CHAPTER 10

CHALLENGES AND OPPORTUNITIES FOR BRIDGING THE RESEARCH–IMPLEMENTATION GAP IN ECOLOGICAL SCIENCE AND MANAGEMENT IN BRAZIL

Renata Pardini[1], Pedro L.B. da Rocha[2], Charbel El-Hani[2] and Flavia Pardini[3]

[1]*Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, SP, Brazil*
[2]*Programa de Pós-Graduação em Ecologia e Biomonitoramento, Universidade Federal da Bahia, Salvador, BA, Brazil*
[3]*Página 22, São Paulo, SP, Brazil*

SUMMARY

In this chapter, we argue that Brazil faces the challenge, but also has the opportunity, of producing creative and effective solutions to bridge the research–implementation gap in the effort to solve environmental problems and achieve sustainable development. We discuss this proposition from the perspectives of the uncertainties of ecological knowledge and the general failure in translating such knowledge into powerful management tools. We claim that awareness on both the limits of knowledge and the central role of questioning to learning, science, and conscientious decision making, in conjunction with the creation of collaborative teams gathering students, researchers, and practitioners, represents a fruitful strategy to bridge the research–implementation gap. To exemplify such endeavor, we describe a set of activities and results achieved at the Federal University of Bahia through the Graduate Studies in Ecology and Biomonitoring.

INTRODUCTION

Despite the respect and trust that society as a whole holds in the promise that science can help solve environmental problems, societal and political inaction remains a great obstacle to the resolution of the complex and drastic environmental problems we face today (Groffman *et al.*, 2010). Part of the explanation to this apparent paradox lies in what has been called the research–implementation, research–practice, or knowing–doing gap; that is, the fact that scientific knowledge is usually neither driven by an effort to solve particular real-world problems nor effectively communicated and transferred to society in general and to

Conservation Biology: Voices from the Tropics, First Edition. Navjot S. Sodhi, Luke Gibson, and Peter H. Raven.

decision makers in particular (Knight *et al.*, 2008; Shackleton, Cundill and Knight, 2009; and references therein). This is not restricted to ecological and environmental sciences; it is indeed a widely acknowledged problem hampering the application of scientific knowledge to the needs of society in general (Knight *et al.*, 2008; Shackleton, Cundill and Knight, 2009).

The research-implementation gap might be even more pressing in developing countries such as Brazil than elsewhere. Brazil not only harbors the largest area of tropical forest in the world (Amazonia), but it also holds great biological diversity in this biome and six others in terrestrial and marine environments. Awareness of how valuable such assets are for present and future generations is growing, and environmental issues, as well as their connections to society and the economy, have been increasingly highlighted in the Brazilian media. Presidential elections in 2010 put environmental matters at the center of the political agenda: Marina Silva, a former environment minister, won 20% of the votes in the first round with an electoral platform based on sustainability issues. Following decades of investments in higher education and research, research institutes, government bodies, and non-governmental organizations are better structured and increasingly well qualified to deal with environmental challenges. There is, however, still much to do. Poverty dominates in several regions, democracy is still considered "flawed" (Economist Intelligence Unit, 2010), and powerful lobbies continue to challenge environmental legislation in Congress (e.g., Metzger *et al.*, 2010). Because of its natural wealth, its young and growing science, and the deep social challenges it faces, Brazil is well positioned to reap the opportunities that can arise from bridging the research-implementation gap in the pursuit of sustainable development.

Here we explore the idea that some of the greatest challenges and opportunities for nature conservation and sustainable development in Brazil lie in the development of an applied ecological science of high quality and effectiveness. We envision this development taking place in close association with graduate education. By high quality, we mean a science that, by recognizing the limits of our knowledge concerning our complex ecological systems, stimulates questioning and innovation and develops protocols to deal with the problems faced by decision makers: urgency, limited resources, and uncertainty. A science that can provide a sound base for decision making in the face of limited knowledge and uncertainty. By high effectiveness, we mean a science that flourishes by taking into account and nourishing the horizontal interaction and mutual learning between academic and practical knowledge, as well as between the scientific community and decision-making institutions. Although other factors also contribute to the societal and political inaction regarding environmental issues, we believe that the ways scientific knowledge is built and disseminated is a major concern, and one that scientists are in position to confront.

CHALLENGES AND OPPORTUNITIES

Given the ongoing expansion of its agricultural and urban frontiers, it is urgent that Brazil develops a high-quality and effective ecological science. The challenge is to do so in the face of the current paucity of knowledge on the structure, function, and resilience of tropical ecosystems, and of the dissociation of such knowledge from management practices. Nevertheless, the combination of rich biodiversity with young and growing science and scientific institutions can also be viewed as an opportunity.

The quality of ecological science: Limits of knowledge and scientific uncertainty

The application of ecological knowledge to environmental management practices in Brazil is indeed a particularly good example of the importance of recognizing the limits of knowledge and thus acting with prudence (Sousa Santos, 2007; Vitek and Jackson, 2008), as well as of dealing with uncertainty and being aware of surprises (e.g., Peterson, Cumming and Carpenter, 2003). This is because our tropical ecosystems are not only complex – systems for which predictions and forecasts are unusually difficult given the large number of drivers, non-linear relationships and interactions among them, contingency on the particular context, and interactions at different temporal and spatial scales (Carpenter, 2002) – but also very poorly known. Basic information such as which or how many species are present is often limited and is generally biased toward particular groups of organisms (Lewinsohn and Prado, 2005). There are few models of the dynamics and functioning of these ecosystems, and the relationship between diversity and function or resilience is poorly known (Scarano, 2007). Obviously the paucity of knowledge greatly increases uncertainty about the responses of our complex ecological systems to human disturbances or management.

However, this knowledge is clearly increasing. Despite the relatively short history of Brazilian ecological science, the country is experiencing exponential growth in the quantity and scientific impact of research (Scarano, 2008), and increasing numbers of scientists are dedicating themselves to studying the impacts of human activities on ecological systems (Grelle *et al.*, 2009). The number of all graduate courses in ecology and environment in Brazil grew from three in 1976 (Martins *et al.*, 2007) to 37 in 2010 (CAPES, 2011), doubling with each decade (Scarano, 2008). The latest data show that 343 students completed their doctorates in the discipline between 2007 and 2009, while 1081 students obtained a Master's degree (CAPES, 2011). The impact of research also increased – 6.5% of 4900 papers published by Brazilian scientists in those three years were accepted in high-impact international journals. As a whole, publications by Brazilian scientists in ecology and environment rank twentieth in the world in terms of number of citations (CAPES, 2011), and Brazil's ambition is to become first in the world in producing ecological information and knowledge (Scarano, 2008).

Given the research-implementation gap, such increase in quantity and impact of research does not necessarily result in effective solving of practical environmental problems. However, the numbers suggest that adjustments to such young and growing science institutions should have an impact on building sound environmental policy (see "Recommendations").

The effectiveness of ecological science: The need for horizontal interaction with decision makers

Although ecological knowledge is surely relevant to decision making (Carpenter and Folke, 2006) and academia is the best equipped societal sector to gather ecological information (Whitmer *et al.*, 2010), the paucity of such knowledge is not the main problem preventing action. Far more influential is the way in which knowledge is usually constructed, decoupled from practice as well as from stakeholders and decision makers (i.e., knowing is not sufficient for doing, Knight *et al.*, 2008; Shackleton, Cundill and Knight, 2009). This is at the base of the research-implementation gap, limiting not only the access to and the utility of the ecological knowledge, but more importantly the potential for learning and adaptation as ways of dealing with uncertainties inherently linked to the management of complex socio-ecological systems (Knight *et al.*, 2008; Shackleton, Cundill and Knight, 2009). The vertical, one-way transference of knowledge or skills from scientists to practitioners is insufficient to bridge this gap (Knight *et al.*, 2008), since decision making depends fundamentally on the practical knowledge, skills, and behavior of the individuals who are directly involved (Shackleton, Cundill and Knight, 2009). To do a better job in this area, we need to reevaluate the approaches currently used to disseminate the results of scientific research.

Although higher education in ecology in Brazil is still mostly academically oriented, and does not train students or scholars specifically for engagement and communication with society, this picture could change in a few years in view of recent governmental stimuli for the establishment of partnerships between researchers and applied sectors. One of the first initiatives of this kind was the creation of a new modality of graduate education in the National System of Graduate Studies – the Professional Master courses. They are suited to help bridge the gap between academic research and decision making because they allow this connection to be built during the training of people who already are (or wish to be) engaged in decision making (Box 10.1; Scarano and Oliveira, 2005; Scarano, 2007). The first two such Brazilian courses in ecology are only a few years old. Only one of them is offered by a public university in close association with academic courses (Graduate Studies in Ecology and Biomonitoring, Federal University of Bahia, www.ecologia.ufba.br, Box 10.1). However, similar courses are recently being established in other universities.

Nonetheless, the limited federal funding to professional courses compared with academic courses brings serious difficulties to their full implementation. In public universities, where tuition must be free, partnerships with other private or public institutions interested in training their employees would offer one way of funding these professional courses. Since the criteria for admission in public universities must be strictly merit-based, however, it is not possible to guarantee positions to the employees of the sponsoring institutions, making the establishment of such partnerships difficult. Consequently, although professional courses might represent one of the instruments most suited to

Box 10.1 An example of a strategy to bridge the research-implementation gap inside universities

A group of researchers from the Federal University of Bahia realized that about a quarter of its graduates were or had been working for state environmental agencies. They often returned to the university, expressing difficulty in applying acquired scientific knowledge to the real problems they faced at work. It was clear that the help they required would demand an integrated and institutionalized strategy to change teaching and training practices. The strategy included: (a) short-term courses and outreach projects in which practitioners together with students from the academic graduate course in Ecology and Biomonitoring developed scientifically informed solutions to concrete problems; (b) the creation of a professional master course (Ecology applied to Environmental Management) for practitioners; (c) the adoption of problem-based learning methods as the main tool in all these activities, since it increases curiosity, helps perceiving the curriculum as pertinent to professional activities, and integrates learning from different components (Barrett and Moore, 2010); and (d) the creation of an online free journal to publish papers focused on the use of scientific knowledge to solve practical problems faced by environmental practitioners (Revista Caititu, http://www.portalseer.ufba.br/index.php/revcaititu).

This experience has been fruitful at many levels: (a) several products derived from these actions were incorporated into everyday work at environmental agencies, making the decision-making process better informed scientifically; (b) practitioners felt capable of better formulating questions and procedures to address the environmental issues they deal with at work; (c) networks of social learning (among practitioners, students, and researchers) were built, outlasting the particular problems around which they were created to solve; (d) the students perceived their efforts in understanding the theories, concepts, and methods in ecology as valuable to address and solve environmental issues; (e) the university is now seen as an effective partner by environmental agencies; and (f) the researchers devote more of their time and thinking to research and teaching activities associated with local environmental problems.

This teaching/training process leading to creative, applicable solutions to practical problems can be exemplified by the results of one of the short-term, problem-based learning courses, which focused on how to evaluate requests for suppression of native vegetation. According to practitioners, a lack of strong theoretical grounds and clear protocols had led to the quasi-mechanical approval of requests at the maximum legal limits of suppression. The goal of the short-term course was to produce a scientifically informed protocol, congruent with the law, which could be applied easily in the context of urgency and lack of information and resources typically faced by practitioners. This was achieved by sharing previous relevant knowledge (and lack of knowledge) and searching for relevant information, interspersed with lectures and consultation with researchers. At the end, the group produced a text (Rigueira *et al*., 2013) that: (a) reviews all pertinent legislation, and the scientific literature that relates habitat amount to biodiversity maintenance, ecosystem services, and human welfare; (b) establishes a protocol for decisions based on three spatial scales (Figure 10.1), models of landscape thresholds (Pardini *et al*., 2010), and precautionary criteria; (c) discusses the practical implications of using this system in the environmental agencies.

The protocol has been used to evaluate suppression requests and some of its criteria are being considered to be incorporated into the guidelines for developing director plans for drainage basins in the state of Bahia. According to practitioners, the ideas and rationale in the text produced further reverberated within environmental agencies, initiating discussions on biodiversity monitoring programs, payment for ecological services schemes, integration of previously disconnected evaluation processes (e.g., fauna and vegetation), and ecological–economic

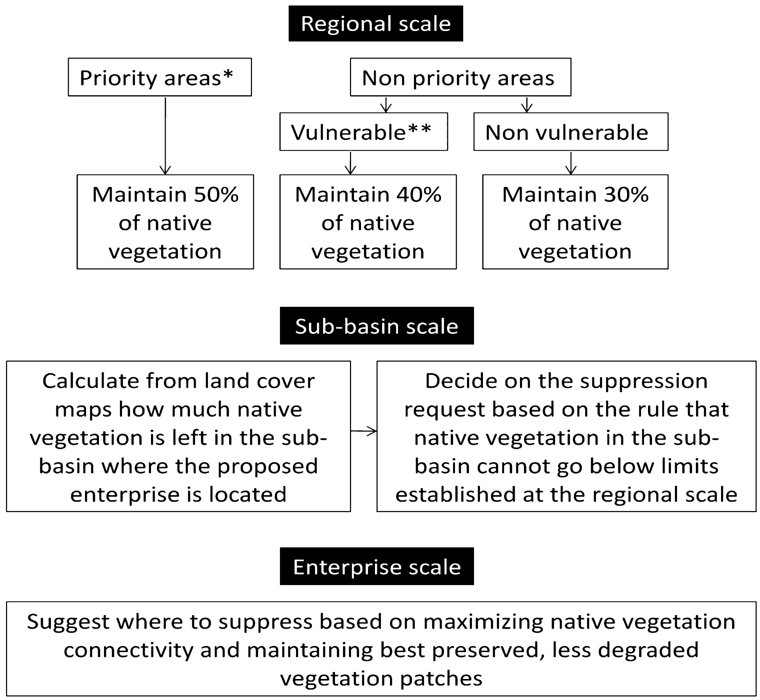

Figure 10.1 Schematic representation of the protocol for evaluating requests for suppression of native vegetation developed by graduate students and practitioners.
*Based on available maps of priority areas for biodiversity conservation
**Based on available maps of vulnerability to desertification
Modified from Rigueira *et al.* Reproduced with permission from Rigueira et al., (2013) Perda de hábitat, leis ambientais e conhecimento científico: proposta de critérios para a avaliação dos pedidos de supressão de vegetação. Revista Caititu.

zoning plans. The effective implementation of these policies, as well as the quality of their results, still needs to be evaluated. However, the experience of this short-term course and other activities developed by researchers from the Federal University of Bahia indicates a solid way to bridge the research-implementation gap.

build creative bridges between research and implementation (Box 10.1), there is still need to establish proper conditions for them to flourish. The inclusion of professional courses in the traditional quality-based federal funding applied to academic courses would solve this problem.

Procedures and standards used by Brazilian universities and funding agencies to evaluate and reward scientists also contribute to the research-implementation gap, as is generally the case in other countries (Knight *et al.*, 2008; Shackleton, Cundill and Knight, 2009; Whitmer *et al.*, 2010). These standards focus on scientific communication within academia, and do not stimulate – and in some instances might even prevent – the planning and implementation of strategies for societal engagement. The evaluation system's standards for both researchers (in the form of a productivity fellowship to scholars) and graduate courses, which directly influence their ability to obtain funding, are focused mainly on scientific publications in peer-reviewed journals. For example, indicators used to evaluate researchers in ecology, botany, and zoology include only the number of published scientific papers, the impact of the scientific journals where they are published, the number of supervised Master's and PhD theses, the coherence of the research program, and the merit of the submitted scientific project (http://www.cnpq.br/web/guest/criterios-de-julgamento). Criteria to evaluate graduate courses in these disciplines follow the same general logic (http://trienal.capes.gov.br/?page_id=568); although social impact is nowadays considered, it contributes only 10% of the evaluation. It is noteworthy, however, that the scientific community itself has a central role in defining and applying those criteria – 877 experienced researchers acted as evaluators in the latest round of evaluation of graduate courses in 2010. Recent changes in the evaluation and funding systems, with the creation of fellowships for technological and industrial development, and transference of technology, are welcome but still timid to overcome the inertia of years fomenting intra-walls communication.

The paralysis in action and decision making

Although there have been some important exceptions in Brazil (e.g., Joly *et al.*, 2010), the limits and uncertainty of scientific knowledge and its disconnection from management practices may frequently result in a reinforcing cycle of paralysis in decision making regarding environmental issues (Peterson, Cumming and Carpenter, 2003). A pressing example concerns how environmental impacts are measured, monitored, and evaluated during the process of licensing enterprises such as hydroelectric dams and expansions of the highway system. The ecological component of such evaluations is mainly based on species inventories and lists (CONAMA – Conselho Nacional do Meio Ambiente – Resolutions number 001/86 and 237/97; IBAMA – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – Normative Instruction number 146 2007). Such lists are expensive to produce and often in themselves insufficient to estimate the ecological impact of proposed enterprises and to define mitigating actions (Gardner, 2010). The reliance on species lists has probably several roots, including the legal importance of the National Red List in regulatory policy in Brazil (for criticism on this usage of Red Lists, see Possingham *et al.*, 2002). However, the paucity of scientific knowledge on our biodiversity and ecological systems, as well as the poor communication between scientists and practitioners, also contributes to the inertia or resistance to use scientifically driven ways of evaluating environmental impacts. This resistance to rely on ecological hypothesis and theory increases the disconnection of the ecological, the social, and the economic components of environmental impact assessments, reinforcing the political discredit of ecological information and knowledge.

Breaking this reinforcing cycle requires the involvement of multiple institutions and actors (Shackleton, Cundill and Knight, 2009), but it crucially depends on changing the ways in which ecological knowledge is generated and transferred, and on breaking the prevalent endogenous conversation within both academic and decision-making sectors.

RECOMMENDATIONS

The quality of ecological science: Limits of knowledge and scientific uncertainty

A fundamental step towards developing a high-quality ecological science concerns education and scientific training, which should embrace failure, ignorance, and uncertainty as opportunities to learn and adapt, and to push forward both theoretical and applied knowledge (Peterson, Cumming and Carpenter, 2003; Root-Bernstein, 2008; Knight, 2009). This certainly requires reformulation of curricula and changing the focus of teaching from addressing only what we know and how we can solve known problems to considering also what we do not know and how we can detect unknown problems. Such approach highlights the fundamental importance of questioning to learning and science (Root-Bernstein, 2008; Witte *et al.*, 2008), as well as to conscientious action and decision making (Vitek and Jackson, 2008).

In the process of pushing forward ecological knowledge, innovation is particularly important for confronting the pressing environmental problems in tropical, developing countries such as Brazil. The use of existing theoretical models and practical protocols to deal with urgency, limited resources, and uncertainty may be inadequate or impractical in our context. We should avoid the apparent easiness of applying already developed protocols or frameworks that rely on detailed but unavailable information, and instead foster the development of viable tools. For example, despite the legal importance of the Brazilian National Red List, the listing process that is based on the IUCN criteria and protocol (Mace *et al.*, 2008) is inadequate, given that basic information needed for accurate assessment is unavailable for the great majority of species in Brazil (e.g., Scarano and Martinelli, 2010). As a result, the National Red List is dominated by naturally rare, restricted-range species, and often does not consider species that, although common, are strongly affected by human activities (Bueno, 2008), decreasing the value of this list to evaluate environmental impacts. In this context, looking for examples and tools in other applied sciences, such as medicine and business, is a promising option (e.g., medical triage, see Bottrill *et al.*, 2008; scenarios of decision making in business, see Bennett *et al.*, 2003; Peterson, Cumming and Carpenter, 2003).

Besides the development of viable tools and protocols, general principles such as the precautionary principle are paramount to decision making concerning environmental issues in the face of limited knowledge and uncertainty. It holds that we should take precautionary measures regarding potential threats that could be irreversible and dangerous (United Nations, 1992). Although the principle has been criticized as excessively risk-averse and unscientific (Brombacher, 1999), there are proper guidelines for its rational use, including epistemic and practical criteria for evaluating if the threat is plausible and if the proposed response is reasonable (Resnik, 2003).

We should also increase efficiency by fostering and rewarding the sharing and synthesis of ecological data as well as interdisciplinary and collaborative work, aiming at developing new analyses and approaches (Kinzig, 2001; Carpenter *et al.*, 2009), which are urgently needed to mitigate environmental problems. Such analyses and approaches are usually not valued highly by traditional academic evaluation systems (Fox *et al.*, 2006).

The effectiveness of ecological science: The need for horizontal interaction with decision makers

To confront complex environmental issues, we should develop "user-inspired" and "user-useful" management approaches that consider both local (practical) and scientific knowledge (Raymond *et al.*, 2010). By breaking with the vertical, hierarchical relationship between researchers and practitioners, in which the latter are limited to the passive role of consumers of scientific products, and building a horizontal approach, in which researchers and practitioners can act as peers in the construction of knowledge, we can confront the problems of relevance and accessibility of knowledge at the base of the research-implementation gap (Kennedy, 1997). Because researchers and practitioners think about environmental issues from different perspectives, dialogue is essential for an integrated picture. Moreover, scientific knowledge is often difficult to access by practitioners because of the complex framework within which it is embedded, both theoretically and empirically. Building avenues for practitioners to get hold – at least partly – of ecological knowledge without passing through the whole trajectory of scientific training traveled by ecologists themselves is thus very important.

The formation of collaborative teams including researchers and practitioners seems to be an effective way to advance in the resolution of both problems. This requires striving to overcome the difficulty of integrating two different kinds of knowledge: academic, which is abstract, generalized, and theoretically grounded, and practical, which is more concrete, situated, and grounded in everyday decision making. There are lessons from the field of education that can help ecologists and other scientists to engage more effectively with decision makers (Shackleton, Cundill and Knight, 2009). Lave and Wenger's theory of situated learning (Lave and Wenger, 1991; Wenger, 1998) is one of many theoretical frameworks that treats learning as a necessarily social process. Social theories of learning take learning not only as a cognitive process, but, above all, as a social practice that shapes what we do, who we are, and how we interpret what we do (Wenger, 1998). From this perspective, learning is seen as an integral and indivisible part of social practice, and, thus, is taken to be situated in "communities of practice" – groups of individuals with distinct knowledge, abilities, and experiences, who actively participate in collaborative processes, sharing knowledge, interests, resources, perspectives, activities, and, above all, practices, thereby building both collective and personal knowledge. The construction of communities of practice integrating researchers and practitioners can provide a way of bridging the research-implementation gap in ecological science and management. If we are successful in doing so, instead of two distinct fields of practice, we will be working in a single field, in which stakeholders and researchers will be engaged in generating relevant research questions, building the knowledge to address them, and implementing the practical protocols to deal with environmental issues and their inherent uncertainty with the necessary prudence (Box 10.1). If students participate in this joint endeavor, they can become full participants in both fields of practice, academic research, and environmental decision making (Box 10.1). Fostering such endeavors depends on reformulating traditional evaluation systems so that researchers are rewarded not only for communicating within the scientific community but also for communicating with other societal sectors that will use the knowledge they acquire for making sound practical decisions.

CONCLUSION

The limited knowledge available concerning tropical ecosystems and the frequent dissociation of such knowledge from management practices are the main challenges, while the rich biodiversity and the young and growing science offer the principal opportunities for bridging the research-implementation gap in Brazil. A fundamental step towards this goal concerns education and scientific training, which should embrace questioning, foster the development of viable tools to deal with urgency, limited resources, and uncertainty, and stimulate the synthesis of ecological data and interdisciplinary work. Far more important though is breaking with the vertical, hierarchical relationship between researchers and practitioners, and consider ways to build communities of practices integrating students, researchers, and practitioners in the construction of our understanding of environmental problems and of the consequences of intervening on them.

ACKNOWLEDGMENTS

We thank Navjot Sodhi, Luke Gibson and Peter Raven for the invitation and opportunity to write this opinion piece, Samanta Levita Coutinho (IBAMA-BA) for providing detailed information on the repercussion, within environmental agencies, of the activities among students, researchers, and practitioners developed at UFBA – Federal University of Bahia, and CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico /FAPESB – Fundação de Amparo à Pesquisa do Estado da Bahia for funding several of these activities (PNX0016/2009). The first three authors (RP, PLBR, and CE) were supported by CNPq research fellowships during the production of this text.

REFERENCES

Barrett, T. and Moore, S. (2010) *New Approaches to Problem-Based Learning: Revitalizing your Practice in Higher Education*. Routledge, New York, NY.

Bennett, E. M., Carpenter, S. R., Peterson, G. D., Cumming, G. S., Zurek, M. and Pingali, P. (2003) Why global scenarios need ecology. *Frontiers in Ecology and the Environment*, **1**, 322–329.

Bottrill, M. C., Joseph, L. N., Carwardine, J., Bode, M., Cook, C., Game, E. T., Grantham, H., Kark, S., Linke, S., McDonald-Madden, E., Pressey, R. L., Walker, S., Wilson, K. A., and Possingham, H. P. (2008) Is conservation triage just smart decision making? *Trends in Ecology and Evolution*, **23**, 649–654.

Brombacher, M. (1999) The precautionary principle threatens to replace science. *Pollution Engineering International*, Summer, 32–34.

Bueno, A. A. (2008). Pequenos mamíferos da mata atlântica do Planalto Atlântico Paulista: uma avaliação da ameaça de extinção e da resposta a alterações no contexto e tamanho dos remanescentes. PhD thesis, University of São Paulo, São Paulo, Brazil.

CAPES (2011) Relatório de avaliação 2007–2009 Trienal 2010. http://trienal.capes.gov.br/wp-content/uploads/2011/02/Ecologia-Relatório-de-Avaliação.pdf (accessed March 19, 2013).

Carpenter, S. R. (2002) Ecological futures: building an ecology of the long now. *Ecology*, **83**, 2069–2083.

Carpenter, S. R. and Folke, C. (2006) Ecology for transformation. *Trends in Ecology and Evolution*, **21**, 309–315.

Carpenter, S. R., Armbrust, E. V., Arzberger, P. W., Chapin III, F. S., Elser, J. J., Hackett, E. J., Ives, A. R., Kareiva, P. M., Leibold, M. A., Lundberg, P., Mangel, M., Merchant, N., Murdoch, W. W., Palmer, M. A., Peters, D. P. C., Pickett, S. T. A., Smith, K. K., Wall, D. H. and Zimmerman, A. S. (2009) Accelerate synthesis in ecology and environmental sciences. *BioScience*, **59**, 699–701.

Economist Intelligence Unit (2010). *Democracy Index 2010*. http://graphics.eiu.com/PDF/Democracy_Index_2010_web.pdf (accessed March 19, 2013).

Fox, H. E., Christian, C. J., Nordby, C., Pergams, O. R. W., Peterson, G. D. and Pyke, C. R. (2006) Perceived barriers to integrating social science and conservation. *Conservation Biology*, **20**, 1817–1820.

Gardner, T. A. (2010) *Monitoring Forest Biodiversity: Improving Conservation through Ecologically-Responsible Management*. Earthscan, London, UK.

Grelle, C. E. V., Pinto, M. P., Monteiro, J. and Figueiredo, M. S. L. (2009) Uma década de Biologia da Conservação no Brasil. *Oecologia Brasiliensis*, **13**, 420–433.

Groffman, P. M., Stylinski, C., Nisbet, M. C., Duarte, C. M., Jordan, R., Burgin, A., Previtali, M. A. and Coloso, J. (2010) Restarting the conversation: challenges at the interface between ecology and society. *Frontiers in Ecology and the Environment*, **8**, 284–29.

Joly, C. A., Rodrigues, R. R., Metzger, J. P., Haddad, C. F. B., Verdade, L. M., Oliveira, M. C. and Bolzani, V. S. (2010) Biodiversity conservation research, training, and policy in São Paulo. *Science*, **328**, 1358–1359.

Kennedy, M. M. (1997) The connection between research and practice. *Educational Researcher*, **26**, 4–12.

Kinzig, A. P. (2001) Bridging disciplinary divides to address environmental and intellectual challenges. *Ecosystems*, **4**, 709–715.

Knight, A. T. (2009) Is conservation biology ready to fail? *Conservation Biology*, **23**, 517.

Knight, A. T., Cowling, R. M., Rouget, M., Balmford, A., Lombard, A. T. and Campbell, B. M. (2008) Knowing but not doing: selecting priority conservation areas and the research–implementation gap. *Conservation Biology*, **22**, 610–617.

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Practice*. Cambridge University Press, Cambridge, UK.

Lewinsohn, T. M. and Prado, P. I. (2005) How many species are there in Brazil? *Conservation Biology*, **19**, 619–624.

Mace, G. M., Collar, N. J., Gaston, K. J ., Hilton-Taylor, C., Akçakaya, H. R., Leader-Williams, N., Milner-Gulland, E. J. and Stuart, S. N. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. *Conservation Biology*, **22**, 1424–1442.

Martins, R. P., Lewinsohn, T. M., Diniz-Filho, J. A. F., Coutinho, F. A., Fonseca, G. A. B. and Drumond, M. A. (2007) Rumos para a formação de ecólogos no Brasil. *Revista Brasileira de Pós-Graduação*, **4**, 25–41.

Metzger, J. P., Lewinsohn, T. M., Joly, C. A., Verdade, L. M., Martinelli, L. A. and Rodrigues, R. R. (2010) Brazilian law: full speed in reverse? *Science*, **329**, 276–277.

Pardini, R., Bueno, A. A., Gardner, T. A., Prado, P. I. and Metzger, J. P. (2010) Beyond the fragmentation threshold hypothesis: regime shifts in biodiversity across fragmented landscapes. *PLoS ONE*, **5**, e13666.

Peterson, G. D., Cumming, G. S. and Carpenter, S. R. (2003) Scenario planning: a tool for conservation in an uncertain world. *Conservation Biology*, **17**, 358–366.

Possingham H. P., Andelman, S. J., Burgman, M. A., Medellín, R. A., Master, L. L. and Keith D. A. (2002) Limits to the use of threatened species lists. *Trends in Ecology and Evolution*, **17**, 503–507.

Raymond, C. M., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G. M. and Evely A. C. (2010) Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management*, **91**, 1766–1777.

Resnik, D. B. (2003) Is the precautionary principle unscientific? *Studies in the History and Philosophy of Biological and Biomedical Sciences*, **34**, 329–344.

Rigueira, D. M. G, Coutinho, S. L., Pinto-Leite, C. M., Sarno, V. L. C., Estavillo, C., Campos, S., Dias, V. S., de Barros, C. and Chastinet, A. (2013) Perda de hábitat, leis ambientais e conhecimento científico: proposta de critérios para a avaliação dos pedidos de supressão de vegetação. *Revista Caititu*, **1**, 21–42. doi: 10.7724/caititu.2013.v1.n1.d03

Root-Bernstein, R. (2008) I don't know! In *The Virtues of Ignorance* (eds B. Vitek and W. Jackson), University Press of Kentucky, Lexington, KY, pp. 233–250.

Scarano, F. R. (2007) Perspectives on biodiversity science in Brazil. *Scientia Agricola*, **64**, 439–447.

Scarano, F. R. (2008) A expansão e as perspectivas da pós-graduação em Ecologia no Brasil. *Revista Brasileira de Pós-Graduação* **5**, 89–102.

Scarano, F. R. and Martinelli, G. (2010) Brazilian list of threatened plant species: reconciling scientific uncertainty and political decision-making. *Natureza & Conservação*, **8**, 13–18.

Scarano, F. R. and Oliveira, P. E. A. M. (2005) Sobre a importância da criação de mestrados profissionais na área de ecologia e meio ambiente. *Revista Brasileira de Pós-Graduação*, **2**, 90–96.

Shackleton, C. M., Cundill, G. and Knight, A. T. (2009) Beyond just research: experiences from southern Africa in developing social learning partnerships for resource conservation initiatives. *Biotropica*, **41**, 563–570.

Sousa Santos, B. de (2007) *Cognitive Justice in a Global World: Prudent Knowledge for a Decent Life*. Lexington Books, Lanham, MD.

United Nations (1992) *Agenda 21: The UN Programme of Action from Rio*. United Nations, New York, NY.

Vitek, B. and Jackson, W. (2008) *The Virtues of Ignorance*. University Press of Kentucky, Lexington, KY.

Wenger, E. (1998) *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press, Cambridge.

Whitmer, A., Ogden, L., Lawton, J., Sturner, P., Groffman, P. M., Schneider, L., Hart, D., Halpern, B., Schlesinger, W., Raciti, S., Bettez, N., Ortega, S., Rustad, L., Pickett, S. T. A. and Killilea, M. (2010) The engaged university: providing a platform for research that transforms society. *Frontiers in Ecology and the Environment*, **8**, 314–321.

Witte, M. H., Crown, P., Bernas, M. and Witte C. L. (2008) Lessons learned from ignorance: the curriculum on medical (and other) ignorance, in *The Virtues of Ignorance* (eds B. Vitek and W. Jackson), University Press of Kentucky, Lexington, KY, pp. 251–272.