Knowledge Dialogue to Attain Global Scientific Excellence and Broader Social Relevance

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To achieve a global brain circulation, *many Latin American countries have incentivized training abroad and publishing in high impact factor journals. Such internationalization strategies are valuable, but we argue that a* knowledge dialogue *is a better model for global science to overcome North–South disparities and to achieve both excellence and relevance.* Circulation *implies transmitting into a system, but* dialogue *highlights the individuals involved in the exchange. Although extant policies are theoretically adequate means of achieving brain circulation, broader impact criteria (e.g., integrating research and education, enhancing underrepresented groups' participation, linking science with national goals) would help attain genuine knowledge dialogue. Using the Argentine and Chilean science systems as case studies, particularly regarding environmental inquiry, we found that these principles are not systematically used but that nascent efforts exist. Lessons from home and experiences elsewhere offer guidance to promote and evaluate science in a manner that reconciles the need for global excellence and local socioecological relevance.*

Keywords: broader impacts, research indicators, science policy, science–society, socioecological systems

Recently, global attention was brought to bear on the noteworthy progress many parts of Latin America have experienced in scientific development and the creation of world-class research groups (see the 11 June 2014 special edition of *Nature*). To simultaneously enhance national scientific systems and integrate them into the global scientific community, Latin American and other developing countries, referred to collectively as *the Global South*, have begun (a) to finance graduate and postgraduate training abroad and (b) to reward publication in high impact factor (IF) journals, indexed in the Journal Citation Reports of the Thomson Institute for Scientific Information. Consequently, the suggestion was even made that the historic brain drain—the loss of academic knowledge experts—of scientists from poorer countries to richer ones has transformed into an era of global *brain circulation*—a planetary flow of scientific personnel and research. However, considering that Latin America contributes less than 4% of global scientific production (de Moya-Anegón et al. 2010) led us to question whether these policies actually produce a meaningful influence on the global circulation of scientific ideas.

At the same time, scientific and technological systems throughout the world are pressured to provide greater accountability and are seeking to demonstrate their benefits beyond academia (Holbrook and Frodeman 2011). A debate has ensued, largely within the science and technological studies (STS) literature, regarding the relative merits of bibliometric indicators or the enhancement of the traditional peer-review system. On one hand, straightforward and transparent metrics allow decisionmakers and citizens to easily assess scientific trends; citation indices and journal IF have become particularly popular. On the other hand, these indicators in isolation from their context have been shown to be insufficient on both theoretical and practical grounds (Ren et al. 2002, Weingert 2005, Pasterkamp et al. 2007). Alternatively, the academic peer-review system is criticized as opaque and insular, but systematic efforts around the world are improving it by including nonacademic stakeholders and broader social relevance standards in the evaluation of scientific proposals and research outcomes (Holbrook 2010).

Ultimately, it is incumbent on the entire scientific community, not just STS scholars, to take part in this debate (see Uriarte et al. 2012). The influence of strategies and standards on promoting and evaluating science transcends any single discipline or scale. Particularly, in the Global South, care should be taken to guard against the uniform or uncritical application of globalized policies. Instead,

BioScience 65: 709–717.
doi:10.1093/biosci/biv046
Advance Access publication 6 May 2015

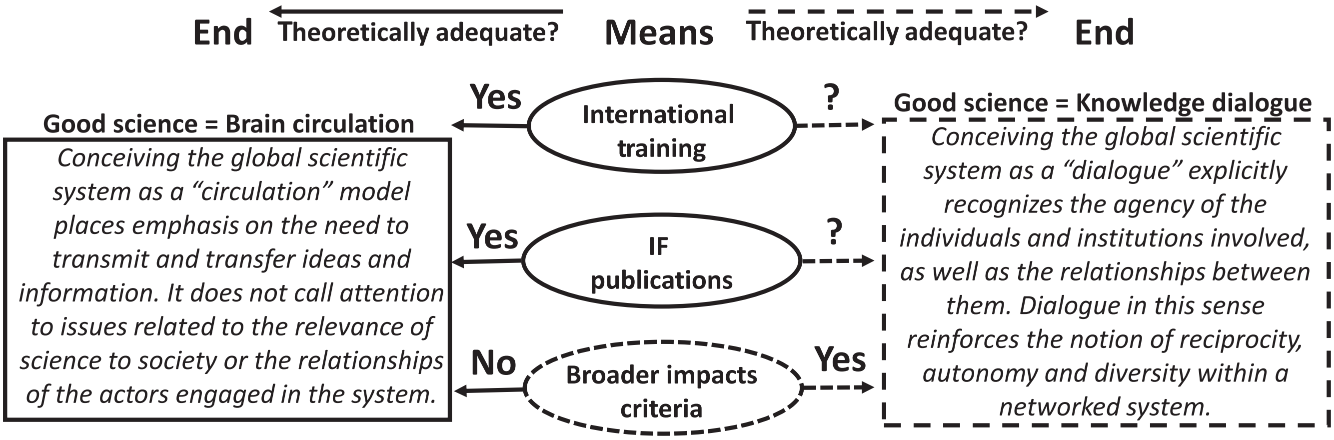

*Figure 1. Determining the theoretical adequacy (*sensu *Holbrook 2010) of science promotion and evaluation standards requires first establishing the end (or goal) and then evaluating the means (or mechanisms) used to achieve it. In this context, all science systems seek to produce good science. However, whether that is viewed as part of a brain-circulation or a knowledge-dialogue model belies distinct expectations and therefore a separate evaluation of the mechanisms to attain them. The solid lines indicate prominent policies highlighted to achieve the global brain-circulation model, whereas the dashed lines are used to represent the means of achieving a system characterized by a global science dialogue with multiple independent actors.*

attention must be given to local and regional contexts, and power relationships must be taken into account, especially in the realm of environmental issues (Biermann 2000). Indeed, science-promotion policies are a way not only to provide accounting for scientific products but also to orient individual or national scientific agendas toward intentional or unintentional outcomes. In this context, we argue that current strategies to create a brain-circulation model of science have become internationalized. Here, we seek to reflect on these policies by drawing on Latin American intellectual traditions that call not just for circulating ideas within the established system but also for achieving an authentic *diálogo de saberes* ("dialogue of knowledges" or "knowledge dialogue") to attain a just and sustainable planet (Leff 2010).

Conceiving the global scientific system as a sort of brain circulation or as a knowledge dialogue embodies two distinct conceptualizations of science. In this article, these two frameworks are evaluated regarding their ends and the necessary means of organizing science to achieve them. Using cases from the Argentine National Scientific and Technical Research Council (CONICET) and the Chilean National Scientific and Technological Research Commission (CONICYT)—particularly, in the realm of environmental inquiry—we assess the status and possibilities of promoting excellent scientific research that is also socioecologically relevant and in dialogue with the rest of the world (Monjeau et al. 2013).

Analytical framework

Two approaches were used to investigate these questions: First, we analyzed the strategies of training abroad and promoting IF publications as ways to create a global brain circulation and compared those with broader impact criteria to generate a knowledge dialogue (figure 1). Then, we reviewed the policies and programs in the Argentine and Chilean national science systems to determine whether broader impacts are formally or inadvertently being addressed in the evaluation or promotion of science.

The theoretical adequacy of the means of achieving desired ends

Holbrook (2010) defined *theoretical adequacy* as "whether the means utilized in a process are in principle well suited to achieving the desired end." This heuristic device allowed us to distinguish the desired end points of particular ways of organizing science and to evaluate these conceptualizations (circulation versus dialogue) as different means–ends models. We assessed the theoretical adequacy of the previously mentioned strategies to achieve these goals, considering that the common goal of all scientific systems is to produce high-quality science (i.e., "good science"). However, the brain-circulation and knowledge-dialogue models connote different expectations (table 1). The former concept expresses a goal of participating in a planetary flow of ideas, in which insertion into the system can be passive or active, but in either case, emphasis is on the act of transmitting. The agency of the participant is not highlighted; rather, the system itself is. In contrast, the latter model gives greater attention to a multiparty interchange or discussion, integrating the participant's local and regional needs and outcomes. Indeed, all definitions of *dialogue* include the conversation or exchange between two or more parties, explicitly recognizing and making visible the role of the actors in the system and the relationships between them. Therefore, we used theoretical adequacy as an analytical tool to consider how

Table 1. The expectations and potential outcomes of the brain-circulation and knowledge-dialogue models.

Shared goals of all "good science" models	Expectations and potential outcomes	
	Brain-circulation model	**Knowledge-dialogue model**
Enhance professional training	+ Rapidly increase scientists *per capita* + Integrate Latin American scientists into a global system + Insert students into dominant scientific cultures (linguistically, socially)	+ Engage the global system from a position of autonomy + Strengthen place-based identity, institutions and approaches – Risks being isolated or insular
Increase quality scientific production	+ Publish rapidly and frequently into established debates + Disseminate scientific information for a global audience (usually in English) + Register patents and intellectual property	+ Ensure national and regional journal strength + Enhance synthesis and review + Facilitate reciprocal translations and intercultural communication venues
Achieve societal relevance	+ Transfer international advances to local benefits – Institutionalize dominant scientific paradigms over local proposals – Decouple individual from systemic incentives – Separate scientists' thoughts and priorities from their local socioecological context	+ Integrate research and education + Enhance participation of underrepresented groups + Link research and national goals + Provide physical infrastructure (e.g., equipment, databases) and platforms (e.g., journals, interinstitutional collaborations, consortia linking research with policy and education)

Note: Although the goal of all scientific systems is to conduct "good science," the way it is conceived and organized has both intentional and inadvertent outcomes ("ends") that can be positive (+) or negative (–). To participate in a global brain-circulation model of science, many Latin American and other countries in the Global South have adopted strategies ("means") that include funding student training abroad and prioritizing publications in high–Journal Citation Reports impact factor journals. Conceiving the science system as a knowledge dialogue, however, makes explicit that national science systems are attempting to meaningfully engage rather than just participate in the flow of ideas that constitute the international debate, implying different expectations from each model.

the measurement and evaluation of these systems should not only include outputs but also the mechanisms used to achieve them.

Training abroad. Scientific training abroad can be formal or informal, including graduate degree programs or postdoctoral fellowships, as well as short exchanges or internships. Chile has intensively implemented this policy. From 2008 to 2013, CONICYT funded 5580 students to attend foreign graduate programs, and more than 90% of scholarship recipients studied in seven developed countries. During the same time period, 4103 doctoral and master's scholarships were awarded for national programs (e.g., BecasChile, CONICYT 2014). In contrast, Argentina's CONICET has prioritized funding national scholarships for graduate study but also provides financing for short stays abroad at the doctoral, postdoctoral, and assistant-scientist levels. Recently, Argentina created a program to fund 1000 scholarships over 4 years to conduct master's degrees, specialization courses, and short-term doctoral-level exchanges abroad.

If Latin America seeks to participate in the global circulation of ideas, the outsourcing approach for scientific training is theoretically adequate: it quickly and efficiently increases the number of scientists per capita in Global South countries. It provides students with high-quality educations and inserts them into globally influential scientific cultural communities. Therefore, this policy not only increases the number of scientists in the Global South but also catalyzes international research networks that facilitate communication and production. For instance, beyond technical and scientific skills, graduates from developed countries gain crucial social and linguistic abilities to participate as more competent transmitters into the established system. All of these aspects of the policy would be appropriate for the brain-circulation model of science by enabling Global South scientists to more seamlessly integrate into the global circulation with as little friction as possible.

However, the theoretical adequacy of outsourcing scientific training to achieve a knowledge dialogue has at least three conceptual and practical deficiencies. First, sending the best students abroad for their educations inadvertently may vitiate national efforts to consolidate quality training programs, thereby weakening the ability of countries to engage with—rather than to respond to—the global circulation (OECD and World Bank 2011). Concomitantly, the policy could institutionalize a generation of Latin American scholars whose formation is based on the dominant scientific paradigms and academic cultures of particular countries, which may not be directly applicable to local or regional conditions (box 1). Finally, beyond the practical and epistemological considerations of developing excellent scientific training programs in the Global South, there is also an ethical dimension of whether it is right for poorer countries to invest their resources in the Global North's consolidated academic programs. Taken together, questions arise of whether this policy, in the absence of broader considerations, is an appropriate means of achieving the desired end of dialogue.

Incentivizing high–impact factor publications. The IF was created for libraries to prioritize the purchase of highly consulted academic journals (Garfield 1955). Although the IF should never be used to evaluate a specific article's performance, this

Box 1. When Southern Hemisphere data do not fit Northern Hemisphere paradigms.

Natural scientists are not commonly taught to question the paradigms they use in research (Williams and Gordon 2014). However, challenging the uncritical adoption of scientific frameworks and concepts can be catalyzed (a) conceptually, by teaching the philosophy of science to make researchers more aware of the approaches they use, or (b) empirically, by obtaining sufficient data to repeatedly test expectations in diverse situations. The case of the Fray Jorge Experimental Site in Chile illustrates the latter.

Since 1989, Chilean and US scientists have studied the ecological drivers affecting biotic communities in the semiarid Fray Jorge Forest National Park. An intensive and extensive research methodology was deployed, with continuous sampling of 20 0.56-hectare fenced plots, where the assemblage of predators and consumers could be experimentally manipulated to determine not only the interactions between them but also their relationship with plants and abiotic variables such as precipitation. These data ultimately allowed ecologists to understand that this biome does not behave as was hypothesized from paradigms developed in the Northern Hemisphere. For example, expectations were based on studies in the Chihuahuan Desert, where biotic variables (e.g., predation) structured communities via top-down processes, but at Fray Jorge, it was discovered that the system shifts to bottom-up effects (e.g., precipitation, plant biomass) and has temporal variability associated with periodic El Niño rain events (Meserve et al. 2003).

As was indicated by Gutiérrez and colleagues (2010), "Whereas we initiated our work on the presumption of a strong overwhelming role of biotic interactions, abiotic factors have been shown to have a strong and often determining role" (p. 88). All of the original lead scientists in this group were from or were trained in the United States, but their perspective changed because of long-term research. Therefore, beyond the scientific data and peer-reviewed publications, these findings were achieved by being embedded in a local context that took time to reveal itself. Crucially, the local University of la Serena simultaneously worked over this period to create graduate programs that not only trained local ecologists but also provided the human and physical resources to perpetuate the program and ultimately link it with the local society via outreach and training programs. The site is also within a national park, and in 2009, it became one of the three founding members of Chile's nascent efforts to create a long-term socioecological research network (Anderson et al. 2010). As such, this example highlights the imperative of achieving research excellence in Latin America by also attending to appropriate infrastructure and institutions, long-term and place-based data, and strong teams that can dialogue with (and not be dominated by) predominant paradigms. Research and the broader context in which it is developed are equally important, and as such, this case also explicitly answers calls to achieve a local to global dialogue of environmental research that comes from the Global South (Parr 2010, Patterson 2010).

indicator expanded to become a nearly universal metric for individuals' academic careers worldwide (Lawrence 2007). The scientific community has increasingly rejected this hegemony (e.g., the 2012 *San Francisco Declaration on Research Assessment* by the American Society of Cell Biology), and within ecology journals, it has been shown that IF inflation even makes year-to-year comparisons difficult (Neff and Olden 2010). However, the IF continues to be promoted, especially for scientific systems seeking to elevate their quality. In Argentina and Chile, the IF-based evaluation and incentive system began to be used in the 1990s. In Chile, universities pay researchers as much as US$4000 per publication (e.g., Diego Portales University 2013) in journals above a certain threshold; monetary rewards are usually half that amount for publications published in the regional periodicals indexed by the Scientific Electronic Library Online. In Argentina, promotion evaluations are based on ranking publications into tiers using scales from IF, Scopus, or similar metrics.

Consequently, the IF incentive strategy pushes scientists to communicate via internationally indexed journals, mostly in English. Although this strategy is a proper means of facilitating the circulation of ideas, it can also inadvertently decrease the diversity and autonomy of national and regional scientific outlets. In essence, journals that are not indexed or have low IF face a negative feedback loop: (a) submission demand decreases, (b) selectivity decreases, (c) readership decreases, and (d) the journal's role decreases. Previously good journals that are part of the history of Latin American science have begun to struggle or become defunct in the globalized scenario dominated by the IF. In the realm of environmental research, Argentina's *Physis*, founded in 1912, closed recently. In Chile, the *Revista Chilena de Historia Natural*, founded in 1897 and one of the oldest natural history journals in Latin America, began to be administered by Springer in 2014. It has now increased its fee per article and requires publication in English. Argentine science policy recognizes these issues and provides some institutional support for a basic core of regional journals considered as part of CONICET evaluations, regardless of indexation (see *www.caicyt.gov.ar*), but these journals are assessed as belonging to a lower tier in professional evaluations. The stronger incentive is clearly to publish on the basis of IF.

At the same time as Latin America's scientists have been pushed toward publishing in international outlets, those same periodicals have become increasingly consolidated. Six private publishing firms from five countries in North America and Europe have acquired more than 5500 of the world's scientific journals, which were previously managed by forty publishers and consortia (Monroe 2007), and in the field of ecology, 62% of the most cited articles are published in just six journals (Ioannidis 2006). Therefore, not only are the diversity and autonomy of scientific outlets threatened, but the sovereignty of scientific information has also been given over to private companies in the Global North. In response, Argentina (as well as Peru) passed legislation on public access of state-funded scientific data via open-access repositories (Argentine Law no. 26,899). In addition, as was noted in the previous section, it is ethically questionable whether the scientific systems of countries from the Global South should be paying fees to Northern Hemisphere publishing enterprises to ostensibly privatize their information without equally strengthening their own national and regional outlets and periodicals.

Nobel Laureate Randy Schekman (in physiology or medicine, 2013) highlighted another dimension in this debate, asserting that an overvaluation of "luxury journals" (i.e., journals with the highest IF) actually harms science's potential contributions to society by focusing a scientist's efforts on excelling individually and for a planetary audience (Schekman 2013). Likewise, we would argue that it does not fulfill the broader goals embodied in a knowledge-dialogue model. Prioritizing the IF as a metric of individual success on an international stage inadvertently discourages scientists from conducting complex, long-term, cooperative endeavors at national and regional levels. For example, recently, a global analysis of ecological publications showed that scientists from the Global South were able to place their articles in higher-IF journals by publishing with colleagues from the Global North (Smith et al. 2014), which is important, but only if it does not come at the expense of regional efforts to understand the dynamics of local socioecological systems or engage in South–South collaborations.

A review of broader impact criteria: Status and possibilities

To determine whether the Argentine and Chilean national science systems are instituting broader relevance considerations that could facilitate a knowledge dialogue, we searched for policies and programs and evaluated them for their relationship with the following five broader impact criteria that have been developed in other parts of the world (Holbrook 2012): (1) integrating research and education, (2) enhancing the participation of underrepresented groups in science, (3) linking research with national goals, (4) developing local research infrastructure, and (5) innovating strategies that embed research in institutional structures for dissemination and application. To facilitate policy recommendations, we organized this assessment around two factors that a knowledge dialogue would require: (1) measuring scientific relevance beyond academic concerns and (2) enhancing the local to regional capacity to address real-world socioecological problems.

Achieving quality, not just quantity; sometimes more isn't better. Argentina and Chile have intimated their desire to reform their scientific funding and evaluation systems beyond traditional academic productivity (i.e., *papers*, which is the word now used in Spanish as well as in English). In both countries, strong initiatives prioritize research related to defined national priorities. For example, social and technological productivity have been emphasized alongside scientific productivity in Argentina's National Science, Technology, and Innovation Plan 2012–2015 (PNCTI) and Chile's Innovation and Competitiveness Agenda 2010–2020 (AIC). The latter of these two, however, is not formally a policy of Chile's CONICYT, and instead, programs in the Ministry of Economy, such as the Millennium Scientific Initiative, have taken a leading role in linking research with social and development outcomes. These planning documents, in turn, have been translated into funding instruments in both science systems that are linked to national priorities. Argentina's CONICET and Ministry of Science, Technology, and Innovation (MINCYT) prioritize "strategic topics" for a portion of research funds and graduate scholarships each year (e.g., in 2014, environment and sustainable development topics included climate change information systems, water resource management, environmental remediation, and recycling). Similarly, Chile's CONICYT has the National Fund for Scientific Development in Priority Areas (FONDAP). Even more explicit, its Basal Financing Program underwrites research centers (4 of 13 include some aspect of environmental research), whose excellence is evaluated not only on the basis of links to national development goals but also on the basis of forming advanced human capital, applying and transferring results to public policy or increasing economic competitiveness, consolidating international cooperation networks, and giving Chilean researchers access to state of the art knowledge related to strategic areas of the country's development.

Recently, Argentina's CONICET announced a process to create new evaluation standards for researchers who are dedicated to technological and social development activities—rather than being dedicated only to basic science—to diversify the definition of being a *researcher*: its approximately 8000 researchers in the national system now include technologists, who work toward applied endeavors with different evaluation metrics (MINCYT 2012). Also, a different type of grant proposal has come out of this process: Researchers applying to a program known as Social and Technological Development Projects must identify specific users of their studies and include those stakeholders in their applications. These efforts represent meaningful efforts to link research with national priorities (criterion 3), to increase the diversity of stakeholders involved in science (criterion 2), and to integrate science with outreach and application (criterion 5), requiring written commitments from users or stakeholders to participate in the study and use the information that is generated (table 2). Chile's CONICYT has a similar applied-research funding mechanism (Fondo de Fomento al Desarrollo Científico y Tecnológico, Programa IDeA) oriented toward solving real-world problems and having economic or social impact.

Regarding other ways of linking science and society, CONICYT's preuniversity education and outreach program, called EXPLORA, stands out. However, an explicit expectation that all science proposals should link research and education (criterion 1) was not found. Similarly, general national

Table 2. Policies and programs from the Argentine and Chilean national science systems evaluated for their relationship with broader-impacts criteria (Holbrook 2012).

Broader Impact Criteria	Argentina	Chile
i. Integrate research and education	• Graduate and postgraduate scholarships to individuals or as part of research grants • Joint scholarships and grants between CONICET and national universities	• Graduate and postgraduate scholarships to individuals or as part of research grants and research centers • EXPLORA (general science education) Program grants, which focuses on preuniversity education and outreach
ii. Enhance participation of underrepresented groups in science	• Inclusion of underrepresented geographic and thematic areas in funding criteria	• Proposals often require estimation of beneficiaries or participants, distinguishing by male, female and indigenous categories
iii. Link research with national goals	• National Science, Technology and Innovation Plan 2012–2015 • Strategic topics funding lines for scholarships and research grants	• Competitiveness and Innovation Agenda 2010–2020 • Basal Financing Program • National Fund for Scientific Development in Priority Areas • Ministry of Economy's Millennium Scientific Initiative
iv. Develop local research infrastructure	• Expressed intention to reform individual-based evaluation to also value group building • Regional Research and Technology Centers in association with national universities	• Regional Centers Funding Program • Nascent efforts to build a long-term ecological research network
v. Innovate strategies to embed research in institutional structures for dissemination and application	• Technological Connection Program • Social and Technological Development Projects • Secretary of Sustainable Development and Environment-led consortia of "Observatories"	• Basal financing of research excellence centers • Scientific and Technological Development Fund • Ministry of Environment's Fund for Environmental Protection • Ministry of Economy's Millennium Scientific Initiative

Note: No systemwide policies were detected, but numerous programs and initiatives exist. Except where noted, these examples are drawn from the formal national science systems (CONICET–MINCYT in Argentina and CONICYT in Chile).

policies exist in both countries to consider some aspects of participant diversity (criterion 2), but greater attention could be paid to not only categories that include ethnicity, gender, sexual orientation, or socioeconomic background but also creating expectations that projects search for innovative ways to overcome barriers to participation rather than tabulating participant gender or ethnicity. Plus, although specific funding mechanisms enhance research infrastructure (criterion 4), we did not find that these standards were generally expected from all scientific proposals, nor did these standards include a more holistic definition of infrastructure outcomes, such as database development or support for the consolidation of local training or field research programs.

All of these examples represent clear achievements in the Argentine and Chilean national science systems to integrate research with national goals (criterion 3) or to link research with outreach and application (criterion 5) (table 2). However, we did not find broader impact policies that were transversal or institutionwide policies. Instead, specific efforts are orienting a portion of national research agendas. Also, these policies mostly emphasized economically derived benefits for the countries' development and used narrow indicators, such as patents. However, such examples are clearly pre requisites for the holistic development of systematic broader impact criteria, which can be learned from experiences elsewhere. Holbrook and Frodeman (2011) noted that the US National Science Foundation made broader impacts a coequal evaluation standard along with intellectual merit but provided great leeway for individual proposals to determine which of the five criteria to address and how. In contrast, the European Commission's Research Framework 7 implemented specific "expected impacts" that all proposals should address and even guided reviewers on how to weigh them. These two cases demonstrate a continuum of how transversal societal relevance criteria can be applied to entire science systems, ranging from flexible to prescriptive approaches.

Enhancing the capacity to address local problems. Broader impact criteria help account for and value other necessary factors required to conduct relevant science, such as building strong local teams and addressing real-world problems for a locality, nation, or region. In this regard, Argentina's CONICET has declared its intention to reform individual-based evaluations, recognizing the "predominance of indicators that consider the researchers' individual trajectories basically from their bibliometric production and the insufficient utilization of criteria that also consider their insertion and performance in working groups" (translated by the authors from MINCYT 2012). However, we found no explanation of how to incorporate or to weigh these multiple criteria, and there is no explicit expectation that social relevance is

Box 2. Achieving excellence and relevance that links Earth's ancient history to Mars.

In 2009, a team of scientists working in the high Andean mountains near the Argentine–Chilean border made a novel scientific discovery: a new location of stromatolites. These rocklike formations are in fact created by microbes, and although their fossils can be found around the world, living forms only exist in rare sites with special conditions, such as high salinity, temperature, or heavy metal concentrations. They are considered relicts of ancient ecosystems, similar to those found on Earth during the Precambrian period and perhaps even similar to the type of life that could potentially exist on Mars. So what is the meaning of such a finding? As project leader María Eugenia Farias recalled to the newspaper *Clarín* (Roman 2011),

> "After the discovery, I had two roads. One was to not tell the community and prepare a grand report to be published in a specialized journal with a high impact. That was the classic path that any scientist would do, but it implied a high cost—in the first place, because it would leave out the fact of the vulnerable state that affected the stromatolites' environment. Also, it implied sending DNA samples abroad, since at that time, we did not have the resources to study them. I chose a different path: First, I told the nearby community what it was all about. The people, including the chief, understood me and became involved in the defense of the place." (translation by the authors)

The path taken by this research team was ostensibly against what the system promoted and rewarded, but today, the Andean Lakes Microbiology Research Laboratory has not only published its findings in diverse national and international journals, but it has also created a cadre of students and technicians to carry on the work. It develops collaborative and coequal relationships with international partners, processing its DNA samples in Argentina—an achievement that took various years of effort. In addition, it has worked with local communities and the national government to protect this unique ecosystem, including the installation of village septic systems, the designation of a provincial protected area, the elaboration of information for tourism, and the training of local citizens. However, when consulted about going outside the national science system to be socially relevant, Farias indicated that, despite the success of her project, there is a need for "policies of funding and long-term support for research that is maintained over time. We already have the first, but the second requires that we know how to put these successful experiences in everyone's agenda" (Bosoer 2012). In this context, the formalization of broader impacts not just as a personal crusade by individual scientists but also as an expectation of all research proposals would be a way to incentivize such actions and make the stromatolites of the high Andes both a case study and an exemplar to be encouraged and repeated throughout the national science systems in Latin America and the world.

required nor a clarification of what that application would entail.

In Chile, there is a nascent effort at teambuilding, the establishment of necessary local infrastructure, and the linking of environmental research with broader societal outcomes via the emergence of a Long-Term Socio-Ecological Research (LTSER) Network (Anderson et al. 2010). As a strategy, LTSER funding and platforms provide much-needed long-term data sets for environmental problems (traditional research excellence) but also facilitate the development of relationships among scientists, the local community, and management agencies (Anderson et al. 2008, 2012). Nonetheless, this approach currently lacks broad representation and institutional implementation in Latin America, and in Chile, it is promoted by a private nongovernmental organization (NGO) with state funds rather than being a formal national science policy. Argentina does not currently participate in this international initiative but has established the concept of long-term *observatories* around the country to monitor and study such issues as desertification and biodiversity, with CONICET being a member of a consortium that includes national universities and the Secretary of Sustainable Development and Environment.

Enhancing our science policies to encompass the local and social context of research would systematically support such initiatives as LTSER-like platforms and reward researchers for dedicating time and effort to create education programs, cooperative initiatives, and study sites that incorporate local socioecological conditions and needs rather than only competing for recognition abroad. Long-term, place-based funding is necessary, but equally important are incentive and evaluation strategies that overcome hegemonic pressures to produce IF publications in a rapid fashion. Far from advocating antiglobalization, we suggest that engaging a global knowledge dialogue will be more productive when countries in the Global South have strong teams, infrastructure, and data that are locally produced but are simultaneously networked with regional and international systems (box 2).

Moving from a brain-circulation model of science to a knowledge-dialogue model

Many Latin American environmental scientists are keen to work for the broader social and policy impacts of their research, but apparently, systemic obstacles often inhibit them from linking their values with scientific actions. For example, invasion biologists in Argentine Patagonia highly value studies related to the phenomenon's social and policy dimensions, but their actual research productivity is biased almost exclusively toward basic ecological questions (Anderson and Valenzuela 2014). Furthermore, although more than 50% of these scientists reported collaborating with environmental managers, teamwork was mostly in the form of consulting rather than in the form of the coproduction of information and results with authorities and policy-makers. Such findings illustrate that, frequently, there is not a problem with the values and priorities of researchers *per se* but rather with the structure of the scientific system itself. Although both Argentina and Chile have various programs seeking to integrate science with society, current policies, the academic culture, institutional structures, or combinations of these factors not only limit researcher involvement in collaborative efforts with managers and other institutions but also penalize research that is combined with outreach, decisionmaking, and education.

However there seems to be agreement about the need to reform our systems, and a great deal has already been advanced. An international seminar of science administrators from throughout Ibero-America in May 2014 explicitly called for the evaluation of both research excellence and relevance (OEI 2014). However, this manifesto did not provide specific recommendations. Instead, the report's evaluation indicators for the region's science only included financial investment in research, the number of scientists and students being employed, and the number of internationally indexed publications being produced. To further illustrate this trend, the 2012 Argentine national assessment of science only included the following indicators of scientific products: the number of students produced in science majors, the number of intellectual property rights submissions, the number of patent applications, and the number of Science Citation Index publications (Arber 2012). Nonetheless, there appears to be a consensus regarding the need for simultaneously attaining quality science and broader societal relevance, but it is equally clear from this analysis that more work is needed to systematize how to determine, promote, and assess relevance and to make these factors transversal criteria in our national science systems.

We suggest that a practical first step is to use Holbrook's (2012) rubric, which synthesizes the types of broader impacts that have been used in scientific systems around the world, to diagnose the current state of broader impacts in extant policies (table 2). Then, more widely applicable standards and expectations for our science systems can be developed in a formal, participatory process of identifying and incorporating these transversally. Emphasis should be put on the process as much as the product to help encompass a greater plurality of values in the planning of scientific research and its subsequent evaluation. This approach would assist Latin American efforts to participate in a global knowledge dialogue by ensuring that there is simultaneous attention to its own needs and an overcoming of power relationships that inadvertently homogenize local knowledge systems and create knowledge monocultures, even within academia itself (de Sousa Santos 2006).

Creating a critical, self-aware, and engaged scientific culture

In an interview after being awarding the Nobel Prize, Laureate Peter Higgs (for physics, in 2013) was quoted as stating that in today's academic climate, he did not think that would get a job given his low productivity (Aitkenhead 2013); Higgs reportedly only published 10 papers after his seminal work on the boson in 1964. Indeed, encouraging publication quantity can lead to the strategy of atomizing scientific novelty to its least publishable unit and can work against the indispensable synthesis of knowledge that is required to solve complex socioecological problems (Fischer et al. 2012). Explicitly incorporating the broader impacts of research into the evaluation of proposals and scientific outcomes is one way to help scientific institutions achieve quality and not just quantity.

But by orienting efforts toward a genuine knowledge dialogue with the global scientific community, Latin American countries will not just uncritically adopt policies such as those highlighted by *Nature*'s evaluation of science on our continent. Instead, reconceptualizing our role in global science would aid our national science systems in building on our own values, cultures, and territorial identity to achieve excellence while confronting our own regional challenges. Scientists would be incentivized—indeed, expected—to also participate in outcomes such as writing school textbooks, collaborating with government agencies, and managing regional editorial outlets. Therefore, new policies and incentives are required, such as those encompassed under the umbrella of broader impacts. Environmental scientists have a particular role to play in this effort, because their success is often not measured by a publication alone but also by the resolution of the environmental problem itself (Meine et al. 2006). Although numerous informal efforts exist to link science and society within the realm of environmental inquiry (e.g., citizen-science programs, observatory networks, governmental environmental agencies, NGOs), integrating broader-impacts criteria into systemwide science evaluation helps turn the collective minds and efforts of thousands of scientists to these issues, validating social outcomes as a formal part of our work.

Rather than focusing on increasing the global brain circulation, we propose that institutions would be better served by innovating and searching for ethical and desirable future science–society scenarios in dialogue, in which the participant is recognized rather than just the participation. The value of global standards and engagement in international networks is clear and unquestioned (e.g., Smith et al. 2014). However, internationalization strategies must not jeopardize localization for relevance. Therefore, we should not be indifferent to these issues and instead address them with equally strong and institutionalized policies that build autonomous and strong scientific systems in and of themselves, regardless of insertion into a wider global system. In that spirit, we recognize the need to publish this article in English and transmit it in a globalized system, but it does not obviate our concomitantly communicating in Spanish and in our own regional outlets, a task of dialogue that we have undertaken with equal commitment.

Acknowledgments

CBA was supported by the PRESS (IIA 1261229) and ECO-Link Projects (GEO 1262148). AM was funded by CONICET and CNPq for a research stay at the Universidade Federal do Rio de Janeiro (PVE 400363/2014-3) and acknowledges colleagues at the Fundación Bariloche. JRR thanks the

Alianza del Pacífico Scholarship and facilities provided for a research stay at Centro de Investigaciones en Ecosistemas at the Universidad Nacional Autónoma de México's Morelia Campus.

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