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The role of research in informing the governance process of the use of ecosystem resources

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Abstract

We argue that cooperative governance is a cornerstone of successful management of the use of ecosystems. Even where good institutions exist, the challenge is to establish a process of "collective action" that enables society to work through conflicting goals and values in a process of structured co-learning as they relate to the use of natural resources. Research enables informed collective action and is therefore central to informed governance of the use of ecosystems. In this paper we establish a framework for evaluating the role of research in informing the governance process. Selected case studies are used to assess how research has informed governance, their findings are discussed and lessons are drawn from these.

Keywords: Cooperative environmental governance; Role of research

1. Introduction

There is a close relationship between society and ecosystems, since society enjoys the benefits provided by ecosystems. However, not all people use the same benefits, and any particular individual's view of an ecosystem will be coloured by their relationship with the ecosystem in question. Thus, the process of ecosystem governance needs to take these differing perceptions into account.

Ecosystems themselves are complex, and the complexities facing sustainable governance of ecosystems add an additional layer to this complexity. Research is central to the sustainable governance of ecosystems, especially when working into this complexity and it provides information and understanding to guide decision-making, as well as to facilitate co-learning between stakeholders. The understanding of the role played by research is important if it is to be employed effectively, and this paper interrogates that role.

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2. Ecosystems and society

Growing appreciation for the biophysical connectedness of nature led to the introduction of the term "ecosystem" (Golley, 1993). There is, however, a paradox in attempting to circumscribe and isolate parts of a biophysical world such as a river or forest ecosystem, while acknowledging the reality of its much wider connectedness, and so we must appreciate that the concept of an ecosystem is a social construct (Bird, 1987). Although the concept has proven itself, and is still useful, ecosystems have no reality in nature and, in time, as society embraced the concept as an aid to managing the use of resources (Cortner & Moote, 1999), the term came to mean different things to different people: scientists saw the concept as facilitating understanding of connectedness and change, whereas society envisaged that ecosystems could be managed to sustain a supply of resources. Importantly, the concept of ecosystems brought science, i.e. structured knowledge about natural systems, into contact with society.

Because they are social constructs, ecosystems, just as the world, are not independent of the observer; rather, the intent of the observer influences what is seen (Kinnaman & Bleich, 2004). This means that, within society, ecosystems are perceived and defined differently by different people according to how they appreciate the value of the goods and services that the ecosystem can provide (Costanza *et al.*, 1997) and how the costs and benefits that may accrue from use of the ecosystem resources are distributed (van Wyk *et al.*, 2006).

It was appreciation of the role of ecosystems as a supplier of resources (goods and services), valued by society and the need to manage demand for these resources that prompted introduction of a system through which the relationships between stakeholders could be managed. This system constitutes governance over the use of natural resources (Rhodes, 1996; Turton *et al.*, 2005).

Ecosystems are complex and dynamic systems. As such they exhibit variations in the supply of goods and services and they also exhibit emergent properties that may be impossible to predict (Senge, 1990; Kay, 2001). Society seeking to benefit from the use of ecosystems has therefore to be enabled to adjust the expectations of its constituents in response to changes both in the ecosystem and in society. The implication is that ecosystem governance operates in a context of uncertainty about the nature and productivity of the ecosystems as well as the expectations of society, and yet ecosystem governance has to be prepared to respond in informed ways. This requires governance systems that are continually able to draw upon and merge current understanding, be innovative and provide strategic direction for research. Rogers *et al.*, (2000) refer to this as "Strategic Adaptive Management".

3. Ecosystems and governance

Because ecosystem governance concerns both the present and the future, long-term relationships between stakeholders are required and so we can envisage that partnerships lie at the heart of such governance systems.

Firey (1960, in Stankey & McCool, 2004) has suggested that it is only with the perception of utility in any landscape element that society assigns the concept of resource, and hence value. Resources can yield value in different forms, commodity, spiritual and cultural. Some, however, hold that nature has intrinsic values outside human utility (Katz, 2000). It seems, though, that how one values an ecosystem depends to a large extent on how one imagines it could be used, even if this is a subconscious assessment. How we value it expresses where we have come from; our history, who we are and our perspectives on the

future, and is a personal perception of reality. This informs us that ecosystems are perceived differently by each person, largely according to the utility value he or she places in the associated resources (goods and services) in the ecosystem. Also, some people may realise value from an ecosystem – a commodity for example – without ever having observed the ecosystem. The result is that, as we may be unaware of the utility value that others place in a landscape; we may not even be aware of some of the resources. This suggests that we cannot have a "complete picture" and, in managing the use of resources, we have to appreciate that there will be multiple perceptions of reality among people viewing the same landscape or ecosystem.

Perceptions of utility value and the mix of these values change continually as they adjust to the dynamics in the ecosystem and society. In other words they reflect complex and continually changing patterns and levels of supply from the ecosystem and demand from society. Because uses may conflict, not all utility values can be accommodated simultaneously and tensions between potential users have to be managed so that they become creative rather than destructive (Senge, 1990). Ecosystem governance thus occurs in a complex, dynamic socio-political state that requires an integrated approach. Such an approach is critical for achieving equity in the distribution of benefits and costs associated with the sustainable use of ecosystem resources. This requirement for governance to be integrated means that it must, by definition, involve interested and affected actors and be able to foster relationships that facilitate shared decision-making.

4. Participatory governance

The utility value of ecosystems is experienced in different ways by different people, separated in time and space, presenting a complex social context for governance. The structure and functioning of ecosystems complicates this further because many associated resources, such as water, air and animals, are mobile and move across permeable political boundaries. This complicates concepts of ownership, resulting in a mixture of private and common property rights. It is how these rights are exercised in unison that determines the success of governance for sustainable use of ecosystem resources.

Collaboration is the learning foundation for achieving management practices that are ecologically effective and socially just (Belsky, 2004). It is not surprising that Selin (2004, p 137) observed that "During the past 15 years, partnerships have emerged as a mantra among policy makers, managers, entrepreneurs, non-governmental organizations and citizens to achieve important conservation and sustainable development objectives". But what are the properties of partnerships and how do we sustain them in order to be prepared to deal with change and the unexpected?

Agency culture and norms can be significant barriers to partnerships in managing the use of natural resources (Cortner & Moote, 1999; Selin, 2004), particularly where this leads to management's obsession with seeking control and stability (Valadez & Sportsman, 1999). Such culture is inappropriate when dealing with complex social and ecological systems characterised by uncertainty and where emergent properties create unforeseeable issues. Given this reality, we can appreciate the importance of actively managing agency culture and norms so that they support emerging strategies (Nyambe, 2005; Nyambe *et al.*, 2005).

Cortner and Moote (1999, p 91) observed ". . .that without citizen involvement in governance, there is no democracy. The price of individual freedom is participation in governance; this is part of the social contract between citizens and the state". However, whilst participation is a prerequisite for democracy, it

does not always lead to democracy (Brinkerhoff & Crosby, 2002, p 79). The relationship between participation and democracy informs us that reciprocity lies at the heart of collaboration in governance. It is achieved through "recurrent iterations" and therefore there has to be sufficient time for iterative decision making (Wondolleck & Yaffee, 2000, p 66). Strategic Adaptive Management (Rogers & Bestbier, 1997) provides an open-ended iterative process for collaborative decision-making but it does not address reciprocity explicitly relying on shared vision and goals to direct "give and take" decisions.

It has been shown above that tensions are an ever-present feature of decision-making within governance of the use of ecosystem resources. This suggests that something more substantive would be required to foster resilience in the interpersonal relationships that underpin reciprocity. So, what is it that engenders and sustains reciprocity, the willingness among participants to seek and support consensus and to honour the social contract between them? Participation provides a foundation for social capital, trust, norms and networks of relationships (Putnam, 1993). Social capital has been defined as the networks, norms and social trust that facilitate coordination and cooperation among people for mutual benefit (Shutkin, 2000). Dekker & Uslaner (2001) view social capital as a non-material, inter-individual resource that enhances the possibilities of cooperation and coordination that a group can utilise to harvest a crop, to organise an association, or to enforce norms. Mutual trust and social norms based on reciprocity are elements of social capital that enable participants in governance to establish legitimate objectives and processes that enable them to cope with the challenges that arise in managing the use of ecosystem resources. This is especially so because so much uncertainty attends predictions of how the social ecological system may respond to change. Because of the properties of social capital it supports resilience within relationships empowering them to manage tensions that arise in collaborative decision-making (Nkhata *et al.*, in press).

The challenges encountered in participatory ecosystem governance are multifaceted and commonly require collaboration for effective resolution. Collaboration is an emergent process distinguished by cooperation and coordination (Gray, 1989). Partnerships require organizational leaders to align resources to create and sustain partnerships (Kinnaman & Bleich, 2004) that enable collaboration so that they improve innovation and problem-solving. Models, such as those by Stacey (1996) and Kinnaman & Bleich (2004), provide an analytical tool that can be used to evaluate case studies drawing distinctions between four primary behaviours of interest: Toleration, Coordination, Cooperation and Collaboration.

5. Research and ecosystem governance

We have argued that, because of the complex dynamic nature of the social and ecological systems, stakeholders hold different understandings, if sometimes only in subtle ways, that are constantly changing. We have posited, further, that collaboration is necessary to direct resource use so that it is just and sustainable. Collective learning is necessary to build and sustain the shared understanding that is required for creative, constructive and effective relationships (Ford *et al.*, 1998; Dyer & Nobeoka, 2000; Brown *et al.*, 2001; Johnson *et al.*, 2004). We learn from integrating our own experiences with those of others, and so "...collaborative efforts expand understanding by generating new information and dealing with uncertainty through joint research and fact-finding" (Wondolleck & Yaffee, 2000, p 29). Collective learning has to be strategically adaptive if stakeholders are to be able to sustain collective learning and manage relationships (Ford *et al.*, 1998; Biggs & Rogers, 2003). This requires stakeholders to interact with each other under a defined set of possible future scenarios (Dyer & Nobeoka, 2000; Brown *et al.*,

2001). However, as we have illustrated this is fraught with challenges centring on political domains, property rights, agency culture and social capital.

It is not surprising that there has been "a rise in discourse-based approaches to natural resource management" (Daniels & Cheng, 2004). This informs us that, for research, the generation of new knowledge, to be effectively targeted and for the pace of learning to be advanced, research has to operate within a broad social context which, in this case, is defined by the process that governs the use of ecosystem resources. Through this process the body of knowledge is continuously re-organised to promote scientifically based co-learning. Kruger & Shannon (2000) have referred to this as "civic science", an approach to inquiry that allows people to learn from each other (Ewert & Stewart, 2004). Distinction has been drawn between citizen science, where citizens act as lay social scientists, and civic science, where scientists work to promote the public good (Krajnc, 2002) as civic scientists (Lane, 1999).

Lubchenco (1998) envisaged a "Social Contract for Science" in which researchers will "(i) address the most urgent needs of society, in proportion to their importance; (ii) communicate their knowledge and understanding widely in order to inform decisions of individuals and institutions; and (iii) exercise good judgement, wisdom and humility". Embodied in this is the notion that scientists are accountable to society and have to contribute to co-learning and participatory governance over the use of ecosystem resources. But how is this to be achieved? Kinnaman & Bleich (2004) suggest that "Academic-service partnerships are the future" and call for "transformation of academic-service relationships that enables and fosters merging of the collective intellectual capacity of both elements".

6. A governance process

The evidence suggests that a governance process for managing the use of ecosystem resources should be: based on collaboration and partnerships; have social and political legitimacy; promote resilience of the social ecological system; develop new information and understanding; provide strategic direction; direct decisions and management interventions; and provide co-learning by doing. However, as discourse-based approaches are inefficient and involve high transaction costs (Daniels & Cheng, 2004) ways must be found to improve efficiency.

Adaptive management in its various forms (Rogers *et al.*, 2000; Brinkerhoff & Crosby, 2002; Oglethorpe, 2002) is a discourse-based process that meets these requirements. As it can incur high transaction costs (Wondolleck & Yaffee, 2000) we have modified it to increase efficiency and to illustrate the role of research in governance of the use of ecosystem resources (Figure 1).

Distinction is drawn between situations in which participants express high levels of agreement on objectives and outcomes, from those in which there is "low-to-moderate certainty and low-moderate agreement regarding the outcomes expected based on defined actions" (see Kinnaman & Bleich, 2004). This enables problems that do not require innovation to be addressed through technically based coordinated efforts. Where there is general agreement on the nature of the problem, the solution and the outcome, the need for discourse is small and thus the transaction costs are also small. In contrast, issues that require innovation for solution because they are characterised by uncertainty and disagreement, are addressed through cooperation. "Cooperation is the highest developmentally, and most complex and resource-intensive interdisciplinary behaviour" (Kinnaman

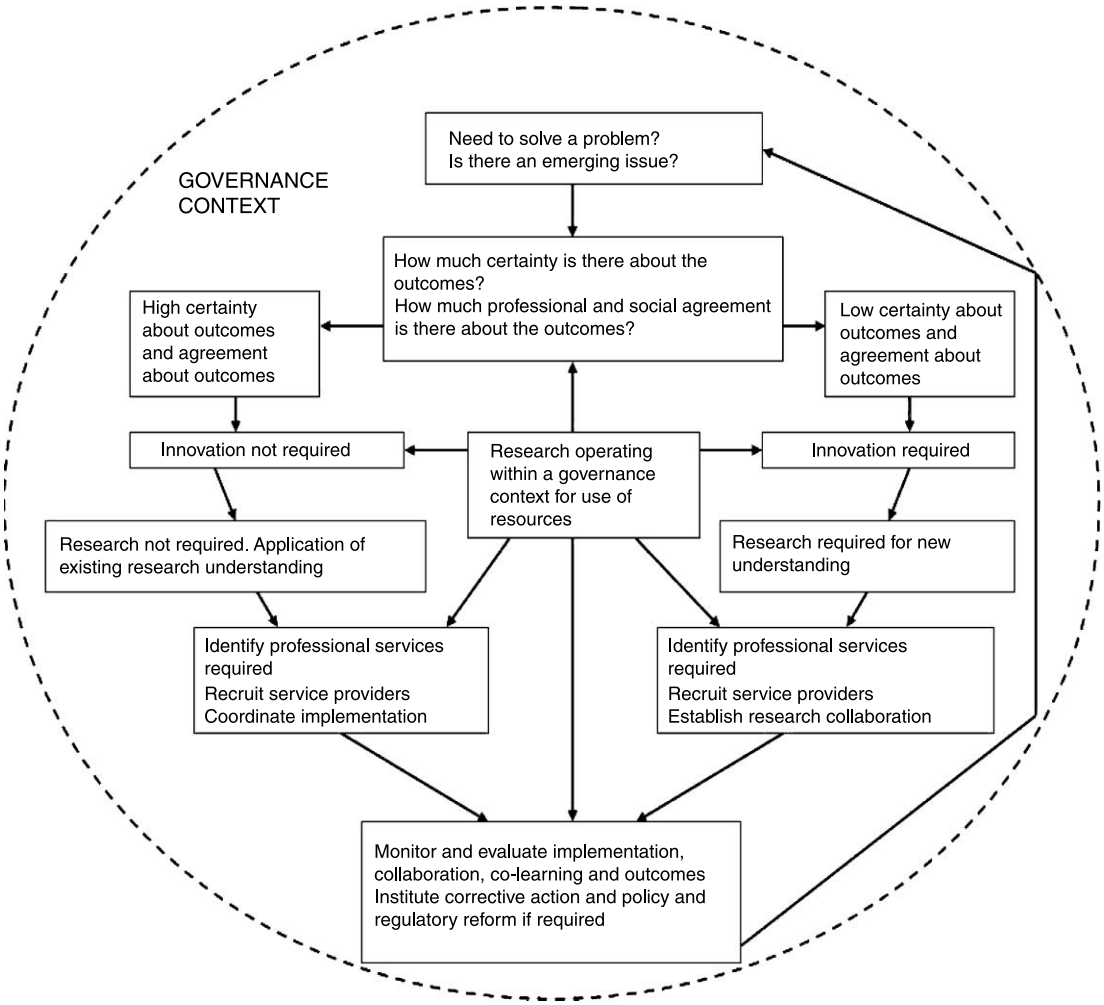

Fig. 1. Research within the context of governance of the use of ecosystem resources. Research has roles to play in how society deals with problems and emerging issues characterized by uncertainty about what stakeholders want and whether this can be achieved. The governance context is defined by a process of adaptive management founded on coordination and collaboration (adapted in part from Kinnaman & Bleich (2004)).

& Bleich, 2004) and therefore involves the highest level of transaction costs. However, as the uncertainty commonly is associated with what may transpire in some future scenario, the issue is one of strategy rather than tactics and there is less urgency. Consequently, it is possible to lower the intensity of transactions by spreading them over time. The model also distinguishes two roles for research: the application of understanding and the generation of new understanding. This distinction helps provide context that enables researchers and the public to better manage expectations they have of research in each situation.

We suggest that separation in this way would reduce transaction costs associated with cooperative governance, would speed up co-learning, and facilitate both civic science (Kruger & Shannon, 2000) and the social contract envisaged by Lubchenco (1998).

7. Case studies

We have used the process depicted in Figure 1 to define criteria for interrogating the performance of selected research initiatives in the context of the "space" defined by the relationships between Society, Science and Government. Selin (1999) has noted the paucity of "longitudinal studies" of partnerships that examine the life cycle or development progression of partnerships. We have endeavoured to track the changing relationships between science, society and government of selected research over time.

The criteria we have developed are framed as questions and the responses are qualitative and subjective, reflecting our general sense of where the project would have been located at any time. Our interpretation is based on reports and other publications emanating from each project.

Criteria

- Need for research. Was the research directed at a problem or an issue?
- Sector identifying the problem or issue. From which sector(s) did the question arise?
- Agreement on outcomes. What degree of agreement was there between the parties on the outcomes?
- Certainty of outcomes. What degree of agreement was there between parties on the certainty of the outcomes?
- Need for innovation. Was innovation required?
- Professional services. Were the required professional services identified and recruited?
- Coordination/collaboration. Was there the required coordination or collaboration?
- Monitoring and evaluation. Was there joint monitoring and evaluation?
- Adaptive management. Was an adaptive management process implemented?

7.1. The trialogue hypothesis

The validity of the Trialogue Hypothesis (Turton *et al.*, 2005) for ecosystem governance states that successful ecosystem governance depends firstly on the existence of effective science, government and society processes, and secondly on effective interfaces between these three processes. We postulated that three processes – the research process, government process and societal processes – would have to interface and achieve collaboration between participating parties if research was to contribute meaningfully to ecosystem governance (Figure 1). We have retained the term "science process" to conform to the nomenclature of the trialogue model acknowledging the close connections between developing new understanding through systematic investigation (research process) and the structuring of knowledge to yield general principles (science process). The case studies described below involve how, over time, researchers engaged a broad range of stakeholders, often with differing perceptions of the system and its resources. We do not assess the research process in these cases. Rather, we assess progress of the science process (structuring the research findings into principles that provide the foundation for common understanding and a shared vision of the way forward). This is often more a process of negotiation that is rooted in "civic science" than it is of conventional science. Sound science is, however, essential to inform the process and to enable stakeholders to assess the consequences of their decisions. This hypothesis has been tested against six case studies where there has been a research programme aimed at solving specific governance issues (Figure 2). We identified the sector in which the issue or

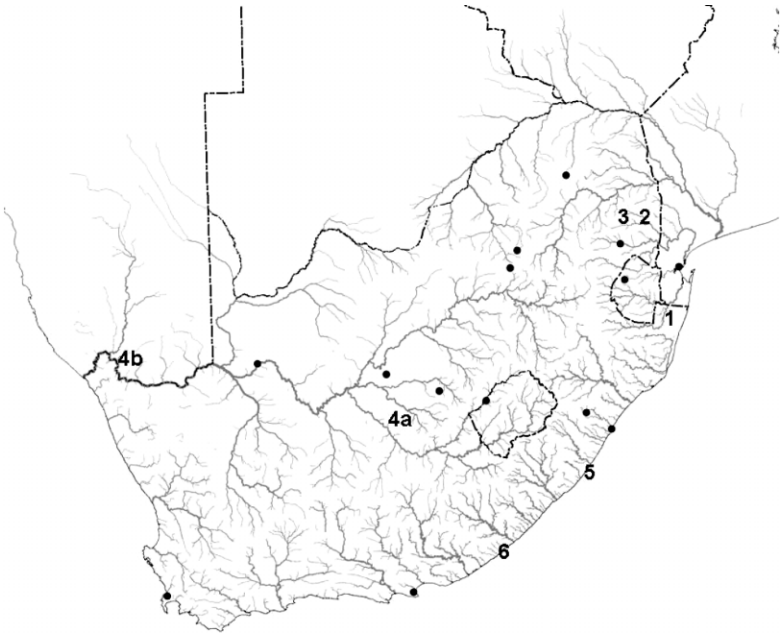

Fig. 2. Map of South Africa showing the location of the case studies referred to below. (1) The Phongolo Flood Plain (2) Kruger National Park Rivers Research Programme (3) The Sabie River Valley (4) The Middle and Lower Orange River Valley (5) The Mtentu Estuary (6) The Tyolomnqa Estuary.

problem was first identified and then followed progress of the collaboration process to solve this. We track the changes on the trialogue diagram as each research programme moved through its phases. In more than one of the case studies the initial research was not successful in resolving the issue or problem and it was necessary to return to the situation to attend to additional aspects not initially addressed. However, even when informed by the shortcomings of earlier phases, subsequent phases were not as successful as might have been anticipated. The lessons learned are discussed with a view to honing the planning of research directed at governance over the use of ecosystems.

The positioning of the various phases of the process on the diagram for each case study is qualitative and reflects our experience of the processes gained through participation in the research and on research programme reports. We use this interpretation to illustrate the flow of the process from inception to the final (or current) position.

7.2. The Phongolo floodplain

The Phongolo (previously "Pongolo") floodplain was effectively isolated from the early development forces shaping the rest of South Africa by the ocean on the East, the Lebombo Mountains on the West and fever-ridden swamps, as well as by tsetse-fly-borne sleeping sickness. Thus, the *amaThonga* were isolated and reliant on the natural resources of the floodplain, and the local economy was based on fishing, cropping and grazing under communal tenure. The Phongolo River upstream of the floodplain was impounded in

1973, which meant that its flow regime on the floodplain came under human control. The dam was constructed with the capability of releasing large floods, so that the floodplain could still be flooded.

Responding to calls from sectors of society that the floodplain should be conserved, government and researchers posed the question "What releases should be made so as most effectively to simulate the natural regime, while conserving the water resource?" (Q, Figure 3). Research, in the absence of local participation (1, Figure 3), determined an allocation and pattern of water release that would sustain ecosystem processes, subsistence dependence on the goods and services of the floodplain and also create opportunities for eco-tourism (Heeg & Breen, 1994). In order to implement flood releases and to facilitate the governance of the processes occurring on the floodplain, government established locally based water committees to recommend on flood releases (Bruwer *et al.*, 1996). Government's intention was that the releases would sustain the ecosystem processes as well as the socio-economy of the people dependent upon the floodplain. These committees were not supported by research that would inform adaptive management and there was no monitoring of the consequences of releases from the impoundment (2, Figure 3).

The ability to control floods reduced the risk of crop damage and consequently crop planting increased in suitable areas of the floodplain. The crop farmers formed a powerful lobby, which came to dominate the water committees and so determined the flood releases. Releases are now made primarily in a way that maximises the opportunity for crop farming, and this has effectively altered the tenurial arrangements, undermining traditional authority. It has marginalised those people dependent on other opportunities associated with a more natural flood regime, such as fishing, and has led to concerns about changes in the ecosystem (Nyambe & Breen, 2002). Appreciation of this issue led government to initiate participatory research with the intention of achieving a more equitable and probably more diverse socio-economy associated with flood releases (3, Figure 3).

This analysis shows that there was need for research; government and scientists identified the issue; there was agreement and certainty between these parties on the outcome of research; innovation and professional services were required. During both the first research phase and the implementation phase there was collaboration, first between government and science and then between government and local people. Monitoring, evaluation and adaptive management were not implemented and what was generally

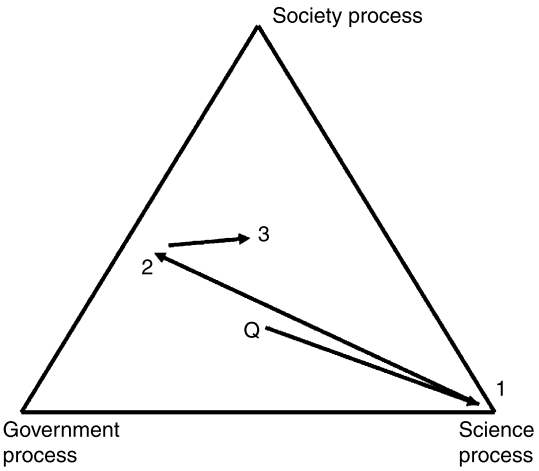

Fig. 3. The Phongolo Floodplain – tracing the research process.

perceived to be failing democratic governance and unsustainable resource use practices led government to define a new issue and to contract further research. But, this time, the research was done in association with local people.

This case study illustrates the potential value of longitudinal studies and highlights the absence of policy directing the relationships between Science, Society and Government, which was a handicap in this instance.

7.3. The Kruger National Park Rivers Research Programme

During the early to mid-1980s certain officials in the Department of Water Affairs and Forestry (DWAF) saw a need to develop the integrated water resource planning process in South Africa. The process was to be piloted on the rivers flowing eastwards from the Drakensberg Escarpment into Mozambique. During the early stages of this process it became apparent that the water requirement for all the sectors, except the environmental sector, was known in sufficient detail so as to enable them to be modelled. But, without the environmental sector's requirements, the process could not be undertaken. The need was identified by DWAF government officials (Q, Figure 4) and research on environmental water requirements was initiated (F. van Zyl, personal communication).

During the initial phase (1, Figure 4) of the Kruger National Park Rivers Research Programme (KNPRRP), despite establishment of a management system between government and the researchers that was intended to promote collaboration, the result was an uncoordinated series of research projects, each addressing aspects of the aquatic ecosystems of the rivers flowing through the Park. While this provided fundamental data and improved understanding, it did not provide the information required by DWAF for integrated resource management nor for enhancement of river management within the KNP. It also did not effectively promote collaboration between scientists.

To avoid the problems experienced in Phase One, the second phase of the KNPRRP was preceded by preparation of a research programme description that was adopted by Park management, government officials and researchers (2, Figure 4). The thrust was to develop the necessary "understanding,

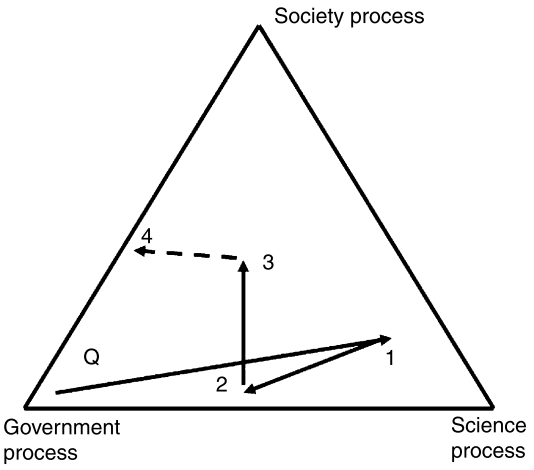

Fig. 4. The Kruger National Park Rivers Research Programme – tracing the research process.

principles and methodologies required for effective management of river systems" (Breen *et al.*, 1998). Research was to be focused on the Sabie River to facilitate the integration of research results from different disciplines. Despite this, collaboration was not as hoped for and tensions persisted between how researchers and managers perceived the issue, with researchers wishing to adopt an adaptive management approach and government seeking precise determinations of the water requirements of the rivers. While collaboration between scientists and KNP Park managers was greatly improved, and new understandings emerged, there was still a sense that the intentions of government had not been achieved. Progress was, however, viewed as sufficiently positive to proceed with a third phase. A programme description was prepared and agreed to by management. The intention of researchers to engage widely in the river catchments was contested and so, whilst some progress was made with engaging society through River Forums (3, Figure 4), it was not as effective as intended (Breen *et al.*, 2000).

Several models and procedures were incorporated into the adaptive management process which was adopted, first by KNP and then more widely within South African National Parks (SANParks). This approach enabled KNP to identify weaknesses in some models and to direct research to improve them. Despite its commitment to adaptive management and appreciation for the imperative of working with other stakeholders in the catchment to derive and support a shared vision and goals, the system failed to respond meaningfully to a drought that caused some rivers to cease flowing through the KNP.

The research was recognised from within the government sector and was issue-oriented. Whilst there was superficial agreement on the outcomes, it was not based on a shared understanding of the issue, even where programme descriptions had been agreed. The result was that there was little agreement on the certainty of the outcomes. Innovation was required but, whereas government sought technical innovation, the researchers sought process innovation. Professional services were required and recruited. Achieving the intended outcomes required collaboration which was achieved with SANParks only towards the end of Phase 3 but only partially with government. This may, in part, be attributed to an organisational culture that promoted a desire to retain control. Once adaptive management had been adopted by SANParks, there was monitoring and evaluation but, in the crisis of the drought, this was too slow to elicit the appropriate response from SANParks management. This also showed that there must be a high level of political will to "step outside the box" and do something different during times of crisis if the processes are to deliver to as intended. Responding to these deficiencies, a new process (4, Figure 4) is currently underway which should have stronger societal/government processes.

7.4. The Sabie River Valley

The Sabie River flows through four main categories of land use, each of which has distinct water requirements, before flowing across the South African border into Mozambique. In the upper Drakensberg Escarpment Area the main category of land use is commercial timber plantations. As the river reaches the lower escarpment the land use changes to commercial agriculture, mainly irrigated fruit orchards, giving way in the foothills and plains below the escarpment to densely settled small-scale irrigation. The fourth category of land use is conservation, where the river flows through the Kruger National Park before crossing the border into Mozambique.

It became apparent that there was insufficient water allocated to the small-scale irrigation farmers and, through the auspices of the Sabie River Working Group, a societal organization, negotiations were

initiated to transfer a surplus allocation of water from the commercial to the small-scale farmers (Q, Figure 5). Researchers were requested to facilitate the negotiations between all the stakeholders. In this case, the problem was defined by society and scientists, and existing understanding was sufficient to achieve the desired outcome. Professional services of facilitation and commitment from affected parties were required. In spite of efforts to include all stakeholders, the government agency responsible did not engage in the process until it was well advanced, nor did it commit to the process. Because it did not fully support the process initiated by society, and because it would have to sanction any reallocation rights of water use, the process was inefficient. The transaction costs of reaching agreement and implementing the changes that needed to be made were too great for both the Forum and the researchers and thus the process stalled (1, Figure 5).

Failure of the appropriate government agency to legitimise this process and to collaborate prevented the achievement of the planned outcome. It may be implied that government was not fully committed to participatory ecosystem governance, or perhaps that the prevailing organizational culture inhibited attainment of this. This indicates that there should be provision in policy that enables processes emerging within society to establish their legitimacy in a timely manner. Once legitimacy has been accorded to a process, it should also result in committed support from government (Van Wilgen *et al.*, 2003).

7.5. Blackfly in the Orange River Valley

The flow of the Middle and Lower Orange River became regulated by the construction of two large impoundments: Van Der Kloof Dam in 1978 and Gariep Dam in 1979. Farmers were quick to adjust their irrigation strategy from one of storing their water allocation on-farm to one of abstracting directly from the river. The situation was complicated by the use of these two impoundments by the energy utility to boost the national energy generation at times of peak demand, which amounted to water being released for a few hours each evening during winter, which resulted in a consistently higher-than-natural winter flow. Scale became an issue, because the energy utility considered itself a national stakeholder and

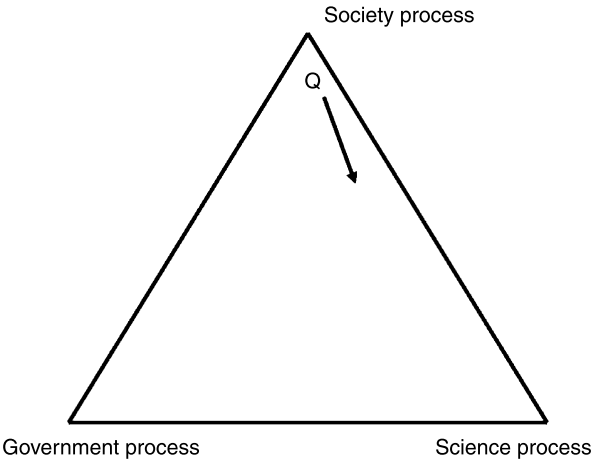

Fig. 5. The Sabie River Valley – tracing the research process.

declined to get involved in the issues at the scale of the Valley, and so accepted no accountability for their part in maintaining the higher-than-natural winter flows (Palmer, 1997).

The higher and more constant winter flows made more habitat available for the over-wintering blackfly larvae. One result of this flow regulation was that blackfly populations, which had always been present in the system, reached pest proportions and began to have substantial economic impact on the livestock production of the Orange River Valley. This impact was estimated at approximately R30 million annually in the early 1980s (Palmer, 1995, 1997).

The problem was identified by the agricultural sector (Q, Figure 6), which directed its complaint to the National Department of Agriculture (NDA) (1, Figure 6), which tried to control the blackfly population through flow regulation. This required coordination between the energy utility and the NDA. However, this was not successful for two reasons. Firstly, the over 800 km of river that had to be regulated from the lower of the two major impoundments meant that water would have to be shut off for a considerable time to be effective, which would be likely to impact negatively on both irrigated crops downstream and on indigenous fauna. Both of these impacts were unacceptable. Stakeholders recognised that the issue was complex and that they lacked the required understanding to achieve the desired outcome. Research was initiated by the NDA in 1991, although with minimal liaison with the resident agricultural community, with the overall aim of developing a practical and effective blackfly control programme (2, Figure 6). The backbone of this control programme was a monitoring programme to warn of a potential outbreak of the fly and a control programme which offered a choice of two larvicides for their control (Palmer, 1995, 1997).

The researchers withdrew from the valley in 1997 after devising both a monitoring and a control programme. These programmes were left largely in the hands of the NDA (3, Figure 6) and worked satisfactorily for two further years. During this period the control programme was run largely from the NDA Head Office in Pretoria, far outside the valley.

The blackfly control programme failed during the higher-than-usual flows of the summer of 2000. Responding to the lack of appropriate response from the previous programme in time of crisis, a new process is now underway which is designed to have stronger societal input. If successful, the outcome of this research will be a process whereby the blackfly control in the Orange River Valley is the joint

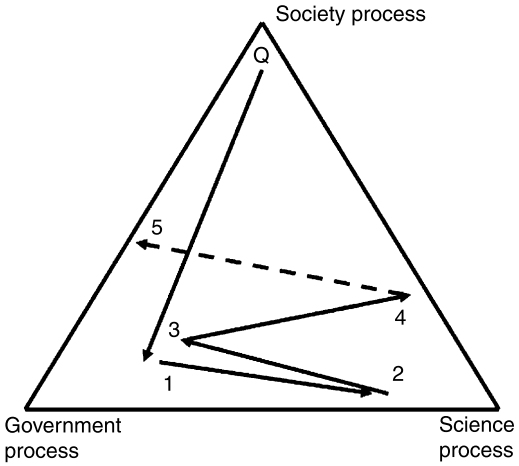

Fig. 6. Blackfly in the Orange River Valley – tracing the research process.

responsibility of the stakeholders living within the Valley and the NDA (5, Figure 6), with the governance centred in the Orange River Valley itself.

During the first phase, the solution to the problem and the outcomes were agreed upon between the energy utility and the NDA. However, as the outcome was not achieved, a research issue arose that was addressed largely by the NDA and researchers. Once this failed, during longer periods of high flow, society again identified a research need, but this time they did not direct their concern to the government agency that would normally address such issues. During the current phase the focus is on establishing a governance process that enables adaptive management. These observations indicate that society was consistently marginalised in the process, despite being the first to identify and communicate the problem.

The processes that operated can be best categorised as "periodic cooperation", as there was little evidence of collaboration. Although the current phase is designed to "embed" a governance process involving the three actors of the trialogue and to promote ongoing collaboration, there is no policy directive that supports collaborative adaptive management, as is required for ecosystem governance. The evidence also suggests that an organisational culture may exist that inhibits participatory governance.

The initial process did not give sufficient weight to the contribution that society had to make; all the accountability was retained by the government and science sectors. The current phase of the research initiative aims to transfer this accountability to structures within the Orange River Valley itself, thereby assigning accountability to the community itself. An important part of this current phase has been the involvement of all the stakeholders, including the energy utility, in the process.

7.6. The Mtentu Estuary

The Mtentu Estuary is a permanently open deep-water estuary which provides habitat for Giant Kingfish (*Caranx ignobilis*), a popular angling species, during the early summer each year. The east bank is occupied by the impoverished *aMadiba* community, whilst the estuary and west bank fall in a protected conservation area. The estuary itself was a declared a protected area in which no fishing was allowed. One responsibility of the officer in charge of the conservation area was ensuring that no fishing took place in the estuary. This was not done, however, as fish taken from the estuary continued to provide a source of protein for members of the *aMadiba* community. As a result of this lack of policing, fishing boats from further up the coast came into the estuary, particularly during the time when the Giant Kingfish were present, and plundered the resources. Conflict grew between the community, who were promoting eco-tourism, the "foreign" fishermen and government. The policy prohibiting fishing also conflicted with opportunities to establish a profitable catch-and-release sport fishery.

A process was initiated, through the *aMadiba* community, to facilitate the alignment of policy with a desired situation in the area (Q, Figure 7). It was predominantly a response to a problem and action research was directed at the process that involved the national and local conservation agencies responsible for the estuary, as well as at the *aMadiba* community. The outcomes of this process were that the community was authorised to challenge illegal activities on the estuary, and that the policy was changed to allow subsistence fishing in the estuary. A concession was granted that allowed the community to partner with a commercial operator to operate a catch-and-release fly-fishing operation during the time when the Giant Kingfish are present in the estuary. The overall outcomes have been a policy and governance that are more supportive of the community, that lead to better management practices and to more sustainable use of the resources (1, Figure 7) (Lewis *et al.*, 2005).

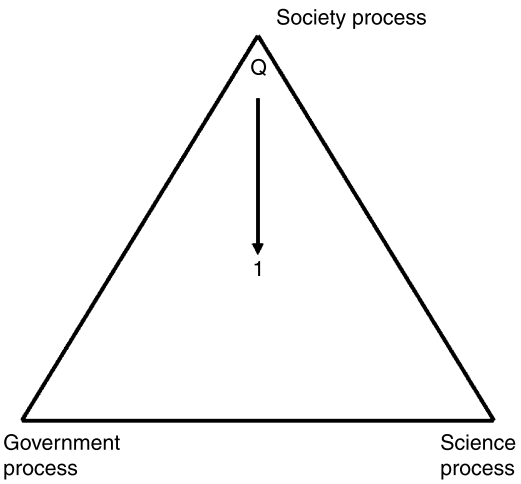

Fig. 7. The Mtentu Estuary – tracing the research process.

This case study illustrates the application of a process designed by researchers to bring together society (the *aMadiba* community) and government to learn from each other and to derive shared goals and procedures. The process led to agreement on and certainty about the outcomes. Innovation was not particularly required, but professional scientific and facilitation services were required. The anticipated outcome was collaboration between government and the community, and subsequently between the community, the fly-fishing operator and the government. With the exception of the monitoring and evaluation required by the concession given to the operator, there is no monitoring and evaluation of the process and adaptive management is not practiced (Lewis *et al.*, 2005).

7.7. The Tyolomnqa Estuary

The Water Research Commission, in fulfilling their mandate, had concerns about the use of estuarine ecosystems on the south east coast (former Transkei) of South Africa and commissioned the Eastern Cape Estuaries Management Research Programme (ECEMRP). Conceptualised as providing information for management, the programme was launched with the participation of interested parties from society. The Chalumna (now Tyolomnqa) estuary cottage owners attended the launch and solicited support in resolving conflict around the use of the estuary. There was conflict between the holiday cottage owners on the east bank and the people of the *Sandile* community, who lived on the communal land on the west bank, as well as between the angling clubs from the city of East London (Buffalo City Metropole) and the residents on both banks of the estuary. The east bank residents sought to control access to, and use of, the estuary to protect their sense of place and to conserve fish stocks. The west bank residents were not unified in their intentions, although they shared the view that they should derive greater benefit from the estuary and its resources. The angling clubs objected to the perceived privatisation of common property.

One sector of society identified a dimension of what was a complex problem and mobilised the ECEMRP to provide facilitation (Q, Figure 8). At the start there was neither agreement on the nature of

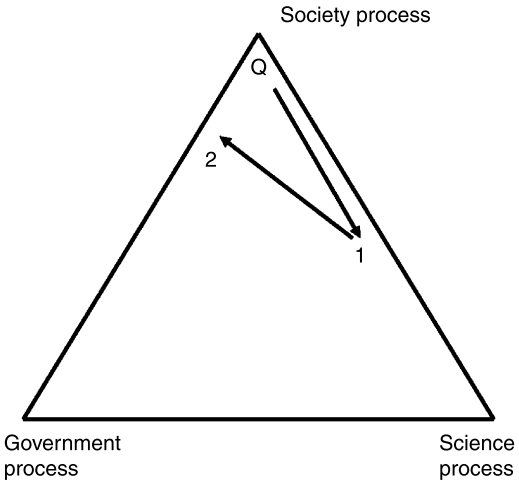

Fig. 8. The Tyolomnqa Estuary – tracing the research process.

the problem nor on the anticipated outcomes. Initially, the research process worked mainly with the three conflicting estuary user groups and with local government representation from the Buffalo City Metropole, although local government was not involved in the conflict (1, Figure 8). Although at first perceived as a problem not requiring innovation, it became apparent that research was required to understand differences in perceptions of the conflicting groups and the implications of local government policies for locally based governance. Using this understanding, the parties engaged a strategic adaptive management process by sharing concerns and working to create a common vision. Once this had been achieved, the platform for and role of local governance in the area was established (2, Figure 8) (Lewis *et al.*, 2005).

In order to address the expectations of disadvantaged communities, the east bank residents sought to promote an estuary-based tourism development on community land on the west bank. This initiative exposed legitimacy questions concerning the representatives participating in the process and around political profiles, requiring sensitive facilitation. Ultimately, the process and participants achieved legitimacy among local people and politicians and tourist facilities are now under construction.

This case study exposed the heterogeneity of civil society. One sector defined a problem in terms that were substantially different from how other sectors defined it. Action research was required in order to understand the issue, and professional facilitation was required to reach agreement on outcomes. However, the study also highlighted that, whilst it may not be possible to achieve complete agreement, those who disagree still need to support the process. The study also showed how, in ecosystem governance, emergent properties such as political profiling can affect the process. Governance needs to be dynamic, continually sustaining relationships between science, society and government. Adaptive management is central to achieving this.

This study worked with governance issues on a single estuary. However, it differed from the Mtentu Estuary case study in that the conflict was between different sectors of society, rather than between society and government. For this reason, it was not necessary for government to play a role in the initial process. This initiative was successful, as it succeeded in generating a common vision for the Estuary amongst all the estuary users, and this has paved the way for further developments around the Estuary.

8. Discussion and conclusion

8.1. Complex systems

Using these case studies, we illustrated that the role of research in informing governance of the use of ecosystems is played out in complex, dynamic socio-ecological systems. There is an inherent heterogeneity in society, and opportunism operates as sectors perceive and seek to take advantage from the changes that arise. On the Phongolo floodplain this was as a result of new control over river flow, where sectors of society used the political opportunity of river regulation to expand their own agricultural interests, whereas in the Tyolomnqa Estuary it was as a result of new economic and political opportunities. The complex and dynamic nature of ecosystems also displays emergent properties, as shown in the blackfly case study, where river regulation led to unexpectedly high populations and then, even where river flow was regulated to manage the populations, unexpected flows caused populations to become problematic. This informs us that the role of research in the governance of the use of ecosystems exhibits periodicity, with periods of high activity and periods of lower activity characterised by monitoring "vital signs" that provide cues for action. These vital signs should be incorporated within the framework of strategic adaptive management to ensure that informed management decisions are taken in a timely fashion.

8.2. Organisational culture and social capital

Whilst it is the responsibility of government to govern, the intention of governance is that it should create opportunities for society to participate. This requires that government should exhibit an organisational culture that facilitates participation. The case studies illustrate situations where the organisational culture has supported a process leading to satisfactory outcomes (Mtentu and Phongolo) and others where this has not been so (blackfly and KNPRRP). Clearly, if society is to be mobilised to participate widely in ecosystem governance, then more consistent behaviour is required.

We have also shown that the resolution of complex issues requires participation that is founded on social capital. In the Tyolomnqa study the stakeholder groups did not have sufficient shared social capital to be able to engage each other and to find lasting solutions. Once this was built up, they had a platform on which to base negotiations around emerging political issues.

8.3. Property rights

Three case studies illustrate the importance of property rights. In the case of the Phongolo, the research process did not address property rights in the governance of the use of ecosystem resources. Consequently, the "solution" proposed failed to appreciate some consequences of river regulation. In the Mtentu study, securing tenure for the Amadiba Community was central to achieving a desired-outcome tenure. In the Tolomnqa, it was the annexation of rights that was at the centre of the dispute and this had to be resolved before there could participatory governance.

8.4. Research cooperation and civic science

We illustrated that ecosystems are a social construct and that they are commonly perceived differently. The case studies, particularly the Phongolo, the KNPRRP and the blackfly research programme, show clearly the importance of reaching a common understanding about the problem or issue and the ecosystem context in which it finds expression. In the Phongolo and blackfly cases, society, i.e. the local stakeholders, were not drawn into the process. A solution was presented to them, rather than being generated together with them. Later, although local people participated, scientific understanding of ecosystem functioning was not structured into the process and many of those participating had not internalised this understanding from the earlier research. The opportunity to build civic science had been lost and, with hindsight, we should not be surprised at the responses received from stakeholders. In the KNPRRP, shared understanding with the initiating client was never really achieved. In these three cases integration and participation were not effective. Without participation there can be no prospect for cooperation. At best, there was a degree of collaboration. Even within the research sector, the KNPRRP failed to achieve cooperation in Phase One. Subsequent phases saw collaboration among researchers (Phase Two), and then collaboration with KNP (Phase Three). The failure of the collaborative initiative with the River Forums illustrates deficiencies in governance, particularly in policy and practice. Policies did not favour discourse and practices were strongly influenced by sectoral rather than by shared interests. The networks that are essential for effective governance were not established and supported.

The Mtentu and Tylomnqa Estuary projects were problem- rather than issue-based, in that neither required new research. The challenge was to establish governance (the networks, dialogue and civic science) that would enable stakeholders to find common ground and define a shared future. Both succeeded in establishing collaboration, new social capital (trust, norms and respect) and solutions to the immediate problem were found.

8.5. Policy and civic science

In all cases, except that of the blackfly, monitoring and evaluation were not structured into governance. The consequences of this are shown in the case of the Phongolo and in the KNPRRP, where governance failed. In the Mtentu there are emerging problems with governance within the local community sector. This informs us that the solution to a problem or issue requires ongoing "servicing", and that this should be achieved through governance, which is also the way to resolving emerging problems without always having to seek external intervention or support. This analysis points to deficiencies in policies and practices for constructing governance and civic science framed in the context of shared understanding of ecosystems. It also points to the notion that ecosystems should be what the affected parties need them to be. In a governance sense, society needs a utilitarian perspective of ecosystems, rather than a purely scientific one. The bounds of the ecosystem must be defined by the issue or problem, and so the scale and definition will change from time to time and more than one ecosystem may be under scrutiny at the same time. The findings show that a more systemic approach is required if a constructive relationship between research and governance is to be institutionalised. This need is not peculiar to South Africa or to developing countries, although they may sense greater urgency (van Wyk *et al.*, 2005). Experiencing the same challenge, the United States Government introduced the Government Performance and Results Act "to increase the confidence of the American people in

government in general and, specifically, to increase the confidence of the American people in science and technology" (Cozzens, 1997).

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References

Belsky, J. M. (2004). Global forces in social science approaches to natural resource management. In *Society and Natural Resources: A Summary of Knowledge*. in Manfredo, M. J., Vaske, J. J., Bruyere, B. L., Field, D. R. & Brown, P. J. (eds). Modern Litho, Jefferson, MO.

Biggs, H. C. & Rogers, K. H. (2003). An adaptive system to link science, monitoring and management in practice. In *The Kruger Experience: Ecology and Management of Savanna Heterogeneity*. du Toit, J. T., Rogers, K. H. & Biggs, H. C. (eds). Island Press, Washington, DC, pp. 59–80.

Bird, E. A. (1987). The social construction of nature: theoretical approaches to the history of environmental problems. *Environmental Review*, 255–264, (Winter).

Breen, C. M., Dent, M., Jaganyi, J., Madikizela, B., Maganbeharie, J., Ndlovu, A., O'Keeffe, J., Rogers, K., Uys, M. & Venter, F. (2000). *Contract Report of the Kruger National Park Rivers Research Programme (KNPRRP)*. WRC TT130/00. Water Research Commission, Pretoria.

Breen, C. M., Dent, M. C. & Mander, M. (1996). *The Pongolo River and its People – Past Present and Future*. Presented at the Salzburg Seminar. Unpublished occasional paper, Institute of Natural Resources, Pietermaritzburg South Africa.

Brinkerhoff, D. W. & Crosby, B. L. (2002). *Managing Policy Reform: Concepts and Tools for Decision-Makers in Developing and Transitioning Countries*. Kumarian Press, Bloomfield, CT.

Brown, J., Isaacs, D. & the World Café Pioneers (2001). The World Café living knowledge through conversations that matter. In: *The Systems Thinker.* Pegasus Communications, Cambridge MA.

Bruwer, C., Poultney, C. & Nyathi, Z. (1996). Community-based hydrological management of the Phongolo Floodplain. In *Water Management and Wetlands in sub-Saharan Africa*. Acreman, M. C. & Hollis, G. E. (eds). IUCN, Gland, pp. 199–211.

Cortner, H. J. & Moote, M. A. (1999). *The Politics of Ecosystem Management*. Island Press, Washington, DC.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Niell, R. V., Paruelo, J., Raskin, R. G., Sutton, P. & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature 387 (May*, *15*, 253–260.

Cozzens, S. E. (1997). The knowledge pool: measurement challenges in evaluating fundamental research programs. *Evaluation and Program Planning*, *20*(1), 77–89.

Daniels, S. E. & Cheng, A. S. (2004). Collaborative resource management. In *Society and Natural Resources: A Summary of Knowledge*. In Manfredo, M. J., Vaske, J., Bruyere, B. L., Field, D. R. & Brown, P. J. (eds). Modern Litho, Jefferson, MO, pp. 127–136.

Dekker, P. & Uslaner, E. (eds) (2001). *Social Capital and Participation in Everyday Life*. Routledge, London.

Dyer, J. H. & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal*, *21*, 345–367.

Ewert, A. & Stewart, B. (2004). Philosophical perspectives on natural resources. In *Society and Natural Resources: A Summary of Knowledge*. in Manfredo, M. J., Vaske, J. J., Bruyere, B. L., Field, D. R. & Brown, P. J. (eds). Modern Lithon, Jefferson, MO, pp. 9–20.

Firey, W. (1960). *Man, Mind and Land*. The Free Press, Glencoe, IL. In: Stankey, G. H. & McCool, S. Social Sciences and Natural Resources Management. In: *Society and Natural Resources: A Summary of Knowledge* (Manfredo, M. J., Vaske, J. J., Bruyere, B. L., Field, D. R. & Brown P. J (eds)). Modern Litho, Jefferson, MO. pp. 21–34.

Ford, D., Gadde, L., Hakansson, H., Lundgren, A., Snehota, I., Turnbull, P. & Wilson, D. (1998). *Managing Business Relationships*. John Wiley & Sons, New York.

Golley, F. B. (1993). *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts*. Yale University Press, New Haven, CT.

Gray, B. (1989). *Collaborating: Finding Common Ground for Multiparty Problems*. Jossey-Bass, San Francisco.

Heeg, B. & Breen, C. (1994). Resolution of conflicting values of the Pongolo River and Floodplain (South Africa). In *Wetlands and Shallow Continental Water Bodies. vol. 2*. Patten, B. C. (ed.). SPB Publishing, The Hague, pp. 303–359.

Johnson, J. L., Sohi, R. S. & Grewal, R. (2004). The role of relational knowledge stores in inter-firm partnering. *Journal of Marketing*, *68*, 21–36.

Katz, E. (2000). Another look at restoration: technology and artificial. In *Restoring Nature: Perspectives from the Social Sciences and Humanities*. Gobster, P. H. & Hull, R. B. (eds). Island Press, Washington, DC, pp. 37–48.

Kay, J. J. (2001). Ecosystems, science and sustainability. In *Proceedings of the International Workshop: Advances in Energy Studies: Exploring Supplies, Constraints and Strategies, Porto Venere, Italy, 23–27 May*. Ulgiati, S., Brown, M. T., Giampietro, M., Herenderen, R. & Mayumi, K. (eds). Department of Environment and Resource Studies, University of Waterloo, Ontario.

Kinnaman, M. L. & Bleich, M. R. (2004). Collaboration: aligning resources to create and sustain partnerships. *Journal of Professional Nursing*, *20*, 310–322.

Krajnc, A. (2002). Conservation biologists, civic science and the preservation of BC forests. Journal of Canadian Studies Available at: http. /wwwfindarticlescom/p/articles/mi_qa3683/is_200210/ai_n9120057.

Kruger, L. & Shannon, M. (2000). Getting to know ourselves and our places through participation in civic social assessment. *Social Natural Resource*, *13*, 461–478.

Lane, N. (1999). The civic scientist and science policy. In: *Science and Technology Policy Yearbook* American Association for the Advancement of Science, Washington, DC, ch 22.

Lewis, F., Hay, D. & Sihlophe, N. (2005). *Establishing and implementing Cooperative Management Systems at four Estuaries in the Eastern Cape*. Investigational Report No. 260. Institute of Natural Resources, University of KwaZulu-Natal, Pietermaritzburg.

Lubchenco, J. (1998). Entering the century of the environment: a new social contract for science. *Science*, *279*, 491–497.

Nkhata, A. B., Breen, C. M. & Freimund, W. A. (in press). Resilient social relationships and collaboration in the management of social-ecological systems. *Ecology and Society, 12*.

Nyambe, N. (2005). *Organisational Culture and its Underlying Assumptions as a Determinant of Response to Change: A Case Study of the Conservation Sector in KwaZulu Natal, South Africa.* PhD dissertation. Centre for Agriculture and Development, University of KwaZulu-Natal, Pietermaritzburg.

Nyambe, N. & Breen, C. (2002). Environmental flows, power relations and the use of river system resources. In: *Proceedings of the Fourth International Ecohydraulics Symposium: Environmental Flows for River Systems, Cape Town 3–8 March*.

Nyambe, N., Breen C. & Fincham, R. (2005). Organisational culture as a function of adaptation and responsiveness in public agencies. In: *International Symposium on Ecosystem Governance, Kwa-Maritane, South Africa, 10–13 October.* CSIR, Pretoria. Symposium manuscripts.

Oglethorpe, J. (2002). *Adaptive Management: From Theory to Practice.* Island Press, Washington, DC.

Palmer, R. W. (1995). *Biological and Chemical Control of Blackflies (Diptera: Simuliidae) in the Orange River*. WRC Report No. 343/1/95. Water Research Commission, Pretoria.

Palmer, R. W. (1997). *Principles of Integrated Control of Blackflies (Diptera: Simuliidae)*. WRC Report No. 650/1/97. Water Research Commission, Pretoria.

Putnam, R. (1993). *Making Democracy Work: Civic Traditions in Italy*. Princeton University Press, Princeton, NJ.

Rhodes, R. A. W. (1996). The new governance: governing without government. *Political Studies*, *44*, 652–667.

Rogers, K. H. & Bestbier, R. (1997). *Development of a Protocol for the Definition of the Desired State of Riverine Ecosystems in South Africa.* Department of Environment Affairs and Tourism, Pretoria.

Rogers, K. H., Roux, D. & Biggs, H. (2000). Challenges for catchment management agencies: lessons from bureaucracies, business and resource management. *Water SA*, *26*, 505–511.

Selin, S. (1999). Developing a typology of sustainable tourism partnerships. *Journal of Sustainable Tourism*, *7*, 260–273.
Selin, S. (2004). Natural resource partnerships: bridging practice and science. In *Society and Natural Resources: A Summary of Knowledge*. Manfredo, M. J., Vaske, J. J., Bruyere, B. L., Field, D. R. & Brown, P. J. (eds). Modern Litho, Jefferson, MO.
Senge, P. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organisation.* Doubleday, New York.
Shutkin, W. A. (2000). *The Land That Could Be: Environmentalism and Democracy in the Twenty First Century*. IT Press, Cambridge, MA.
Stacey, R. D. (1996). *Strategic Management and Organisational Dynamics*. Pitman, London.
Stankey, G. H. & McCool, S. F. (2004). Social sciences and natural resource management - Chapter 3. In *Society and Natural Resources: A Summary of Knowledge. Prepared for the 10th International Symposium on Society and Natural Resource Management*. Manfredo, M. J., Vaske, J. J., Bruyere, B. L., Field, D. R. & Brown, P. J. (eds). ISSRM, Jefferson, Missouri, pp. 21–34.
Turton, A. R., Hattingh, J., Claassen, M., Roux, D. R. & Ashton, P. J. (2005). Towards A Model for Ecosystem Governance: An Integrated Water Resource Management Example. Paper presented at the *International Symposium on Ecosystem Governance, Kwa Maritane Bush Lodge, Pilanesberg, South Africa, 10–13 October*. CSIR, Pretoria.
Valadez, A. M. & Sportsman, S. (1999). Environmental management: principles from quantum theory. *Journal of Professional Nursing*, *15*, 201–213.
VanWilgen, B. W., Breen, C. M., Jaganyi, J. J., Rogers, K. H., Roux, D. J., Sherwill, T., van Wyk, E. & Venter, F. (2003). *Principles and Processes for Supporting Stakeholder Participation in Integrated River Management*. WRC Report No. 1062/1/03. Water Research Commission, Pretoria.
van Wyk, E., Breen, C. M., Rogers, K. H., Sherwill, T., Roux, D. J. & van Wilgen, B. W. (2006). The ecological reserve: towards a big vision, complex reality: building common understanding of policy intention for river management in South Africa. *Water SA*, *32*(3), 403–409.
van Wyk, E., Breen, C. M., Sherwill, T. & Magadlela, D. (2005). Challenges for the relationship between science and society: developing capacity for ecosystem governance in an emerging democracy. In: *International Symposium on Ecosystems Governance, Kwa-Maritane, South Africa, 10-13 October*. CSIR, Pretoria. Symposium manuscripts.
Wondolleck, J. M. & Yaffee, S. M. (2000). *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Island Press, Washington, DC.