Natural sciences and environmental issues: a contribution from the philosophy of environmental sciences

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Abstract: The environmental issue has been considered a 'starting point' for certain epistemological transformations that aim at rethinking the way of performing science and interpreting the nature-society relationship. In this paper, we will explore controversial disputes in the natural science field through the analysis of a particular case study: the socio-environmental issues (SEIs) in the Argentinean Gran Chaco. Analysing the relation between scientific problems and SEIs and the traditional scientific approximations, our conclusions point that environmental issues arouse challenges to the sciences, to the way they are thought of, situated and built. They make manifestation of the idea that it is crucial to recover the 'for what' of the scientific practice, building a science that dialogues with other voices and with a starting point in local and situated problems.

Keywords: philosophy of biology; nature-culture; environmental issues; Gran Chaco; genetically modified organisms; GMOs; science and society; scientific problems; environmental philosophy; dialogue of knowledge.

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1 Introduction

The philosophy of biology is a discipline with barely five decades of development, using as its criteria institutional and conceptual consolidations. In its earlier stage, considering Ruse (1973) and Hull's (1974) work, it pretended to collaborate in an attempt to reduce biology to chemistry and physics. However, this initial role rapidly changed. A decade later, triggered mainly by Ernst Mayr's work, philosophy of biology abandoned this earlier aim given the apparition of autonomist theses of 'life sciences' with respect to

other fields of knowledge. However, with the beginning of a new century, these aims would also undergo meaningful modifications. For instance, in Pigliucci's (2008) proposal, we can recognise three main aims for the philosophy of science, allowing extrapolating this scenario to philosophy of biology:

- prescriptive or descriptive activities of the scientific practice
- methodological and conceptual analysis
- enquiries about the interface between science and society.

This paper focuses on the third axis proposed through the critical analysis of the contributions and discourses generated from within the academic community in the context of issues of different hierarchies.

In particular, our aim is to analyse controversial disputes in natural sciences in the context of the so-called 'environmental issues' through the analysis of a particular case study: the SEIs in the Gran Chaco. The rest of this paper is organised in five sections. In the following section, we will present some aspects of the environmental issue and certain criticisms associated to the natural sciences traditional perspective. In the third section, we will analyse the socio-environmental situation in the Argentinean region of the Gran Chaco to be able to make a distinction between scientific problems and SEIs, establishing a linkage with the case study proposed; in the fourth section, taking the case presented as the starting point, we will try to elucidate which are the environmental sciences traditional approximations to SEIs, highlighting the limitations found in each case. Finally, we will point out some conclusions, presenting a possible horizon for scientific practice in which ethical reflection is integrated intrinsically into scientific research, and the voices of the different actors of the issue in question are articulated to achieve pluralist resolutions.

2 Materials and methods

As regards the general methodology of this paper, given it integrates aspects concerning philosophy and theoretical biology and other environmental sciences, it is based on the detailed study and critical analysis of the problems and the different solutions presented in bibliographical references. Academic publications of different fields related to environmental issues were analysed, specifically of the different environmental sciences and the philosophy of sciences, philosophy of biology, chemistry and agronomy.

3 The environmental issue and its linkage with sciences

Since the 20th century, and mainly since the decade of the 1960s, environmental deterioration has become visible, emerging in an extreme form. According to the Millennium Ecosystem Assessment (2005), in the last 50 years, anthropogenic changes to natural ecosystems at the global scale have been the most dramatic in terms of extension and intensity in the history of humankind. Modification at the global scale has led to the proposition that we are facing a new geological period, the Anthropocene (Crutzen, 2002; Steffen et al., 2011). Among these changes, we can present the so-called 'sixth mass extinction' (Barnosky et al., 2011), climate change, modification of nutrient cycling,

deforestation, air, water and soil pollution, among others (PNUMA, 2010). These new scenarios started to become visible for different sectors of society as a worldwide problem that demanded an urgent reaction and solution. Environmental movements founded during the 20th century demanded changes in the ways of exploiting natural resources and in the relationship with the 'non-human', which escaped the materialistic-mechanistic logic and reinforced a linkage with nature, different from the productivity-consumption-exploitation dynamic (Adams, 2004; Brennan and Lo, 2015; Stone, 2014). In fact, some authors supported the idea that it was not until the emergence of the environmentalist movements that changes in the environment were seen as "…logical and even desired consequences of human and social progress…" (Prado, 1996, p.163). What used to be considered as different and isolated aspects, such as soil and water pollution, species extinction or deforestation, started to be seen under the same veil, as symptoms of a greater illness, as edges of what has been called the environmental issue of global concern (Lathinian, 2010). The environmental issue, initially brought to the forefront by environmental groups, nowadays impacts different NGOs, public institutions, international organisations and many social movements and has also promoted certain epistemological and disciplinary changes. In relation to the latter, it is important to highlight the emergence of new scientific disciplines related to the aforementioned topic, such as conservation biology (Sarkar, 2005; Soulé, 1985); the modification of preexisting disciplines, such as the integration of large scales in disciplinary ecology (See di Pasquo, 2013, 2014), and also the orientation of epistemological proposals for the analysis of environmental issues, such as the epistemology of complexity (García, 1994; Morin, 2004). As regards the emergence of new epistemologies and disciplines, the Argentinean author Rolando García highlights that "…studies concerning the environmental issue have made evident, on reiterated occasions, the insufficiency of the traditional scientific methodologies…" (García, 1994, p.2). Another author on complexity, Morin (2004), points out that 'simplifying thinking' – characteristic of traditional science – through an 'elementist', non-relational and deterministic *worldview*, is partially the cause of current environmental problems. Many authors support the idea that modern science stands in virtue of a radical separation between nature and culture and a supposition of inferiority of nature in reference to culture (Merchant, 1999). Since Modernity, the 'natural' has been interpreted from a mechanistic and materialistic perspective that promoted an amoral exploitation of the 'natural world' (Bowler, 1998; Leff, 2007; Núñez, 2011).

It is based on the approaches presented that the environmental issue has been considered a 'starting point' for certain epistemological transformations that aim at rethinking the way of performing science and interpreting the nature-society relationship (Fernández Guerrero, 2010; Leff, 2007; Núñez, 2011). The linkage between science and SEIs has been changing. For example, in ecology – mainly since the mid-20th century – certain authors have proposed to consider this science as an 'objective and neutral' discipline that should only understand patterns and regularities of nature (Peters, 1991), while other authors have assumed this science as the knowledge that constitutes the base for environmental issues resolutions (Callicott, 1989). Other positions have suggested integrating different voices, which cover scientific and non-scientific knowledge, to solve environmental problems (see Berkes, 1998; Berkes and Folke, 2004; Leff, 2007). We will return to this perspective later.

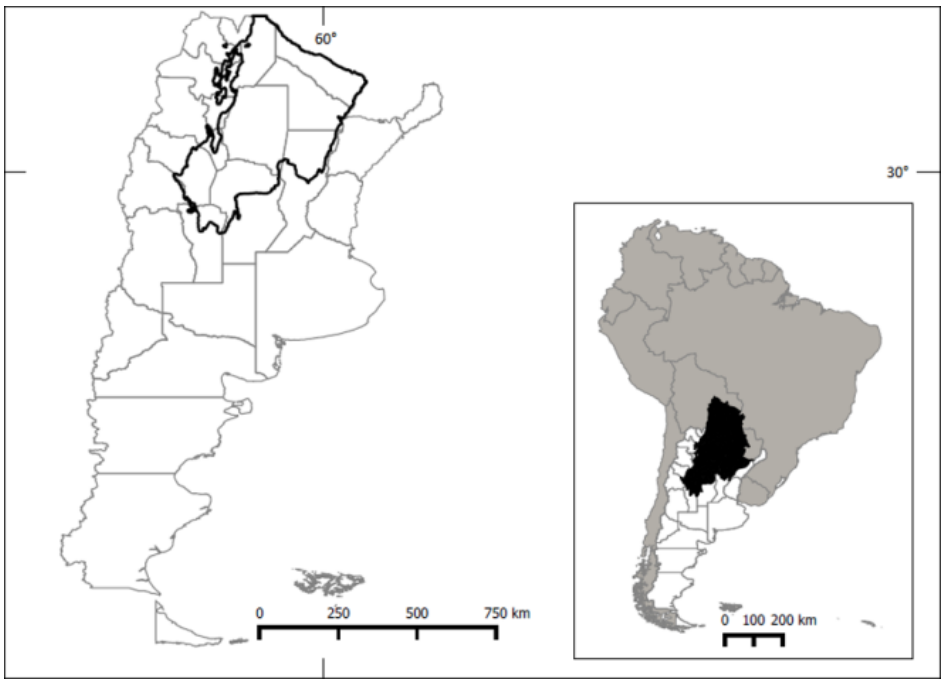
The existing debate is focused on the role of sciences in the environmental issue, and we will try to make a contribution on this question. We will start the analysis through a

particular case study that will allow for reflection on the current linkage between the natural sciences and the environmental issue, and, from there, to picture a desirable horizon for that linkage.

4 Case study: Argentinean Gran Chaco

The 'Gran Chaco' is an ecoregion located in the south-central part of South America (Figure 1), which is characterised by being an immense flat area covered by large extensions of woods of 'quebracho' (*Schinopsis sp.*) alternated with palm trees, '*algarrobos*', '*simbolares*', '*espartillares*' and grasslands. This region includes territories of Argentina (62.19%), Paraguay (25.43%), Bolivia (11.61%) and Brazil (0.77%). In this paper, we will focus on the Argentinean fraction. The 'Gran Chaco' constitutes the largest wooded area of South America, after the Amazon (Bachmann et al., 2007). Because of its high biological diversity, which includes numerous species of plants and animals, the 'Gran Chaco' is considered a hot spot for biodiversity conservation (Maldonado, 2005; TNC et al., 2005). In the social aspect, it is important to highlight that different native tribes inhabit this region, which has made the 'Gran Chaco' to be considered as the most relevant area in Argentina in ethnographic terms (Gordillo, 2006). In this territory, there are also rural areas of the so-called '*criollos*' and some important cities such as San Miguel de Tucumán, Salta City, Santiago del Estero, Formosa City and Resistencia.

Figure 1 Argentinean Gran Chaco (Map of the study area built with shape files provided by the NGO 'ProYungas')



In Latin America, and particularly in Argentina, during the past decades, a policy of economic 'growth' based on an extractive model has deepened, generating numerous socio-environmental consequences (Buch, 2013). One first characterisation of the extractive model describes it as "the activities that remove large volumes of natural resources, [that] are not processed (or processed very little), and are exported" (Gudynas, 2009, p.188). In the 'Gran Chaco', one of the main extractive activities is industrialised agriculture oriented to cropping with genetically modified organisms (GMOs), particularly soy and cotton. The authorisation and entry of transgenic soy into Argentina dates to 1996 and since then different types of crops have been replaced by it. Together with the entry of GMOs to the region, non-cultivated areas or familiar establishments have been integrated for agro-industrial production. In this way, the so-called 'agricultural expansion' is presented as one of the main environmental and social problems of this region (Grau et al., 2005). The progress of the agro-industrial model has had and continues to have as a consequence a strong rate of deforestation of the wooded mass of the Chaco region. From 1997 to 2008, 26% of the wooded surface of the province of Salta (included in the region of study) has been deforested (Paruelo et al., 2011). According to the report of the TLC (2005), 55% of the native woods of the Argentinean Chaco region remains standing while the Paraguayan and Bolivian Chaco region preserves 69% and 86% of the native wooded surface, respectively. This situation puts into relief the complex network of socio-environmental consequences that we will briefly present in this paper. On the one hand, the loss of wooded surface relates directly with the loss of habitat for numerous species and, consequently, a decrease in biodiversity. These woods are also territory of numerous indigenous communities, which are directly affected in various ways: by the decrease in the resources they obtain from the woods, by the loss of habitable space, by the expropriation of their lands, among others. But the transgenic crops not only bring as a consequence the massive deforestation but also use as input numerous types of chemicals that affect different forms of life (López et al., 2012). This scenario has also many health consequences in the rural population as different illnesses related with air, water and soil pollution and others linked to a poor diet, related to territory loss and poverty. At the same time, the production of agro-commodities proposes a certain type of large-scale industrialised agriculture that threatens small farms of the local population. In this direction, Svampa (2012, p.18) points out that "the territories chosen by the capital are considered 'socially drainable' or sacrificeable territories". Thus, this situation implies that many native tribes and '*criollos*' are moved out from their lands (Paruelo et al., 2011). This land clearing results in the migration from rural to peri-urban areas, generating an increase in poverty, sanitary problems, among others.

From this brief description, we can picture the socio-environmental situation on the Argentinean 'Gran Chaco' and characterise certain components, of which some are more related with social aspects – like migrations, increase in poverty, loss of local autonomy – and others with mainly environmental aspects such as the loss of biodiversity, degradation of ecosystems and loss of wooded area. However, all of these components are narrowly linked. That is to say, we face a case study in which political, economic, biological, chemical, technological and ethic dimensions blend and lose their boundaries. Under these conditions, it behoves us to reflect on the role of the natural sciences. For this, we must take into consideration some suppositions on which scientists currently base their work, such as the fragmentation of disciplines and their international character that blurs boundaries between countries (Bourdieu, 2003). On the basis of these

considerations, we will then analyse the differences between an SEI and a scientific problem, using the case of the Gran Chaco as a starting point.

4.1 Scientific problems and socio-environmental issues

To enquire about the disputes and controversies related to the role of natural sciences in the SEIs, it is necessary to characterise and analyse the linkage between these two spheres. To do this, it is important to take into consideration that, traditionally, when SEIs have involved science and technology, the idea that these issues could be resolved through a techno-scientific approach has prevailed, giving the principle of authority to specialised scientists and their technological proposals. In this way, with the objective of approaching from a critical perspective to this situation, which avoids the 'phagocytising' of the SEI in merely scientific problems, it is appropriate to ask ourselves: what is a scientific problem? What type of problems do natural sciences try to resolve? From the perspective of philosophy of sciences, Kuhn's position (1999 [1962]) shows that in every case, scientific problems receive a determination given by a general scheme, by a particular way of analysing the world that the author calls 'paradigm'. In this way, we can recognise that one of the first characteristics of problems in the natural sciences is their theoretical character. This does not mean that practical applications are not (necessarily) contemplated, and, moreover, that its foundation and meaning are found within its own corresponding theoretical frameworks. The second characteristic of scientific problems that we will analyse is related to the degree of generality involved. This generality is expressed, on the one side, through the formulation of 'laws of nature', universal laws that impress on scientific issues a general character given by those laws (e.g., in the case of inheritance laws in biology). On the other hand, generality links with the abstraction of the entities under study and the extrapolation to different entities (e.g., studies related to the functioning of the digestive system use certain biological models in laboratory and the conclusions obtained are applied to other types of organisms). In this way, problems that are based on and solved by theories or universal laws inevitably inherit a general character. Finally, the third aspect related to the problems of natural sciences refers to whether those problems are simple or complex. Generally in natural sciences, we can see that reality is formed by simple entities and that their dynamic could be explained by the mentioned laws of nature (Morin, 2004). This can be evidenced by the reductionist approach of various subdisciplines of biology (Caponi, 2004).

From the different aspects analysed, *the problems of natural sciences* could be characterised as *theoretical, general and simple*.

Concerning the SEIs, we could define them as problems of a community referring to aspects considered fundamental for its existence and welfare, in a specific time and place. In this sense, SEIs are always site-specific and, at the same time, taking into account that the environmental aspect and social context are not dissociable, these issues integrate biological, social, economic, labour and legal aspects, among others. Their characterisation is not given by the theoretical frameworks/scientific paradigms. For instance, it is important to recognise that between 1960 and 1970, meaningful environmental problems were identified and reported by different environmental movements while ecology, insofar as a scientific discipline, still lacked the approaches and tools of analysis that included the complexity thereof (Bowler, 1998; di Pasquo, 2013; Núñez, 2011). So, even though SEIs can be related with environmental sciences, they exceed their explanations and modelling and do not necessarily depend on a

scientific theoretical framework for their delimitation and meaning. This is why we can point out, in a first attempt, that SEIs are *practical* given that they alter the living conditions of different communities. In opposition to the theoretical scientific problems, SEIs are not determined by theoretical frameworks.

The second fundamental characteristic of an SEI is its *site-specificity*, leading to a singular and historical character. Definitely, a certain issue can have various types of relations with global phenomena and processes (e.g., global warming, international economic policies). At the same time, it is bisected by biological, chemical and physical aspects of a general nature. However, beyond those relations and contexts, its nature is necessarily site-specific. Stated in other words, an SEI always escapes the pretended horizon of legality proposed for scientific problems and presents itself in a conjunctural instance, although always maintaining a relationship with larger processes and context.

The third and last aspect of an SEI is its complex nature. Given that in an SEI different social actors and power relations, technologies, biotic and abiotic aspects are involved in a given historic contingency, we can characterise SEIs as complex problems that cannot be approached through the analysis of certain isolated components. That is to say, in the SEIs, cultural, biological, physical and technological aspects converge, are interdependent and cannot be comprehended through fragmentary studies. Consequently, we recognise as the main characteristics of an SEI its *practical*, *singular* and *complex* nature.

Returning to the case study of the Gran Chaco, in the first place, its practical nature can be recognised in complaints of the local population. Evidence of this is, for example, the QOPIWINI settlement, which integrates QOM, Pilagá, Wichí and Nivaclé indigenous communities who made a collective claim for the expropriated territories dating back to 1995, the year in which the governor of the province of Formosa gave away the indigenous territories to multinational enterprises. In 2010, the organisation that nucleates different communities (QOPIWINI) was founded and a settlement was set up in Buenos Aires City, demanding the devolution of territories and reporting state repression. Thus, the SEI presented is not of a theoretical nature, rather it demands a practical resolution. In the demands of the settlement, the linkage between modes of life and the SEI is seen. On the other hand, we can recognise its site-specific character, i.e., its singularity. Here converge certain socio-political particularities, worldviews of different cultures that inhabit the region and a delimitation of a particular historical period linked to the expansion of the agricultural frontier and the introduction of transgenic crops since the end of the 1990s. We can see that this singular nature is related to other global processes and phenomena (such as globalisation and the dynamic of the stock exchange) and with general aspects such as biological or chemical. Finally, its complex nature can be pictured from multiple angles: through the numerous actors and interests involved, such as the State, corporations, indigenous groups or other local population; through the different angles of the problem in which biological, chemical, technological and cultural aspects converge and through the consideration of the interdependence of global and site-specific processes and the relations between the general and singular in this region. Here, the complex historical framework becomes relevant, revealing a problem that began centuries ago regarding the condition of the indigenous communities in the USA.

Having analysed some of the main characteristics of the scientific problems and the SEIs, we could ask how we can relate these two fields that have such different characteristics. Using the case study of the Gran Chaco, we will try to understand the way

in which natural sciences can make partial contributions in the comprehension or resolution of SEIs. In other words, the methods, models and concepts of natural sciences would not be the starting point to approach SEIs but, on the contrary, we will try to understand the specific role of natural sciences as one possible 'arrival point'.

4.2 The role of natural sciences

If we want to analyse the role of natural sciences in this SEI, it is a priority to identify the different social factors involved and their discourses. As a first approach, an enquiry of the different documents and explicit and implicit voices involved with the problem under study can be made, together with the identification of their relationships and hierarchy. We can, at first glance, recognise at least nine types of discourses associated to different actors: the discourse of the natural sciences, of the social sciences, of social movements, of local communities, of enterprises, of the media, international political-economic discourse (e.g., sustainable development), state discourse and legal discourse. Among these different discourses, different relations and legitimising (or delegitimising) forms will appear. It is important to highlight in this analysis that the discourse of the natural sciences is just one among many others. However, the biological dimension of the SEIs tends to be oversized, ignoring the socio-cultural factors of the problem and generating, consequently, limitations for its resolution (Lins Ribeiro, 2007; Núñez, 2011).

One second dimension to take into consideration is the one referred to fields of knowledge that can contribute to the resolution of the problem in question. Again, we find different approximations: the knowledge of natural sciences – and inside this field different disciplines with different theories are included – knowledge of social sciences, of management and of local communities, among others. As we have mentioned, there are numerous discourses and fields of knowledge spanning this issue and those of the natural sciences are just one among them, where the type of participation is far from being obvious. Here, we should recognise, however, two types of approximations linked to the natural sciences. On the one hand, natural sciences gives theoretical explanations and describe different phenomena using certain theoretical frameworks (in a logocentric perspective). On the other hand, natural sciences integrate technological projects for the resolution of different issues. Here, the concept 'techno-science' appears referring to sciences involved in large projects, which aim at serving different interests (economic, military, etc.) (Linares, 2008). In recent decades, the hope for resolution of different issues has been placed in technological solutions. In Argentina, this confidence was expressed, for instance, in the National Plan of Science, Technology and Productive Innovation 'Argentina Innovadora 2020' (Ministerio de Ciencia, Técnica e Innovación Productiva, 2012), the aim of which is:

> "Boosting inclusive and sustainable productive innovation based on the expansion, the advance and the full exploitation of national scientific-technological capacity, thus increasing economic competitiveness and improving the wellbeing of the population within a sustainable development framework."

From this perspective, inclusion and social and environmental welfare are in the hands of scientific development. One of the most controversial examples of this perspective is the case of GMOs, which are proposed as a possible solution to SEIs. However, in the analysed case of the Gran Chaco, this technology is involved in the origin and even is the

main cause of the problem presented. Referring to the terminology proposed by García (1994), we face a case in which science and technology participate in the 'mechanisms of physical and social deterioration'. Given the confidence placed in technology, we should recognise that the techno-scientific responses for the complex problems leave aside many of the key aspects of the problems in question (Linares, 2008; Massarini and Schnek, 2015). For instance, in the case under study, the claims of the indigenous groups exceed the technical aspect and manifest themselves as an ethical–political problem that seeks the recognition and legitimacy of the State. From what is presented earlier, we should recognise that in the SEI considered, many actors with different fields of knowledge exist and that these actors have different relations between them. Then, from a pluralistic perspective, we wonder what the role of the natural sciences is to collaborate with this situation. To answer this question, we have characterised two current approaches that are usually presented by the natural sciences to cope with environmental problems. The first one consists of a science to diagnose damage and the second one of a science for the generation of alternatives. We will delve deeper into these two approaches using the case of the Gran Chaco.

4.3 A science to diagnose damage

One frequent approximation of the natural sciences, particularly of biology, related to environmental issues consists of research and development of tools for the determination of the damage produced by a certain agent. As we have pointed out, one of the problems in the Gran Chaco is poisoning with agro-toxics. In this line, we find research oriented at determining the biological effects of agro-toxics in different organisms. Glyphosate has been one of the main agents associated to the problem linked with transgenic organisms. Related to this, Eric Seralini in France and Andrés Carrasco in Argentina are referents of a science that has denounced the biological effects of GMOs and glyphosate (see Benachour and Séralini, 2009; Gasnier et al., 2009; Paganelli et al., 2010). The controversy around these studies has been presented from within the very same scientific community, claiming methodological errors or lack of evidence (see Hilbeck, 2015). Even though these studies have been the battle flag for many social movements, it is important to highlight that the response of their detractors has been to play the same game. The Argentinean researcher Alfredo Zurita has written a note in which he supports the idea that:

> "It is not correct to say, like I have seen in the press that the recently deceased Dr. Carrasco has 'demonstrated' the 'lethal' effects of glyphosate on human health. His experiments with frogs only allow hypothesising that there 'could be' stronger effects than those currently demonstrated and so the application of glyphosate should for now be made with extreme precaution." (Data Chaco, 2014)

In this direction, it would appear that science should demonstrate, with the evidence of 'good science', the hazardous effects of the chemicals used. The burden of proof is reversed. Avoiding damage is no longer left in the hands of those who alter the environment but in the hands of the scientists who *a posteriori* must prove the hazardous effects of the agrochemicals. This logic omits the precautionary principle, which postulates that:

> "When there is danger of serious or irreversible damage, lack of information or lack of scientific certainty cannot be used as a reason to postpone the adoption of efficacious measures, according to the economic cost, to avoid the degradation of the environment." (General Law on the Environment, 25675, Article 4)

Considering then such principle, we should recognise that "uncertainty in this context does not exonerate [any party] from responsibility; on the contrary, it reinforces it by creating a duty of prudency" (Lascoumes, 1997, p.131). Currently, given the work on effects of glyphosate and other poisons, we would be in condition to postulate the necessity of the application of the precautionary principle that accounts for the knowledge and claims originated around those substances.

Even though in Argentina, and with the figure of Andrés Carrasco, the approach of a science for diagnosis has been an element recovered by environmental movements, we should recognise that the diagnosis of damage can only be applied once the damage has been made. That is to say, late. On the other hand, the scientific evidence is presented in a superior hierarchical level compared with the other voices that have been reporting such damage, like those of the local communities. On the basis of this hierarchy of knowledge, battle with the opposite side is performed under the same rules of play: those in which only academic knowledge participates. And even within this hierarchical order, another hierarchy appears where certain disciplines are more important than others. For instance, in relation with GMOs, knowledge of the genetic and molecular biology fields has greater impact than that of the field of ecology (Francese, 2015; Ho, 1998; Hubbard, 2013). However, what both fronts forget is the principle of precaution associated to an ethic of stewardship. In this perspective, the principle of precaution or prevention seeks to safeguard those who *could* be exposed to substances that scientifically corroborated or not are potentially harmful for people and the environment.

4.4 A science for the generation of alternatives

The perspective of a science that proposes solutions for given problems is frequent in the environmental arena. For instance, the models of sustainable development (e.g., models of sustainable fishing or sustainable deforestation) are usually based on ecological models that apply to certain places (see Pauly, 2002). A proposal that has arisen from within the natural sciences and that has had meaningful repercussion is that referring to 'ecosystem services' (Costanza et al., 1997; Fisher et al., 2009; Worm et al., 2006). This term refers to "flows of materials, energy and information from natural capital stocks, which combine with manufactured and human capital services to produce human welfare" (Costanza et al., 1997, p.254). In Gran Chaco, environmental conservation mediated by the notion of ecosystem services has its origin in the project 'GEF 3623: Incentives for the conservation of ecosystem services of global importance', whose aim is the design and assessment of different mechanisms of payment for environmental services (PES) (Kronenberg and Hubacek, 2013; Milder et al., 2010; Scullion, 2011; van de Sand, 2012). This project is starting to be implemented in the Chaco region, where courses, training and surveys are being developed. In reference to this proposal, we must highlight some elements that limit success in the resolution of SEIs. To begin with, it is important to point out the difference between *working* and *resolving*. In many cases, the sustainability models applied are developed being disconnected from the socio-political context. The complexity of the SEI is, in many cases, irreducible to models with finite

variables. In this direction, many models developed do not 'belong' anywhere; they omit cultural diversity and social, political and economic variables of certain regions and territories. So, the extrapolation of these models to the real world – because they are not able to interiorise the complexity of the situation and to include 'non-expert' voices – loses efficacy. They *work* but they do not *resolve*. In this way, many times global solutions are imported – thought of from the 'non-place' – and attempted to be applied in a particular SEI. These solutions generally do not resolve particular problems that take place in a singular site given that they do not consider what the practical problems of the local people are. Limitations are presented when a science with 'Universalist' pretensions suggests alternatives for a specific community. In the case of PES applied to the case study, one of the controversies appears when we consider the different *worldviews* of the local communities. The notion of welfare given by the 'comfort' of goods and services is not at all a universal concept and the logic of appropriation, payment and capitalisation of nature may not find echo in the indigenous communities that inhabit the region. Kusch (2007, p.142) points out that while 'technology [and science] is conditioned by the cultural horizon in which it is produced', many times 'foreign' technologies do not respond to local problems. This author takes the case of a region in Bolivia in which, during a drought, hydraulic pumps were installed to solve water scarcity. The project failed utterly: the Aymara community rejected the hydraulic pumps. The author suggests interpreting the episode through the analysis of the relation between technology and culture. According to Kusch (2007, p.144), 'culture is priority and gives birth to its own technology'. With non-site-specific techno-scientific responses, objects are imported, not techniques. Solutions for foreign problems are imported and they do not consider what he calls 'cultural ecology'. In this sense, cultures produce strategies to live better and the importation of objects and techno-scientific solutions does not respond to this cultural horizon. The challenge lies in thinking of how to articulate modern science with other *worldviews* and idiosyncrasies belonging to the communities of each region. In other words, we should reflect on how to weave a dialogue among different fields of knowledge that integrates different voices, without a pre-established hierarchy that imposes supremacy of scientific knowledge.

5 Conclusions

Given the characteristics of the SEIs, natural sciences could make meaningful contributions in collaboration with other fields of knowledge and voices – not only those specific to the discipline – in a 'dialogue of knowledge' (Leff, 2006, 2007). This dialogue situates science and contextualises it. The dialogue has meaning in a particular circumstance in relation to a specific topic. In this way, going back to the proposal of García, research would be triggered by a particular problem, leaving aside techno-scientific proposals that lack conjuncture and context, which abstract and isolate the problem and impose solutions.

Now, to integrate voices, to face environmental issues, it is necessary to point out that one of the aspects that borders and is intertwined in environmental issues is ethics. What world do we want to inhabit? What social bonds do we want to have? What value do we place on nature? These questions give rise to ethical debates the answers to which may be generated not only in academic spaces but also in many other social groups. Recognising the validity of these questions from within the natural sciences could be an important step

to start articulating sciences with other actors involved in the different environmental issues. However, natural sciences traditionally have been thought of as disconnected from ethical reflection (Heler, 1996; Linares, 2008; Marcuse, 1968). This disconnection was linked with the notions of objectivity and neutrality of scientific knowledge, where 'subjective' values would remain outside the realm of scientific knowledge production and possessing an inferior level of hierarchy (Heler, 1996; Kincaid et al., 2007; Marcuse, 1968; Rodríguez Alcázar, 1997). An example that still remains active is the case of bioethics, which presents itself as a mediator between scientific developments and ethical reflection. This naturalisation of the separation between science and ethics has been questioned and criticised from many fields, mainly history of science, philosophy of science and sociology of science (Chakravartty, 2015; Echeverría, 2003; Heler, 1996; Linares, 2008; Marcuse, 1968; Reiss and Sprenger, 2014). Briefly, such critics consider science as a practice that is socially and historically situated, which establishes complex bonds with different actors and with the productive systems, involving multiple ends and values.

In the context of the environmental issue, a current challenge seems to be the integration of ethical reflection into the core of scientific practice. In this direction, a possible horizon consists in consolidating a science that critically analyses its own fundaments, the application of the products generated and the techno-scientific discourses. Demolishing the separation between science and ethics could be a first step for a site-specific approach to SEIs in which local context, structural problems and social demands around the environmental issue are considered. Through this interiorising, the resolution of SEIs is no longer left in the hands of an abstracted and general science but is presented as a collective effort among the different actors involved.

In conclusion, SEIs arouse challenges to the sciences, to the way they are thought of, situated and built. They make manifestation of the idea that it is crucial to recover the 'for what' of the scientific practice, a 'for what' linked with ideas of welfare and a welfare culturally and politically determined. The challenges are important because the question about the meaning of science enquires as to the underlying socio-politic and techno-scientific context. A context that is oftentimes supportive with a science in which "What is involved is the spread of a new ideology, which undertakes to describe what is happening (and meant) by eliminating the concepts capable of understanding what is happening (and meant)" (Marcuse, 1968, p.195). In this sense, the question about the meaning of science implies the question about the forms of living collectively and the ways in which those forms are decided in debates that do not have a single solution.

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