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Current issues in environmental management in Australia – what do people think?

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Abstract: In 2010, the International Council for Science (ICSU) and the International Social Science Council (ISSC) published their *Grand Challenges in Global Sustainability Research*, seeking to mobilise researchers in a 10-year scientific effort to address what they call the "grand challenges in global sustainability". In this paper, we ask whether these Grand Challenges are relevant to Australian environmental management. We examine this from two angles, insights from public perception surveys, and our own survey data. Public attitudes surveys indicate public ambiguity on the knowledge base, a finding that implies an immediate need for improved public communication of scientific knowledge. Our on-line survey, attached to a conference, *Innovative Solutions for Environmental Challenges*, targeted Australian environmental managers and scientists' views on critical issues. The results mirrored global scientists' views on the need to find ways for the scientific, social and political communities to work together to develop innovative approaches to solving future environmental concerns. Importantly, we found that the specific responses were context and scale dependent, while highlighting the inherent tensions between maintaining production and consumption, and protection of resources and ecosystem services.

Key words: environmental management, environmental policy, sustainability research, attitude surveys

The International Council of Science's Grand Challenges in Global Sustainability Research

In 2010, the International Council for Science (ICSU) and the International Social Science Council (ISSC) published their *Grand Challenges in Global Sustainability Research* ICSU (2010). In seeking to mobilise researchers to address what they call the "grand challenges in global sustainability", they advocate a ten-year scientific agenda.

> Over the next decade the global scientific community must take on the challenge of delivering to society the knowledge and information necessary to assess the risks humanity is facing from global change and to understand how society can effectively mitigate dangerous changes and cope with the change that we cannot manage. [ICSU, 2010:6]

Their case is based on a definition of global sustainability research that builds upon and integrates expertise within the sciences and humanities, and applies to social-environmental research questions of human interactions with the Earth system. It is an important agenda in that, while it recognises the value of the natural sciences, it advocates that the lessons of such science have to be mediated through the social sciences to take effect; this is the challenge of delivering to society the knowledge and information.

As in any good communication strategy, this is not simply a matter of talking more, but of fully engaging social processes. In this regard, the authors of the report argue that tackling the grand challenges requires a stronger involvement and greater integration of the social sciences, health sciences, engineering and humanities, along with the natural sciences, with disciplinary and interdisciplinary research providing the trans-disciplinary basis for effective use of scientific results by society and decision-makers. This is an agenda from the centre of science, but nevertheless serves as a useful reminder of the social context of environmental science.

In rehearsing familiar mantras – that any research should be scientifically important; that there needs to be global coordination; that the science needs to be relevant to decision makers; and research should be capable of leverage – the authors settle on five specific, if still very broad, challenges. While reflecting a scientistic or reductionist approach to problem-solving, they nevertheless provide a process approach to expanding the import of science into the social realm. Importantly, however, it may be relevant to question how relevant such an approach is to the environmental issues that the global community perceives.

- **Challenge 1: Forecasting.** Improve the usefulness of forecasts of future environmental conditions and their consequences for people.

- **Challenge 2: Observations.** Develop the observation systems needed to manage global and regional environmental change.

- **Challenge 3: Thresholds.** Determine how to anticipate, recognize, avoid and adapt to rapid global environmental change.

- **Challenge 4: Responses.** Determine what institutional, economic and behavioural changes can enable effective steps toward global sustainability.

- **Challenge 5: Innovation.** Encourage innovation (coupled with sound mechanisms for evaluation) in developing technological, policy, and social responses to achieve global sustainability.

Approaches to critique: Are these Grand Challenges relevant to Australian environmental management?

We examine this issue from two perspectives, insights obtained from public perception surveys and our own data regarding environmental management concerns. Our approach attempts to mirror the fundamental presumption of the ICSU Grand Challenges that social engagement is critical. Our paper reports on an early phase of research that examines the utility of this frame as a heuristic to better progressing scientific understanding into the socio-political domain. By engaging professional and practitioner environmental managers, specifically to seek information on their long-term (decadal) and professional environmental concerns and perceptions, we start to address the ICSU Grand Challenge: how well does the Forecasting-Observations-Thresholds-Responses-Innovation model align with practitioner perceptions of long-term issues and needs? The next phase will be an analysis of contemporary environmental management research publication patterns, again to examine the degree of alignment between the Grand Challenge and current practice.

Scientific background

Around the world, scientists are expressing their concerns about the ability of the earth system to sustain a growing population with an ever increasing demand for the Earth's resources. A stark example of such published concern is Rockström *et al.*'s (2009) analysis of what they call the "safe operating space for humanity", published in *Nature*. Rockström *et al*. (2009) developed a model of the safe operating space for nine environmental systems, contrasting what they considered to be the safe operating limits against the current position for those variables they consider measurable. In their analysis, the boundaries in three systems – climate change, rate of biodiversity loss, and human interference with the nitrogen cycle – have already been exceeded. Importantly, they also argue that two others – chemical pollution and atmospheric aerosol loading – cannot yet be quantified. Such studies reflect engagement with the Forecasting-Observations-Thresholds aspects of the Grand Challenges model, and in doing so, draw attention to the need for social engagement through the Responses-Innovation component.

In response to this latter need, Bradshaw *et al*. (2010), for example, in describing the relative environmental impact of human activity across the globe, provide evidence-based modelling that contributes directly to Response-Innovations end of the Grand Challenges model, with clear implications on the setting of priorities. Their modelling used available indicator data – measures of natural forest loss, habitat conversion, marine captures, fertilizer use, water pollution, carbon emissions and species threat – and concluded that suitable data is available for the majority of the 228 countries considered. Their study demonstrates that environmental performance is complex, drivers of environmental impact are variable, and countries perform poorly for different reasons; increasing wealth was the most important driver of environmental impact. Their study also draws attention to the science-society linkages in this matter, and supports calls to better integrate disciplinary and/or scientific paradigms for a

more holistic approach to understanding and social action. Reid *et al*. (2010) argue that "progress in understanding and addressing both global environmental change and sustainable development requires better integration of social science research".

Public environmental concerns and perceptions

Public attitudes research surveys provide insights into informed social views on environmental concerns. These vary in scale, which in itself is important, given the potential tensions between the daily and neighbourhood scale of individuals' lived experiences, and the regional to global scale of many issues. Importantly, these provide benchmark statement regarding the non-scientific community's perspectives on environmental issues. Understanding this perspective is important if the scientific community is to communicate itself to society and government better.

To place Australia in context, the global perspective of the World Values Survey provides interesting insights. It was a large-scale, cross-national and longitudinal survey research program, which included questions replicated since the early 1980s (WVS, 2011). The 2005-2008 survey indicated that the majority of respondents from 27 participating countries identify three serious global environmental problems: (i) greenhouse and/or global warming; (ii) biodiversity loss; and (iii) pollution of lakes, rivers and oceans. The parallels with Rockström *et al*.'s conclusions are clear.

Within Australia, the 2007 Australian Survey of Social Attitudes provides a more complex regional perspective with regards to attitudes towards environmental issues (ADA, 2011). It is the third in a biennial series, and examines social attitudes and behaviour amongst Australian citizens. The 2007 survey included questions on attitudes and behaviours regarding the environment. The most urgent environmental issue for Australians in 2007, according to this survey, was drought (42%), followed by climate change (26%), pollution (11%), renewable energy (6%), logging of forests (4%), nuclear power and destruction of wildlife (3% each), waste disposal, loss of biodiversity and soil degradation (c.1% each). The closer alignment of respondent and issue scales is clear, although the meta-theme of climate and climate change echoes the global survey (WVS, 2011). The lower levels of concern regarding pollution and wildlife depletion perhaps reflect regional conditions, in which instances of pollution and human interference with natural chemical pathways and of wildlife depletion are relatively invisible in the Australian environment (c.f. Chang & Kristiansen, 2004); this low concern contrasts the recognition of the key role that understanding and controlling global pollution in protecting against system collapse (Turner, 2008). Reflecting regional immediacy and visibility of issues, likewise, water was the number one environmental concern for most Australians surveyed by IPSOS Eureka in 2008, with water health, wastage and storage topping the poll for the second year in a row; the drought was also highlighted, followed by renewable energy and illegal waste dumping (IPSOS, 2008). All polled significantly higher than global warming and climate change.

Other Australian community attitude surveys have, likewise, revealed mixed results with respect to environmental issues. According to the Australian Bureau of Statistics, concern for the environment has been in steady decline, and had reached its lowest point since their survey's 1992 start (ABS, 2006). Australian Bureau of Statistics data reveal that, in 1992, 75% of all Australian adults stated that they were concerned about environmental problems; by 2004, this proportion had declined to 57%. This trend is mirrored in other, more recent surveys with regard to attitudes to climate change. When asked to select an issue that the Australian respondents would take action on if they were in charge, 46% selected climate change in 2008, down from 55% the previous year (IPSOS, 2009). Importantly, the same survey revealed that almost one in ten Australians question the validity of climate change. Patterns of concern differ by age. A survey of young people in Queensland revealed that the majority of 12 to 24 year old respondents were highly concerned about the environment (Fielding, 2009), with nearly three-quarters of 18 to 24 year olds being quite a bit or very concerned about protecting the environment and just over half being equally concerned about climate change. Protecting the environment was ranked second amongst all social issues, with availability of water, climate change and land clearing being, for younger people, the three most important environmental issues facing Queensland and Australia.

The IPSOS survey also revealed that, at least several years ago, nearly half of all Australians believe the government was on the right track to prevent climate change (IPSOS, 2009), although a Reuters News poll conducted by IPSOS indicates that only 35% of adults surveyed in 23 countries believe their own government and business leaders are taking the right steps and pace to prevent global climate change (IPSOS, 2009). In their recent review of surveys of attitudes on climate change in Australia, Leviston *et al.* (2011) identified three important trends:

- Most respondents believe that climate is changing, but only a minority believe that the change is attributable to human activity.

- Beliefs about climate change are strongly related to political preferences, voting behaviours and gender, but there are no clear relationships between beliefs, location, age or income.

- Most respondents believe that Australia should take action on climate change without waiting for global consensus, but there is no consensus on specific policy.

In terms of the Grand Challenges Forecasting-Observations-Thresholds-Responses-Innovation model, it appears there is a mixed public view on the knowledge base. Such ambivalent public views on what the scientists would argue are fundamental scientific concerns presents a potential impediment for the successful communication of scientific observation and forecasting, let alone prediction and acceptance of thresholds. In the immediate term, based on these survey results, a challenge remains to the successful communication of scientific knowledge, a challenge that has to be overcome before strong social and governmental response and innovation may be expected to become widely accepted.

The Australian environmental science and management community's views on global environmental challenges

In June 2011, Southern Cross University held a conference entitled *Innovative Solutions for Environmental Challenges*. The conference aim was two-fold: (i) to determine what the strategic needs and challenges for environmental management are over the next decade; and (ii) to identify the collaborations needed to define an integrated socio-environmental research agenda for 2011-2021. In tandem with this conference, an on-line survey was run in the lead-up to the conference, and an environmental challenges workshop run during the conference. Here we overview the results of these activities.

Innovative Solutions for Environmental Challenges Conference

The conference brought together a range of environmental and social science experts from across the disciplines to discuss new and pioneering solutions to our greatest environmental challenges. Participants talked about the challenges of: climate change adaptation in coastal Australia; biodiversity loss; the effect of climate change on food security; wastewater management; and integrating environmental education into school curriculums. Speakers addressed the matter of combining practical insights from the environmental *and* social sciences to develop social and ecological approaches to solving environmental problems. The conference, in a broad sense, reminded the delegates, in the words of one presenter, that "There is no Planet B, just lots of Plan Bs". Key recurring issues amongst the papers and ensuing discussions included: the importance of process and knowledge, particularly systems thinking (c.f. Harich 2010) and inter-disciplinarity (c.f. Kastenhofer *et al.*, 2011) ; the roles and strengths of modelling and sound methodology (c.f. Vanclay *et al.*, 2003; Voinov & Bousquet, 2010); and the importance of understanding and working within social processes (Lee, 1999; Reid *et al.*, 2010). In terms of modelling and methodology, conference delegates highlighted the value of listening and paying attention to people, the role of engaging community in problem solving, and the use of scientific methodology as (in addition to conventional scientific data collection) an invaluable vehicle for dialogue and community engagement (cf. Phillipson *et al.*, 2012). With regards to working within social process, the conference delegates reflected on the importance of good public policy and governance, and of the role of culture, cultural understanding communication and education in achieving sound environmental management outcomes. While such conclusions are not novel, for many scientists they present a challenge in the way they work. Examples of scientific data collection projects that engage community and create community empowerment before the data collection is completed provided examples to scientists of the value of community engagement.

The Greatest Environmental Challenges to 2021 Workshop, run during the conference, and engaging around twenty delegates, focussed on what delegates perceived to be the key environmental challenges of our time across three scales – regional, national and global – and

their responses to each challenge. Concern regarding climate change emerged as a key theme, particularly at the global scale, with concerns around pollution, waste, energy, biodiversity loss, water, and food security also featuring prominently. While these reflect concerns about natural or material resource use, abuse, supply or depletion, interest also focussed on several social processes. In particular, social apathy and self interest were raised as significant environmental challenges (cf. Lorenzoni *et al.*, 2007). The needs to address social apathy (c.f. Fischer, 2010; Heath & Gifford, 2006; Treanor, 2010), to integrate social values in natural resource management (c.f. Reid *et al.*, 2010), for sustainability education (Australian Government, 2009; Australian Government, 2010; Jones *et al.*, 2010), and for a re-think of economic and political structures (Lee, 1999; Speth, 2008), were all recognised as potential responses to environmental challenges. One participant's response was apposite. In reflecting on the social response required in regards to key regional environmental challenge, the participant noted that "at present [key environmental challenges are] mainly left to the already over-committed and dedicated minority who care deeply and understand the issues and how to turn information into action … still only a small percentage of the population" (c.f. Dono *et al*., 2010; Fielding *et al.*, 2008).

These outcomes provided affirmation of the validity of the Grand Challenges Forecasting-Observations-Thresholds-Responses-Innovation model. Presenters provided a rich vein of evidence on the Forecasting-Observations-Thresholds end of the model, while the conference discussions gravitated towards the need for social response and innovation. Probably the most significant innovative idea was the notion that a scientific data collection project can be a powerful vehicle for community empowerment. Indeed several delegates discussed the inherent tensions implicit in such a finding: that formal approval (funding) for a scientific study is more readily justified through a claim of the anticipated scientific rather than social outputs and outcomes, and that many projects have gained significant social outcomes long before the scientific analysis has been completed.

The Greatest Environmental Challenges to 2021 Survey

The *Greatest Environmental Challenges* survey was an online survey run from March – May 2011, targeted at Australian professional environmental managers and scientists from government and non-government agencies and institutions around the country. A request to participate was distributed by email through, and with the support of, professional and institutional email networks, and received 337 responses. The survey sought feedback on environmental scientists' and managers' views on what they thought are greatest regional, national and global environmental challenges facing Australia over the next ten years. Publication of the full analysis is currently in preparation (den Exter *et al*., in prep); here we present a summary of the results (Figures 1 to 3).

Figure 1 Summary of the regional environmental challenges facing Australia, as reported by Australian environmental managers and scientists in the 2011 *Greatest Environmental Challenges to 2021* online survey.

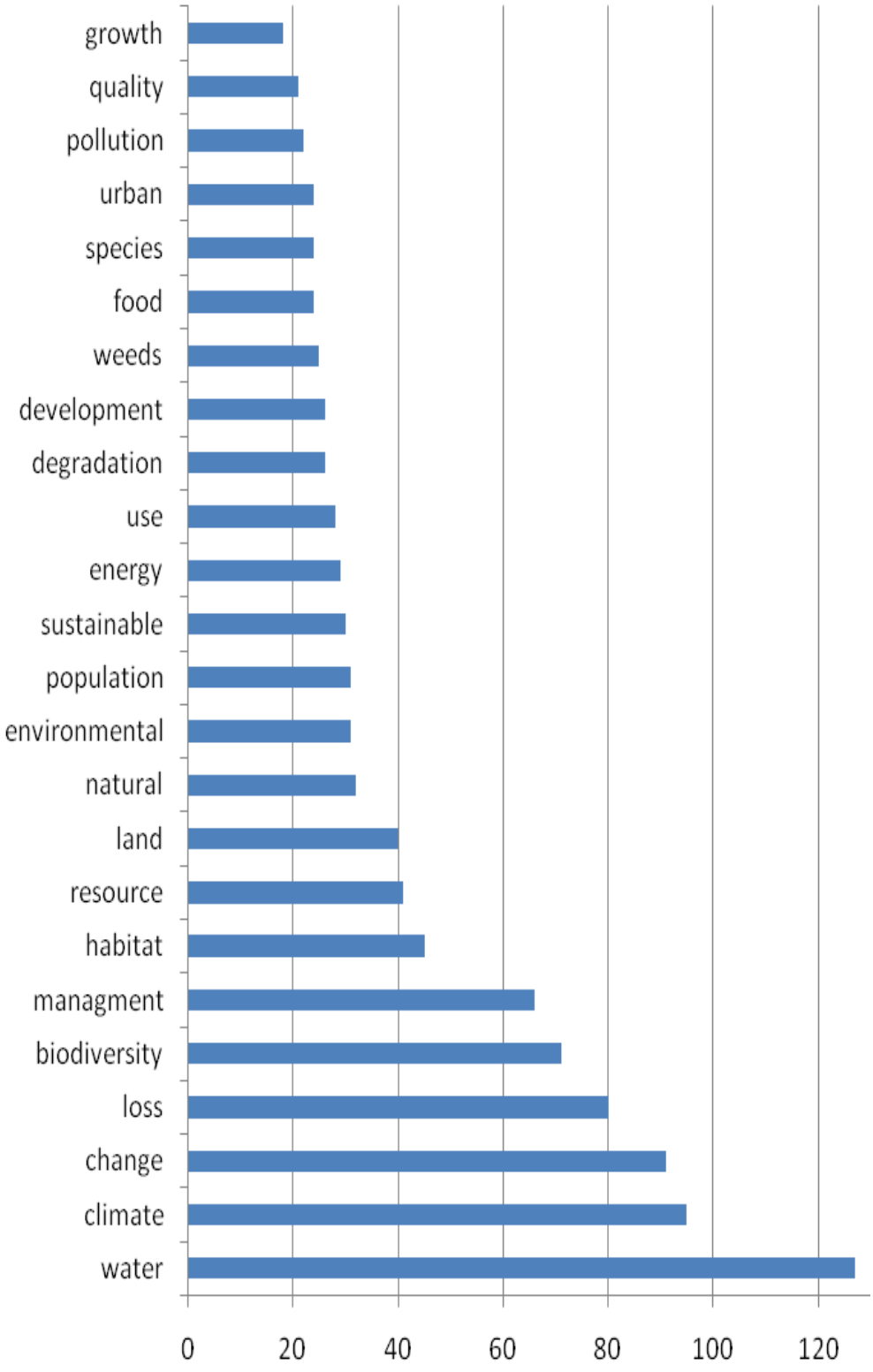


Figure 2. Summary of the national environmental challenges facing Australia, as reported by Australian environmental managers and scientists in the 2011 *Greatest Environmental Challenges to 2021* online survey.

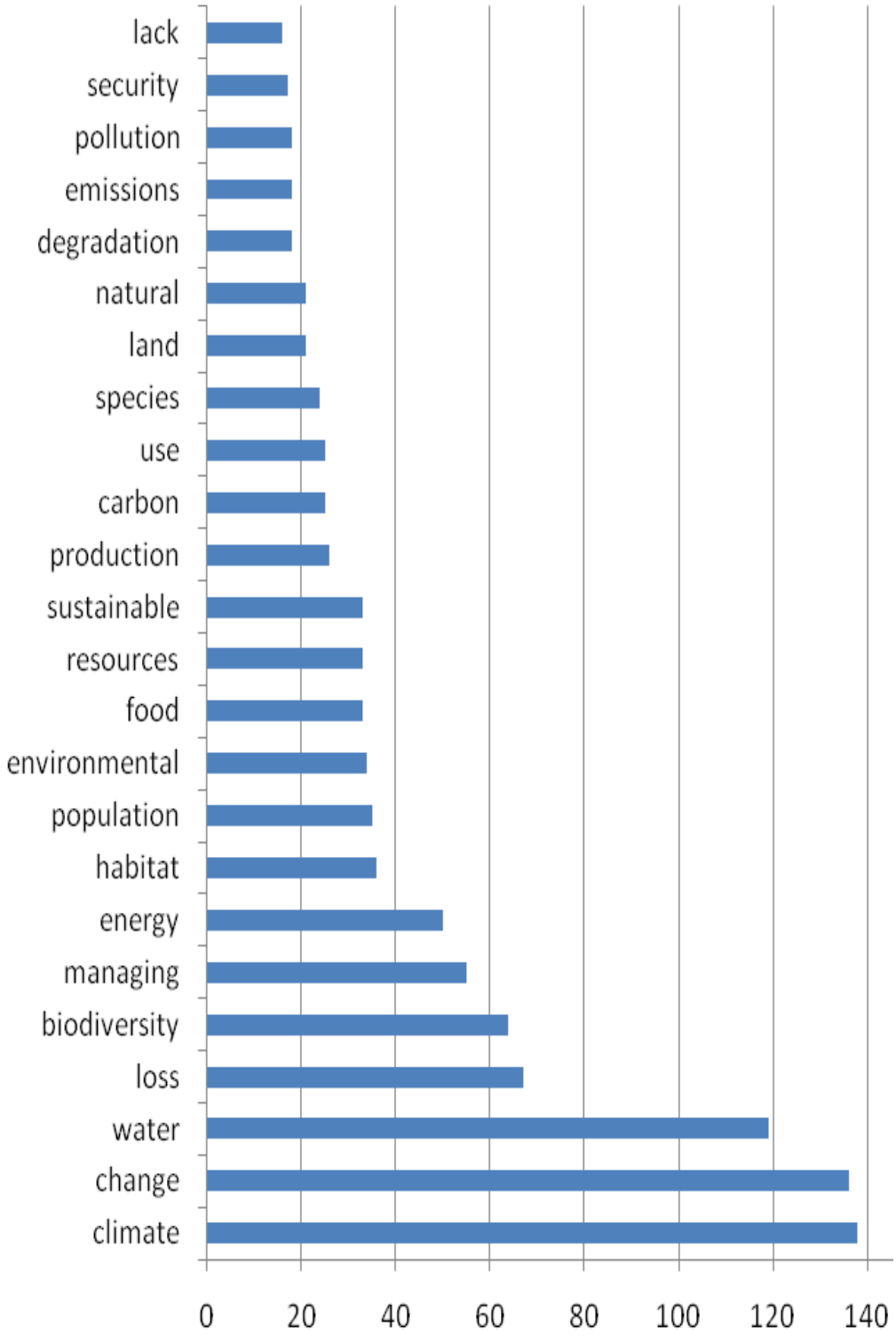
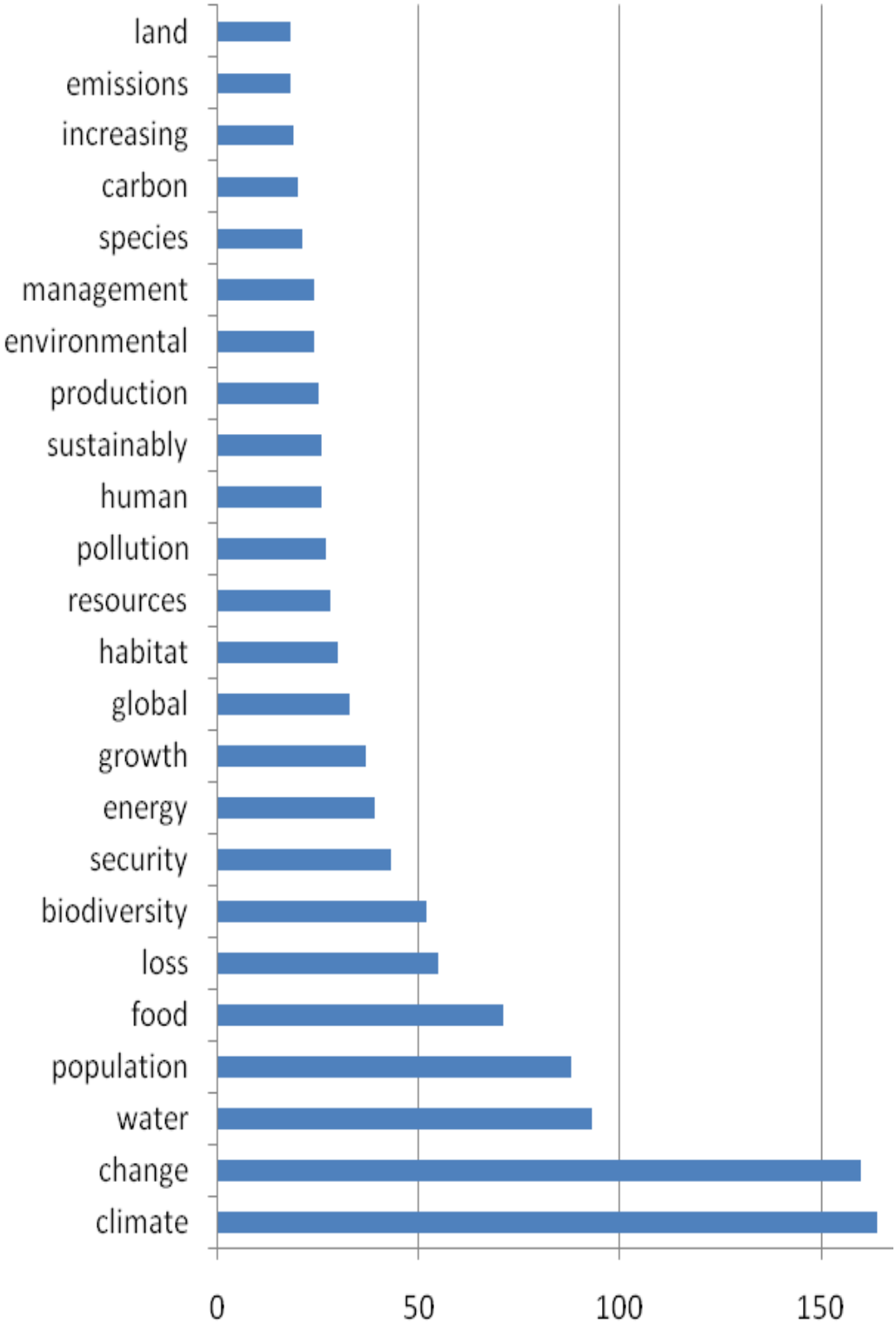


Figure 3. Summary of the global environmental challenges facing Australia, as reported by Australian environmental managers and scientists in the 2011 *Greatest Environmental Challenges to 2021* online survey.



Overall, climate change tops the list for the majority of respondents as the national and global issue of greatest concern and comes second as a regional concern. Other high ranking concerns include population growth, energy, water, land degradation and loss of biodiversity. Of interest is the differing perception of regional, national and global concerns. Respondents identify a wide range of issues at the regional scale, including many individual issues. These loosely cluster under headings such as: habitat and biodiversity loss; land use (especially agriculture) and urban environments; landscape management; water; and population change. While this pattern may be understood in terms of the relative scales of such issues (c.f. Kok & Veldkamp, 2011) and the immediacy of their local and short-term affects – and thus visibility – there is one notable low concern, natural disasters. The pattern of concern is more focussed at the national scale, with climate change dominating concerns. Interestingly, while this is an overwhelming response, it is often expressed in a generic way, only stated as "climate change". Other concerns focus around biodiversity and habitat (various specific concerns), as well as a range of issues about managing sustainability, articulated in terms of social, population, government and food supply issues. Equally interestingly, given the national (Federal government) political focus in 2011 on the carbon tax, issues of the carbon tax, emissions and related concerns are low on the lists, as was energy supply. Finally, at the global scale, there are two big issues, climate change and population growth. A few respondents mentioned energy supply.

While these results may be read to infer a prioritisation list of issues, there are two more important conclusions to be drawn from the data. First, the issue of scale and context is crucial. The immediate point of interest, reflecting the differences already noted above between the public perceptions identified in the World Values Survey and the Australian Survey of Social Attitudes (WVS, 2011; ADA, 2011), is the role that scale has to play in people's understandings and perceptions of critical issues (c.f. Holling, 2004; Kok & Veldkamp, 2011; Peterson, 2000). In the *Greatest Environmental Challenges* survey, regional concerns focus on specific, local, on-the-ground issues, and hence there is a greater diversity in the issues of concern. At the national scale, while there is a significant concern about a generic "climate change", there is also stronger focus on politics, bureaucracy, social process, and management. The global scale retains concern about climate change, but introduces population growth and related issues, reflecting a recognition that population pressure is probably not an issue of significant concern within Australia, but recognised to be so more important globally.

The second important conclusion lies in the survey highlighting the tensions between maintaining current levels of production and consumption, while protecting scarce resources and ecosystem services. By way of example, some survey responses express concern that Australia does not have strategies to accommodate future energy needs while reducing our carbon footprint. Concerns regarding food security as a national issue also reflect this tension. This survey also mirrors, at the Australian scale, what global scientists are saying about the need to find ways for the scientific, social and political communities to work together to develop innovative approaches to solving future environmental concerns with scientists, governments and the community (c.f. Gunderson & Folke, 2011; Lee, 1999; Silvertown 2009). Nearly three-quarters of the respondents indicated that they, or their organisation, have developed strategies or policies to address key environmental challenges, and around two-thirds responded that their organisation had implemented such strategies.

When asked about the relationship between science and governance, responses varied. 66% of respondents agreed that scientific researchers supply the information they need to implement their environmental policies or strategies; over 20% disagreed, while 10% were unable to comment. Conversely, respondents, when asked if policy makers have adequate information for policy development and implementation, were more ambivalent: 12% strongly disagreed, 29% disagreed, 26% were neutral, 26% agreed, and 7% strongly agreed. Likewise, responses regarding where scientific data is lacking were varied. A number of respondents suggested that the issue lay in the lack of political will rather than data. Their list is telling: in assisting decision making for long term outcomes; in understanding fine scale impacts of climate change; in relation to the impacts of mining; in predicting the effects of land use change and development; in providing local baseline data on resource condition (soil, water, biodiversity, vegetation condition, invasive weeds, etc.); in the presentation of scientific data to managers who "don't have time to read"; and in understanding and predicting cumulative change and impacts.

Discussion – So what?

This review echoes Bradshaw *et al.*'s (2010) conclusions that environmental performance is complex, and that the drivers of environmental impact are variable. If the scientific evidence, which seems to be largely accepted as crucial to appropriate social and political decision-making, is going to be accepted and acceptable, then an understanding of the complexity and diversity of public opinion and perception is vitally important (c.f. ter Mors *et al.*, 2010). While the ICSU see their Grand Challenges in terms of five components – forecasting, observations, threshold, responses, innovation – the perspective taken here focuses on the fourth, the responses. Indeed, the paper examines only part of the responses, the social understanding or perception of the challenges. While there is a scientific case to be made for the need to "improve the usefulness of forecasts of future environmental conditions and their consequences for people … [to] develop the observation systems needed to manage global and regional environmental change … [and to] determine how to anticipate, recognize, avoid and adapt to abrupt global environmental change", our observations suggest there is a urgent need to work on the social response, that is, to "determine what institutional, economic and behavioural changes can enable effective steps toward global sustainability" (ICSU, 2010:10-14).

Three key factors from our review require further work.

First, while politics and political inclination comprise a key factor (Leviston *et al.*, 2011), it is notable that politically-current environmental issues do not necessarily come to the fore in attitudes survey. Our survey of professional environmental managers and scientists indicate a level of insulation against current debates, with the relative lack of concern regarding matters such as the carbon tax, a hot Australian Federal government political issue in 2011. The social context of the respondents – as professional people engaged in the management of natural resource – may also play a significant role, in that their engagement with the issues is probably more formalised, structured and bounded: they were responding, after all, as

professional people. In a similar vein, Fielding's (2009) data with younger people indicate a social construction of environment that appears to differ from the general public, a social construction that most likely reflects social processes such as recency of schooling, role of further studies, social networking, engagement with alternative and counter cultures (Snow 1990), etc. This notion of social identity is important. Crompton & Kasser (2009) suggest that the environmental movement, in its efforts to change the policies and practices of governments and businesses, and to influence the behaviours of individuals, neglects an important third level of intervention: human identity. Their focus was on three aspects of human identity: self-enhancing and materialistic values and goals; in-group/out-group dynamics; and responses to fear and threat. While arguing that these often contribute to environmentally problematic values and behaviours, their argument could be taken further to support a nuanced engagement of the official environmental science and management community with broader communities, based on understandings of the social identities of these communities.

Secondly, the issue of scale is important (c.f. Holling, 2004; Kok & Veldkamp, 2011; Peterson, 2000). The contrast between the outcomes of the World Values Survey and the Australian Survey of Social Attitudes (WVS, 2011; ADA, 2011) reflects the role that scale has to play in people's understandings and perceptions of critical issues. Our survey also identifies this matter: it perhaps comes as little surprise that the greater the difference in scale between a respondent's lived experience and the issue at hand, the less likely it is for a respondent to understand the issue or to engage with it in anything other than a conceptual or abstract sense (Duerden & Witt, 2010). The generic "climate change" concern amongst environmental managers is an example, where even amongst well-informed professionals, the generic concern is important.

The third key factor is the tension inherent in the science-society relationship (c.f. Gunderson & Folke, 2011; Kastenhofer *et al.*, 2011; Lee, 1999). It has been noted above that while the ICSU grand challenges in global sustainability is of the global scientific community "delivering to society the knowledge and information necessary to assess the risks humanity is facing from global change …," it is still a fundamentally scientific agenda, in its structure, organisation and language. It is predicated on science delivering, rather than society receiving, or, better, an integrated science-society dialogue. Dilling & Lemnos (2011), for example, describe the differences between the "science push", where researchers and information providers determine what type of science is produced and disseminated, and the "demand pull", where priorities in the generation of new knowledge are determined by those making decisions outside of the scientific community, and the iterative "co-production of knowledge between scientists …and stakeholders" (Figure 4). Much of what we describe here – the Grand Challenges model, Rockström *et al.*'s (2009) and Bradshaw *et al.*'s (2010) analysis, and the responses of both public attitude surveys and the Greatest Environmental Challenges to 2021 survey – represent a primary focus on the science or, at least, the natural resources, rather than the social aspects of environmental issues. Rockström *et al.*'s (2009) analysis primarily engages the Forecasting-Observations-Thresholds component of the Grand Challenges model, while drawing attention to the need for social engagement with the Responses-Innovation component. Bradshaw *et al*. (2010), likewise, draw their primary data from Forecasting-Observations-Thresholds component of the Grand Challenges model, but of

necessity draw attention to the science-society linkages in this matter, supporting calls for better integration of disciplinary and/or scientific knowledge for social action.

Figure 4. Setting scientific knowledge agendas (after Dilling & Lemnos, 2011). Top: the science push – researchers and information providers set the agenda for what type of science is produced and disseminated. Middle: the demand pull – priorities in the generation of new knowledge are set by those making decisions outside of the scientific community. Bottom: iterative co-production of knowledge between scientists and potential users and stakeholders.

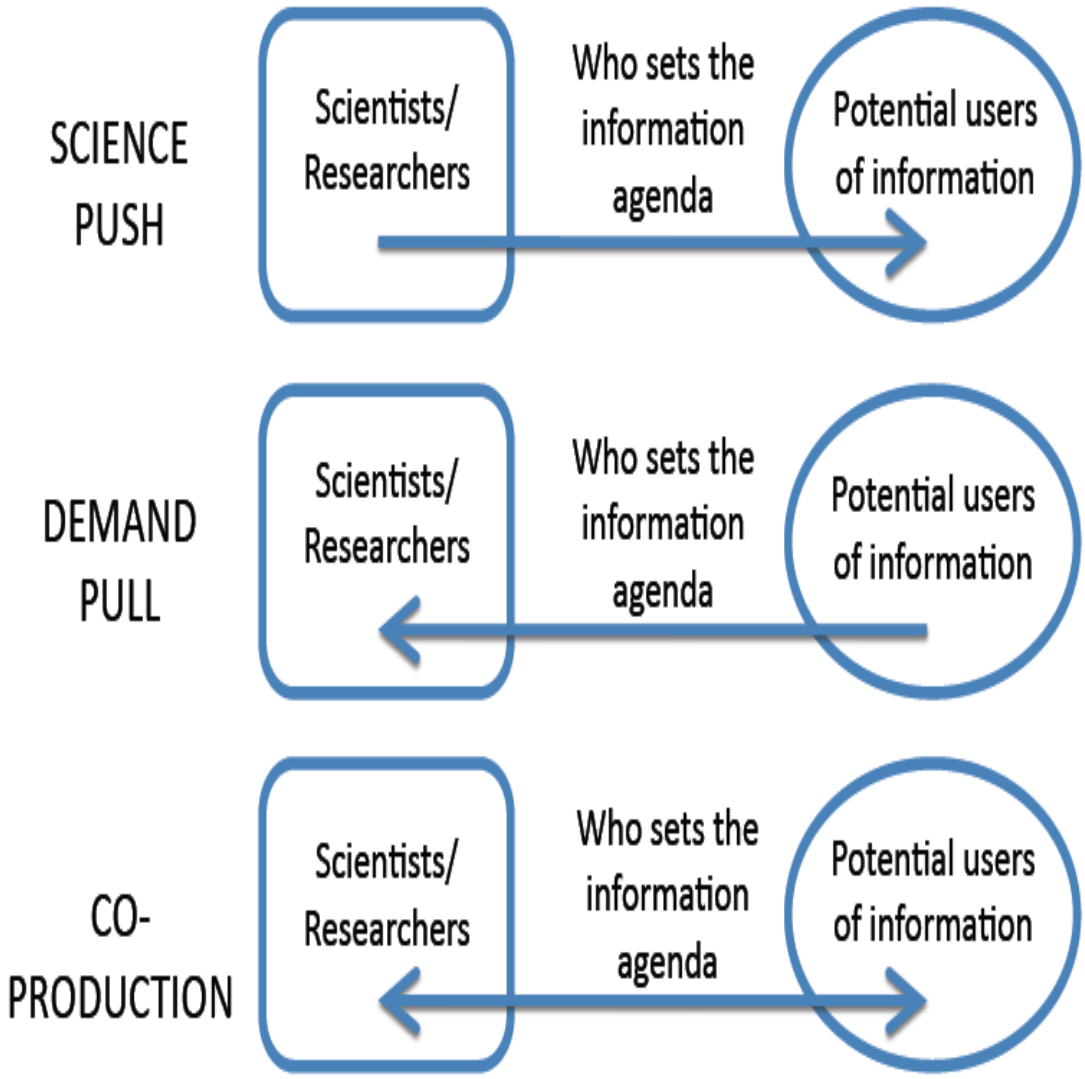
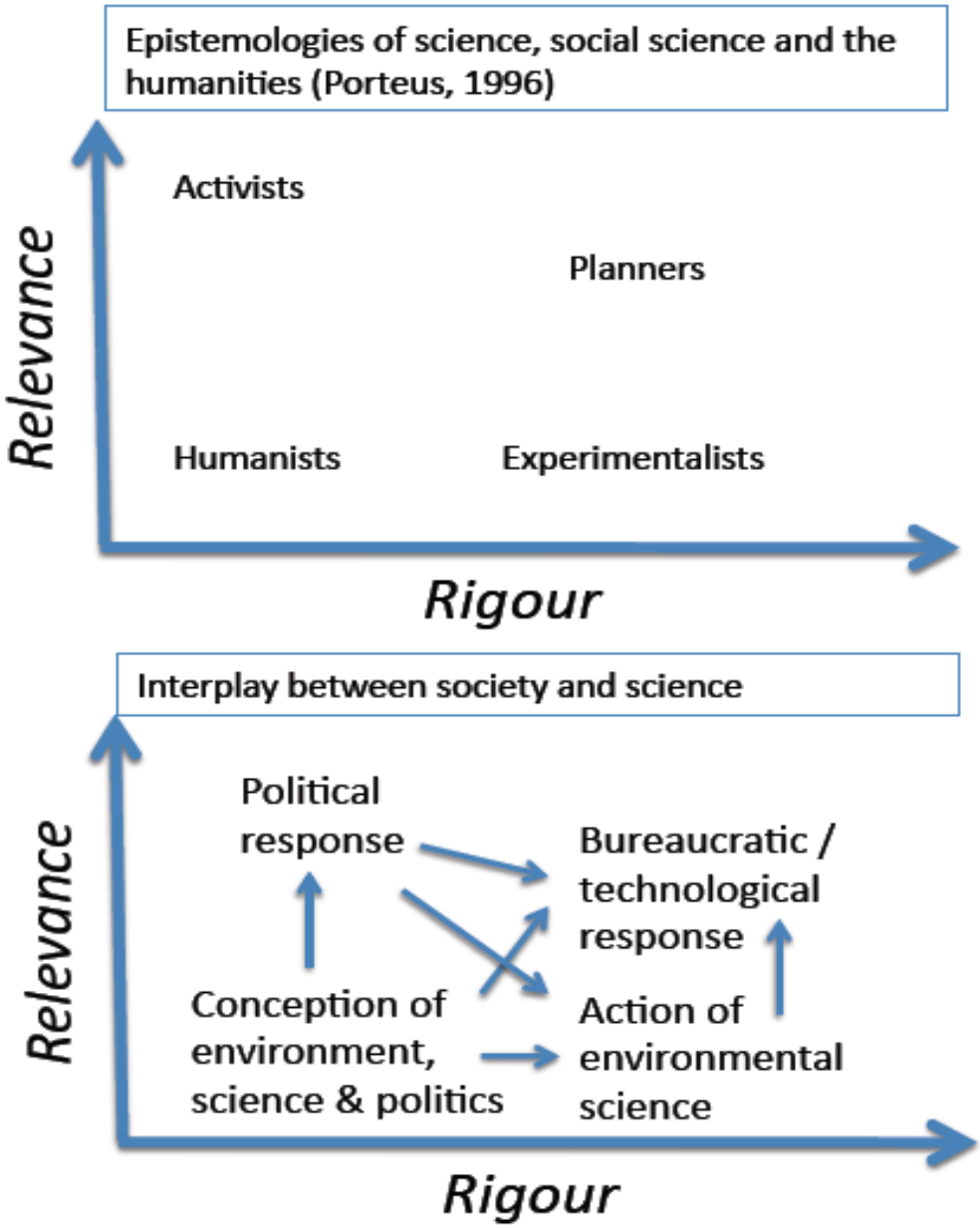


Figure 5. A depiciton of the interplay between science and other social uses of knowledge and information – and hence the essence of the ISCU's Grand Challenges – articulated through the interplay between rigour and relevance as a mediation between the epistemologies of science, social science, and the pragmatism of political action and public management (after Porteus, 1996).



This tendency of building on the material or scientific evidence – the Forecasting-Observations-Thresholds end of the model, but drifting into the social implications, the Responses-Innovation end of the model – is reflected in both the Australian Survey of Social Attitudes (ADA 2011) and the Innovative Solutions for Environmental Challenges conference and its Greatest Environmental Challenges survey. The Social Attitudes Survey reflects a mixed or ambivalent public view on the scientific knowledge base, and thus a challenge for the science of observation and forecasting, let alone prediction and acceptance of thresholds. While the scientific community may find this unpalatable (Besley & Nisbet, 2011), it remains faced with the challenge of communicating scientific knowledge to both the public and the government. For this reason, the ICSU's fourth Grand Challenge – the Response – is so important.

The ambivalence evident in the Greatest Environmental Challenges survey respondents' views – remembering that the respondents are professional environmental managers – on the role of science information and its communication into policy is important. They mostly agree that science provides the information needed to implement environmental policies or strategies, while mostly questioning whether policy makers have adequate scientific information for policy development and implementation (Besley & Nisbet, 2011). Likewise, their commentary on where they consider scientific data to be lacking is telling, especially where their perceived gaps lie in informing fine scale climate impacts, managing land use change, development or local scale resource condition, or understanding the complexity of cumulative change and impact. These are important pragmatic limitations, emphasised by comments regarding presentation of scientific data to managers who "don't have time to read". Their ambivalence regarding their relative confidence in science's ability to deliver information, but management's inability to receive it (cf. Besley & Nisbet, 2011) highlights the importance of understanding and mediating the cultures of parties in a communication relationship: this has little to do with the science *per se*, and much to do with group culture (cf. Bendell, 2000).

While such responses may be readily dismissed by scientists who defend their scientific data in terms of rigour against such social misuse or misunderstanding of the science (Besley & Nisbet, 2011), they reflect the social reality, indeed the critical essence, of the interplay between science and society (c.f. Gunderson & Folke, 2011; Kastenhofer *et al*., 2011; Scarlett, 2010; van Wyk *et al.*, 2008). This reality may be articulated in many ways; one useful model is the interplay between rigour and relevance as a mediation between the epistemologies of science, social science and the humanities on the one hand, and the pragmatism of political action and public management on the other (Porteous, 1996). Environmental science – the Forecasting-Observations-Threshold component of the Grand Challenges – is represented in Figure 5 at the lower right-hand area of the rigour-relevance field, implicitly informed conceptually from the lower left-hand area. The social responses, whether political bureaucratic or technocratic – the Responses-Innovation components – are situated in the upper part of the field. The essence of the ISCU's Grand Challenges lies in making the connections from the lower to the upper parts of this field, in other words in mediating between rigour and relevance.

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