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ORIGINAL PAPER

Initiating dialogue between scientists and managers of biological invasions

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Abstract We describe an initiative to improve the flow of information between researchers and managers as part of two international scientific symposia on biological invasions held in South Africa in 2008 and 2009. Formal workshops and information sessions for land managers were run during the symposia. At the end of each symposium, the managers ran dedicated question-and-answer sessions on the research they felt was needed to improve their work. We discuss the potential of such interventions to increase interaction and awareness between researchers and managers of biological invasions. The symposia certainly provided the managers with opportunities to think about broader issues and develop contacts, but problems with terminology use and the lack of solutions specific to their context tempered the value of their experience. Conversely, researchers at times under-estimated the managers perceived relevance of their presentations to management. The structured and facilitated attendance of managers of invasive plants at international conferences on invasion biology is one mechanism for at least narrowing "the gap" between science and management.

Keywords Biological invasions · Invasion science · Science and society · Management · Science communication · Working for Water

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Introduction

Biological invasions provide fascinating tests of ecological and evolutionary theory, but also represent major challenges to natural resource management. For the management of biological invasions, and indeed for natural resource management generally, governments and the wider public expect scientists to provide advice to managers (see discussions in Lockwood et al. 2006; Sutherland et al. 2004, 2006; Chown et al. 2009). Which species should be prioritised for control? What risks do these organisms pose to biodiversity and ecosystem functioning? What is the best way to control them? Scientists, whilst often providing advice for policy and action, are usually also interested in gaining a more general

or fundamental understanding. Does ecological theory hold up when investigated using data from biological invasions? How can biological invasions be used to inform evolutionary biology, biogeography, or community ecology?

While the study of biological invasions provides an excellent opportunity to advance general understanding and produce particular quantitative predictions useful for management (Lawton 1996; Blackburn et al. 2009), the different goals and motivations of land managers and scientists can act as a barrier to communication (Huenneke 1995; Roux et al. 2006; Sheley et al. 1996). Indeed, as a consequence of their differing priorities, motivations, and approaches, the two groups can find themselves embedded in two different worldviews with little overlap in the terminology and conceptual foundations used for formal communication. However, several strategies can be used to understand and benefit from the various, often unique, perspectives of different stakeholder groups, such as secondments and sabbaticals (Gibbons et al. 2008) or the formation of advisory committees (Wondolleck and Yaffee 1999).

Lindenmayer et al. (2008) state that knowledge transfer and implementation are still lacking in landscape conservation. Cowling et al. (2008) call for management to be "institutionalised in a suite of learning organizations that are representative of sectors that are concerned with decision-making and planning". To bridge the research—implementation gap, Knight et al. (2008) prompt researchers to "source research questions from practitioners". However, practical mechanisms for activating such suggestions are lacking in many areas of natural resource management, including management of invasive species (but see Esler et al. 2010).

In South Africa, land managers, scientists, and other stakeholders interact on specific collaborative conservation planning projects (Knight et al. 2006; Rogers 2006), such as the Succulent Karoo Ecosystem Planning, Cape Action for People and the Environment Plan, and the Environment and Sub-tropical Thicket Ecosystem Planning Project. All of these projects implemented human resource capacity building through training and mentorship activities, and these activities were recognised as integral to the success of such collaborations (Knight et al. 2006). Beyond such dedicated interactions, there are also opportunities to meet and discuss work at local specialised scientific meetings, e.g. the Arid Zone Ecology Forum (http://www.azef.co.za/) and the Fynbos Forum (http://www.botanicalsociety.org.za/cu/fynbosforum.php), as well as through specialised training courses.

Here, we describe a combined approach, where managers of invasive species were provided with a structured and facilitated course as part of their attendance at two international scientific symposia and given a specific session at each symposium to pose questions to a scientific forum (i.e. the symposium delegates comprised mainly scientists). We discuss the lessons learned and suggest some improvements for future education and interaction initiatives.

Methods

Training and information workshop

The motivation for the training and information workshop came from the senior management of the Working for Water programme (van Wilgen et al. 2010), who wanted to provide South African managers working on on-the-ground issues of biological invasions an opportunity to listen to broader issues relating to their day-to-day concerns and training in the science of biological invasions. To provide a global setting for running these workshops, we took the opportunity provided by two international scientific symposia on biological invasion held locally. We hoped that the wide group of researchers working across a wide range of ecosystems and taxa would provide a stimulating environment in which to run the workshop. The meetings and workshop also provided both formal and informal opportunities for communication and interaction between the scientists and managers.

In November 2008, the Department of Science and Technology-National Research Foundation Centre of Excellence for Invasion Biology (C·I·B) commemorated the 50th anniversary of the publication of Charles Elton's seminal work "*The Ecology of Invasions by Animals and Plants*" (Elton 1958) by running a symposium (hereafter "the Elton symposium") consisting of a series of keynote addresses given by fourteen prominent invasion biologists, followed by discussion sessions (Garcia-Berthou 2010). In August 2009, the C·I·B hosted the 10th International Conference on the Ecology and

Management of Alien Plant Invasions (EMAPI), a symposium involving 240 delegates, over 100 oral presentations, and various poster and discussion sessions.

We invited 27 land managers to attend these symposia. These managers were predominately from the South African Working for Water programme (van Wilgen et al. 1998, 2010), and typically had some university-level training, but little post-graduate scientific training. They manage the clearing of invasive plant species in different parts of South Africa.

The other conference delegates were international scientists or upper-level managers, mostly associated with universities and government research facilities. Several senior managers from Working for Water attended the symposia, but were not part of the workshop.

Prior to the commencement of the symposia, we held an introductory briefing session for the managers. This involved people introducing themselves, explaining where they came from, and the region and invasive species they managed. We then provided the managers with an explanation of what the symposia would involve, and discussed the general motivations and backgrounds of the other symposia delegates. We anticipated that some technical terms would be used that were likely to be unknown to them and therefore provided definitions of some keywords in the form of a handout (they also recorded any terms they did not know during the course of the symposium, see Supplementary Material). Finally, we discussed the aims and objectives of the workshop, in particular that from our view-point it was an opportunity to learn about the science of invasions in a broad global context, and that all the other delegates would be very keen to hear about their on-the-ground experiences.

The workshops were designed around the symposium schedules such that the managers could attend all talks/sessions. The Elton symposium was held in plenary throughout, whereas EMAPI had at most three concurrent sessions. We gave the managers questionnaires to rate each presentation or session they attended (see Supplementary Material 1). The questionnaires were used to prompt discussion at the end of each day and identify topics that needed clarification. We also used the questionnaires as a means of assessing the value of the workshop.

During breaks in the meeting (i.e. morning and afternoon teas and lunch) we held discussions with the managers. These were opportunities to address any questions they had arising from the symposia presentations and, as a group, to discuss the applicability of the research presented to management in South Africa. In addition, 10 min "snap sessions" were held, where an invited scientist presented their research on invasive species in an informal setting, followed by ~20 min of general discussion on the given topic.

An aim of the workshop was to provide a facilitated opportunity for the managers to pose questions to the other delegates of the symposia. The managers were asked to identify what they consider to be the key research questions that are relevant for the management of plant invasions in South Africa. We then formulated the questions and issues raised and presented them to the managers later in the meeting for re-wording and consensus. Towards the end of each symposium, the managers led open sessions where they posed these questions (Table 1) to the other symposia delegates for debate and consideration in an open forum.

To provide some background against which to assess the manager's responses, we asked keynote speakers and session chairs to complete a questionnaire similar to that of the managers (Supplementary Material 1).

The total monetary cost of the workshop (including conference registration, travel, accommodation, and travel allowance for the managers and the time of staff who co-ordinated the workshops with managers) was estimated at US$50 000, the bulk of which was paid by the Working for Water programme.

Results and discussion

Here we focus on a few general insights, as our intention for the questionnaires was to prompt discussion and to create a means for the managers to communicate their views of the symposia to us. However, we would, in future, use a more structured questionnaire so that insights into resolving the communication gap between scientists and managers could be explored in depth.

Based on their questionnaire responses managers found most of the presentations at both symposia

Table 1 The questions that managers posed to the audience at the open manager-led session of the Elton symposium

Questions posed by managers to scientists
Are there quantitative measures of how much restoration is required? Are the systems actually rehabilitated? What should we replace invasive species with?
How do we deal with range expansion? When a species begins appearing in an area that is assumed to be unsuitable, should we leave it despite climate change? How can we be pro-active? What modelling is being done?
Are there predictive tools to deal with a particular species before it gets bad? i.e. What environmental thresholds or what particular life stages act as indicators of future problems.
What do you do when you control one species and other invasive species then come in? How do we deal with this invasive cocktail?
At what point do we abandon control? Do the species ever just integrate? In some cases might the system still function?
People are always negative about invasive species. Is it really worth controlling the species in some cases? What are the positive aspects of invasive alien species? Can these plants be utilised?
There is often no information or research available to us on new emerging invasive species, yet we are supposed to make immediate management decisions. We need to understand species reproductive mode to assist with control, containment and spread; what to spray; how to cut; e.g. Pom Pom weed (*Campuloclinium macrocephalum*).
When a new species appears and we think it is invasive, how can you speed up the legislative/regulatory process? Often it seems delayed by scientific arguments. Time is often important and the indecision is frustrating.
How do you address species that spread across borders and manage them at a local scale? (Local collaboration instead of at higher governmental levels).
Where do you start looking for your pathway? How is the invasive getting into a local area? Where is it starting?
How do we keep momentum with existing programs when there are often "flavour of the month" programs? Continuity of existing programs can be compromised by external priorities.
How successful are our control efforts? We need monitoring, and particularly feedback from research.
What are the ecological impacts of the control methods we use? i.e. independent assessment of herbicides.
How do you close the gap between researchers and on-ground implementation? i.e. addressing flow of information.
How do we link the scientific and social elements of invasion?

Manager's questions were reworded in some instances

"interesting" (118 out of 199 responses to question 4 were rated 4 or 5 on a scale of 1–5 see Supplementary Material 1) and they often "learnt something new" (109 out of 209 responses were rated 4 or 5 question 5). At the EMAPI symposium, where there was a choice of presentations to attend, managers attended those presentations which were more relevant to management [there was a correlation between manager's attendance (measured by the number of questionnaires submitted for a given session) and whether session chairs deemed the presentations relevant to management (question D), Spearman's rank correlation rho $= 0.53$, $P = 0.017$]. However, at the Elton symposium, where managers attended all presentations, the managers found more management-relevance in the presentations than the speakers (Wilcoxon paired-signed rank test, $V = 2687$, $P < 0.01$, number of observation $= 111$).

While these results suggest the managers were benefiting from the symposia, the managers recorded several phrases and words commonly used in invasion biology for which they required clarification (e.g. propagule pressure and polyploidy, see Supplementary Material 3), moreover many others terms required clarification during our discussions. During the open session, the managers' questions were highly relevant and fundamental (Table 1), but were not expressed in the same manner as the conference delegates, or using the terminology typical of the science meeting. The question phrasing shown in Table 1 is the result of

group discussions facilitated by us that continued until the managers reached consensus.

Consistent, meaningful terms are required for successful communication, and specific terms can have legislative implications. Yet invasion scientists (and others) still argue about the definition of an *invasive species* (e.g. Valéry et al. 2009; Wilson et al. 2009). Such debate occurs among ecologists for numerous terms and definitions (see Hodges 2008; Moore et al. 2009), but it can be counter-productive if a management decision is needed quickly (Simberloff 2003). The managers expressed their frustration that such central issues were still being debated.

During the symposia, terminology was clearly a barrier to information flow (see Supplementary Material 3), but there is a broader issue about the complexities of knowledge transfer. The management of invasive species in South Africa (and undoubtedly elsewhere) is affected by numerous inter-acting biological, sociological, and economic issues. The questions posed by managers (Table 1) span many different disciplines. These broader issues were often complex and involved valuation (i.e. target and transformation knowledge as per Kueffer et al. 2008). In comparison, the symposia talks predominately dealt with causal relationships, particularly biological processes (i.e. systems knowledge as per Kueffer et al. 2008). As the different groups have different perspectives on the issue of biological invasions, the workshop can be viewed as an attempt at boundary management (Kueffer et al. 2008). In this context, the manager-led open sessions involved deliberation on the framing of adequate research questions.

The second main issue is that scientists and managers often adopt different strategies for knowledge transfer, Roux et al. (2006) describe this as a "push and pull" scenario where scientists "push" new knowledge while managers "pull" the required science into the management domain. However, it was apparent from the manager's comments that they found many of the more applied talks (at EMAPI in particular) of low relevance as these did not address issues specific enough to the managers' work. In contrast, the more theoretical talks allowed the managers the space to think broadly about issues they were facing; the managers scored these talks as being of higher relevance to management than either the session chairs or the presenters.

One method that overcame this problem was the "snap sessions". In these sessions managers had the opportunity to ask questions and discuss issues amongst themselves and with the scientist. This highlighted the applicability of current research to their own situation and gave an insight into how talks at the conference could be applied to their work. In these sessions the information and terminology could be discussed with appropriate background information. Both managers and scientists had the opportunity to share their view-points and relevant information. These sessions provided an opportunity for knowledge to be digested and discussed. In a study of what information conservation managers use to support their decision making, Pullin et al. (2004) found that that the majority of conservation actions remain experience-based and rely heavily on traditional land management practices. They found that scientific papers were rarely consulted for decision making. During the workshop discussions the managers expressed similar sentiments, stating they do not read scientific papers (see Table 1. "How do you close the gap between researchers and on-ground implementation? i.e. addressing flow of information"). Furthermore, they expressed their frustration that they did not have time to read papers, and even if they wanted to, did not necessarily have ready access to them. While only in a very preliminary way, we believe initiatives such as the workshop discussion groups and snap sessions are at least an attempt at starting to bridge the knowing-doing gap, as these sessions provided managers (decision-makers) with more information to potentially support their future decision-making.

We also noted two other points of interest from discussions with the keynote speakers and session chairs. Not surprisingly, those scientist who chose to pursue a career in biology for applied reasons tended to meet managers more often than scientists who were more interested in theoretical understanding (see Supplementary Material for the wording of the questions, rho $= -0.50$ from a Spearman rank correlation test, $P = 0.002$, $n = 35$). Second, as invasion biology is a rapidly expanding discipline (Richardson and Pyšek 2008; Davis 2009) and one that is relatively new, we expected the younger scientists to have been more likely to have started their career in what is now termed "invasion biology". However, in our strongly biased sample we found no such relationship (14 out of the 35 scientists surveyed started their careers in

invasion biology including five aged over 60, rho = −0.15, $P = 0.39$ from a Spearman rank correlation test between approximate age and whether they had started in "invasion biology"). People have been working on biological invasions for many years, although invasion biology perhaps has not always been recognised as a sub-discipline.

Lessons learnt

It is our opinion that both the snap sessions and the manager-led open session were successful in facilitating knowledge transfer. It was important, particularly as the symposia were grounded in science, for managers to have the opportunity to discuss the current successes, hurdles, and novel issues confronting the management of biological invasions in South Africa. Knight et al. (2008) highlight the need to specifically ask practitioners to identify the needs to better their practice, rather than having scientists being prescriptive. Here we attempted such an approach and indeed opportunities were created for interaction, potentially instigating organisational learning that involved representative sectors (Cowling et al. 2008).

While the time commitments to such workshops can be hard to justify given workloads and conflicting priorities, we would suggest that only towards the end of the workshop were we beginning to make progress (this was also a sentiment expressed by some of the managers). This highlights that unless both parties are motivated, it will be difficult to bridge the gap. Managers and scientists will have to acknowledge the time required to undertake these exercises, and for this reason must have the support of their institutions and colleagues. Although we held pre-symposium introductory discussions, we underestimated the scope required of such briefings. In the context described here, more attention needed to be given to ensure that the managers received a good grounding in scientific terminology, research frameworks, and paradigms, before the symposia. In future we would also advocate briefing sessions for the conference delegates prior to the manager-led open session, to ensure that they understand the context, objectives and framework under which managers operate. Moreover, in such a setting it is easy to be distracted by terminology, instead of focussing on key concepts (i.e. the fundamental aims of successful resource management). In future we would try harder to have managers contribute to the writing of a paper such as this one, we feel it would bring a more holistic perspective to the issue of bridging the gap, and urge others to try. Unfortunately it was beyond the scope of this exercise and the manager's time commitment.

Finally, perhaps the biggest lesson for us from the open session was the managers' response to a scientist's question about "how they felt about their work". Everyone was moved by how passionate the managers are about what they do. In their view, Working for Water has gone far beyond simply clearing alien plants. It has improved the lives of many South Africans, particularly in the poorest communities.

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