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CHAPTER 3

Getting Technical Information into Watershed Decision-Making

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Given the complexity and diverse social perspectives surrounding many watershed-scale resource management issues, the challenge facing science is how, where, and when can it best contribute to developing the understanding that will support more sustainable decision-making. This chapter introduces a collaborative learning approach to improve the use of information within environmental research initiatives. It illustrates this approach as a knowledge management cycle that helps different stakeholders access and integrate information more effectively, and ultimately changes how they see a situation and consequently go about managing it. It then looks at a similar cycle of science activities, but casts them into an interdisciplinary approach. Both cycles use examples drawn from resource management case studies in New Zealand. Focus is given to a key component of these cycles—that of improving learning, particularly in getting people to challenge their underlying assumptions. To achieve this it is suggested that interdisciplinary science teams need to broaden their membership to include specialists with integrative social skills.

Changing context for management

Over the past two decades, the challenges facing landowners and natural resource managers have multiplied. Where once rural agricultural and horticultural environments were viewed as single-sector-oriented productive landscapes, they now face the pressures of demands by new players who expect to be heard—for instance those interested in voicing their views on landscape, recreation, conservation, and/or tourism. Furthermore, a growing interest in developing policy to support sustainable development operates at a range of scales intersecting with decisions made at grassroots, local, regional and national levels. While landowners may make the ultimate decisions "on-the-ground," others play an active role in creating the context (positive or negative) that guides sustainable development efforts. Only a decade ago, scientists working in most rural environments were at least confident in the knowledge they were dealing with what everyone knew was an agricultural system. Today, whether rural landscapes should be regarded as agricultural, tourism, recreation, conservation or even cultural systems—or some combination of all these—is increasingly problematic and contentious.

In response to these issues we are beginning to see the increased use of multi-stakeholder processes that facilitate the wide involvement of people in problem solving and decision making with respect to issues and plans that involve or impact on them. This multi-stakeholder approach anticipates that natural resource management is increasingly characterised by apparently conflicting social perspectives, and emphasises processes to provide those involved with a better understanding of other points of view. These approaches explicitly recognise that natural resource

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management in the age of sustainability is not characterised so much by problems for which an answer must be found, but rather by issues that need to be resolved and will inevitably require one or more of the parties to change their views (Bawden et al., 1984). However, in the main, the application of these more inclusive approaches within agricultural research and development still fail to grasp the nature of the rapidly evolving social forces that are driving rural systems today. There are few references in the agricultural research and development literature to participatory projects other than those that involve two main groups (farmers and scientists) dealing with agricultural management issues. Yet as communities and agriculture change, the juxtaposition of farming and other rural activities has become a battleground over water and related nutrient management issues, as well as other community impacts of changing land use (Abdalla and Kelsey, 1996).

Despite the important role which science can play within natural resource management, researchers need to be aware that ecological information is only one factor affecting the way in which decisions on natural resource management are made—and it is not always the most significant. Other factors include political judgement, legal or financial necessity, personal or group bias, and commercial or international pressures. While science has, in the past, derived much of its power from its independence, in contested areas this strength is also its weakness. To make a difference in real-world problems research teams must work closely with those who have the power to change practices on the ground, developing what Pretty (1988) calls "interdependent relationships" with key stakeholders involved in the problem situation. When information or knowledge-based systems are developed in conjunction with end-user groups, the technology is often more innovatively designed around social, economic, or cultural values and needs, and may acquire a sense of ownership by groups such as community, agency, land manager or indigenous groups (Reynolds and Busby, 1996; Harmsworth, 1998). For this to happen science must be developed and integrated within the wider decision-making contexts of the organisations and groups involved in natural resource management.

In response to this there has been an increasing number of science programmes in the natural resource management area that are being developed through collaborative or social learning approaches in conjunction with different stakeholders. To be successful, the science in these programmes needs to be broadened from the conventional view of research, *i.e.* proceeding along a straight line, commencing with a hypothesis, seeking out facts that prove or disprove this, and finally pulling out conclusions, which may then be displayed in a model or published in a paper (Wadsworth, 1998). This broadened view of science (Figure 1) will include a number of questions, common to collaborative learning inquiries in other areas. These relate to the development of the hypotheses themselves, and the subsequent implementation of the resulting "new ideas"—to ensure that science is better placed to make a difference on-the-ground.

There are many scientists, and science programmes, that are adopting this wider view of research. Increasingly researchers and practitioners are sharing theories and methods that demystify science and follow collaborative problem solving and dispute-resolution principles such as inclusion, cultural sensitivity, developing shared definitions, and empowering end-users. However, because the collaborative learning component remains largely hidden in conventional research proposals and published conclusions, its application in design and practice can often be less rigorously reviewed than the design and practice of

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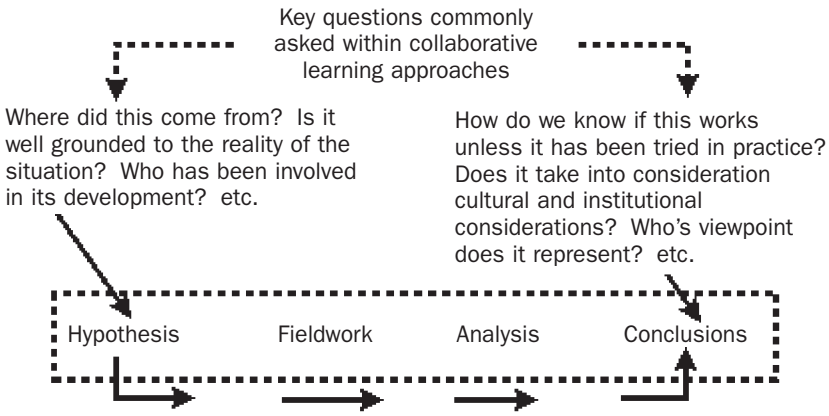
Figure 1
Steps within the wider research process showing relationship between collaborative-learning-based and conventional research (Adapted from Wadsworth 1998).



other research steps. Accordingly, if the science community wishes to ensure the relevance and rigour of collaborative research initiatives within multi-stakeholder situations, then it needs also to overtly use review or evaluation approaches that ensure that programmes are examined within this broader context.

Collaborative (or social) learning, then, is one approach that makes its primary objective changing resource management practice by improving the use of information by different groups. It is best used when seeking to improve environmental management situations characterised by multiple social perspectives (Allen et al., 2001a). In general terms, collaborative learning refers to the capacity of a group to assess the results of their efforts, rethink how they go about their tasks, and use new ideas to change established practices (e.g. Huber, 1991). Underpinning the concept is the recognition that people learn through active adaptation of their existing knowledge in response to their experiences with other people and their environment.

In pursuit of a collaborative learning research program

Just gaining acceptance for this broader view of science within a traditionally structured research environment is no small feat. Moreover, implementation brings some additional challenges. Collaborative research requires the active participation of multiple-stakeholders already active in the problem context. The generation of information and active inquiry into its useful application can only take place through the living laboratory of the social system where resource management decisions are being made. However, effective collaboration is not always easy to arrange, especially in relation to environmental issues, which are often characterised by conflicting social perspectives.

One way of achieving this is to find a point where different groups of people (sectors and/or disciplines) agree on a common problem and work together to solve it. This might be by pooling different knowledge sources, sharing resources and skills, or each doing a different part of

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what needs to be done. However, a problem-solving system, in this sense, is more than just its resulting research components. Rather, it is a "social system" within which people learn by interaction to create new knowledge and broaden their perspective of the world (Ison, 1993).

Core to collaborative learning research programmes is the learning. Specifically, cyclical, reflective and inclusive processes of learning are needed to generate the connection between science and other information providers, and the appropriate decision makers in a watershed or region. Adaptive management, "learning-by-doing", and action research are all related cyclical-based learning approaches that offer methodological guidance to the management of contextual and problem-applied research programmes.

One promising initiative is in the area of adaptive management (AM) that is emerging through the integration of ecological and participatory research approaches (Lee, 1993; Gunderson et al., 1995; Bosch et al., 1996, Dovers and Mobbs, 1997; Christensen et al., 1996). Adaptive management in this sense refers 'to a structured process of "learning by doing" that involves much more than simply better ecological monitoring and response to unexpected management impacts' (Walters, 1997). Similarly, the process of learning by building on experience is a natural one for most people, and action research is gaining popularity as a framework for formalising and making this process more effective. As a number of reviewers point out, this learning consists of an iterative and cyclic approach with four major phases: plan, act, observe and reflect (Susman and Evered, 1978; Masters, 1995; Zuber-Skerritt, 1991). The underlying assumptions on which all these approaches rest is the existence of an experiential-based learning cycle (from Kolb et al., 1979) which suggests that people can learn and create knowledge: (a) on the basis of their concrete experience; (b) through observing and reflecting on that experience; (c) by forming abstract concepts and generalisations about what to do next; and (d) by testing the implications of these concepts in new situations, which will lead to new concrete experiences, and hence the beginning of a new cycle. This learning cycle is illustrated in Figure2.

Managing information and knowledge

The provision of timely and relevant information is obviously a key factor essential to improving learning. However, this is often difficult to achieve in natural resource management, where the wide range of stakeholders means that information is highly fragmented across groups. Access to such information can come from a range of sources. Science is a main contributor, but there is also a growing acknowledgement of the need to draw upon local and traditional knowledge systems. Formal monitoring of the results of management actions to confirm (or otherwise) their effectiveness is another key source of new information. However, to promote the sound use of information within a decision-making environment, a number of additional supporting social processes must also be provided. One approach is to view it as a learning cycle with some generic process steps required to support knowledge management. These steps are illustrated in Figure 2.

The skills required for managing this process will naturally vary according to the specifics of the initiative. For instance there is a substantial difference between pursuing a collaborative approach within an already well-functioning situation, and trying to initiate collaboration in a social environment characterised by existing conflict. In the latter case the need for effective facilitation and expert mediation of conflicts is definitely greater. This section of the chapter looks more closely at each of these steps in turn, paying particu-

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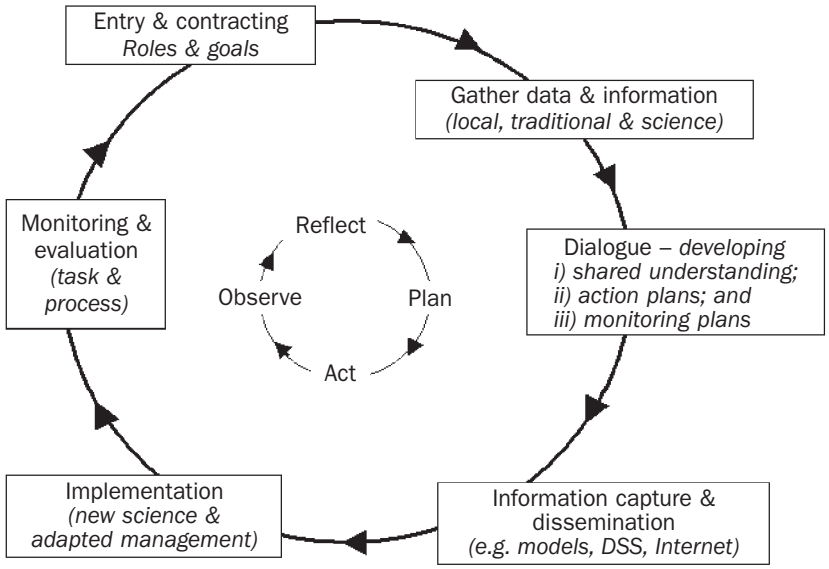
Figure 2
Circles of learning. The inner circle illustrates an experiential learning or action research-based cycle (Kolb et al., 1979). The outer cycle shows similar steps in a knowledge management approach to collaborative science and stakeholder problem solving (from Allen et al., 2001a).



lar attention to issues of trust and relationships that may arise, and how these might be addressed.

Entry and contracting. This first phase includes identifying and involving relevant people, building relationships, and establishing the ground rules for working together. The aim in any successful participatory approach is to build relationships that make it easy for people to talk about their needs, share information, and work together. Stakeholders develop a common understanding of the perceived issue, and collectively decide on the project goals and the different roles that groups will undertake. Building this climate for change is the single most important step in initiating any collaborative approach.

Just as with personal relationships, previous experience is one of the most important influences on community attitudes to collaboration. People may be extremely reluctant to enter into a second participatory process if they have been involved in an unsuccessful one in the past—"we've already tried that and look what happened!" The emotional part of the conflict (which often forms a hidden barrier to uncovering the real issues) may have to be dealt with first.

Department of Conservation staff as part of their ongoing efforts to protect the black stilt (kaki), a rare New Zealand wading bird, provided a good example of how this challenge can be met. The agency was concerned that to gain better access to bird habitat on private land they had to increase private landholder involvement in recovery efforts. However, when landholders were canvassed to ascertain their support

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for a meeting to resolve these issues, it became apparent that they saw issues over the black stilt as symptoms of a wider problem of "lack of trust" between farming families and the Department of Conservation. In response, addressing the issue of access to the black stilt was postponed, and a series of workshops were held to improve relationships between local Department of Conservation staff and landholders (Allen et al., 1998). Common ground was reached during these workshops and a number of positive steps to improve working relationships were identified and implemented. Building trust in this way is one of the main reasons why successful participatory processes take time. Importantly, in this case, both parties regarded this exercise as being a first step in a much longer process.

Another major stumbling block in initiating collaborative approaches to environmental management is in identifying and gaining the active involvement of the right people within the process. This means time and resources must be allocated at the project level to achieve this, paying particular care to involve key stakeholders (e.g. farmers, local communities, women, industry) and groups with traditional or indigenous rights, who, in the past, have often been marginalised within the collective decision-making process. In New Zealand, the Treaty of Waitangi suggests that Mãori are more than stakeholders. Rather they are in partnership with Government or local government.

However, gaining the involvement of key players is not always easy, and stakeholders may be unwilling to put time and resources into this initial phase of entry and contracting. In contrast to the black stilt project discussed above, the Whaingaroa Catchment Management Project (Kilvington, 1998) is an example of an attempt at establishing a collaborative environmental management initiative that was frustrated at the initial entry and contracting stage through a failure to address a fundamental conflict between key stakeholders. The intention of this project was to establish a working group of agency and community stakeholders to address issues such as erosion of the catchment and siltation of the harbour by generating a commonly agreed catchment management plan. Although the management rights of the indigenous community (tangata whenua) and their relationship with the local government environmental management agency were of primary concern to the tangata whenua, that issue was deemed a conflict outside the process of setting up a collaborative community and agency management group. This unresolved conflict resulted in a failure of participation of one of the key stakeholders to the detriment of the project as a whole.

Likewise, as Horn and Kilvington (2002) found, pest control operations can run into trouble when there is not enough time and effort invested in the early stages of a consultative process. Most institutions involved with pest control operations start consulting only after they have made a plan, so that the consultation process occurs only just before the implementation phase of an operation. The result is often a great deal of time spent dealing with conflict, which makes all concerned very uncomfortable. Greater investment at the early stages generates a great deal more benefit. The experiences of communicators involved in these processes shows us that if communities are involved in generating a plan rather than in just approving that plan, they will be more amenable to that plan being implemented both for the present project and for later projects. It takes a long time to generate a plan in this way but the time that it saves later in the process makes it worth the investment.

Other collaborative projects involving indigenous communities (Harmsworth, 2001) demonstrate the length of time required to build credible relationships and

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trust before entering into collaborative or participatory projects, and the need to build and maintain a solid platform for participation. Essential prerequisites when developing relationships with indigenous groups include respecting cultural protocols, following culturally appropriate steps, early identification of key players and viewpoints, and lengthy discussion of issues and work programmes through forums such as hui (participatory and culturally focused meetings).

This initial phase is also the stage at which ground rules for groups working together need to be established. This will minimise unnecessary "process" conflict caused by misunderstandings and lack of agreement on how the rules of dialogue and decision making are set. Intervention in conflict can occur at any stage, but is clearly much more likely to be effective when it is introduced early in a process of getting stakeholders to work together.

Gather data and information. Many groups possess information of a technical, cultural, or economic nature that is of great value for developing environmental solutions. However, the flow of this information between different levels and groups in society is often inadequate. For example, years of experimentation with different management strategies to achieve different goals have provided individual land managers with much knowledge about local land-use and environmental systems. Unfortunately, this knowledge is seldom available to the community on a collective basis. Similarly, much of the valuable knowledge accumulated by scientists is fragmented, held in different databases and, consequently, is not readily available, even to other scientists.

Often this information remains fragmented because we do not have the mechanisms to collect it. However, strong emotions associated with information also often create a barrier to its availability. Among science researchers much personal self-worth and commercial worth is linked to the information generated. Fear over misrepresentation affects researchers' willingness to offer their information for use in systems over which they have no future control. Many other stakeholders may have similar fears, with some justification, that their information might be used incorrectly, or against them, if released. In the broadest sense, information systems need to be designed to overcome such fears by building trust and confidence between information providers and users. In many cases, as the following examples show, this will need to be achieved through the development of clear guidelines or protocols for information use.

The implications for emerging research initiatives are well illustrated in the tussock grasslands of the South Island high country. Only a decade ago, research emphasis was directed towards improving the efficiency of an extensive pastoral system. Indeed, there are few references in the agricultural research and development literature internationally that refer to participatory approaches other than those that comment on farmers and scientists dealing with agricultural management issues (Allen, 1997). However, research funding today is increasingly directed towards addressing issues of sustainability, and hence meeting the needs of a range of different stakeholder groups concerned about the impact of natural resource management practices, who had for some time considered themselves in opposition to one another. When scientists in the Government-funded Tussock Grasslands Research Programme (Bosch, 1997) initially approached farmers about identifying proposed research sites to look at soil and vegetation trends, access was denied. Farmers were unsure about what use would be made of the subsequent research findings. However, because the project process was prepared to openly address this conflict, and bring in the appropriate

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skills, the situation was resolved. The subsequent conflict management exercise established information management protocols that enabled the research to proceed. These protocols protected the rights of landowners to be advised of research results prior to their being released to third parties, and provided for discussions by the different stakeholders involved of the implications of research results before publication (O.J.H. Bosch personal communication).

Conversely, in the Whaingaroa Catchment Management Project referred to previously, water quality data held by local landowners were withheld during the process of collecting and collating information on the catchment. The landowners were uncertain as to how this information might be interpreted by other members of the community. The use of conflict resolution skills and the development of clear, commonly agreed protocols for the use of this information would have allayed their concerns.

In participatory projects to develop information systems with indigenous groups (Harmsworth, 1998), the central focus of the research was how to build systems to record and store indigenous knowledge along with mainstream science knowledge, such as cultural heritage and natural resources, whilst protecting the confidentiality and sensitivity of information, maintaining cultural integrity, and acknowledging intellectual property rights. A number of useful models were produced which ranged from oral knowledge transfer to geographic information systems (GIS) and multi-media, where information was systematically organised and accorded degrees of protection to access using knowledge frameworks. These frameworks influenced the design of the information systems, and examples of GIS show that specific layers of confidential information can be protected and connected to other knowledge sources, such as people and organisations.

Dialogue: Making sense of information. Raw information needs to be understood and interpreted so that it becomes useful for addressing the issue under consideration. However, that information may have different meanings and hence values in different situations. Making sense of information has two principal components. First, all stakeholders must agree and clearly understand the intended use for the information. This may, for example, be to resolve a particular environmental problem or to attain a particular resource management goal.

The second component is the context within which the information was originally collected, which is a key to its strengths and weaknesses. This includes clarifying such issues as why the information was collected and by whom; what its source is (e.g. practical experience, observations, science research etc.); does the information relate to a specific situation or site and can it be extrapolated to other situations? Skilled facilitation is needed to ensure that all participants and stakeholders share a common understanding of these two components of new information.

Enormous gains can be made by promoting an understanding of what different stakeholders and other groups such as local land managers, or indigenous people, have to offer to the resolution of complex environmental problems. However, there is often an understandable reluctance on the part of agency and research staff to bring together factions where there is a risk, or perceived risk, of conflict. For example, staff in most, if not all, of the high country research initiatives that preceded the Tussock Grassland Programme have tended to work separately with Department of Conservation staff and local farming families, or solely with one or other group, largely to avoid having to deal with possible conflict. Yet, as these two groups collectively manage all the tussock grasslands in this area, and as one of the main land-use debates revolves around determining trade-offs and synergies between conservation and pastoralism, there is

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little doubt that both groups would have been better served by science had they been provided with more, well-facilitated opportunities to come together and discuss the implications of emerging research findings.

Similarly, stakeholder conflicts involving indigenous groups highlight the need for groups and researchers to have an in-depth cultural, political, and historical understanding before entering relationships, a commitment to focus on and resolve issues, and a desire to form partnerships. Generally when working with indigenous peoples it is essential to start discussions within a culturally safe and sometimes neutral environment, to identify potential conflicts early, and proceed sensitively with community dialogue processes and group interaction. A common New Zealand model, the "Treaty partnership model," is often used to illustrate the way indigenous peoples prefer to start dialogue in isolation of other stakeholder, government, or community groups until the timing for collaborative discussion is right. Indigenous groups often feel more comfortable discussing issues and research themes in their own environment first, such as on a marae (cultural and social meeting place) or a selected venue, before joining with other groups and researchers.

Once the right collaborative environment is established, the use, interpretation, and sharing of information and knowledge can then be discussed in the context of the issues being addressed. Collaborative working environments involving researchers, stakeholders, and tangata whenua are immensely valuable when in a context for addressing specific issues, because they provide forums which identify the present level of understanding, information availability, access, knowledge interpretation, new forms of knowledge, and information gaps and areas deficient in knowledge. The aggregation of shared knowledge between groups is pivotal to improved understanding of complex land-use and environmental systems, and greatly enhances the ability to make collective, informed, quality decisions relating to environmental, social, cultural, and economic issues.

An example of the ways in which trust can affect the ways in which information is used is provided by the information generated to support the widespread use of 1080 poison (sodium monofluoroacetate) for pest control operations in New Zealand. Agencies have tended to grapple with the science information about 1080 poison and develop plans without the input of other stakeholder groups. They then provide information to persuade the others that their plan is the right thing to do. The trouble is that where the information is provided primarily by one stakeholder to persuade others, the result has been blatant mistrust of that information, no matter how reliable and unbiased the provider believes it to be. Naturally, communities faced with the prospect of poison being dropped all over the local area are unhappy, and seek out information that might help them stop that happening. Interestingly in this situation, the pests are forgotten and the use of 1080 has become the central point of argument. This highlights a need to be clear about goals in the first place.

In comparison, sometimes agencies have gone into an area and reached agreement about killing pests (i.e. have been clear that their goal is to improve ecosystems by killing pests) and then asked the community to work with them to decide the best way to do it. In these situations the communities involved have been more open to the information that is provided and have been able to add their own perspectives into the plan. This means, for instance, that there are places where different techniques are used because people want some places to be safe for their dogs, or they want to protect their water supplies. The change in the process and the time of entry and contracting therefore can make a huge difference to the way in which informa-

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tion is used and the way in which groups trust each other's information.

When conflict erupts and is poorly handled it may be as damaging as conflict-avoidance. Bad experiences with former approaches may severely jeopardise the chances of building constructive future working relationships. This is often the case when working with indigenous groups, where bad experiences, previous conflict, and poorly developed initial approaches are very difficult to rectify. Managing successful community dialogue processes requires the creation and managing of safe environments for debate, including finding appropriate times, developing the right questions, and ensuring that the different scales and levels that stakeholders are operating on can be addressed. The worse the past experience a community has, the greater the time required to re-enter into some kind of collaborative working relationship.

Ongoing, and structured, community dialogue as described above provides those who participate in the process with immediate access to new ideas and perspectives, which may help them re-evaluate their current research, management, or policy strategies. There is still a need to capture, store, and provide this information for the benefit of those who did not have the opportunity to be directly involved. In this regard, the processes described above also provide the structured resources to support the development of a number of technologically based information components that are relevant to the needs of the wider community of potential users, and consequently more likely to gain their acceptance.

Information capture and dissemination. Using these collaborative approaches provides all those directly involved with a learning environment in which useful knowledge is developed through a participatory process. At the workshops, the participants clarify questions, sort information on the basis of its applicability to addressing these, and identify the starting points for all of the stakeholders and their consequent information needs. Essentially, this provides a way of understanding information relevant to the entire problem, and with this it is possible to develop an information management system so that the knowledge may benefit all those who have not had the opportunity to be directly involved.

The Internet is emerging as a useful platform for knowledge sharing, particularly for managing complex environmental information. A major strength of the Internet is that it allows people to create, annotate, link together and share information from a variety of media, including text, graphics, images, audio and video. Moreover, involving people in developing hypermedia-based systems, helps to promote collaborative learning and problem solving (Allen et al., 2001a). Not only are users of a system likely to have a greater commitment to one they have helped to develop, but also they are likely to have a greater understanding of any changes needed to make it work.

Implementation (new science and revised management). The idea, of course, is that by becoming involved in the process outlined above land managers and policy makers will get the support they need to develop new and improved strategies. Similarly, at any given time the information base can play an important role in helping land managers and scientists jointly to determine new research priorities. Because it acts as a framework to display existing knowledge, the information base helps identify knowledge gaps and prioritise new research initiatives. This is a continuing process, as evolving knowledge, technologies and value systems inevitably change our perceptions and provide new areas and issues for research (Stuth et al., 1991).

Monitoring and evaluation. Clearly, for such an information system to advance sustainable natural resource management

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successfully in the long term it needs to be continually refined and updated. It must also clearly define with end-users what the information needs are, and the form and context in which information and knowledge should be presented. Many of the issues already raised in this chapter will continually re-occur as the process continues. As new science emerges from the work of different groups and agencies, ways of ensuring its debate and dissemination will need to be renegotiated. As we seek to encourage the provision of new information from stakeholders (e.g. community-based monitoring systems), we will also have to provide the climate and assurances that such information will be used constructively to guide new ways forward—and not as a means of penalising the very people that are providing this information.

Participatory evaluation processes are particularly important in these kinds of long-term endeavours, not only to ensure that a project stays on track, but also to help reinforce to researchers and stakeholders alike that continued involvement is worthwhile (Allen, 1997; Kilvington, 1998). They are also essential for determining whether the project outcomes or the goals are being met and provide a dynamic mechanism for social, cultural and scientific interaction and evaluation. Tracking and acknowledging success can be combined with a number of other initiatives to avoid "burn-out" among the different participants and maintain enthusiasm and motivation.

Collaborative approaches should be flexible, and designed to grow. It may be appropriate to defer involvement of reluctant stakeholders in the beginning, and new stakeholders may be identified along the way. It is always important to consider the timing for bringing groups together and, as mentioned previously, it may be more culturally appropriate and progressive to work separately with some groups at the commencement of a project, with a view to building collaboration or participation as the project evolves. Overall the process must be able to change to accommodate this growth. Community involvement helps create ownership and a feeling of accomplishment in working together to solve a problem. This group dynamic will encourage others from the community and government agencies to participate and provide and manage the information required for making decisions about sustainable resource use.

Managing integrated and interdisciplinary initiatives

In trying to develop an approach to collaborative management, where science can make a valid contribution to enhanced understanding, it is impossible to go past the issue of interdisciplinarity. As multiple viewpoints impinge on complex environmental problems, so the usefulness of science knowledge generally requires the combination and integration of knowledge from various science disciplines (Van den Bessalaar and Heimericks, 2001). Multi-disciplinary approaches are more commonly attempted than interdisciplinary ones. These involve viewing the topic from a variety of disciplinary perspectives, but not examining the fundamental assumptions at the base of those perspectives, nor purposefully integrating knowledge from them into a novel interpretation. Interdisciplinary approaches include an explicit analysis of the underlying assumptions of each discipline, as the "facts" from any one area are critically evaluated in the light of the "facts" from the other disciplines (Randolph-Macon College n.d.).

Interdisciplinary research therefore requires different teams and skills to more conventional science. Minnis et al. (1994) point out that the core participants in a true collaboration "represent complementary domains of expertise." They plan, decide, and act jointly. They also think

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together, combining independent conceptual schemes to create original frameworks. They show commitment to sharing resources, power and talent, avoid the domination of single views, and vest authority for decisions in the group. The outcome of the collaborative endeavour reflects a blending of all contributions. This is no easy arrangement to set up or maintain and has significant implications for the manager of such an interdisciplinary-based initiative. Foremost the manager must carefully consider the composition of the team, the needs of the different members, and the unique management role required.

To draw together a team with diverse disciplinary backgrounds rests on developing a good collective sense of the whole at the same time as identifying the roles and contributions of the components. To function in a competitive research environment, interdisciplinary programmes must also address concerns of researchers trying to balance their need to progress within disciplines at the same time as investing in a collective enterprise. This will undoubtedly involve negotiations over intellectual property, authorship, and other cornerstones of science research careers. Furthermore to ensure that the integration and learning requisites for interdisciplinary and collaborative research take place, the programme needs to look beyond science research contributors in its team make up, and include skilled facilitators of multi-party learning processes.

Earlier we presented a cycle of steps (Figure 2) for developing knowledge through collaborative initiatives. In Figure 3 we reconsider these steps and present how different members of an interdisciplinary research team might manage them.

An interdisciplinary, collaborative learning research process clearly has too many roles to be filled by a generalist scientist. Each project or inquiry will be unique, but Figure 3 gives some sense of the range of skills that can be required. In this example, which is drawn from work carried out to help address the problem of an invasive weed in the South Island high country of New Zealand, members of the interdisciplinary initiative can be seen to comprise collaborative learning researchers, ecologists, researchers with skills in developing decision support systems, as well as farmers and conservation managers (Bosch et al., 1996; Allen et al., 2001b)

Because there are individuals from different disciplines, sectors, and even institutions involved in interdisciplinary projects, there are new challenges for those charged with nurturing and managing such initiatives. Perhaps one of the most visibly apparent challenges is that of building a common language. This needs to start with agreement of the problem or issue to be addressed. While this sounds easy, it is harder in practice. For example, while all parties may wish to restore a wetland in New Zealand, the ecologist in the group may wish to recreate a particular system that occurred say before colonisation. An indigenous Maori may wish to see the wetland restored in terms of cultural aspirations, which could include a focus on traditional uses such as weaving and food gathering.

Difficulties for learning-based approaches

The challenge for the interdisciplinary research leader lies in the fact that learning can be difficult, even at an individual level. Accepting new information that challenges the way we think and the things we do is, even with the best of wills, difficult to undertake, to accomplish, and to sustain (Michael, 1995). Finding out about problems also implies that we may have to act to correct them. What often stops us doing this is an anxiety, or the feeling, that if we allow ourselves to enter a learning or change process, if we admit to ourselves and others that something is wrong or not right, we will lose our effectiveness, our

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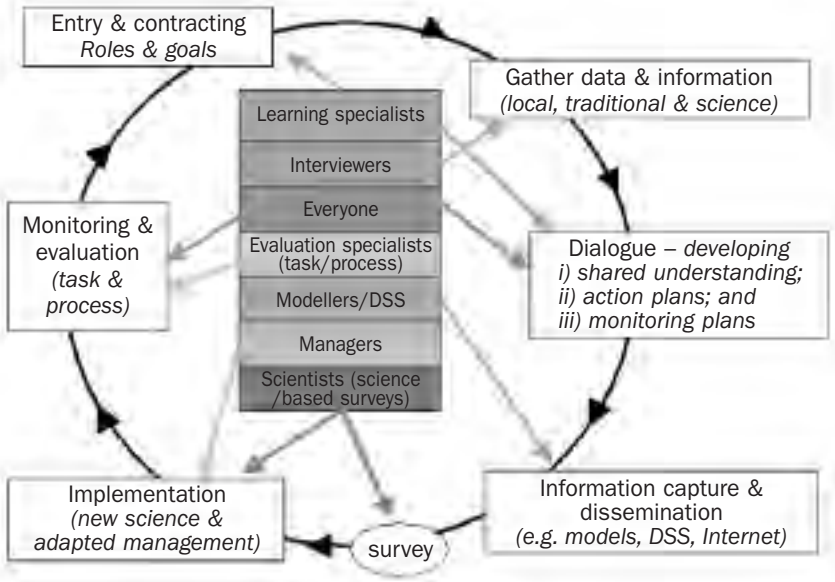
Figure 3
An example of the range of roles in an interdisciplinary problem-solving endeavour (adapted from Bosch et al., 1996 and Allen et al., 2001b).



esteem, and maybe even our identity. Most of us need to assume we are doing our best at all times, and it may prove a real loss of face to accept and even "embrace" errors. Adapting poorly or failing to realise our creative potential may be more desirable than risking failure and loss of esteem during the learning process (Allen and Kilvington, 1999).

Because of this, "learning, which mostly upsets beliefs and habits in individuals and organisations, is hardly likely to be embraced easily and enthusiastically, even though there is a growing, and sometimes powerful, recognition of the need for change" (Michael, 1995). Indeed, as Argyris et al. (1985) points out, individuals and organisations have a number of defensive reactions that resist change—or learning—by preventing open dialogue and the integration of new information that may challenge their existing world-views (values, assumptions, paradigms, etc.). These defenses include making some subjects "undiscussable", or an unawareness that their "espoused theory" —the world view and values people believe their behaviour is based on-is different to their "theory in use"—the worldviews and values implied by their behaviour (Argyris et al., 1985).

Accordingly, as these authors suggest, the first response to any inquiry into a mis-match between intention and outcome is likely to be the search for another strategy that will satisfy the "governing variables", the belief systems and values which the individual or organisation is trying to maintain. For example, if a land manager views his/her enterprise solely in terms of sheep production and notes that the vegetation condition of the land is deteriorating, the action strategy will likely be to try a different grazing regime. In such a case

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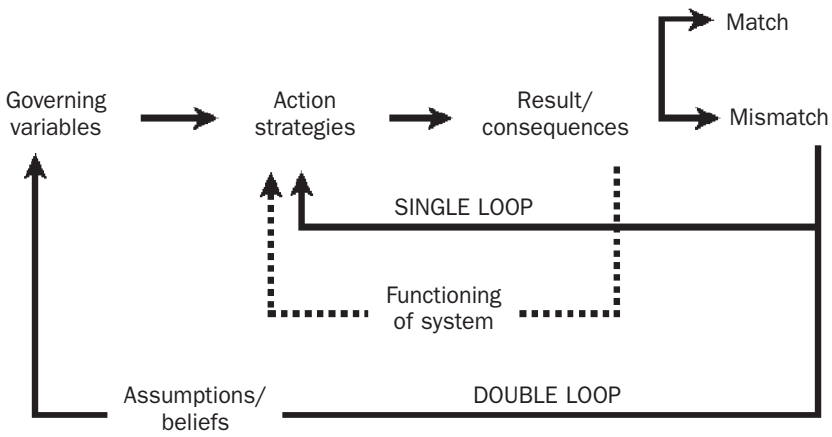
when new strategies are used to support the same governing variable (i.e. the land as a sheep production system) this is called single loop learning (Figure 4). A similar science example might arise in response to funder requirements for a scientist to be more participative. The response might be to find a "friendly" group of people to work with that are happy to acknowledge the scientist as the "unquestioned expert" —the governing variable.

However, another possibility is to change the governing variables themselves. For example, rather than try a new grazing strategy, the land manager may choose to initiate a more open form of enquiry. The associated action strategy might then be to look at how the enterprise could function as a tourism or forestry system for example. The scientist may choose to involve appropriate stakeholder groups in a more collaborative approach, changing the role of the scientist to one of a co-researcher and recognising that the role of "expert" is more a matter of perspective. These cases are called double-loop learning, and involve more fundamental shifts in people's belief systems and values. In this way they can often minimise the gap between espoused theory and theory-in-use.

Accordingly, Mezirow (1991; quoted in Bunning, 1995) draws attention to the need to address three elements through the reflective process: (a) content, the substantive issues involved; (b) process, how such issues were raised and addressed; and (c) premises, which are the values, assumptions, paradigms and whole framework of individual and collective mindsets, which inevitably influenced what was attended to and what was not, and other issues such as goals, process and interpretation.

Developing double-loop problem-solving approaches is thus a critical part of changing people's actions in respect to the environment. However, it also requires the action researcher to deal with the defenses of individuals and organisations—which is no small undertaking! In many cases this will mean having to address situations in which participants may feel embarrassed or threatened. However, as Grudens-Schuck (1998) points out, unless research and education programmes build specific processes

Figure 4
Single and double-loop learning (Adapted from Argyris, 1985).



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for confronting people about unworkable theories and organisational defenses, the use of local knowledge and interpretations of events cannot be a sound foundation for collaborative learning and positive change.

Concluding comments

In the broadest sense, interdisciplinary research endeavours such as those described in this chapter are intended to improve efforts to share information by building trust and confidence between information providers and users. The aim is to help information providers and users work together to address important issues collaboratively. Under such a collaborative approach the guidelines and strategies developed by the stakeholders will draw on a larger base of information than that available to any one of the parties acting alone. Because these are developed against this richer information base, they are likely to result in more effective outcomes. The probability of commitment to, and adoption of, changed practices is also likely to be higher. Allotting appropriate time and skills to manage conflict and build relationships is an important component of planning projects if the aim is to help different stakeholders and indigenous groups share information and develop solutions to shared problems.

Finally, this chapter has identified some critical factors for ensuring the success of a collaborative learning approach to improve the use of technical information within natural resource management. They include:

- Effective processes for building and maintaining trust.
- The ability to communicate clearly and place problems and information in their wider context.
- Time to develop a common context or language.
- Cultural considerations and processes.
- An appreciation that people do not learn easily and without effort.
- The need to balance the development of technical information with social and cultural processes to ensure that such information is effectively shared, understood, and used to change environmental practice on-the-ground.

To take up these challenges, interdisciplinary science approaches need to include personnel with complementary skills in the management of participation and conflict, and the integration of biophysical and social aspects of collaborative learning. As much attention will need to be paid to review and evaluate the processes by which such endeavours encourage learning, as is currently given to assuring that good technical research is being done.

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