and farmers' access to seeds. Responses were framed in terms of efforts to resist those proposed changes. We sought to encourage a broader, longer-term view of the problems posed by existing seed innovation practices, and of possible solutions. In particular, we sought to encourage reflection on the potentially problematic effects of existing seed innovation trends on crop diversity, the diversity of agricultural systems that new seeds were able to support, on the structure and ownership of the seed industry and on patterns of future agricultural development. Bringing in experience from other countries, where stricter intellectual property rights are more established, was an important means of fostering that longer term and broader perspective. In terms of solutions to those wider set of problems, we also sought to shift discussion away from the defensive approach of trying to lobby Congress over reforms to the seed law, and explore a more offensive strategy such as our emerging proposal to create a parallel open source system. Much of our earlier work in the project involved trying to persuade many initially reluctant actors that our alternative way of thinking about and addressing our shared focal problem might be viable.

Once Bioleft had been established, we have been involved in an on-going process of reframing as expectations between the various actors directly involved within Bioleft have differed, and as we have collectively tried to align those expectations or at least reach workable consensus. Although all of the people directly involved in Bioleft share the core idea that existing seed innovation systems, dominated by a few large companies, cannot

support a more sustainable agricultural system, and that amore decentralised, and open and democratic breeding system is required,there is less consensus, unsurprisingly about how to build such a system. With what specific objectives, using which tools, through what processes and involving which actors? And how 'open' should seed licenses be? How much information can or should farmers register in relation to the performance of the seeds they are testing in order to contribute to the process of collaborative breeding? Should Bioleft charge for certain products or services? Which form of governance is best suited to ensure wide participation and democratic decision making, but at the same time preserve the spirit of the initiative?. These are some of the questions we are continually discussing and negotiating, and that to the extent to which we reach some agreement within the team, we advance in the direction of creating common expectations. In part, disagreement reflects different interests and perspectives of those involved, but there are also competing ways of thinking about, or framing these issues in relation to disciplinary background and between academics and practitioners (especially between scientific breeders and farmers). We do not need to fully agree at every stage with regard to every issue in order to continue developing Bioleft, but we have noted that it is the implementation of ideas in practice that helps to develop shared expectations about what is possible and acceptable. Throughout the whole process, negotiation is crucial, as is a willingness to let go of top down control and direction.

Our collaboration with actors outside of the Bioleft team has also involved efforts to articulate, discuss and sometimes reframe objectives and expectations For example, experience working with the seed breeding group at the University of Buenos Aires working on recovered tomatoes has been a good example of the need and efforts involved to create workable alignments around shared ideas and aims. Looking to the future, it will be important to create space to discuss and negotiate ideas about open source innovation with actors within the dominant seed innovation regime. For example, many domestic seed firms adopt a business strategy based on being first movers in seed innovation, which is entirely compatible with some open source ideas, at least in terms of the free circulation of germplasm for plant breeding. We think there are strong possibilities to work with such actors, although this will require challenging mainstream assumptions about intellectual property and innovation.

7. Innovation and alternative pathways:

Bioleft was created and developed under the assumption that innovation is one of the main drivers of transformation. The initiative is developing and testing a novel, disruptive way to develop and exchange seeds and information; one that, in clear contrast with the market driven mainstream seed innovation system, is based on cooperation, collaboration and solidarity, and not only on profits (which are possible within this alternative system, but not via the exclusive appropriation of seed germplasm). A key challenge for us has been to think about how seed innovation, in the absence of the legal ability to exclusively appropriate new knowledge (embodied in a new seed variety) can nevertheless work. The key inspiration here is open source software, and Bioleft, like other open source seed initiatives in other countries is exploring how those ideas can be adapted and applied in seed systems.

In order to prosper in the Argentinean context - where the actors and institutions that help to constitute and reproduce dominant agricultural systems are extremely powerful - we were interested in whether a disruptive idea like Bioleft could act as a 'bridging' innovation, linking actors with different ideas, and perspectives on, and priorities about, food and agricultural sustainability. It is not too difficult, for example, to imagine innovations such as an open source breeding initiative that both promise to support greater diversity in

agricultural production with the development of domestic technological capabilities, thus 'bridging' across the priorities of different institutional actors, and creating actionable consensus. This seemed important because we wanted to create alliances between actors that possess different resources, able to bring in and link the skills, knowledge, political support and markets that will be needed if more sustainable and socially just, but disruptive, pathways of change are to be politically and practically viable.

Initially we tried to interest people in open source seed breeding ideas who held very different views of the problems posed by seed market concentration and agricultural intensification, such as the domestic seed industry trade association (which represent both large and small seed firms), but here we failed. We did however find that the idea of an open source seed breeding initiative resonated with university-based seed breeders, rural NGOs, agro-ecological producers, and scientists from the government's agricultural research service. We subsequently found that farmer-breeders, organic farmers who produce for export on medium sized farms, small seed firms in the organic and biodynamic sector, and farming associations representing small family farmers, were also interested. This coalition of actors and institution provided the basis upon which we began discussing and developing Bioleft. There are three reasons why we think we managed to interest those different groups of actors, even though they might not necessarily agree on what a more sustainable agricultural system might look like, or what the priorities are for achieving a more sustainable agricultural system.

First, the open source idea behind Bioleft is appealing because all those groups want to ensure that useful seed varieties and traits bred by the public sector and by farmers themselves are not captured by large seed firms in the future, which would restrict their widespread use for breeding, irrespective of any divergent views about what a more desirable set of future agricultural practices should consist of. Second, open source seed innovation is interesting to actors who want to sell or provide new seeds, to those who are primarily interested in ensuring unrestricted access to seeds, and those interested in expanding crop biodiversity. Thirdly, an institutional innovation like Bioleft is compatible with the existing mainstream seed breeding system and with the associated legal structure based on strict intellectual property rights. It can be accommodated without major changes to the *status quo* even though, as we would argue, it is quite a radical idea and suggests a transformative change in the ways seeds are created, shared, sold and used.

The key more general point here and one that we think is interesting is that innovations that can 'bridge' divergent perspectives on sustainability play an important role in forming alliances between different interests, and thus help to reconfigure social relations around socio-technological systems in ways that can open up space for more sustainable pathways of change.

8. Networks, Alliances and Collective Agency

We have put considerable effort into forming alliances with a range of people and institutions as we have developed Bioleft, and of embedding Bioleft within wider networks. This has been key to making the initiative begin to work. At the beginning of the project, with only a handful of social scientists as part of our core team, and some limited funding, it was clear we lacked the capacity to take the idea of an open-source breeding initiative very far. This was especially so given that none of us were central actors in either the mainstream

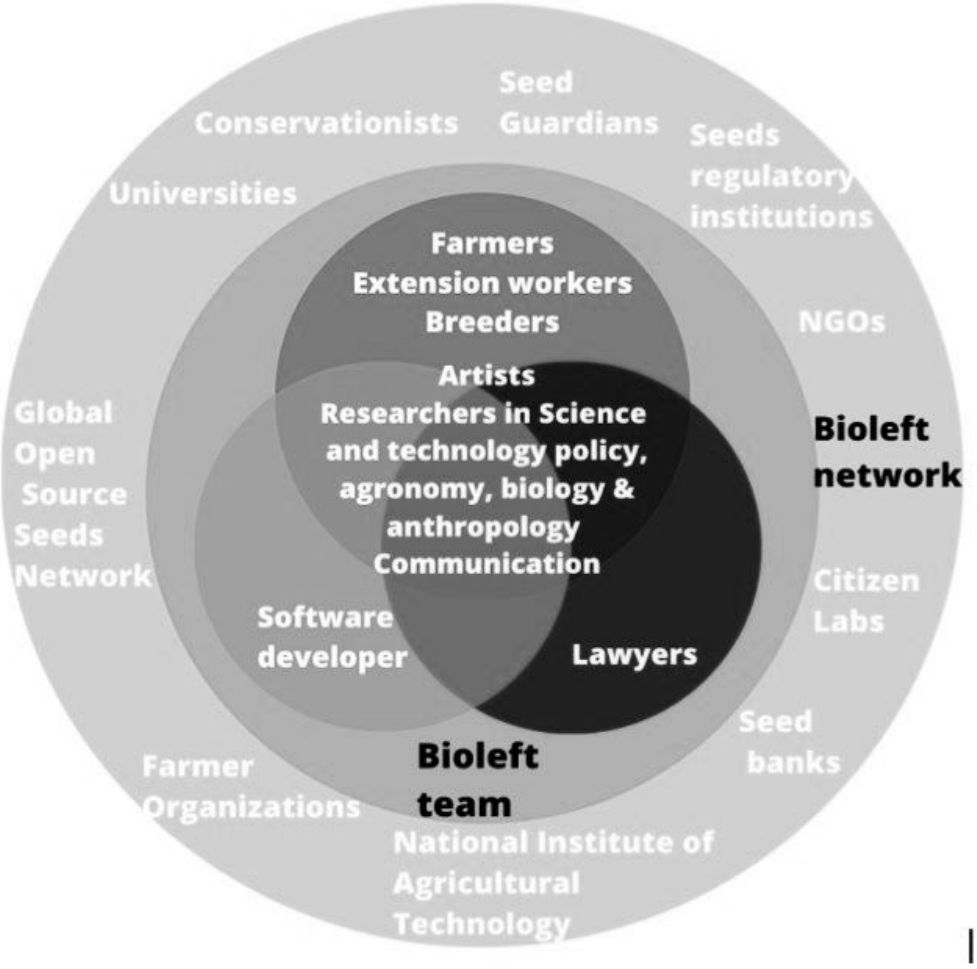
Argentinean seed system or the various social movements that sought to challenge that regime (although we had good contacts in each of these, mainly through previous research work).

We therefore sought to expand our core team to include people with different sets of skills and knowledge, and that were involved in wider seed and agricultural networks of various kinds. Over the period from 2015 to 2019 we slowly added diverse people both from within and outside academia to our core team, with expertise in agronomy, intellectual property law, journalism, plant breeding, agricultural extension, anthropology, economics, and software programming as well as farmer-breeders, representatives of farmers organizations, and a manager of a small seed firm (see Figure 2). We have also worked intermittently with designers, a visual artist and a musician. Adding people gradually has been important so as to ensure that we develop a consolidated group, and that we have been able to take advantage of development opportunities as they arise.

It is striking just how broad our core team is, in terms of backgrounds and expertise, and we have learnt that establishing a venture, such as Bioleft, from scratch really does require such diversity. This might not be news for entrepreneurs starting a new business or non-profit organization, but from the perspective of traditional academic-led research it has been an eye-opener, despite the contemporary emphasis on the importance of trans-disciplinary work. Early on in the initiative, it was obvious that we would need people with expertise in agronomy and intellectual property law in order to be able to understand plant breeding, to communicate with and enrol breeders, and to develop an open source license in a way that worked within the framework of domestic legislation and practice. We subsequently realised that communication would also be vital, in part so as to gain support from different kinds of communities (and so we employed a journalist, who was already working on ideas around commons, and worked closely with a filmmaker). By 2017 we also managed to persuade a senior university plant breeder, an extension worker and two farmer-breeders to work with us, which has been key, not only for their expertise, but also their access to plant breeding and farming networks.

People on our core team have either given their time voluntarily (which has been a little easier for those employed by universities, with relative flexibility as to how they allocate time) or were paid for part time work, or have worked with us as part of a funded doctoral programme. We raised a small amount of additional funding, beyond the end of the initial project, which has been vital to enable some of our team to be paid, and for our fieldwork costs. Critical to our ability to enrol a trans-disciplinary group is that people have been very enthusiastic about and ideologically committed to the ideas behind an open, collaborative form of production (and so willing to gift their time to the initiative or exchange it for less money that they could earn elsewhere), We have also run Bioleft in a relatively non-hierarchical manner so that people who participate in the core team feel they have agency to influence how the initiative develops, which has helped enthuse people, and persuade them to continue working with us.

Figure 1. Alliances and network expansion

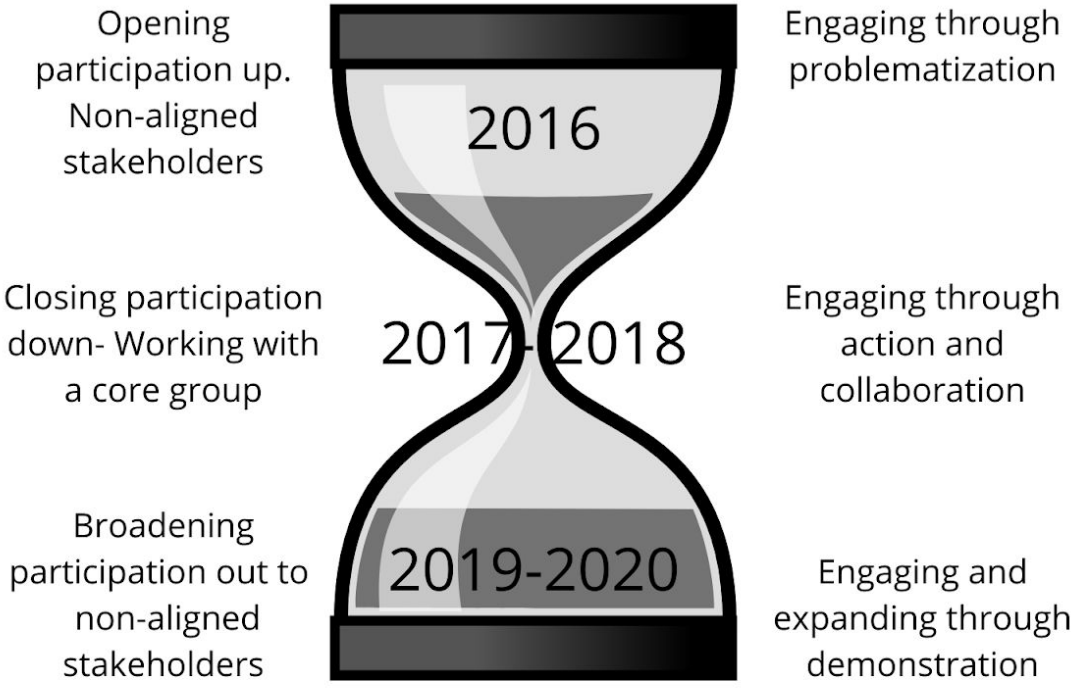


Beyond developing our core team, we have also put a lot of effort into creating a wider network of support with potential allies, and of linking Bioleft to existing, broader seed and agricultural networks. Those potential allies and wider networks include domestic actors, such as government departments, seed banks, alternative farming associations and rural social movements and existing networks of public sector plant breeders interested in, say, breeding in fodder crops (as shown in Fig 1). They also include international bodies such as overseas universities and global funding agencies working on sustainability issues, and a global network of open source seed in initiatives, which one of us from Bioleft currently chairs.

In building that wider network of support we learnt two things. Firstly, it was more productive, in the early stages of the project, to try and enrol people and institutions who shared our overall perspectives on the problems with existing seed systems, and the values implicit in open-source solutions. Very early efforts to try and work with more diverse groups did not work well, as described earlier in this chapter. Yet, once Bioleft was operating, in the sense that we had begun releasing new seed varieties, working with institutions such as the National Institute for Agricultural Technology, the National Seed

Registration Authority, and some medium sized domestic seed firms, was more productive because we were able to demonstrate the ideas behind Bioleft. Figure 2 shows the sequence of our engagement strategy followed in this respect, with an initial attempt to talk to and collaborate with a heterogenous group of people and institutions, followed by a narrowing down to a more aligned group, and finally broadening once more.

Figure 2: Bioleft engagement strategy



The second issue we learnt was that given few resources on our part, in terms of both funding and core team members, it was important and useful to try and find, and take advantage of, synergies with other, existing initiatives and networks on seed breeding in order to advance our project. For example, by collaborating with existing public sector breeding initiatives, for example on open pollinated maize and tomatoes, we could begin to test whether our open source licenses might work in practice, as well as enlarge the community of people working with Bioleft.

During the early phases of developing Bioleft we were not very influential within the Argentinean seed system. Whilst actors within the mainstream seed system (e.g. established seed firms, seed trade associations and agencies within the Ministry of Agriculture) did not view us as a direct challenge to the *status quo,* for the reasons we described earlier in this chapter - for example, we were not campaigning to change existing intellectual property law - ideas about open source innovation were nevertheless met with scepticism. In part this was because it was not clear that there was a viable business model behind the idea of Bioleft. At the same time, many actors who have traditionally resisted mainstream seed systems were distrustful of our initiative. Here campaigners had typically sought to preserve

farmers rights to save and reuse seed, and were hostile to any system of property rights. Since Bioleft proposed to use contract law and existing intellectual property law to mandate sharing people were suspicious.

Our agency to influence other actors and nurture change, as a group of people collaborating in the development of Bioleft, is in part individual, and in part the collective actions of our team and other actors within the networks which we are part of. At an individual level, influence varies depending on the different kinds of expertise, authority and contacts that members of our core team possess - in relation to any given topic or issue. For example, one plant breeder, who became part of our core team in 2017, was very well regarded and influential, both within the national plant breeding community, but also within parts of national government with whom he had previously interacted closely. His presence as part of Bioleft was key to ensuring that other plant breeders turned up to events and became interested in working with us, and in opening avenues to contacts within government and other public sector institutions, and persuading those actors to take the initiative seriously.

The collective agency of our initiative is more difficult to identify and understand. In part, it appears to be a product of the combination of appropriate kinds of expertise, contacts, and then actions, of the core team as whole, as well as the ways in which we have managed, or otherwise, to work together and with people in our wider networks. For instance, we were only able to work effectively with a open source software company - which we had contracted to work with us - once we also employed a programmer within our core team. The programmer was able to understand the kinds of things that the breeders and farmers within our group were interested in and to then translate these in interaction with the software firm, in ways that other members of the team had been unable to do successfully.

In another example - where we failed to persuade others to work effectively with us - we co-organised a seed fair in 2018 in the north of Argentina with organizations belonging to two national associations representing family farmers, hoping to enrol those organizations into Bioleft. Even though we had planned the event with representatives of the national associations, who were enthusiastic about Bioleft, only a handful representatives of farmer´s organizations participated, and with their own agenda, which bore little resemblance to our plans. A lack of prior interaction with family farmers organizations, and some misunderstandings and poor communication within our networks contributed to those difficulties.

Another way in which we can understand the source of Bioleft's collective agency, and we think an important one, is as a result of the practical demonstration of our ideas. By releasing new open source fodder crop varieties, maize varieties and ancient tomato varieties with an open source agreement, and generating media coverage about those initiatives, we have encouraged plant breeders, farming organizations and an interested public to join the initiative and experiment with us in ways that merely writing or talking about a new idea could never match. For example, the government agency responsible for registering seed varieties is willing in principle to find a way to allow 'informal' seed varieties released with a Bioleft license to become legally registered – something that would undoubtedly be far more difficult if Bioleft was just an idea on paper. Of course, writing and talking about new ideas remains important in trying to persuade the academic community, policy-makers and other stakeholders about how best to think about problems, and about how they might act on them. But by doing so, alongside socio-technical experimentation, those activities become a more powerful source of agency.

9. Specific insights from the Argentinean case

We conclude by highlighting some of the key things we have learnt about the process of developing Bioleft. First, is that both social and technological innovation are central to processes of system transformation. The sustainability transitions literature has always emphasised that whilst new kinds of technological artefacts may provide opportunities to solve social problems in a more sustainable way, those artefacts cannot be meaningfully separated from the novel or reconfigured social processes that - in combination with new artefacts - constitute an innovative technological practice. Attention in sustainability innovation policy nevertheless often tends to focus mostly on creating material novelty, as if unsustainable material artefacts, such as chemical pesticides, are the fundamental problem, rather than the social institutions and practices that have evolved to create and support the use of those artefacts. Our experience with Bioleft underscores how new ways of organising activities, with new more sustainable logics and principles, and that motivate and mobilise different kinds of actors, are for us the key innovation in thinking about reconfigured seed systems. Novel artefacts, in the sense of new kinds of seeds, and then perhaps in the longer term and indirectly, reconfigured agricultural production practices, flow from those new social practices.

A second thing we have learnt is that the kinds of social innovations Bioleft has been experimenting with need to be disruptive in order to offer a more sustainable pathway of change; they need to try and build an alternative, based on a different, imagined future. Doing so is difficult, not least because the kinds of actors that need to start doing things differently, such as plant breeders, agricultural extension staff, regulators and farmers, work and operate within existing structures and institutions for organising seed breeding and production. A novel idea for doing things in a more sustainable way not only needs to appeal to a relatively wide range of actors with different perspectives, interests and institutional locations (a 'bridging innovation', as we have described it in this chapter) but perhaps more importantly, it is much easier to pursue and develop such ideas if they avoid fundamentally challenging those existing structures and institutions, so that they do not get destroyed from the outset by existing interests. The dilemma here is that novel ideas that do not fundamentally challenge existing structures and institutions often offer little in terms of sustainability. Open Source ideas are a very good example of a social innovation that might be able to finesse that dilemma. They are quite profound in their implications, and offer, at least symbolically, an imagined future that appeals to many people, but they can also operate alongside existing institutions and practices, and do not directly or at least immediately undermine them.

Third, we want to emphasise the importance of trans-disciplinarity in building a team of people that are able to explore and begin to develop a research-led social innovation. This is crucial, not only to obtain the wide range of capabilities involved in this kind of action-oriented research, but also to gain access to the diverse communities and networks that putting any innovation into working practice will need to to negotiate with and involve. By bringing plant breeders, extension workers, seed firms and farmers into our core research-action team, our initial ideas were tested, contested and expanded to accommodate the views and concerns of these communities. For example, we had to adapt our ideas about the design and content of open source clauses in order that public sector breeders were able to transfer their varieties with our contracts in ways that fulfilled the requirements of their institutions. We also had to pay much more attention to issues of accessibility and user interfaces when developing our digital platform in order to enable communication with different types of farmers. And in experimenting with participatory breeding, the extent to which knowledge generation can effectively be decentralised and

performed collaboratively is an issue that we could not begin to address properly in the absence of the diverse views, knowledge and experience of our transdisciplinary team. As emphasized earlier in this chapter, the ability to demonstrate how an in initiative works, even if only as a prototype, is a critical source of agency, for example in terms of persuading people and institutions to support us and work with us

Fourth, In building the core team of Bioleft it has been very important, for us, to move from processes of co-design and co-production, as emphasised in the sustainability science literature, to a process of co-ownership. Novel solutions to sustainability problems perhaps not only have to be developed jointly, but they also need to be appropriated by all actors. An imagined future needs to be shared. This, of course, has its difficulties, not least the practical and time consuming need to constantly negotiate how an initiative like Bioleft should develop,and to relinquish some degree of power over that process.

Fifth, as the socio-technical transitions literature emphasises, and as we have discovered in practice, putting novel ideas into working practice requires that existing institutions also evolve to accommodate those new ideas, which requires the ability to persuade others of new ways of conceptualising problems and the ability to exert political influence. So, in building networks of support for Bioleft it has been crucial not only to consider enrolling actors that can help to build the initiative from within, for example, by bringing in complementary capabilities, but also from the outside, by bringing in people who have the capacity to lobby and influence existing institutions. For instance, new seeds, bred by farmers can only be exchanged within an open source system if existing regulatory institutions do not penalise the activities performed by small and medium size farmers, on the grounds that those farmers are not registered as seed traders and if the seeds they develop are not stable, unique and uniform as existing regulations require. In aiming to deal with this problem we have had to lobby and persuade the National Seed Institute to consider changing wider regulatory rules to accommodate Bioleft activities.

Finally, we have also learnt that the contexts and cultures in which we have created our initiative are important to take into account when thinking about why and how ideas like Bioleft have been feasible to develop, and whether or not the process and design might work in the same ways in different settings. Argentina is a country where civil society is very active and demanding, and where there is a low level of trust in Government. This leads some groups of actors to support grassroots initiatives that could address some current sustainability challenges. As researchers, we took advantage of this and worked as intermediary actors between farmers, breeders and institutions, helping to create a civil society-based initiative with our role as bringing people together, obtaining resources and combining knowing and doing.

References

Barry, J., & Proops, J. (1999). Seeking sustainability discourses with Q methodology. *Ecological Economics*, *28*(3), 337–345. https://doi.org/10.1016/S0921-8009(98)00053-6

Brieva, S., Ceverio, R., & Iriarte, L. (2008). *Trayectoria de las relaciones socio – técnicas de los derechos de propiedad intelectual en la agricultura argentina: los derechos de obtención de semillas (DOV) en trigo y soja desde principios de los años '70 a la actualidad.* http://xxijhe.fahce.unlp.edu.ar/programa/descargables/brieva_ceverio_iriarte.pdf

Elzen, B. (2008). Anchorage of Innovations: Assessing Dutch efforts to use the greenhouse effect as an energy source Anchorage of Innovations : Assessing Dutch efforts to use the greenhouse effect as an energy source. *Research Policy (Submitted)*, *May 2014*, 1–28.

Ely, A. and A. Marin (2016) Learning about 'Engaged Excellence' across a Transformative Knowledge Network, IDS Bulletin 47(6)

Ely, A., van Zwanenberg, P., Wach, E., Obaya M. and A. Cremaschi (2017) Seeding ideas: knowledge brokering and recombination for agricultural transformations, https://steps-centre.org/blog/seeding-ideas-knowledge-brokering-recombination-agricultural-transformations/, accessed 17/1/2020

Falcon, W. P., & Fowler, C. (2002). Carving up the commons-emergence of a new international regime for germplasm development and transfer. In *Food Policy* (Vol. 27). www.elsevier.com/locate/foodpol

FAO (Plant Production and Protection Division). (2019). *What are seed systems?* What Are Seed Systems? www.fao.org/agriculture/crops/thematic-sitemap/theme/compendium/tools-guidelines/what-are-seed-systems/en

Fess, T. L., Kotcon, J. B., & Benedito, V. A. (2011). Crop Breeding for Low Input Agriculture: A Sustainable Response to Feed a Growing World Population. *Sustainability*, *3*(10), 1742–1772. https://doi.org/10.3390/su3101742

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*, 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Gomiero, T., & Pimentel, D. (2011). Special Issue: Towards a More Sustainable Agriculture Guest Editors: Maurizio G. *CRITICAL REVIEWS IN PLANT SCIENCES*, *30*. https://doi.org/10.1080/07352689.2011.553147

Hubbard, K. (2009). Out of Hand:Farmers Face the Consequences of a Consolidated Seed Industry. In *Farmer to Farmer*. http://www.farmertofarmercampaign.com/OutofHand.FullReport.pdf

Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., Mccarthy, J. J., Schellnhuber, H. J., Bolin, B., Dickson, N. M., Faucheux, S., Gallopin, G. C., Grubler, A., Huntley, B., Jager, J., Jodha, N. S., Kasperson, R. E., Mabogunje, A., Matson, P., … Svedin, U. (2001). *Sustainability Science* (Vol. 292, Issue 5517). www.iiasa.ac.at

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, *10*(2), 175–198. https://doi.org/10.1080/09537329808524310

Luby CH, Goldman IL (2016) Freeing Crop Genetics through the Open Source Seed Initiative. PLoS Biol 14(4): e1002441. https://doi.org/10.1371/journal.pbio.1002441

MacDonald, J. (2019). Mergers in Seeds and Agricultural Chemicals: What Happened? *Amber Waves:The Economics of Food, Farming, Natural Resources, and Rural America*, *2019*(1).

Marin A. (2015). El futuro de las semillas y la agricultura en Argentina. *Revista CeI*, *65*, 84–93. http://aargentinapciencias.org/wp-content/uploads/2018/01/RevistasCeI/tomo65-3/6-Marin-cei65-3-8.pdf

Marin, A., Ely, A., & van Zwanenberg, P. (2016). *Co-design with aligned and non-aligned knowledge partners: implications for research and coproduction of sustainable food systems COSUST Special Issue: Co-Designing Research on Social Transformations to Sustainability;* https://core.ac.uk/download/pdf/74226465.pdf

Marin Lilia Stubrin J da Silva Jr, A. J. (2015). *KIBS Associated to Natural Resource Based Industries Seeds Innovation and Regional Providers of the Technology Services Embodied in Seeds in Argentina and Brazil, 2000-2014*. http://www.iadb.org

Miller, C. A., & Wyborn, C. (2018). Co-production in global sustainability: Histories and theories. *Environmental Science & Policy*. https://doi.org/10.1016/j.envsci.2018.01.016

Osman, A. M., Almekinders, C. J. M., Struik, P. C., & Lammerts van Bueren, E. T. (2008). Can conventional breeding programmes provide onion varieties that are suitable for organic farming in the Netherlands? *Euphytica*, *163*(3), 511. https://doi.org/10.1007/s10681-008-9700-y

Phelinas, P., and J. Choumert. 2017. Is GM soybean cultivation in Argentina sustainable? *World Development* 99:452-462. http://dx.doi.org/10.1016/j.worlddev.2017.05.033

Rip, A., & Kemp, R. (1997). *Technological change*. https://www.dphu.org/uploads/attachements/books/books_2786_0.pdf

Schmitz, H., & Scoones, I. (2015). *Accelerating Sustainability: Why Political Economy Matters*. https://opendocs.ids.ac.uk/opendocs/bitstream/handle/123456789/7077/ER152_AcceleratingSustainabilityWhyPoliticalEconomyMatters.pdf?sequence=1&isAllowed=y

Schot, J., & Geels, F. W. (2007). Niches in evolutionary theories of technical change. *Journal of Evolutionary Economics*, *17*(5), 605–622. https://doi.org/10.1007/s00191-007-0057-5

Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537–554. https://doi.org/10.1080/09537320802292651

Smale, M., Cohen, M. J., & Nagarajan, L. (2009). *Local markets, local varieties*. https://www.researchgate.net/profile/Melinda_Smale/publication/46442203_Local_markets_local_varieties_Rising_food_prices_and_small_farmers'_access_to_seed/links/55b15e5608ae092e964fe960.pdf

Smith, A. (2007). Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis & Strategic Management*, *19*(4), 427–450. https://doi.org/10.1080/09537320701403334

Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy, 39*(4), 435-448

Tamara Perelmuter. (2008). Las semillas en disputa: un análisis sobre del rol de la propiedad intelectual en los actuales procesos de cercamientos. el caso Argentino. *Revista Museos.Es*, *4*, 1–20.

van Zwanenberg, P., Cremaschi, A., Obaya, M., Marin, A., & Lowenstein, V. (2018). Seeking unconventional alliances and bridging innovations in spaces for transformative change: the seed sector and agricultural sustainability in Argentina. *Ecology and Society*, *23*(3), art11. https://doi.org/10.5751/ES-10033-230311