**The rocky path from policy-relevant science to policy implementation – a case study
from the South American Chaco**

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Abstract

Why does co-produced, policy-relevant, adequately communicated science fail to influence policy implementation? Analysts of the science-policy interface often focus on the societal relevance of the research questions and on the strategies to convey findings to the political sphere. We argue that these conditions are necessary but not sufficient. We analyze a case study from Argentina, the process leading to the Córdoba Provincial Law for the Protection of Native Forests, in the light of two contrasting models of the science-policy interface: the Information Deficit and the Power Dynamics models, and conclude that the second better describes the process. We propose some broad conditions that should influence the likelihood of a piece of scientific knowledge to be incorporated into environmental policy implementation.

Introduction

Controversies on the role of science in society, dating far back [1-5], have now regained momentum in the face of the formidable ecological and sustainability challenges of the 21st century [6-9]. There is a vast and heterogeneous corpus of literature on the science-policy interface, and more specifically on why science cannot find its way into policy more easily [10-18]. There is convergence among authors in pointing that, in order to influence environmental policy implementation, scientific knowledge should (a) address questions and demands identified by the wider community; (b) be framed within an interdisciplinary context; (c) be designed or at least produced in coordination with the users; and (d) be communicated in a way that can be understood and appropriated by them [13,15,19-22]. But sometimes all these conditions are not enough to ensure effective incorporation of scientific findings into environmental policy implementation. The main arguments as to why this happens can be summarized, perhaps simplistically, in two broad categories.

The first one, called “Information Deficit Model” (also known as “Deficit Model” or “Science Deficit Model”, it is probably the most popular approach among scientists [23-26]. It proposes that the reason for the poor translation of scientific findings into policy implementation is the lack of public understanding of science. The science-policy interface

is seen as a two-player game where scientists have to produce and deliver sound scientific knowledge to policy makers who, in turn, will produce appropriate policies. The model follows a linear and unidirectional trajectory from the identification of relevant research questions by scientists to the adoption of recommendations based on its results, in the form of favourable changes in policy. The public is assumed to be “deficient”, in the sense that their mistrust in scientific contributions is attributed to their ignorance of the underpinning science [24]. The lack of impact of science on policy is usually seen as scientists’ failure to address relevant research questions and/or properly convey the message to politicians, or as the incapacity of policy makers to “read” the scientific message in an appropriate manner. According to the critical view of Lawton [23], this model assumes that, were policy makers more adequately briefed with relevant, policy-oriented scientific findings, “correct” policies will follow. In other words, it is basically a technical-communicational problem.

The second category or arguments, called “Power Dynamics Model”, conceives the science-policy interface as a multidirectional and iterative process where power relationships play a critical role. Keeley and Scoones [10] suggest that policy making and implementation consist of a broad course of action where many actors and types of knowledge are involved and where decisions and actions evolve iteratively over time, rather than linearly. Instead of been the instrumental execution of rational decisions, it is an inherently political process, in which scientific knowledge is only one element. This model identifies four major interrelated components [10,11]:

a) *Discourses and narratives*: What is the dominant ‘policy narrative’? How is it framed through science, research, or other types of knowledge? What are the alternative narratives and how are they grounded? Narratives are socially constructed, developed, and defended storylines, which do not necessarily need to be based on sound empirical knowledge to be considered legitimate. Policy narratives intend to show in which way policy should proceed and are part of the political arena where ideologies and interests are ever conflicting and negotiated upon [27]. Different narratives are not equally important or compelling, or count with similar levels of approval or legitimacy. Issues of power, value, political interests, types of knowledge and conjunctural aspects make some of them more appealing than others. When they consolidate, they become “common sense” and are normalized by institutions, interest groups and governments. If hegemonic, they become part of people’s everyday practices and may be reinforced through time.

b) *Actors and networks*: Who is involved and how they are connected? Which are the main alliances and disputes among social actors? How social networks evolve along time?

c) *Politics and interests*: What are the prevailing power dynamics and power relationships? What are the power trajectories of actors and networks advocating for different policies? Policies are frequently seen as objective, value-free, based on the results of the best

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4 105 available knowledge, and responding to a wider societal interest. However, they are often
5 106 the result of the interests of particular groups.
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8 108 d) *Policy spaces*: To what extent are policy makers restricted in their decision-making by
9 109 forces such as the power of a dominant actor network or dominant narratives? Within this
10 110 context, “moments of policy space” may emerge allowing alternative perspectives to
11 111 challenge dominant discourses and political positions.
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15 113 For this model, the process involves not just two main actors, but a whole network of them,
16 114 with different trajectories and interests, and representing different alliances and conflicts.
17 115 Scientific knowledge is just one of the various factors that influence policy in the context of
18 116 the socio-economic disputes and political struggles that take place in society [10,28].
19 117 Rather than being a technical, rational and instrumental process, environmental policy
20 118 implementation is eminently a political process.
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24 120 Drawing upon a case study, here we analyze the science-policy interface and discuss why
25 121 interdisciplinary, policy-relevant, co-produced scientific knowledge fails to influence
26 122 policy making. We focus on the discussion of a provincial law aiming at protecting the
27 123 native forests of the Gran Chaco Region in the Province of Córdoba (Argentina). We
28 124 conclude that the Power Dynamics Model best explains the failure of policy-relevant
29 125 science to influence policy implementation in our case study. More generally, we suggest
30 126 that this model provides useful insight into the role of scientists in environmental policy
31 127 implementation.
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35 130 **A case study - forest protection in the Gran Chaco**

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37 131 In Argentina, Chaco forests are threatened by the rapid expansion of industrial agriculture,
38 132 in particular intensive annual-crop cultivation and semi-intensive cattle ranching (Box 1).
39 133 In order to regulate this land use change process, in 2007 the Argentine National Parliament
40 134 passed a law (Law 26331)¹ aimed at protecting the remaining native forests in the country,
41 135 as well as the livelihoods of campesinos and indigenous peoples traditionally making a
42 136 living from them. It defines three main conservation categories (red, yellow and green) for
43 137 areas with very high, intermediate, and low conservation value, respectively, and prescribes
44 138 the activities allowed in each category. It explicitly promotes the restoration, conservation,
45 139 and sustainable use of native forests, as well as protecting the ecosystem services that they
46 140 provide to society. This law is a general framework from which each province is expected
47 141 to produce its own law for following a strict protocol concerning procedural as well as
48 142 technical aspects. Specifically, each of the provincial laws should be the product of a

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¹ Full text of the Law 26331 available from <http://infoleg.mecon.gov.ar/infolegInternet/anexos/135000-139999/136125/norma.htm>

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4 143 participatory process involving a wide spectrum of social actors, whose representatives
5 144 should meet in an *ad-hoc* commission (Comisión para el Ordenamiento Territorial del
6 145 Bosque Nativo, or COTBN). It also mandates a series of regional public hearings open to
7 146 all citizens.
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11 148 The government of Córdoba Province appointed its Commission in 2009 in order to discuss
12 149 its provincial law. The participants, coming from a number of organizations, soon
13 150 converged into two interest networks of social actors: the pro-environment network (PEN),
14 151 and the pro-agribusiness network (PAN). They had contrasting views about what to do
15 152 with the remaining forests, how to approach agriculture and -ultimately- what model of
16 153 development to follow (see next section, in particular Table 1). The PEN gathered different
17 154 social actors and individuals sharing broadly similar ecological and social interest but with
18 155 heterogeneous degree of experience in the political arena, and very limited experience in
19 156 working together. In contrast, the PAN was a group that had been working together for
20 157 decades and had extensive experience in influencing policy-making. The economic and
21 158 political interests and visions of these groups were differentially reflected in the Provincial
22 159 Parliament: the PEN position was supported by a minority of legislators, while that of PAN
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33 163 Soon after the Commission was formed internal disputes arose and most PAN
34 164 representatives walked away claiming that the Commission was controlled by
35 165 environmental fundamentalists [29]. The Commission continued operating, this time with a
36 166 clear PEN majority. The Provincial Parliament opened a discussion space coordinated by a
37 167 ruling party legislator, in which the Commission met periodically with the ecology working
38 168 group of the Parliament in order to analyze different proposals.
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42 170 A number of natural and social scientists offered their research findings and expertise to the
43 171 Commission, with different degrees of involvement at various stages of the process,
44 172 contributing to the PEN or PAN arguments. Some of these scientists –ecologists,
45 173 geographers, rural sociologists, agronomists, economists, lawyers, medics– provided the
46 174 technical foundation to the bill that the Commission was charged to submit to the
47 175 Provincial Parliament. Some other researchers –agronomists, economists, lawyers–
48 176 provided technical support to the PAN’s position outside the formal work of the
49 177 Commission. The two national public universities of Córdoba Province (Universidad
50 178 Nacional de Córdoba and Universidad Nacional de Río Cuarto) officially supported the
51 179 PEN position and the Commission’s bill.
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58 181 The PAN’s position was that native vegetation other than the best preserved forests was
59 182 agronomically not productive enough, because the native herbaceous layer does not provide
60 183 enough forage, and the closed shrub layer hinders cattle access. The proposed management
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actions were (a) the partial or total removal of the woody vegetation using a roller chopper , in order to release resources (mostly light) for the herbaceous layer, and facilitate livestock mobility through it; and (b) the sowing of exotic high-yield pastures such as *Cenchrus ciliaris* and *Panicum maximum* to boost cattle carrying capacity [30-32] .

Our interdisciplinary research team was invited to participate in the public hearings and in the meeting space between the Commission and the Provincial Parliament, on the basis of what was explicitly considered relevant research findings. We had developed a novel interdisciplinary conceptual framework and methods focusing on the links between biodiversity, ecosystem services, social heterogeneity and land use change [33]. Key stakeholders actively participated in the research. Our findings, presented in detail in Ref. [34] and summarized in Box 1, showed how different social actors perceived, valued and appropriated ecosystem services and how they associated them to major ecosystem types in the Chaco region. A clear picture emerged in terms of the number and quality of ecosystem services provided by different ecosystem types and their importance to stakeholders. This, in convergence with the findings by several other research groups working inside and outside the Commission, had implications for the conservation value –and thus the need to protect or sustainably manage– different ecosystem types in the context of the new Provincial Law. The old-growth lowland Chaco forest was highly valued by all sectors of society (Box 1); in addition it now represents a minuscule proportion of the area of the Province [35-37], mostly under governmental ownership and/or protection. Therefore there was no major disagreement over granting them the maximum protection status contemplated by the National Law. The focus of the dispute between PEN and PAN were the secondary forests and species-rich shrublands. These are the most extended ecosystem types in the region [34,37,38], and are mostly in private hands [39]. Critically, they provide key ecosystem services underpinning campesinos' livelihood strategies, as well as being valued by other rural and urban social actors as sources of a wide range of regulating, provisioning and cultural ecosystem services [34,40]. There is also evidence of their capacity to regenerate, at least to some degree, under appropriate management [38,41-43]. In addition, the expansion of modern agribusiness generates stark conflicts between the two ways of farming often resulting in campesinos put out of business and forced to emigrate [39,44,45]. Therefore, if no legislation prevented the expansion of industrial agriculture over Chaco native ecosystems, there would be significant negative consequences for ecological integrity and for ecosystem services valued by a range of social actors, as well as the loss of campesinos' livelihoods and their likely expulsion from the land. On the other hand, for the few members of the PAN who continued participating in the discussions, these ecosystem types symbolize ecological degradation and social backwardness [44], which modern agribusiness has the capacity to replace with more productive farming systems, that could fuel local and regional economies [46], including better social services

in cities and towns. Both positions were clearly communicated to the wider public and well covered by the press.²

Two bills reached the Provincial Parliament between June and July 2010. One was produced by the Commission following the official process described above, as prescribed by National Law 26331, and it was never debated in Parliament. It was instead replaced by another bill, representing the PAN interests, less than 24 hours in advance of the session, and was debated and passed on 10 August 2010 by 52 votes against 12³. As well as being in stark contradiction with state-of-the-art ecological and environmental thinking and empirical evidence in the field, the new Provincial Law 9814/2010⁴ did not follow the participatory process mandated by the National Law [29] and favored one economically powerful social group over all others stakeholder groups involved. The new legislation allows the conversion of the complex mosaic of ecosystems present in the region into industrial agriculture, provided a certain administrative process is followed. After the approval, an action for protection of constitutional rights was presented to the Supreme Court of Justice by Universidad Nacional de Río Cuarto on behalf of PEN, and was dismissed on formal grounds. After this political defeat, the PEN lost momentum and agency capacity and stopped generating actions as a group.

The Provincial Law process in the light of two models of the science-policy interface

Can the two models described in the introduction shed light on the process of discussion and passing of the Córdoba Provincial Law for the Protection of Native Forests? According to the Information Deficit Model, the scientific knowledge produced -which “ticked all the boxes”, including availability to policy makers in an appropriate and timely

² Sandra Díaz – La Voz del Interior – 30 March 2010

<http://www.lavoz.com.ar/content/los-fachinales-conservan-el-60-del-carbono-de-cordoba>

COTBN – La Voz del Interior – 27 July 2010

<http://www.lavoz.com.ar/ciudadanos/se-movizaron-para-exigir-la-sancion-de-la-ley-de-bosques>

La Voz del Interior – 21 July 2010

<http://www.lavoz.com.ar/ciudadanos/otra-vez-hay-riesgo-de-que-no-se-apruebe-la-ley-de-bosques-0>

McHardy (President of Sociedad Rural Argentina –Jesús María, Province of Córdoba in the newspaper La Mañana de Córdoba –12 April 2010). Sociedad Rural Argentina is an association of large-scale farmers and ranchers, founded in 1868.

http://www.lmcordoba.com.ar/nota/9684_ley-de-bosques-fuertes-criticas-del-campo-entidades-aseguran-no-haber-sido-escuchadas

³ At that moment the two main political parties (Unión por Córdoba and Unión Cívica Radical) supported PAN’s interests and together controlled 48 out of the 70 parliament seats. The third political force (Frente Cívico y Social) had 11 legislators of which six voted in favour of PAN’s position and five in favour of the PEN’s. The remaining 11 legislators, belonging to 10 minority political forces, were mostly aligned with PEN’s bill (seven votes).

⁴ Full text of the Law 9814/2010 available from

<http://aplicaciones.ambiente.gob.ar/archivos/web/OrdTerrBN/file/leyes%20prov/C%C3%B3rdoba%20-%20Ley%20N%C2%BA%209814.pdf>

manner, effective communication to, and appropriation by the public- should have been effectively incorporated into policy. Therefore, this model does not appear to illuminate the process or offer obvious ways to improve action in the future.

In order to analyse the process from the perspective of the Power Dynamics Model, in which scientific input is just one of the elements to be considered in a complex social-political interplay, we dissected the process using the four categories proposed by Ref. [10]: actors and networks, discourse and narratives, politics and interests, and policy spaces (Table 1). It is clear from the table that what was at stake went well beyond environmental issues. Two networks of social actors clashed, representing contrasting narratives, political trajectories and interests. Environmental groups allied with campesinos organizations, despite representing a wider section of society and having presented a project that was procedurally more appropriate and with a narrative based on wider scientific evidence, failed to impose their position. Agribusiness farmers allied with agroindustry and conservative political parties imposed their interests over the mandate of a pre-existing national law. This expresses a historical power alliance between economic and political powers that uses the institutional framework of the State in their own benefit, disregarding wider environmental and social costs [29]. Power struggles between similar networks, resulting in similar outcomes, have been observed in the case of the laws for the protection of native forests introduced by other provinces [47-50]. The active involvement of a wide range of social actors and networks, including major scientific organizations widely respected by society at large, had minimum influence in the Provincial Law. Power asymmetries –based on historical trajectories as well as on present policy spaces– were simply too large to allow the participatory process to have a strong imprint on policy implementation [29]. The passing of the Córdoba Provincial Law for the Protection of Native Forests is therefore well explained by the Power Dynamics Model: relevant social-ecological science failed to be incorporated into environmental policy implementation because the latter is not simply “information-limited”. Rather, it represents the net outcome of a much wider interplay of socio-political factors.

Conclusions and wider implications

The case study shows the limitations of scientific knowledge to effectively influence environmental policy implementation. This is not a “delivery problem” where the scientific findings fail to reach the appropriate policy maker, nor is a “communication/translation problem” where the message is not graspable by target audiences. Rather, policy-making is a highly contested, non-linear and multi-sectoral field where the interplay of institutions, subjectivities, values, interests, power relationships, as well as knowledge, plays a role; science is just one element in this wider framework. Therefore, the expectation of smooth unidirectional “research lab-policy implementation-positive change” is arguably narrow-

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4 288 minded as well as unrealistic. This might present a discouraging picture to some
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6 289 researchers interested in influencing the environmental science-policy interface. If policy
7 290 implementation is the result of a much wider and intricate societal dynamics, and the
8 291 outcome ultimately depends on sheer balance of power, what would then be the role of
9 292 scientific knowledge in the process?
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12 294 Far from denying the importance of science in environmental policy, our work suggests that
13 295 its role is crucial, but things are considerably more complicated than “just” doing relevant
14 296 science in frequent consultation with stakeholders and making findings available in a well-
15 297 packaged form. While scientific production requires only following the internal rules of
16 298 good practice, engaging in policy implementation unavoidably involves additional rules
17 299 and considerations [10,13,15,23].
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22 301 Is it possible to anticipate how likely is a piece of scientific knowledge to be incorporated
23 302 into environmental policy implementation? Using the categories of analysis of the Power
24 303 Dynamics Model, and on the basis of the present case study and other cases in point, below
25 304 we propose four broad conditions to consider in anticipating successful incorporation: the
26 305 sectors of society that are likely to benefit or lose, the ability to convey and communicate
27 306 compelling narratives, the integration with wider social-actor networks, and the emergence
28 307 of socio-political windows of opportunity. In all cases, the scientific finding is assumed
29 308 (equally) internally solid, directly relevant to the environmental issue at hand, and available
30 309 in accessible format to the stakeholders involved.
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36 311 a) **Prospective winners and losers** (pertaining politics and interests according to the Power
37 312 Dynamics Model categories). *Scientific knowledge is more likely to be incorporated into*
38 313 *policy implementation when it aligns with the interests of the sectors that concentrate the*
39 314 *larger shares of political power in society, either on their own or through alliances.* For
40 315 example, in our case study, social-ecological scientific recommendations about Chaco
41 316 forests antagonized the economic interests of sectors with high political power. Other
42 317 recommendations, such as municipal regulations to sort and recycle household waste in the
43 318 province, have been implemented and adopted more easily.
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49 320 b) **Compelling storylines** (discourses and narratives). *Scientific findings that are*
50 321 *encapsulated in compelling, widely-communicated storylines, and are well understood and*
51 322 *appropriated by society, are more likely to be integrated into policy.* Policy narratives
52 323 simplify reality by offering straightforward explanations of what the problem is, what the
53 324 solution should be, and which would be the likely consequences of not doing what needs to
54 325 be done. How much social support can be rallied behind a narrative depends on its internal
55 326 consistency, but also on external factors, such as resonance with cultural tradition,
56 327 alignment with the dominant “common sense” discourse, and even fashion and lifestyle
57 328 trends. The dominance of any narrative, however strong, is not permanent, and its
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legitimacy is eventually contested. Scientists in association with other social actors can help developing consistent narratives backed by state-of-the-art interdisciplinary evidence. They can also unveil weaknesses or contradictions in narratives that are not based on sound or updated scientific knowledge. For instance, in relation to our case study, prevailing narratives have turned into common sense the idea that the replacement of native forests by industrial agriculture will lead to development and well-being for society as a whole. The work of scientists (e.g. Refs.[35-39,51-56]) has supported with empirical evidence an alternative narrative in which native forests provide multiple societal benefits, and have questioned the net society-wide wellbeing outcome of industrial agriculture (Box 1, Table 1). Compelling narratives are inextricably linked to communication strategies. Effective communication is indispensable -although, as argued earlier, not sufficient- for science to influence policy. Available means of communication include interviews, documentary and fictional pieces in the mass media, social networking websites, blogs, brochures, public events, artistic performances and exhibitions, and meetings with policy-makers. There is a wealth of information and examples coming from communication and education sciences, as well as from the advertising industry, on how to best convey a given message to different audiences. As a general rule, storylines that are short, clearly reasoned, attractively presented, surprising, and relate to the experience of the audience are more likely to be adopted.

c) **Seating at the table** (actors and networks). *Scientific knowledge is more likely to be incorporated into policy implementation when it has been appropriated by, and is well integrated into the agenda of a wide range of social actors with active representation in the negotiation process.* Scientists can share their findings with groups of interest such as civil-society and governmental organizations, and thus contribute to integrate their products into their agendas. Such social actors often have more experience on advocacy activities, better knowledge about administrative procedures, and a more fluent communication with the press than researchers. Examples of how scientists can enhance the chances of their products finding their ways into policy implementation include carrying out on-demand primary research or assessments of existing evidence, producing timely policy briefs on issues considered strategic by these stakeholders, and getting actively involved in scientific advisory panels with enough agency capacity.

d) **Windows of opportunity** (policy spaces). *Scientific knowledge that can timely contribute to create or take advantage of social-political windows of opportunity should have higher chances to be incorporated into policy implementation.* Policy making is often, but not always, ruled by dominant narratives, economic and political structures, or by the interests of the most powerful players. Power balance and social actor conflicts and alliances are constantly being renegotiated and recreated. Unexpected turns can occur, brought about by conjunctural factors, shifts in relative power, new alliances, or the interests of powerful individuals, allowing the emergence of new, more favorable, policy

spaces [10]. These moments of favorable policy space allow alternative narratives to gain momentum. For example, in the process leading to the Córdoba Provincial Law the Pro-Environment Network were clearly defeated. However, the National Law 26331 mandates the re-discussion of provincial laws every five years in order to update conservation priorities. The research team that carried out the study of Box 1 is also involved in this new stage opened by the provincial government in 2014, with representation in the Native Woodlands Executive Unit (Unidad Ejecutora de Bosques Nativos) recently appointed by the Ministry for Water, Environment and Public Services. Despite the fact that main power relationships are similar to those observed during the discussion of the Provincial Law of 2010, the conjuncture is different. There is growing societal concern about the effects of the expansion of industrial agriculture on human health as a result of agrochemicals associated to industrial agriculture, some of which had resulted in court rulings and new governmental regulations [39,57-60].⁵ There is also increasing awareness of anthropogenic climate change and the importance of forests in mitigation and adaptation strategies, triggered by international factors - such as the release of the latest IPCC report [61] and the recent Pope's Encyclical Letter *Laudato Si'*, as well as by local events, such as seasonal water shortages and unusual weather patterns followed by floods⁶. If the preparatory and parliamentary processes are carried out as scheduled, this new moment of policy space might increase the chances of the next version of the Córdoba Provincial Law for the Protection of Native Forests to incorporate relevant social-ecological scientific knowledge and provide more effective protection of native Chaco forests and their societal benefits.

These conditions are presented as working hypotheses, rather than recommendations, and a discussion of their relative relevance in different societies around the world is beyond the scope of this article. Failure of a piece of scientific knowledge to meet these criteria for success should be taken as a way to anticipate difficulties and target efforts, rather than as discouragement for engagement in the policy-science interface. Indeed, scientific findings with the least expected success in becoming part of policy are sometimes the ones with the highest transformative potential.

⁵ As a result of societal concerns on the negative impacts of industrial agriculture on people's health, several municipalities are forbidding the use of pesticides in 500-1500 m strips around towns. For instance, the ban for the use of pesticides recently approved by the Municipality of Monte Maíz, a rural town located at the heart of the agricultural region of the Province of Córdoba. See

http://www.lmcordoba.com.ar/nota/210010_ediles-aprobaron-crear-una-zona-de-resguardo-ambiental-en-monte-maiz

⁶ *Laudato Si'* is available at http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

For media coverage of recent drought and flood events see: <http://www.lavoz.com.ar/regionales/sierras-chicas-poca-agua-y-mas-protestas>; and <http://www.lavoz.com.ar/ciudadanos/cientificos-de-la-unc-explican-las-causas-de-las-inundaciones-en-sierras-chicas>

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7 **Acknowledgements**
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This article is a contribution of Núcleo DiverSus, supported by Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad Nacional de Córdoba, FONCyT (PICT 554), SECyT (Res. 203/14), PIP 1145-201101-0040, and the Inter-American Institute for Global Change Research (IAI) CRN 2015 and SGP-CRA2015, which were supported by the US National Science Foundation (grants GEO-0452325 and GEO-1138881).

Box 1. Ecological change and socio-ecological conflicts in the Gran Chaco

With about 1.3 million km², the Gran Chaco is the second largest natural biome in Latin America, after the Amazon forests [62]. In the lowlands at its southern extreme, in Argentina, the natural vegetation is an open xerophytic forest dominated by *Aspidosperma quebracho-blanco* and *Prosopis flexuosa*, alternating with patches of scrubland [35,37,38,63]. Historically, it has been occupied by campesinos and aboriginal peoples carrying out a wide range of non-intensive agricultural and hunting and gathering practices, coexisting with large-scale cattle ranches. During the last decades, a combination of technological, economic and political factors, together with a wetter climate, have fuelled the replacement of the natural vegetation by annual crops, particularly soy, and semi-intensive cattle ranching [35,36,43,54,64]. As a result of these accelerated land use changes, a series of deep social transformations and consequent social and ecological conflicts have emerged among different social actors [39,53,55].

Drawing upon the interdisciplinary conceptual framework and multi-stakeholder participatory methodology proposed by Díaz *et al.* [33], Cáceres *et al.* [34] studied how different social actors with stakes in the Córdoba Province portion of the Gran Chaco perceived and valued different ecosystem services, and how they associated them with different components of biodiversity, ecological attributes, and ecosystem types. The valuation consisted of a quantitative-qualitative social valuation scoring that circumvented the problems associated with monetary valuation in comparing the perspectives of different social actors with contrasting worldviews and shares of power. Six major ecosystem types and five relevant social actors were identified (columns and rows in Figure 1, respectively). Individual perceptions on ecosystems services were surveyed through 163 individual interviews, and the links between ecosystem services and the ability of ecosystems types to provide them were discussed in seven focus groups with stakeholders.

Although all social actors perceived all ecosystem types as multifunctional, they showed markedly different perceptions of and interests in the ES provided by them. The main research findings are summarized in Fig. 1, where each cell contains the ecosystem services that each social actor associated to each of the six ecosystem types. Subsistence farmers perceived and used nearly all the identified ecosystem services and relied mostly on those ones provided by the most pristine ecosystem types. Extension officers and policy makers also identified many ecosystem services linked with the different ecosystem types. However, large farmers and cattle ranchers recognized a dependency on only a small number of ecosystem services. Therefore, the rapid expansion of agribusiness occurring in this region is a threat to a large number of ecosystem services considered valuable by a wide range of SA. Overall, the most pristine ecosystem types (i.e., primary forests, secondary forests, and species-rich shrublands) were the most valued by social actors. “Fodder trees and shrubs for goats” and “wild fruits for human and animal consumption”

were the most important ecosystem services for subsistence farmers. “Water retention and regulation by soil and vegetation” and “soil fertility for crops and pastures” were prioritized by large farmers; while “fodder grasses and herbs for cattle and horses” and “soil fertility for crops and pastures” were the most important for cattle ranchers. Unlike capitalized farmers, subsistence farmers, have a heavy reliance on the ecosystem services provided by native forests and shrublands. Ecosystem services valued by urban and remote societies such as “climate regulation for humans and domestic animals”, “carbon sequestration”, and “water retention and regulation by soil and vegetation” are also best provided by the most pristine ecosystems. For full description of methods, results and implications, see Ref. [34].

Figure 1. Ecosystem services perceived as important by social actors and their link with the ecosystem types that are able to supply them, based on the results of seven stakeholder focus groups. The number between brackets in the first column represents the total number of ecosystem services perceived by each social actor. Reproduced from Ref. [34].

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Figure

Figure 1

Table 1: A description of two contrasting perspectives involved in the discussion of the Córdoba Provincial Law for the Protection of Native Forests (Law 9814/2010), following the categories suggested by Refs. [11,12]; see the Introduction for explanation of each category.

	Pro-Agribusiness Network	Pro-Environmental Network
Policy narratives	Argentina has an enormous potential for grain production and export. Its modern agriculture is bound to occupy an important role as a global food and energy provider. Pampean lands have been fully put into production long ago, therefore agriculture has to expand over new, non-Pampean regions in order to meet growing global demands. Vast areas in these regions are already degraded and therefore of little value. Radical environmental groups and short-sighted environmental legislation are putting obstacles to agricultural expansion. This is retarding development, and excluding backward sectors of society living in marginal areas from progress and modernization.	Argentina is a socially and environmentally heterogeneous country. Chaco forests provide a wide variety of ecosystem services, which are essential for the livelihoods of campesinos, aboriginal peoples and the rural poor. Urban and remote societies also benefit from some of these ecosystem services. The expansion of industrial agriculture is not the solution but part of the problem of poverty and asymmetric development. Agroecology and other farming approaches that foster sustainability have the ability to fulfill societal demands while preserving the environment.
Actors and networks	Capitalised farmers' associations, agroindustry, scientists backing agribusiness, ruling political party and other conservative legislators. Alliance with deep historical roots between agribusiness interests and the conservative provincial government and other conservative parties. High lobbying power.	Campesinos' organizations, grassroots groups and organizations, NGOs, social and environmental scientists, left-wing and centre-left legislators. Network mostly newly built to participate in the discussion of the Provincial Law. Low lobbying capacity.
Politics and interests	National and international interests linked to the production, commercialization, industrial manufacture, and financing of agricultural commodities. They promote policies that foster economic freedom and relax environmental regulations and safeguards.	Provincial and national interests sided with environmental groups and grassroots organizations defending ecological integrity and approaches to farming that do not jeopardize the sources of income of less-advantaged rural social actors. They advocate for policies compatible with a more equitable access to ecosystem services and a more ecologically sustainable and socially inclusive path to development. They promote strong social and health safeguards, Some of them promote strong environmental and biodiversity-conservation regulations.
Policy spaces	(a) International markets show a steady demand for agricultural commodities produced by Argentina; (b) Argentina's 2001 economic crisis and external debt require the hard currency that	(a) There is a growing concern about the negative impacts of industrial agriculture on people's health; and (b) recent extreme-weather events (i.e., rains well above average, followed by floods)

commodities can generate.

have produced extensive damages in the Province of Córdoba and have raised people's awareness about the buffering effects of native forests.