Benefits of collaborative learning for environmental management: Applying the Integrated Systems for Knowledge Management approach to support animal pest control

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Abstract: Resource management issues continually change over time in response to co-evolving social, economic and ecological systems. Under these conditions adaptive management, or 'learning by doing', offers an opportunity for more proactive and collaborative approaches to resolving environmental problems. In turn, this will require the implementation of learning-based extension approaches alongside more traditional linear technology transfer approaches within the area of environmental extension. In this paper the ISKM (Integrated Systems for Knowledge Management) approach is presented to illustrate how such learning-based approaches can be used to help communities develop, apply, and refine technical information within a larger context of shared understanding. To outline how this works in practice we use a case study involving pest management. Particular attention is paid to the issues that emerge as a result of multiple stakeholder involvement within environmental problem situations. Finally, the potential role for the Internet in supporting and disseminating the experience gained through ongoing adaptive management processes is examined.

Key Words Natural resource management, collaborative learning, adaptive management, ISKM, extension, multi-stakeholder information networks, Internet

Introduction

The role of extension, or information management, in supporting the identification and adoption of best management practices within natural resource management is becoming increasingly difficult. Policy makers, scientists and communities alike are having to recognise the interlinked nature of many apparent resource use problems. Successful outcomes are often dependent on the coordinated actions of decision makers at different levels from farm to region. Consequently, many viewpoints and sources of information have to be shared among the different parties involved, and then integrated to find solutions that will guide the way forward. A major challenge is to help different groups of decision makers identify and apply sound technical information within a larger context of shared understanding.

The changing nature of resource management issues creates a further complexity. Because there can never be perfect knowledge of ecological processes within nonequilibrium systems, the concept of sustainable practice changes as knowledge expands (Burnside and Chamala 1994). Solutions need to be monitored closely during implementation to confirm their effectiveness, and to help refine future actions. In addition, as evolving economic, technical, and social systems continue to impact on management decisions, they will also contribute to changing definitions of best management practices. Accordingly, successful resource management must be based on a process of active adaptive management or 'learning by doing'. Such a process will also help create closer links between science, policy making, and management.

This paper uses the control of bovine Tb vectors as a case study to illustrate how collaborative learning approaches can be used along with more traditional linear forms of information transfer to support improved environmental decision making. It begins by describing the social context and challenges facing those involved in the case study, and then identifies possible solutions that can be used to promote a more active form of information management. It then discusses how the Integrated Systems for Knowledge Management (ISKM) approach can help implement such an active or learning-based approach. The potential for using the Internet to support and disseminate experience gained through ongoing adaptive management processes is examined as part of this. Particular attention is paid to issues resulting from multiple stakeholder approaches within environmental problem situations.

Challenges in improving pest control

The control of bovine Tb vectors in North Canterbury, South Island, New Zealand serves to illustrate challenges in information management, namely, those of providing access to sound information for decision-making, and encouraging the use of that information in changed behaviour that results in improved environmental management.

One facet of bovine Tb management requires that feral vectors are controlled. These include possums, deer, pigs, cats, and mustelids. All these mammals are exotic to New Zealand and, in the absence of natural predators, have spread widely, often to the detriment of indigenous flora and fauna (King 1990). More recently, they have been perceived as major agricultural pests because of their role in the spread of bovine Tb. Much research and management knowledge has been gained in their control over the years, particularly about possums, deer, and pigs, which have all been targeted by hunters for their commercial value. Over recent years mustelids (particularly ferrets) have assumed a growing role in contributing to the spread of Tb, particularly in the South Island (Livingstone 1996), thus illustrating the dynamic nature of goal-setting within environmental management.

In the past pest control was largely undertaken by local government agencies. However, in keeping with the international trend towards decentralisation and individual responsibility, more effort is now required from land managers to support and assist in the management of this problem. As part of this change the Animal Health Board, the national pest management agency for the control of bovine Tb, encourages individual land managers -- and particularly farmers -- to take action against this disease. To this end the Board has facilitated the formation of farmer vector-control groups throughout New Zealand, many of which have been formed in North Canterbury.

While the incidence of bovine Tb was increasing and expanding in North Canterbury there was considerable community motivation to take action. However, other factors serve to complicate efforts to maintain the consistent and long-term efforts needed. For instance, bovine Tb is only visible to farmers when herds are diagnosed as infected. Farmers with newly infected herds are highly motivated to clear them from infection. Once this has been achieved, however, there is a common perception that the Tb problem has been solved, and ongoing enthusiasm for control wanes. Moreover, the cost of infection varies between farm types and is only a problem for farmers with cattle and deer. Other farm enterprises, such as sheep or horticulture, are not affected directly by bovine Tb and so are less motivated to cooperate with their neighbours in undertaking vector control.

Another complicating factor is that ferret numbers are related to the availability of food sources such as rabbits (another introduced pest), a highly visible and expensive problem for many farmers in North Canterbury. Farmers -- particularly those that do not have a visible bovine Tb problem -- are often more likely to focus their resources on rabbit control in preference to ferret control, because ferrets are seen as a useful form of biological control. In the long term, this emphasis on rabbit control may be a good solution, however, as low rabbit numbers can often lead to reduced predator abundance (Norbury and McGlinchy 1996), and so to possible declines in the incidence of bovine Tb.

A further challenge is the need to gather together, and update, all available information. Although there are a number of individuals in both research and management with immense knowledge in one or more areas of pest management, the information within the industry sector as a whole is fragmented. Moreover, even when best management practices have been drawn up, they are continually superceded because of changing ecological knowledge, legislation, social considerations, and land-use practices. New science and management 'experiments' are continually adding to the pool of knowledge leading to new control approaches, and technology. This means that traditional forms of published guidelines quickly become outdated.

Because information flows within environmental management are often complicated by such issues, the related concepts of 'extension' and 'technology/information transfer' have become problematic in recent years. For most of this century they have been used to refer to what was, at the time, a straightforward process of reaching out to users (usually farmers) with new knowledge developed through science. From this perspective, most research initiatives have been, and still are, largely characterised by the linear transfer of technology (TOT) model of research and development. The dominant metaphors are those of 'information transfer', 'technology transfer', 'channels of communication', and 'teaching', most of which arise from mistakenly seeing human communication in the same way as data transferred between computers (Ison 1993). However, as a number of reviewers point out, many of the hidden difficulties and implications related to the dominance of this approach are only now being revealed (e.g., Roling 1988, Russell and others 1989, Ison 1993, Allen and others 1998). In particular, the linear transfer model of extension fails to address adequately both the multiple social perspectives that characterise resource management issues, and the requirements of decision makers in a dynamically changing environment.

This does not mean that the use of linear approaches to extension are wrong. There are very clear examples where this approach is highly successful. For example, it is especially suited to commercial innovations that apply equally to all end-users for whom the technology is developed. 'Commercial' in this sense refers to innovations developed primarily to increase productivity and/or reduce costs (e.g. a cheaper/more effective pest control product). However, where technology transfer -- the use of techniques methods and approaches -- is sought more for environmental reasons (in this case to improve disease management) rather than directly to increase productivity, more active extension approaches are required. Frequently, the costs of adopting such technologies are borne by the individual farmer, while the benefits are social and more widespread. In this case, the on-farm costs of Tb infection are small compared to the risks of international market closure related to the incidence of this disease in New Zealand. With no market signals of this risk, farmer recognition is understandably low, contributing to the variable motivation for Tb control efforts.

The need for more a more active approach to extension

Many environmental technologies today are complex, requiring not just a change in management behaviour but, potentially, a new way of thinking about systems, neighbours, and whole-farm planning. This is consistent with the view expressed by Röling (1993) who argued that moving towards environmental management should be seen as a cumulative and incremental learning process, not as the adoption of innovations.

Underpinning the concept of collaborative learning, which is now being increasingly referred to in organisational development, information system, and extension literature, is the idea of constructivism (Kelly 1955). This challenges traditional approaches to extension that perceived learning to be a passive process. The emphasis was on 'teaching', transferring the information or research results in the most efficient and effective way for end-users to take on board and then apply. From a constructivist perspective it is now generally accepted that people's cognitive maps (belief structures or worldviews) will shape their interpretation of new information, and that these cognitive maps are influenced in turn by the organisation or community grouping to which these people belong (Huber 1991, Michael 1995). Seen in this light, it becomes clear that if we wish to change people's behaviour (for instance, to improve the effectiveness of current pest management activities) then we face the difficult task of 'helping them see the world in a different light' (Bawden 1991).

That this task will be difficult is explained by a number of researchers, who maintain that people have inbuilt, and largely unconscious, defensive measures to ensure the resilience of their worldview (e.g., Argyris and others 1985, Michael 1995). Taken together, these concepts provide strong reasons why linear technology or information transfer workshops and media messages are by themselves insufficient mechanisms to promote change. In contrast, emerging extension approaches emphasise a more active participatory approach to information management and decision making in the first instance. While there will always be a place for traditional extension approaches to disseminate information, it is increasingly recognised that developing the base information requires a more collaborative approach between researchers, extension agents, and users.

Given the diverse set of decision environments inherent in the resource management arena, managing supporting information will, to an increasing extent, rely on technology and telecommunications to fulfil its function. However, by focussing on the social and organisational processes involved in creating and using information, rather than on the technological and transfer components, all the different parties involved are more likely to learn together how to identify and adopt more sustainable management practices.

This emphasises the need for embedding learning in real-word situations, where each learner functions as part of a community of practitioners helping to solve real-world problems. This view accepts that a significant component of learning arises from our interactions or dialogue we have with others, and therefore that the thinking of a community of learners is distributed through networks of conversations. In this way, we can still acknowledge the need for linear extension mechanisms to distribute information, while recognising the need to involve user representatives more closely in the research process itself. This user involvement not only helps keep research and information transfer relevant, it also provides key people in the community with new ideas and perspectives, which they will share with others thus paving the way for improved user thinking and change.

Integrated Systems for Knowledge Management

The Integrated Systems for Knowledge Management (ISKM) approach is designed to support such an ongoing process of constructive community dialogue and to provide practical support for resource management decision making. This framework has been developed in the South Island high country of New Zealand to help communities -- in the widest sense of the term (e.g., land managers, scientists, policy makers, and other interest groups) -- share their experiences and observations in order to develop the knowledge needed to support sound resource management decision-making (Allen and others 1996 and 1998, Bosch and others 1996a).

The ISKM framework (Figure 1) promotes participation and self-help in natural resource management projects by providing clear communication pathways which support dialogue and action. As such, ISKM is not a new project type or innovative development concept, but rather a specific approach that emphasises a number of key steps applicable to developing the knowledge and action needed to change problem situations constructively. The ISKM framework consists of familiar processes used in other fields of cooperation, and was designed around basic management actions, which include: identifying the problem and setting a management target; searching for information on how to achieve the target; implementing the best management practice available; evaluating the outcome; and adapting the management if required. The approach comprises two main phases.

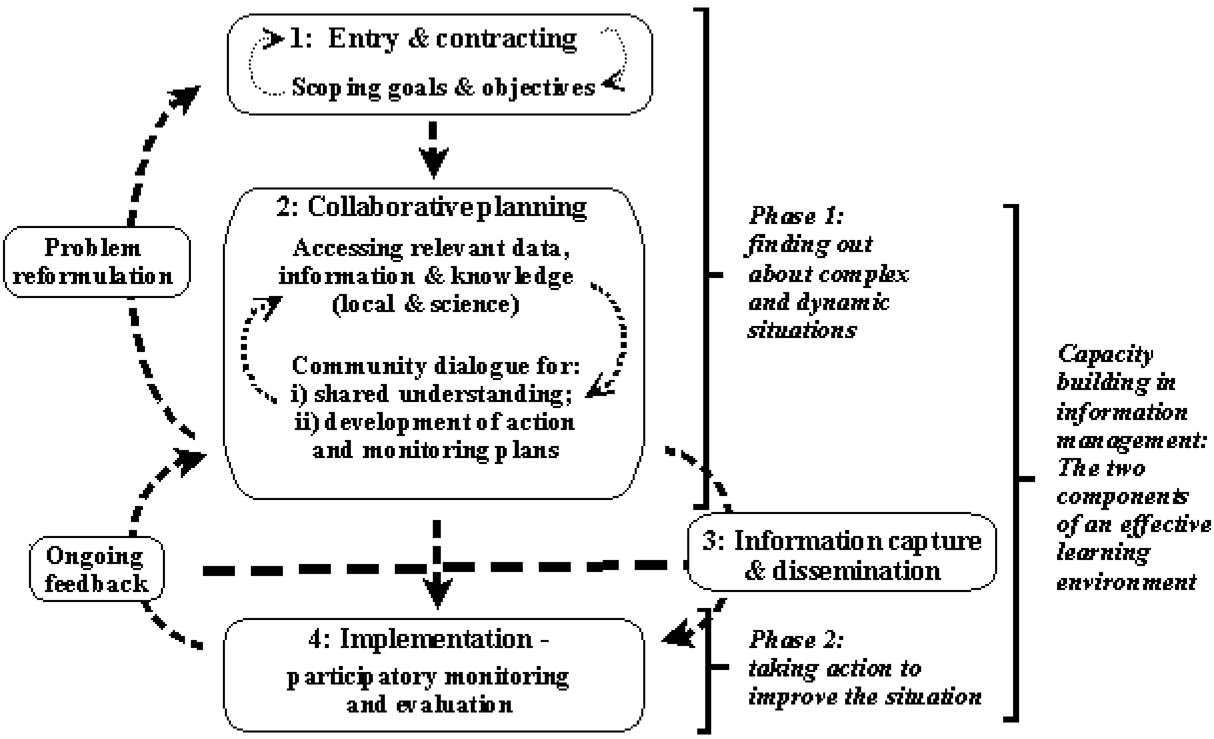

Figure 1: ISKM -- a participatory research framework to facilitate the identification and introduction of more sustainable resource management practices. The two phases interact to create an effective learning environment.

To guide people in carrying out these steps effectively when managing environmental problems, the approach provides a framework to:

- encourage the development of appropriate processes for community participation,
- bring people together to share their knowledge (local and science) and jointly develop best-management practices and/or action plans,
- develop a management information system (with potential benefits to all those that did not have the opportunity to be directly involved),
- monitor and evaluate the outcomes of actions
- develop feedback loops to maximise the benefits from monitoring and evaluation and hence develop a collaborative-learning/self-improving environment, supported by a continually updated information system.

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.

The establishment of such a dialogue first requires an initial scoping process to clearly define the nature of the system under consideration, and the needs and opportunities facing the different interest groups involved. It also addresses who should be involved, and what can or should be changed, etc. Because this provides an opportunity to involve the interested parties in the research process from the outset, it is more likely to lead to the development of opportunities and outcomes relevant to community needs.

In our pest management case study, this phase of the project involved the researchers in working with an already established representative advisory group, the North Canterbury Tb Management Committee (comprising farmers, local government and agency representatives). The project goals and the roles of those involved were also agreed in conjunction with the Committee. Key roles in bringing science and local knowledge together in this project involved the project researchers in taking responsibility for contacting and arranging to meet with pest management scientists, and the farmer Chair of that Committee to organise farmer meetings.

Collaborative Planning

In its simplest form planning can be seen as a two-step process of problem solving: seeking out information; and using this information to develop strategies to improve the situation. The emphasis on problem formulation ensures a focus on the collation and development of 'relevant' information and knowledge. It provides a basis for the design of appropriate processes (interviews, focus groups, questionnaires, etc.) to unlock and access the relevant existing data and information from both local and research communities.

As Bosch and others (1996a) point out, it is important to begin with local knowledge of management goals, problems, and solutions. Land managers have collectively accumulated a vast amount of experience in local environments, and so involving them from the outset ensures better access to their knowledge. In turn, sharing understanding and knowledge between scientists and land managers allows scientists to gain a better appreciation of the opportunities and problems facing land managers in the real world. This is more likely to lead to the development of a structured and comprehensive knowledge-base relevant to community needs (Blokker 1986).

The importance of this was well illustrated in this case study where we began by asking pest management researchers to develop a guide to 'best management practice'. This resulted in a well-constructed framework covering the technical aspects of ferret control, but which, as the farmers pointed out, failed to recognise that effective pest management not only requires a 'knowledge' of control techniques, but also of how to encourage a majority of farmers to 'undertake' these control techniques. As a result of this, work was subsequently undertaken through this project on the social aspects of gaining collaboration and involvement.

Another key consideration during this process is helping different stakeholders recognise the contextual nature of information. A strategy suggested by a conservator, farmer, policy-maker, or environmental group will always have been derived from within a particular social, economic, and ecological setting. Scientific results are similarly derived from within a particular context, which will include factors such as scale, site, and the researcher's personal worldview. Accordingly, the community dialogue process is designed to seek the active cooperation of different group representatives to develop a common understanding of the context in which any individual piece of information becomes relevant. For example, an important consideration in designing field control operations is determining the appropriate spacing to use between traps. In this case study scientists suggested suitable grid spacings to ensure that the ferret's home range was well covered with control traps. However, North Canterbury farmers pointed out that a grid design for trapping may not be the most practical and cost-effective method in a commercial situation, where trapping often has to be combined with other farm operations. Both groups are correct in the context in which they are working.

Accordingly, facilitated workshop formats can be used to provide a learning environment within which participants develop a shared understanding of how others see the world and how that view shapes the way they act in it (e.g., manage their land, carry out their research, develop policy). Indeed, as Huber (1991) notes, it might be reasonable to conclude that more learning has occurred when more and varied interpretations have been developed, because such development extends the range of participants' potential behaviours.

Information Capture And Dissemination

Dissemination of information is crucial to the development of a learning-oriented management system. Where a certain item of information is known only to a few people within an organisation, the possibility that others will find it is weak (Huber 1991). Conversely, when information is widely distributed in an organisation, such that more and varied sources for it exist, retrieval efforts are more likely to succeed, and individuals and units are more likely to learn. Given the decentralised grouping of agencies, land managers, and individuals within the natural resource management arena, the challenge noted above is multiplied several-fold. Yet, if we must go through the hard work of acquiring and making sense of information previously discussed, it is logical to maximise our efforts for storage and retrieval.

The use of ISKM and similar approaches provides, for all those directly involved, a learning environment in which 'useful knowledge' is developed through a participatory process. In addition, this knowledge should be captured to benefit potentially all those who have not had the opportunity to be directly involved. This can be done through a range of media such as minutes of meetings, journal papers, memorandums, reports, the media, telephone, facsimile, and (last but certainly not least) face-to-face conversations, as appropriate. In other cases, especially with more complex problems, computer-based decision support programs can provide a decision-tree type format to guide people through the problem-solving exercise. Here, the Internet is emerging as a new system for managing complex information which allows people to create, annotate, link together and share information from a variety of media including text, graphics, images, audio, and video. The potential of such hypermedia-based systems to promote collaborative learning and problem solving is also being advocated by a number of other researchers (e.g., Carrascal and others 1995, Allen and others 1988 Manninen 1999).

In this way the Internet-based system developed for Tb-vector control in our case-study can be seen to act as a medium to collect, structure, and store information. The design was developed through the ISKM collaborative planning phase and encourages the user to define and then select a management goal. By answering simple questions and being prompted to provide further information with the help of associated models (e.g., monitoring packages), the user can create new information relevant to the issue under investigation. Prompts provide a pathway towards the provision of management advice. Through the use of hypermedia links the user can obtain further explanation and clarification of the assumptions behind selected answers, along with the ability to access associated subject areas.

The iterative approach inherent in the ISKM framework encourages an interactive process where DSS (decision support system) developers and users collaboratively discover new requirements and make refinements to succeeding versions. Through this process the users become authors and presenters of the material within the DSS. As authoring requires analytical thinking about the subject matter in hand, this leads to a deeper understanding (Jonassen 1992). The value in this is obvious when DSS development is seen as a process that can be enhanced by the use of iterative 'soft' systems methodologies emphasising processes of dialogue, feedback, and learning among all the different participants in the situation under inquiry (Miles 1988). This form of DSS development allows the user to learn and experience the system at an early stage, which encourages user confidence in subsequent working versions (Brittan 1980).

The use of hypermedia also allows the capture of a wide variety of supporting information. This enables us to capitalise on the fact that decision making not only relies on 'hard' data such as numbers, facts, and rules, but also on 'soft' information such as tacit knowledge, experiences, critical incidents, stories, and details about why past decisions were made (Schwedersky and Karkoschka 1994). This means users do not have to take decisions for granted and encourages a learning environment that helps constructive and voluntary behavioural change. In the long term, we would envisage such hypermedia-based systems as designed to integrate a diverse array of information sources and to provide users with a more holistic perspective of a complex situation. One of the main advantages of the Internet in this regard is the ability to link directly with related sites maintained by external providers. Another important feature of the Internet is improved interpersonal communication over long distances through the use of e-mail, bulletin boards, and discussion groups. By providing networking capabilities in this way the Internet has the potential to broaden the concept of 'communities of practice' (Brown and Duguid 1991).

The research project in our case study does not necessarily regard farmers as direct users of such an Internet-based system. Clearly, not all farmers have access to computing and Internet facilities. However, in North Canterbury the majority of farmers belong to groups organised around the issue of pest management. These groups are serviced by facilitators and group leaders, and act to develop an effective cooperative environment for learning. The facilitators and group leaders are seen as the interface between the Internet information system and farmers. In itself, the Internet has the potential to form a powerful and immediate link between farmer-group facilitators, group leaders, researchers, and other relevant agency staff. Strengthening this link is seen as a key to effective sharing of information among the diverse range of groups involved in natural resource management.

The Next Steps

This paper has described some of the lessons learnt through following the steps in the first phase of the ISKM process (Figure 1). However, for such a socially inquiring information system to advance natural resource management successfully in the long term it needs to evolve as society and the environment change. While we have not yet been reached this stage in this case study, it is still useful to chart out some of the benefits that could be realised through such an ongoing approach. In particular, the strength of iterative processes such as ISKM, is that they allow for the substance and context of the required information flows to be updated as more knowledge becomes available and different goals are set.

As natural resource end-users (e.g., land managers and policy makers) adopt new strategies and measure the results of their actions (formally adopting the linked concepts of monitoring and adaptive management), they will continually develop new information, which can be brought into successive iterations of the process (Bosch and others 1996b). In a similar way the process can take advantage of an ongoing flow of new data and information from more formal science activities. Accordingly, the nature of work undertaken by individual scientists will not change, the only difference being that the starting point for scientific experimentation is more firmly embedded, or institutionalised, within the community of practice. The earlier processes of ongoing community dialogue will automatically help identify new and relevant research initiatives as knowledge gaps are identified. Importantly, these activities also provide the community with the opportunity to prioritise their information and technical needs as they work more closely with researchers. Because the ISKM process is designed to provide decision support, it also automatically acts to disseminate research results to those end-users who participate in the process.

The process can therefore become iterative, with each iteration serving to maximise the knowledge available to support decision making by those in the community at any time. The addition of different modules and issues will arise from the need to meet a community objective, which may be financial, ecological, or social, or some combination of these. As all the different groups involved cooperate to develop the necessary knowledge and knowledge-based tools, new issues will be raised and the process expanded.

Concluding Remarks

Collaboratively developing new management options and strategies through the ISKM process provides interested parties with the opportunity to learn from local experiences gained within enterprise and catchment-level systems. This provides those involved with an appreciation of management concerns and issues, and gives scientists and policy makers a better feeling of how their contributions fit into the total system. This holistic approach is important because much of the conflict surrounding many resource management issues arises from different interest groups failing to appreciate the perspectives and values inherent in the actions of others. If these groups can be encouraged to share their experiences and viewpoints, there will be a greater understanding of why these differences exist. The use of hypermedia and the Internet provides another pathway to help bring this about.

However, while such participatory approaches to adaptive resource management sound appealing, they bring a new set of challenges for policy makers and scientists who may desire to work more closely with communities (e.g. McLain and Lee 1996, Yaffee 1997, Allen and others 1996, Allen 1997). At the programme level, this means detailed outlines for action can no longer be drawn up at the outset, as problem solving is based on partnerships and cooperation, and not the quest to achieve some externally identified goal. Proposals for actions must be continually reshaped as experience is gained, and as more participants become concerned about a particular issue, cost, or benefit. This requires the use of, and commitment to, an iterative model of testing, feedback, and revision (Sechrest and Figueredo 1993). Because of this, participatory development and research takes time, which creates problems for research funding. Most current funding systems favour short-term projects with concrete outputs and outcomes.

Because these programmes are designed to be responsive to changing community needs, one of the most pressing challenges is to develop and encourage the use of robust participatory monitoring and evaluative (PM&E) processes. Effective collaborative initiatives are the ones that pay attention to both the task and the process, and so meet the needs of the different participants in both areas (Allen 1999). In this regard the task can be defined as what those involved have to do (e.g. reduce pest numbers). The process is concerned with how people and groups work together and maintain relationships. Experience shows that people often neglect process issues, often in order to concentrate on their task. However, both task and process will suffer if they are split from each other. Because task and process are linked in this way, it is also important to measure progress of both.

Internet technology will inevitably play a role in future information systems, not least because it offers a unifying platform for the collection of information. However, the ability to produce and disseminate high-quality, meaningful information through this communication medium, with low levels of 'noise' and redundancy, is still in its infancy (De Conti 1998). It is harder still for agencies and other information managers to be able to craft good information and then use it to: (i) invite stakeholders to take a more active participatory role in its subsequent management; and (ii) through this to improve planning, policy analysis, and decision making. If the Internet is to contribute significantly to the development of a learning environment, these processes must be both ongoing and interactive. There are still challenges in establishing a widespread appreciation that information quality is not just a set of outward characteristics or design decisions, but part of a continuous process in which content and presentation are adjusted to meet user needs. In particular this is a challenge for science organisations where traditional quality control means that end-users rarely see research results until they have been peer reviewed by the science community. However, collaborative research implies that end users need to be involved more closely in all aspects of the research process, not only as peer reviewers but also in commenting on early draft results and presentations.

Future natural resource management projects will increasingly require a greater emphasis on the resources and skills necessary for identifying, gaining access to, building relationships with, and negotiating roles with these different sets of stakeholders. For example, resource scientists seldom have the skills required for communication processes such as entry and contracting. New skills are also needed to develop and work cooperatively in multi-stakeholder networks. In particular, this requires team skills and better recognition of the importance of power sharing, inter-agency collaboration, and local knowledge.

Although co-operative ventures such as those described here will never offer definitive solutions to such elusive issues as sustainability, they can begin to offer a variety of knowledge-based tools and possible courses of action to enable the community to make better informed decisions. In turn, as communication flows between different sectors of the community are expanded and improved, the level of needless conflict surrounding a number of resource management issues should be minimised. Accordingly, this participatory approach represents a framework through which different segments of society can cooperate to develop and work towards a more coordinated set of environmental goals.

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