The implementation crisis in conservation planning: could "mental models" help?

Duan Biggs[1], Nick Abel[2], Andrew T. Knight[3], Anne Leitch[1,4], Art Langston[2], & Natalie C. Ban[1]

[1] Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia
[2] CSIRO Ecosystem Sciences, Gungahlin Homestead, Bellenden Street, Crace ACT 2911, Australia
[3] Department of Conservation Ecology & Entomology, Stellenbosch University, Private Bag X1, Matieland 7602, Western Cape, South Africa
[4] CSIRO Ecosystem Sciences, Queensland Biosciences Precinct St Lucia, Brisbane, Australia

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Correspondence
Duan Biggs, Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia.
Tel: +61 4781 4000; fax: +61 7 4781 6722.
E-mail: ancientantwren@gmail.com

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Abstract

Core to the planning–implementation gap in conservation is the failure to achieve the necessary shared vision and collaboration among typically diverse stakeholder groups to translate conservation assessments and plans into sustained on-ground outcomes for conservation. We suggest that a process of describing and sharing mental models—the cognitive frameworks that people use to interpret and understand the world—provides promising and as yet underutilized techniques for conservation planners to improve implementation success. The processes and techniques associated with the mental models concept have been applied in a variety of fields including business and organization science, risk analysis, education, natural resource management, and climate change adaptation. Our review of mental models illustrates that their application can strengthen the success of conservation planning by: (1) contributing to clear and open communication between stakeholders; (2) aiding in overcoming obstacles to incorporating multiple sources of knowledge; (3) enabling shared ownership of a conservation plan; and (4) improving social assessments. Techniques to explicitly communicate mental models can contribute to each phase of a conservation planning process—assessment, planning, management, and review. Conservation planners have much to gain by eliciting and sharing mental models in conservation planning processes.

Introduction

The implementation crisis in conservation planning is one of conservation's greatest challenges. Although conservation planning is a social process that encompasses assessment, planning, and sustained management of areas important for achieving conservation goals, conservation planning approaches continue to emphasize ecological over social considerations (Knight *et al.* 2006). In addition, despite a growing literature on techniques for allocating conservation investments (e.g., identifying priority areas for protecting biodiversity), conservation assessments are rarely translated into actions that benefit conservation. This is called the research–implementation gap, or planning–implementation gap (Knight *et al.* 2008).

Core to the planning–implementation gap is the failure to achieve the necessary collaboration among typically diverse stakeholder groups to translate conservation assessments and plans into sustained on-ground outcomes for conservation (Knight *et al.* 2008; Smith *et al.* 2009; Nkhata & Breen 2010). This failure arises in part because individual stakeholder groups hold specific values and perspectives on how the world functions, and hence how natural resource decisions should be made (Adams *et al.* 2003; Sayer & Campbell 2004; Pahl-Wostl 2006). While differences in values and perspectives are not the only source of conflict and failure—power struggles, institutional barriers, lack of participation opportunities, and uncertainty are some of the many challenges to overcome in conservation (Satterfield 2002; Brosius & Russell 2003; Lewicki *et al.* 2003)—the marked differences between values and perspectives of stakeholder groups, as well as variation within groups (Vennix 1999; Wondolleck & Yaffee 2000; Dietz *et al.* 2003) are crucial impediments in many conservation planning processes. In this review, we suggest that a process of describing and sharing mental models (hereafter referred to as "mental model processes")—the cognitive frameworks that people use to interpret and understand the world—provides promising, and as yet underutilized, techniques for conservation planners to improve implementation success.

Several frameworks for conservation planning exist and most share similar elements of assessment, planning, management, and review (Margules & Pressey 2000; Knight *et al.* 2006; Pressey & Bottrill 2009). The assessment phase entails defining the problem, scoping and costing the planning process, identifying stakeholders, and describing the context of the planning region. The planning phase uses information from the assessment to identify conservation objectives, preferred scenarios, and implementation options. The management phase implements and maintains conservation actions, while the review phase reconsiders and reassesses conservation achievements and opportunities. These phases are iterative, often with feedbacks, rather than a simple linear sequence. Conservation planning frameworks implicitly recognize the importance of a structured approach to decision-making (e.g., Gregory 2000; Gregory *et al.* 2001) and emphasize the importance of stakeholder engagement throughout the process (Gregory 2000; Knight *et al.* 2006; Pressey & Bottrill 2009).

While conservation planning has evolved from an ecological focus (e.g., Margules & Pressey 2000) to include social considerations (e.g., Gregory 2002; Knight *et al.* 2006; Pressey & Bottrill 2009), the techniques for social assessments and collaboration lag behind ecological assessments. Many conservation plans approach social considerations as if they are biodiversity assessments: they list stakeholders (similar to listing known biodiversity elements), and collect spatial data on socioeconomic variables such as human uses of the land- or seascape (similar to mapping biodiversity elements) (Ban & Klein 2009; Pressey & Bottrill 2009). Through the use of decision support tools (e.g., Marxan, C-Plan), human uses in the land- or seascape are frequently interpreted as costs, and conservation objectives are optimized while costs to people are minimized (Ban & Klein 2009). Such assessments ignore the complexities of human psychology and potentially result in missed opportunities for meaningful engagement of stakeholders in the planning processes.

A key opportunity for increasing implementation success of conservation plans is to engage stakeholders more inclusively in the planning process. A review of the stakeholder engagement and collaboration literature suggests that challenges to collaboration in conservation and natural resource management primarily stem from three sources: (1) lack of clear and open communication (Schuett *et al.* 2001; Schusler *et al.* 2003; Knight *et al.* 2006; Cowling *et al.* 2008), (2) obstacles to incorporating multiple sources of knowledge (Knight *et al.* 2006; Ban *et al.* 2009), and (3) lack of shared ownership of a conservation plan (Wondolleck & Yaffee 2000; van Kerkhoff & Lebel 2006; Cowling & Wilhelm-Rechmann 2007; Cowling *et al.* 2008). It is in these aspects of collaboration, and in strengthening social assessments, that the processes associated with mental models may have the most to offer conservation planning.

We present the case for addressing these challenges to strengthen conservation planning through a process of eliciting and sharing mental models among stakeholders. Mental model processes are one of many strategies promoting conflict resolution and collaboration (e.g., Satterfield 2002; Lewicki *et al.* 2003). Other strategies include negotiation, mediation, arbitration, and adjudication (Bercovitch & Jackson 2009). We focus on mental models because their elicitation can illuminate stakeholder perspectives to identify areas of both disagreement and common ground, thereby strengthening social learning. Social learning occurs when people who share diverse perspectives and experiences develop a common framework of understanding and basis for joint action (Schusler *et al.* 2003). The stimulus for this article comes from the authors' experiences of personal successes and failures in community-based conservation and conservation planning initiatives in sub-Saharan Africa, Australia, and North America.

Mental models

Definition and history of mental models

Mental models are the cognitive frameworks that people use to interpret and understand the world, and comprise an individual's pattern of knowledge (Bower & Morrow 1990; Carley & Palmquist 1992; Atman *et al.* 1994). They incorporate deeply engrained, often unquestioned, assumptions of the world and how it functions, affect how individuals filter, process and store information, and guide understanding, reasoning, prediction, and ultimately, action (Figure 1) (Lyles & Mitroff 1980; Senge 1990; Ajzen 1991; Bosch *et al.* 2003). Due to the limitations of the human mind, mental models selectively filter and interpret the overwhelming amounts of incoming information (Sabatier & Jenkins-Smith 1999). They are necessarily, and by definition, partial views of the world (Vennix 1999), but valid to those who hold them. For

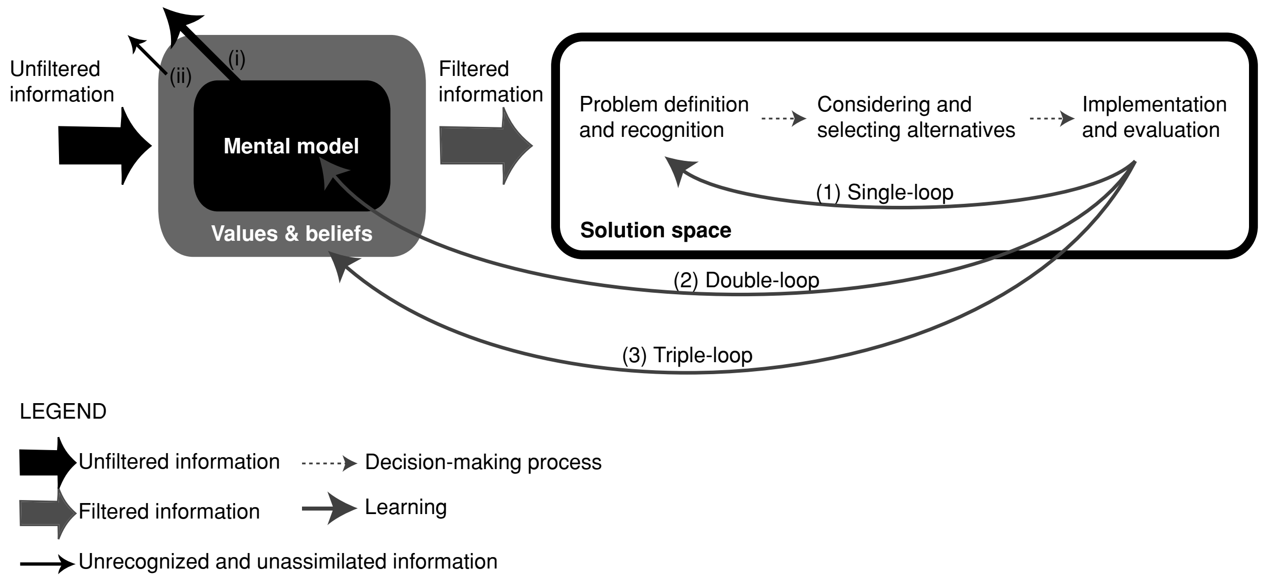

Figure 1 Illustration of single-, double-, and triple-loop learning in a mental model. A mental model, informed by values and beliefs, acts as a filter that selects information from the real world. The mental model, using filtered information, informs the decision-making process that takes place within the solution space. The decision-making process consists of problem definition, recognition, weighing up, and selection of alternatives and implementation and evaluation of decisions. (1) Learning often operates only within this existing mental model, which is known as single loop learning. In single-loop learning, much of the incoming information is not recognized or considered in decision-making (i) because it is incompatible with the mental model; (2) Double-loop learning entails active questioning and potential adaptation of the mental model. In double-loop learning the solution space is expanded as the amount of incoming information that is unrecognized and unassimilated is reduced (ii); and (3) Triple-loop learning entails the active exploration and adaptation of individual's values, beliefs, and ideological attitudes. When these beliefs are questioned and changed, the mental model is altered to accommodate the new learning. Successful triple-loop learning enables the most inclusive approach to conservation planning with the largest solution space as stakeholder's values and beliefs are actively questioned and explored.

example, an aquatic ecologist may have a different understanding of the aquatic ecosystems in a park than the ranger, but it is still only a partial understanding, though one that facilitates scientific goals. Similarly, our (the authors') mental model of conservation planning is influenced by our training, experiences, collaborators, and the literature we are exposed to, and may differ from academics in, for example, anthropology. Table 1 describes how mental models differ from, and overlap with, the related concepts of perception, values, and worldviews.

The concept of mental models originated in psychology (Craik 1943), and associated techniques have been widely applied in fields including business and organization science (e.g., Senge 1992), risk analysis (e.g., Cox *et al.* 2003), education (e.g., Kearney & Kaplan 1997), natural resource management (e.g., Kolkman *et al.* 2005; Biggs *et al.* 2008), and climate change adaptation (e.g., Lowe & Lorenzoni 2007) (Table 2).

Forming, refining, and sharing mental models

Mental models are shaped by social, cultural, and environmental factors, as well as experiences, including failures and successes (Figure 1) (Gentner & Stevens 1983; Senge 1992). Individuals use experiences to build their own models to interpret the world and shape their responses to it (Kelly 1955). The individual compares experiences with their existing mental model, and if the match is good, it can remain unchanged. If the new information does not match, it can be modified or the information rejected. However, humans have a strong tendency to accept information that matches existing constructs, shedding the rest (Kelly 1955). Therefore, major changes to mental models are not made readily, which contributes to the failure of many conservation efforts.

Language has a strong influence in the development of mental models (Carley & Palmquist 1992; Lakoff 2004). Definitions of concepts and boundaries between them are often set linguistically, affecting how mental models are formed and how they are changed (Johnson-Laird 1983). Thus, when actors in a participatory conservation process speak different languages, they may differ in their mental models of the same landscape on those grounds alone.

Mental models are informed by social and cultural influences, which means they operate at both individual and group scales (Langan-Fox *et al.* 2001). Therefore, while individuals have their own mental models, they share similar elements with the models of others. For

Table 1 How the mental model concept differs from and overlaps with related terms. Definitions adapted from: Dietz *et al.* 2005; Mirriam–Websters online (http://www.merriam-webster.com/); Oxford English Dictionary online (http://www.oed.com/)

Term	Definition
Attitude	Manner, disposition, or feeling with regard to a person or issue; tendency or orientation, of the mind: for example, a negative attitude. Mental models contribute to a particular attitude
Belief	A firm opinion or acceptance of a fact. Mental models are both informed by beliefs, and affect how beliefs can be modified (Figure 1)
Discourse	A mode of organizing knowledge, experience, and ideas that is rooted in a particular cultural, ideological, and historical context
Mental model	The frameworks that exist in the minds of individuals to interpret the world. They are formed by cultural and environmental factors and past experiences.
Perception	Quick, acute, and intuitive cognition. Mental models filter incoming information and affect the way a situation or issue is perceived.
Values	The principles or moral standards of a person or social groups, the generally accepted or personally held judgment of what is valuable and important in life. Values affect the way mental models are structured (Figure 1)
World-view	Synonym for Weltanschauung, a particular philosophy or conception of life and the world that may be associated with a specific culture. The description of a mental model unpacks the framework, values, and beliefs associated with a particular worldview.
Ideology	A set of beliefs characteristic of a social group or individual

two people to communicate effectively, they need not have the same mental model, but each should at least be able to understand the other's (Kelly 1955; Schusler *et al.*, 2003). The concept of a shared mental model is useful in multistakeholder conservation as it represents the degree to which a common conceptualization of an issue exists. One way that shared mental models may develop is through iterations of interaction that enables the

Table 2 Use of mental models in natural resource management and other fields

Field	Description	Key references
Climate change	Elucidating lay understanding and risk perception as well as expert conceptualizations of the causes and impacts of climate change to improve communication and understanding.	Read *et al*. 1994; Kempton 1997; Lowe & Lorenzoni 2007
Rangeland science	Elucidates the differences in understanding among rangeland farmers, management agencies, and researchers as to how rangeland systems work and how they should be valued and managed.	Abel *et al*. 1998a,b
Water resource management	Maps mental models to analyze the policy controversies and problems at a cognitive level to stimulate communication and learning.	Kolkman *et al*. 2005, 2007
Forestry management	Used mental models to assess whether there is an adequate level of consensus among forestry scientists in Canada for sound implementation of a policy for the Emulation of Natural Disturbances (END)	Klenk *et al*. 2008
Business science and organizational learning	Expounds the value of understanding the mental models of staff so as to effect innovation and positive change.	Senge 1990; Spicer 1998
Conflict resolution	Argues for the use of mental models exercises in conflict resolution to better understand the values, needs and objectives of different parties	Luis Pinzón 2000
Education	Uses mental models and cognitive mapping to understand how learning takes place	Greca & Moreira 2000; Jonassen 2003; Coll *et al.* 2005
Ergonomics (human engineering)	Outlines the distinction and measurement of individual, team, and shared mental models	Langan-Fox *et al*. 2001
Risk analysis and management	Describes mental models and their role in the evaluation, communication, social amplification, and management of risk	Svenson 1988; Morgan *et al*. 2002
System dynamics	Apply mental models as a tool to better understand complex systems that involve human decisions	Doyle & Ford 1998; Vennix 1999

coconstruction of a similar representation of an issue, creating a basis for shared understanding and joint action (Langan-Fox *et al.* 2001, Schusler *et al.* 2003).

Mental models and single-, double-, and triple-loop learning

The concepts of single-, double-, and triple-loop learning explain the type of learning associated with changes to mental models (Figure 1). Single-loop learning refines an existing mental model and assists in changing practices and actions (Argyris 1999). Double-loop learning questions the mental model itself, and can result in some modifications (Argyris 2005). Triple-loop learning questions the values and beliefs that underlie the mental model, and can result in a major restructuring, or reordering of values therein (Wierdma 1992, cited by Altman & Illes 1998; Peschl 2007). As with mental models, single-, double-, and triple-loop learning operate at individual and group scales (Peschl 2007). Successful social learning therefore entails double- and triple-loop learning at the scale of an organization or group of stakeholders.

The conflicts and challenges that surround management of elephant impacts in South Africa's Kruger National Park illustrate single-, double-, and triple-loop learning. Historically, park managers' perception of negative effects of elephants on biodiversity led to an extensive culling program (Whyte *et al.* 2003). Single-loop learning in this example would mean changing the season or procedures used for culling; learning takes place within the existing mental model. In recent years, ecologists illustrated the role of the spatial distribution and patterns of vegetation use by elephants as determinants of their impacts on biodiversity, and not solely elephant population size (Scholes & Mennel 2008). A shift by park management from managing the numbers of elephants, to managing their impacts, specifically in ecologically sensitive areas, represents double-loop learning. The changed management action may be to cull smaller numbers of elephants in sensitive areas only. Such a management shift represents a change in the mental models of park managers about the relationship between elephants and the ecosystem. In addition, from the early 1990s onward, increasingly vocal animal rights groups voiced a value-based opposition to elephant culling, and the Park's neighboring communities requested meat from culled elephants as an additional source of protein. Triple-loop learning by park management would require an active questioning of the values that underpin their mental models. As an outcome of triple-loop learning, managers may relocate instead of cull elephants due to a shift toward considering animal rights (Scholes & Mennel 2008); or continue culling but donate elephant meat to neighboring communities. Of importance in triple-loop learning is the active questioning of the values that underpin a mental model.

As part of learning, experience plays a vital role in supporting change in mental models.

Because major changes are not made readily, refining or adapting mental models through experiences (Kelly 1955) is critically important for conservation efforts. Verbal explanation may be sufficient to trigger refinement when the listener's model is similar to that of the speaker. For major change that involves triple-loop learning however, stronger experiences are needed. For example, a conservation project that aims to convince farmers to switch from cattle farming to ecotourism and wildlife conservation may conflict with a farmer's deeply held values and existing mental model about farming. Persuasive experiences from a participatory planning process are probably required to change the practices of such farmers.

Eliciting, analyzing, and presenting mental models

The range of techniques used to illustrate and elicit mental models has expanded in the past two decades and include content analysis, procedural mapping, task analysis, cognitive mapping (Carley & Palmquist 1992; Biggs *et al.* 2008), and consensus analysis (Biggs *et al.* 2008) (Table 3). Different presentation options exist for these techniques. Generalized linear modeling or nonparametric statistical methods can detect differences and show similarities between stakeholders' mental models. Principal component analysis and classification methods can represent differences diagrammatically (Abel *et al.* 1998a; Biggs *et al.* 2008). Influence diagrams, the most common way to present mental models, represent relationships among variables and how they form the structure of a mental model (Abel *et al.* 1998a; Biggs *et al*. 2008). For example, influence diagrams are used to illustrate how mental models of commercial agricultural producers differ from subsistence farmers in South Africa's Crocodile River catchment (Figure 2) (Biggs *et al.* 2008).

Contribution of mental models to conservation planning

Based on the success of their use in other disciplines, we hypothesize that the process of describing and sharing mental models among stakeholders may strengthen collaboration and success of conservation planning by: (1) contributing to clear and open communication

Table 3 The main techniques used to elicit and share mental models

Technique	Description	References	Elicitation	Analysis & representation
ARDI (Actors, Resources, Dynamics, Interactions)	A companion modeling approach that elicits the diversity of understandings that exist in mental models with respect to the main actors, resources, dynamics, and interactions in a nonconfrontational way. It is an action research tool designed to build consensus and a shared mental model around a vision.	Biggs *et al.* 2008; Etienne *et al*. 2008	√	√
Content analysis	Words or phrases from written texts or transcripts from interviews are classified, and the categories are assumed to represent concepts. Statistical modeling can infer the relative importance of different concepts from the frequency with which they are used, thus show differences and similarities in stakeholders' mental models. Classification trees can also be used, for example, to group the concepts hierarchically by stakeholder type.	Carley & Palmquist 1992; Biggs *et al*. 2008		√
Consensus analysis	Developed in cultural anthropology and investigates the extent of sharing of words, concepts, information, and knowledge among individuals. Enables statistical analysis to determine whether there is sufficient agreement among stakeholders to suggest that they have a shared mental model.	Biggs *et al*. 2008		√
Procedural mapping	Attempts to characterize the implicit and explicit procedures and thought processes used by an individual to perform a given task, or as they walk through a landscape.	Conway & McCracken 1990; Carley & Palmquist 1992; Niewöhner *et al*. 2004	√	
Scenarios to elicit concepts	A researcher presents a subject with a particular situation or problem and gains insight into the subject's mental models on the basis of responses to questions and interpretations and predictions.	Sternam & Booth Sweeney 2007; Biggs *et al*. 2008	√	

between stakeholders; (2) aiding in overcoming obstacles to incorporate multiple sources of knowledge; (3) enabling shared ownership of a conservation plan; and (4) improving social assessments. Techniques that encourage stakeholders to make their mental models more explicit can contribute to each phase of a conservation planning process in different ways (Table 4. (Knight *et al.* 2006; Pressey & Bottrill 2009).

Clear and open communication

Clear (i.e., understandable, unambiguous) and open (i.e., honest, frank) communication is important throughout all conservation planning phases, and particularly in planning and management (Table 4). Effective communication is a two-way process and requires an awareness of, acknowledgment, and understanding of another's message. A process of describing and sharing mental models makes the models explicit by encouraging their communication in a clear and open way, which in turn can strengthen the level of agreement in a multistakeholder process. Agreement is enhanced because the level of understanding improves among different stakeholders as they become more aware of their own and others' mental models (Kolkman *et al.* 2005).

An understanding of the differences and similarities of stakeholders' mental models can also inform communication and engagement strategies. For example, in a conservation planning initiative that aims to facilitate a switch of farmers from cattle to ecotourism, the mental models of farmers and on-site conservation managers may be quite similar, but those of urban-based ex situ land-owners may differ substantively. Communication approaches to encourage participation of the urban-based landholders may therefore need to be different from those for rural-based cattle farmers.

Accounting for multiple sources of knowledge

Eliciting and sharing mental models can strengthen the uptake of multiple sources of knowledge, thereby improving the conservation planning process. Conservation

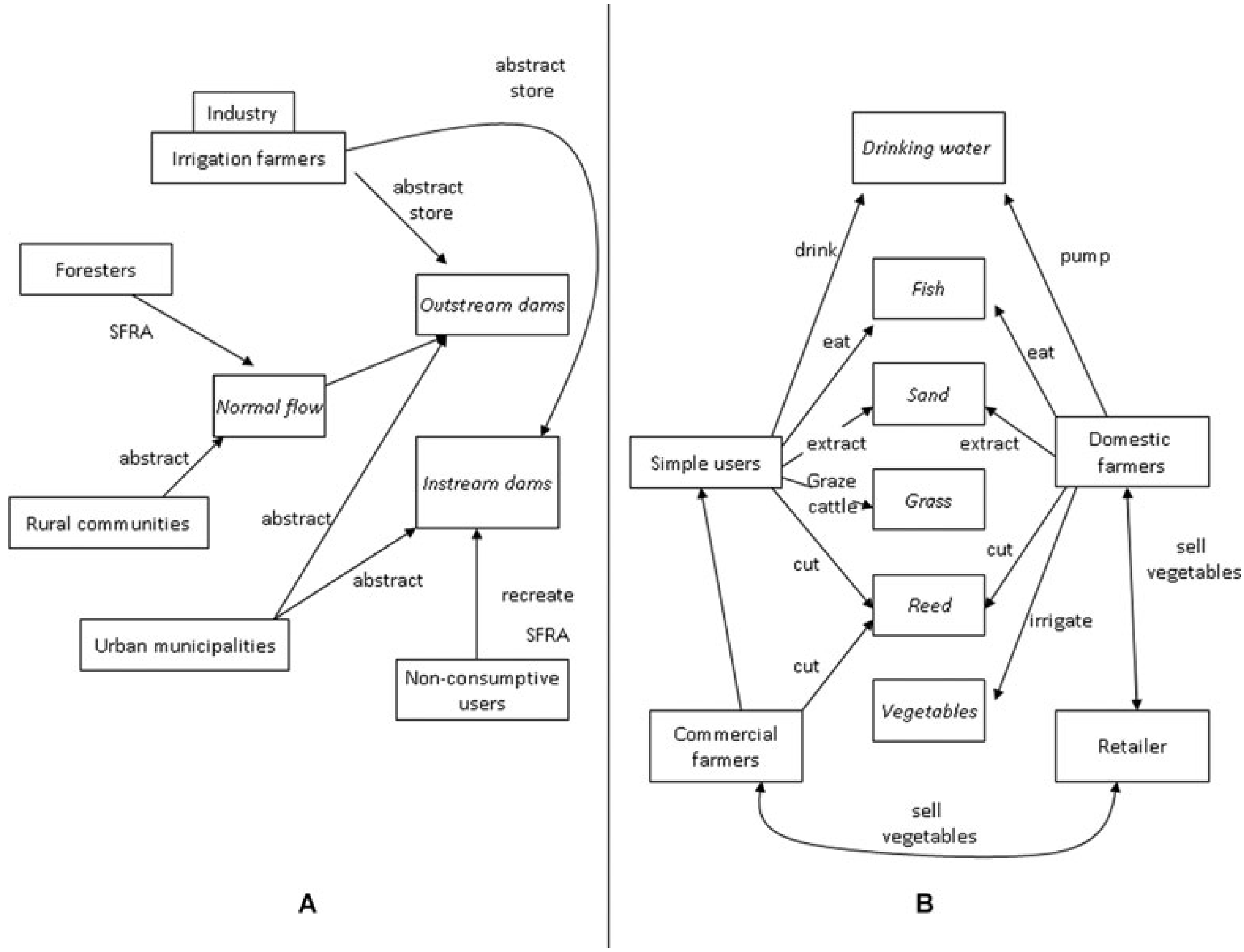

Figure 2 Influence diagrams of commercial agricultural producers (a) and near-subsistence users (b) of water use and availability in the Crocodile river catchment in South Africa. Boxes indicate entities or actors, normal font refers to resource users and italics represent the resource. The arrows indicate how resources and resource users link to one another. A commercial agricultural producer's mental model of water use and availability (a) is focused on what a river can provide for flows and storage for irrigation and industry, with only a small consideration for ecosystem health. A near-subsistence user's mental model (b) reflects a more survivalist perspective and has more emphasis on the specific ecosystem services that water delivers to people, and the competition between different water resource users. The near-subsistence user's mental model makes a distinction between domestic farmers who engage in some farming and simple users who do not. The description and sharing of the mental models of both commercial producers and near-subsistence users will aid conservation managers and facilitators in engaging with both stakeholder groups in the development of a conservation plan that includes water use and availability. The Crocodile River forms the southern boundary of the Kruger National Park and sufficient flow is important for maintaining the river's ecological integrity. Outstream dams are maintained by pumping water and are situated away from the river. SFRA refers to Stream Flow Reduction Activities such as planted forestry. Instream dams are situated on the river itself. Industry refers to mines, factories, and other large-scale manufacturers that use water in the catchment. Irrigation farmers see themselves similar to industry as users of water (i.e., abstract and use water for economic production) (from Biggs *et al*. 2008).

planning is enhanced by negotiation and incorporation of multiple values and sources of scientific and nonscientific knowledge (Knight *et al.* 2006; Ban *et al.* 2009). For example, local or traditional knowledge can add valuable information assimilated through generations of experience that shorter-term scientific studies cannot (Gadgil *et al.* 1993; Berkes 1999). In addition, through the integration of local knowledge systems into conservation plans, conservation opportunities that are compatible with existing practices, and/or resonate with existing beliefs and values may become apparent (del Campo & Wali 2007; Pomeroy & Douvere 2008). If scientists are reciprocally aware of their own mental models and those of others—and the values, inconsistencies, and possible logical flaws that

Table 4 Benefits of applying mental models techniques per conservation planning stage (Knight *et al.* 2006)

Stage	Description of stage	Informs stage structure and implementation	Enhances communication between stakeholders	Fosters shared solution space to strengthen understanding	Defines perspective on "the problem"	Elucidates conservation opportunities and constraints	Facilitates stakeholder "buy-in" when collaborating	Facilitates conflict resolution	Evaluation reveals changes in stakeholder values	Facilitates frank self-reflection of successes/failures
Assessment										
Landscape, cultural, and political scoping	Assessment of biophysical, human, social, economic, and political environment	√	√	√	√	√				
Problem definition and data development	Goals, opportunities, and constraints defined; data identified and collected	√	√	√	√	√				
Visioning future scenarios	Future scenarios developed and evaluated in context of opportunities and constraints	√	√	√	√	√	√	√		
Land management model	"Optimal" mix of conservation instruments and institutions defined	√	√	√	√	√	√	√		
Systematic assessment	Locations, instruments, and stakeholders prioritized for implementing action	√	√	√	√	√	√	√		
Planning										
Planning products	Prioritization outputs refined to user-useful and user-friendly products	√	√	√	√	√	√			
Preferred stakeholder scenarios	Identifying preferred future scenarios, including mix of conservation instruments and institutions, defined by stakeholders	√	√	√	√	√	√	√		

Continued.

Table 4 continued.

Stage	Description of stage	Informs stage structure and implementation	Enhances communication between stakeholders	Fosters shared solution space to strengthen understanding	Defines perspective on "the problem"	Elucidates conservation opportunities and constraints	Facilitates stakeholder "buy-in" when collaborating	Facilitates conflict resolution	Evaluation reveals changes in stakeholder values	Facilitates frank self-reflection of successes/failures
Schedule action	Timing of proposed implementation of conservation actions (when, where, and what) defined	√	√	√	√	√	√			
Implementation strategy	Agreed directions on the responsibilities, actions, and funding for implementation	√	√	√	√	√	√	√	√	
Management										
Enabling	Building the capacity of stakeholders for implementation	√	√	√	√	√	√	√	√	
Mainstreaming	Integrating conservation activities into the daily processes of other sectors	√	√	√	√	√	√	√	√	
Implementation	Undertaking the actions that change human behavior toward achieving goals	√	√	√	√	√	√	√	√	
Designed landscape	Conservation actions implemented	√	√	√	√	√	√			
Review										
Monitor/observe	Measuring impacts of implemented actions and evaluating effectiveness	√	√	√	√		√		√	√
Reflect	Taking stock of achievements, failures, and learning from these	√	√	√	√				√	√

underlie them—they are more likely to accept and incorporate alternative and nonscientific sources of knowledge (Kolkman *et al*. 2005).

Enabling empowered, shared ownership of the conservation plan

Success of conservation planning initiatives lies in part in their ability to empower a comprehensive range of stakeholders to support and engage whole-heartedly in effective and sustained collaboration for conservation action (Brosius & Russell 2003; van Kerkhoff & Lebel 2006; Cowling *et al.* 2008). Elicitation and sharing of mental models, by helping stakeholders understand each others' point of view, may enable collaborative behaviors, and enhance shared ownership of a conservation plan as stakeholders develop more empathy for each other. However, the acceptability of a conservation plan to stakeholders may be further extended if their mental models are operationalized within the plan. For example, stakeholders' mental models of landscapes can be incorporated in spatial prioritization maps for conservation and other land-uses (Abel *et al.* 2002)) (Figure 3, Supporting Information S1).

Disagreement and conflict between stakeholders often impairs the emergence of a strong sense of shared ownership of a plan (e.g., marine reserve planning process for the Channel Islands National Marine Sanctuary, California; Mize 2006). Expressing mental models within proposed plans can aid in more effective facilitation of disagreement and conflict by making clearer the basis of disagreement. Where disagreement stems from differences in the understanding and conceptualization of an issue, this can be clarified and a higher level of agreement between stakeholders can be achieved (Verweij *et al.* 2010). If disagreements are rooted in fundamental differences in values, open discussion of different mental models can help identify areas of common ground and types of actions that may attract support. For example, discussions between conservation professionals and prodevelopment decision-makers in South Africa led to a mutual understanding of the importance of the maintenance of ecosystem services and economic development for impoverished communities over time (Pierce *et al.* 2005; Reyers *et al.* 2009).

A conservation process that is receptive to different societal beliefs and values, and supports social learning and shared ownership, is more likely to enable the emergence of creative solutions for conservation (Brown 2003; Nkhata & Breen 2010). Abel *et al.* (2002) provide an example involving pastoralists and conservationists in New South Wales, Australia, a region characterized by tensions between wool production and conservation interests. Eliciting and mapping the mental models of pastoralists and conservationists showed that there were objectives shared by the two groups that provided opportunities for conservation on pastoral land. It also became apparent that pastoralists had many of the skills and equipment needed to manage land for conservation. Furthermore, falling prices for wool meant pastoralists were seeking other sources of income. This enabled conservation stewardship schemes to become established on pastoral land (Abel *et al.* 2002) (see also Supporting Information S1).

The techniques encompassed in Actors, Resources, Dynamics, Interactions (ARDI) can be particularly useful in enabling shared, empowered ownership of a conservation plan. ARDI is an action research (simultaneous and interactive research and implementation) process designed to build consensus and a shared mental model around a vision (Etienne *et al.* 2008). ARDI's innovation lies in the coconstruction of a conceptual model of the operation of a landscape, based on shared points of view on the current situation and on confronting opinions on probable future scenarios (Biggs *et al.* 2008). The shared exploration of alternative future scenarios, and the ways in which stakeholder groups conceptualize the constraints and opportunities in different scenarios through their respective mental models, enables stakeholders to build a reflective, shared understanding of each other and themselves.

Improving social assessments

In the assessment phase of conservation planning, social and ecological assessments are usually carried out to provide context for the planning process, and here the elicitation of mental models can provide improvements. Social assessments are often limited to a listing of relevant stakeholders and collection of spatial human use data (Ban & Klein 2009; Pressey & Bottrill 2009). Several mental model techniques are relevant to the assessment phase of conservation planning. For example, content analysis (Table 3) can be used to assess similarities or differences of stakeholders' mental models (Carley & Palmquist 1992; Biggs *et al.* 2008). Content analysis is a technique whereby words or phrases from texts or transcripts are categorized in order to compare mental models of stakeholder groups. Consensus analysis (Table 3) is a related technique that explores the extent of sharing of words, concepts etc. among individuals or groups, enabling statistical analysis to determine whether stakeholders have shared mental models (Biggs *et al.* 2008). The reapplication of mental model techniques used in the assessment phase can illustrate whether stakeholders

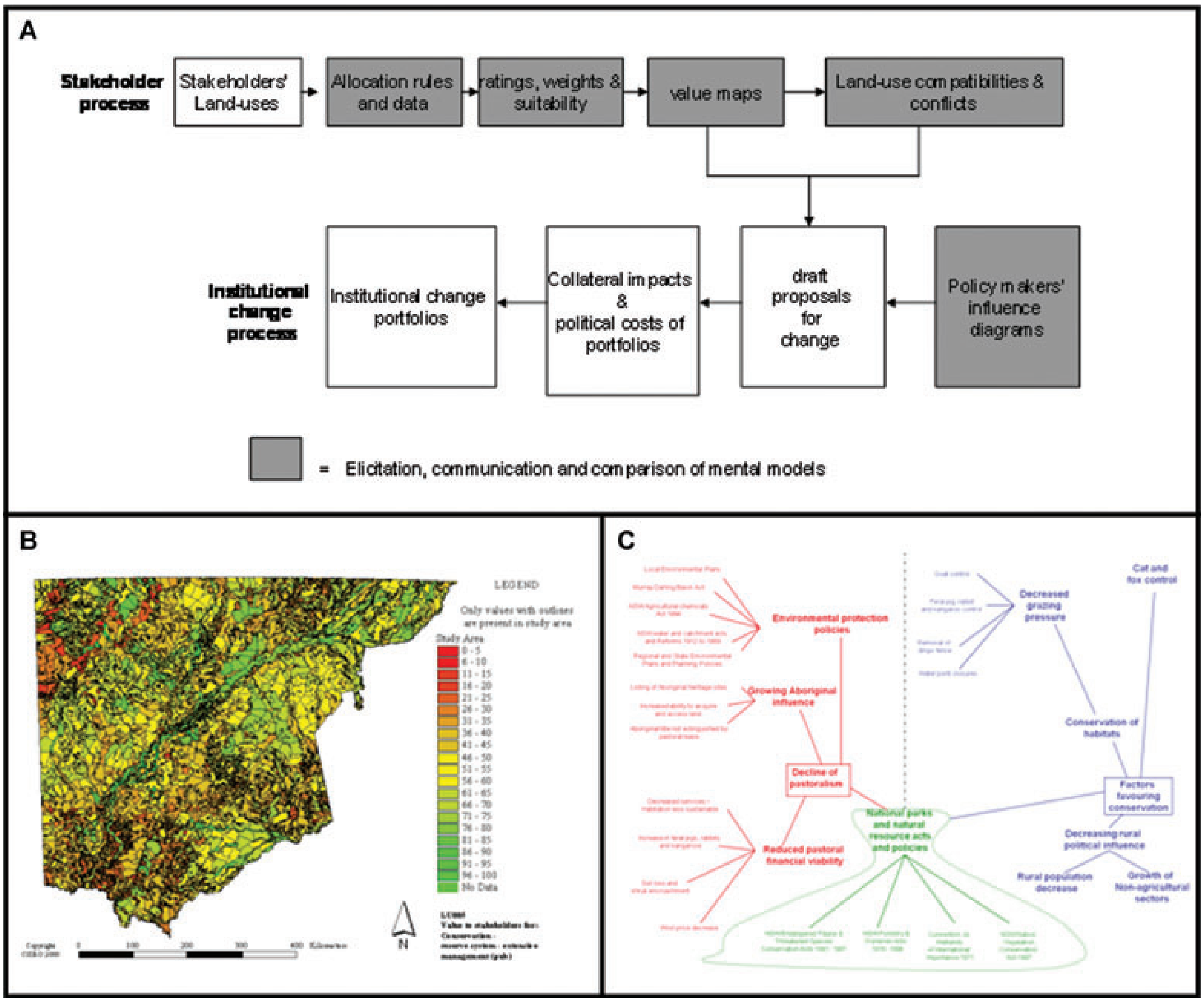

Figure 3 Use of mental models in conservation planning, an example from New South Wales, Australia. (a) This flow chart illustrates the project structure of the Sustainable Use of Rangelands in the 21st Century project. The project ran as two participatory processes—one for stakeholders, one for institutional change. The stakeholder process elicited stakeholders' values, and their mental models of land use compatibilities and conflicts. The institutional change process elicited policy makers' mental models of factors favoring or reducing the interests of each stakeholder group; (b) As part of the mental models process, maps were produced that depict spatial values associated with mental models. This map illustrates values of conservationists for land of national parks; and (c) Mental models of farmers and conservationists were illustrated as an influence diagram. It depicts factors influencing the decline of farming according to farmers (red) and factors favoring conservation according to conservationists (blue), and served to identify areas of agreement (green). The mental models exercise enabled the identification of new opportunities for conservation interventions on private farmland. See Appendix S1 for a full description of the case study and Figures 3 and 4 in Appendix S1 for legible versions of (b) and (c).

have adjusted their mental models, which can, in-turn, inform next steps in the planning process.

Limitations and evaluation of success

Use of mental models in conservation planning will not be a panacea to resolve the implementation gap. Impediments to implementation success go beyond differences in understanding, value, and perspectives. Additional obstacles include power struggles, institutional and bureaucratic barriers, lack of capacity of communities to engage, and top-down decision-making with limited opportunity for real participation (Arnstein 1969; Satterfield 2002; Brosius & Russell 2003; Lewicki *et al.* 2003). In other cases, differences in values, beliefs, and objectives may be so fundamental that consensus, and therefore collaborative conservation, is not achievable despite sharing of mental models (Kolkman *et al.* 2007; Delgado *et al.* 2009). In such cases, however, a process that includes mental models may identify this earlier, point toward changes needed for collaboration to occur, or indicate that conservation resources could be spent more meaningfully elsewhere. Mental models may thus produce more efficient allocation of scarce conservation resources (Nkhata & Breen 2010). Also, when challenges to social learning stem from a technical limitation to sharing knowledge (e.g., complicated reserve selection algorithms), mental model processes may only be of limited value (Verweij *et al.* 2010). Moreover, the description and sharing of mental models will be of most value in strengthening the success and sustainability of conservation planning initiatives if there is a long-term commitment to dealing with the different world-views, values, and expectations that exist in multistakeholder environments.

If conservation planners adopt the use of mental models as we suggest, the contribution of processes that describe and share mental models to the achievement of conservation outcomes should be tracked and measured (Kapos *et al.* 2008; Pullin & Knight 2009). Cost and benefits should be considered. In particular, mental model processes take time and resources. Understanding how much these processes enhance planning outcomes, compared to when they are not used, and relative to other techniques that support collaboration and conflict resolution, is of paramount interest. However, it is difficult to collect evidence of the value of eliciting and sharing mental models to conservation outcomes for two reasons. First, the benefits of using mental models processes may occur outside of project timeframes (Kapos *et al.* 2008)—they may only become apparent after the second or third round iteration of planning, as different stakeholders get to know, understand, and trust each other more (Knight *et al.* 2006). Second, reasons for failure to achieve conservation outcomes may be external to the collaborative process, or the increased collaborative success achieved.

Evaluating the effectiveness of mental models processes for conservation planning therefore requires assessing the effectiveness and success of the collaborative process, shorter term and intermediate gains in reducing threats (e.g., Salafsky & Margolius 1999), longer-term collaborative success, and ultimately conservation benefits. A controlled experiment that describes and shares mental models in one group of planning initiatives but not another may not be ethically or practically feasible. However, retrospective analyses of the collaborative and ultimate conservation benefits of using mental models processes can be conducted and contrasted with other planning and implementation processes that do not include mental models.

Conclusion

We suggest that the use of mental models in conservation planning can support the understanding and accommodation of a plurality of values, perceptions, and beliefs among stakeholders, thereby increasing the chance of implementation success. The collaborative process of sharing one another's mental models can strengthen: (1) awareness of stakeholders' own internal assumptions and values, and how these relate to others; (2) the identification of commonality between stakeholders; (3) the emergence of a common vision for action based on the coconstruction of a shared mental model that enables an empowered and joint commitment to achieving conservation outcomes; and (4) improve social assessments. Thus, conservation planners have little to lose and much to gain by applying mental models techniques in conservation planning processes.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Supporting Information S1: Case study of the use of mental models in conservation planning in western New South Wales, Australia

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