Does Modelling Need An Image Consultant?

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EXTENDED ABSTRACT

Many of us know the potential benefits of modelling—an improved understanding of the system being considered and the prediction of future scenarios. But who really cares about modelling? Many government bureaucrats and politicians want to know what is going to change in the future but why do many people's eyes glaze over as soon as modellers start introducing their model? Modelling or a broader area that we could call 'predictive science' is in desperate need of an image consultant to encourage decision makers to better understand and support this branch of science but also to help modellers understand and meet their clients' needs.

The natural resource management field involves complex scientific and anthropogenic interactions. Modellers need to be able to mix science with art to produce models that incorporate and simplify this complexity. Is it too much to ask them to provide concise information to managers that meet their needs without providing too much technical detail on their model? Probably yes. Most decision makers are not experts in modelling and want to know the overall interpretation of the results that come from the model and how much they can trust these results, rather than technical details of the model.

Communication of uncertainty is one area in modelling, and science generally, that attracts a great deal of attention and criticism. Identifying uncertainty may be difficult but scientific assessments must consider this and articulate what is known, to have them considered and accepted by decision makers. On the other hand, government decision makers need to understand enough about modelling and uncertainty to ask the right questions and have realistic expectations.

Information transfer between technical experts and decision makers is a two-way street and requires both parties to understand the other's position. Modellers and modelling groups (be they consultants, research groups or academics) are using different approaches to try and improve information transfer between scientists and decision makers. The most common approaches include:

- Encouraging scientists to communicate in a more transparent way appreciating that this requires an understanding of the managers' needs.

- Training managers in modelling appreciating that training needs to be targeted to the managers' needs (they need overview information rather than technical detail).

Knowledge brokering is a potential way of 'improving the image of modelling'—ensuring modellers and decision makers are interacting effectively. The idea of 'brokering' could describe tools such as decision support systems with models or knowledge bases embedded within the user-friendly interface. Or a brokering individual, a 'knowledge broker', could be used as an intermediary to understand and explain both modellers' and decision makers' positions and information needs. Other options are also available to improve information transfer including better data management systems, specially tailored training sessions and greater stakeholder involvement in the modelling process.

This paper provides a commentary on experiences gained from working with government agencies on the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) project: *Modelling, Monitoring and Management Interfacing for Waterways (3M Project).*

1. INTRODUCTION

Knowledge and understanding of environmental systems is expanding at a rapid rate. However, a 'catch-22' situation often occurs—where important questions are asked, more knowledge is gained but this results in more questions and the realisation that there is more complexity than previously thought. We are now in the 'information age' and although this means more information is available, managers have more scientific questions and timeframes for making decisions are decreasing. Managers have less time to trawl through large volumes of information (Barchiesi 2003). Decision makers want to understand possible future scenarios but often scientists and modellers find themselves talking to an audience with little understanding of complex predictive science issues.

The dialogue between scientists and decision makers goes both ways. And scientists' understanding of the context that decision makers work in can be lacking. On the flip-side, decision makers may have unrealistic expectations and may not understand what input modellers need to answer their questions. Modellers and decision makers need to understand each other better and learn to communicate their needs. Both parties need to understand the constraints imposed on each other by issues of consistency, confidence and uncertainty of results.

Modelling or a broader area that we could call 'predictive science' is in desperate need of clearer communication awareness. An image consultant could encourage decision makers to better understand and support this branch of science but also help modellers understand their clients' needs. This paper seeks to explore some fundamental issues with using modelling techniques to answer management questions. The interaction of modellers with community-based groups and individuals is also worthy of investigation, but will not be covered in this paper.

Some recommendations for options that can be employed at the start and throughout modelling projects to encourage better productivity and a positive future relationship are discussed. This paper is mainly a commentary from the experiences gained through working with government agencies on the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) project: *Modelling, Monitoring and Management Interfacing for Waterways (3M Project).*

2. SO WHAT IS THE PROBLEM?

Many of us know the potential benefits of modelling—the understanding gained of the system being modelled and the prediction of future scenarios. But who really cares about modelling? Many stakeholders, including government decision makers and politicians want to know what is going to change in the future but there is a real disconnect between these two groups with regards to understanding and expectations. This is a serious problem. It seems that many people's eyes glaze over as soon as modellers start introducing their model, even though the stakeholders may have commissioned the modelling work in the first place.

From our experiences and from consulting various literary sources, it seems that the following issues are reducing productivity or positive progress between managers and modellers:

- lack of understanding about the management context
- ineffective consideration of needs: both modeller and manager needs
- ineffective communication potentially affecting: relationships between modellers and managers, expectations, and understanding about consistency and uncertainty
- problems with consistency and uncertainty

2.1. Management context

To examine the problems mentioned, scientists must first understand the management context in which they are working. Many scientists would agree that science cannot operate outside politics due to the ever-increasing pressure for limited funding money. So awareness of the needs of funding bodies and decision makers is critical.

Government and community organisations are operating within a political and economic context they often cannot control. This context could be described as 'frantic' with the:

- increase in workload for individuals
- increased need for definitive answers within very short timeframes
- decreased funding and staff
- increased volume of information available

Knowledge management is a way for organisations to offset some of the problems mentioned above. 'Knowledge management' generally means: the organisation of important data, information and knowledge with the aim of attaining understanding

and wisdom (figure 1). The management of knowledge (be it explicit or tacit) is paramount to an organisation's survival (Wiig 1999). But as Barclay and Murray (1997) suggest, organisations are 'making a really ugly mess of managing information', let alone managing knowledge well.

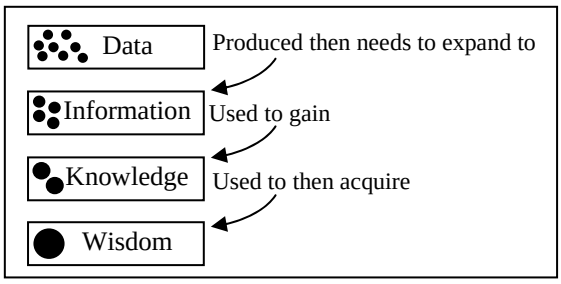

Figure 1. A diagram of the conceptual progression from having data to acquiring wisdom. The processes indicated by the arrows are not discrete progressions from one stage to the next. Note: some scholars include 'understanding' as another stage (Bellinger et al. 2004).

Not only is the management of large volumes of data and information important. Organisations are greatly affected by knowledge loss when experts move on or retire from their positions. There is strong desire to capture existing knowledge within the organisation, to highlight the knowledge gaps, and encourage both individual and group knowledge transfer within the organisation (Cram 2002).

Modellers need to understand how their information fits into the big picture—that managers prefer information resources that will help them gain knowledge and understanding—not raw data and complex technical explanations (Barchiesi 2003; Wilson 2002). A survey by the Coastal CRC (Tilden et al. 2005) showed that natural resource managers rated executive summaries of reports as the most useful form of paper-based media. This indicates that managers often want overview information. Managers also prefer consistent information that they can trust from a known source, not necessarily the 'expert in the field' (Barchiesi 2003; Tilden et al. 2005).

2.2. Communication problems

Modellers and managers typically communicate and prioritise their issues in different ways. Managers often have to deal with problems that are nebulous and complex. Breaking the problem up, perhaps using a systems approach may help to discuss the issues but prioritising or understanding these smaller problems can be difficult with other managers, let alone adding scientists into the mix. Breaking down of communication between management and modellers can be likened to the problems caused by the 'cone of silence' (figure 2) in the hit television series *Get Smart*.

The cone of silence, a device meant to prohibit eavesdropping and to enhance messages, was activated when the Chief and Smart needed to talk about important matters. Unfortunately it would always malfunction and they could not communicate effectively. Usually they ended up shouting in order to be understood. They were always unsuccessful.

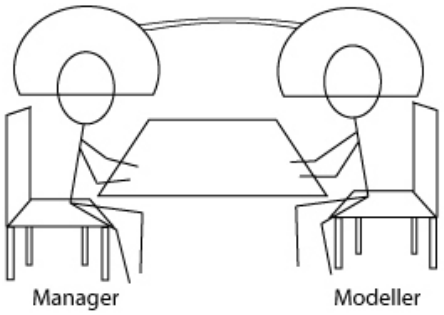

Figure 2. Perhaps managers (decision makers) and modellers are operating under a malfunctioning 'cone of silence', despite their best efforts

Communication theory maintains that there is a message sender and a message receiver and between these, an interface where the message is changed for whoever is receiving the message. Through this exchange between decision makers and researchers, highly-technical language can hinder information exchange. Wilson (2002) explained the link between communication and knowledge as: communication messages (in whatever form) 'do not carry "knowledge"; they constitute "information", which a knowing mind may assimilate, understand, comprehend and incorporate into its own knowledge'.

In summary, effective communication must be employed to ensure sufficient information and knowledge transfer. Good information transfer is particularly important for defining expectations, from both modellers and decision makers. Managers can articulate what they can give the modellers, so the expectations of the modellers are adequate, for example relating to data provision and funding support. Understanding the needs and expectations for modelling information can help modellers tailor their work for the best outcomes, for example relating to spatial resolution, uncertainty and eventual use in policy or planning decisions.

2.3. Problems with Consistency and Uncertainty

Natural resource assessments are syntheses of information from laboratory and field experiments, scientific literature reviews, integrated modelling analyses, and the experience and judgement of scientists. There is inherent uncertainty in each component including the final compilation by report writers. When modelling information is presented to decision makers there is always a question of how much they can trust the results.

Read any journal article and it will be clear that error needs to be quantified. There is a focus on reducing uncertainty from modelling applications so that results are taken seriously. However, this increased focus on uncertainty, particularly over the last twenty years, has possibly resulted in the slowing down of decisive action (Michaels and Monforton 2005).

Within government decision making, decisions need to be backed up with strong science and quantified uncertainty. This has particularly been due to the increase in legal action both against and by government organisations (Michaels and Monforton 2005). On the flip-side there is a push for 'adaptive management'—making a decision with what is known. So, ultimately, uncertainty needs to be identified transparently but it should not stand in the way of moving forwards (Pielke 2005).

3. OPTIONS

There are many options for tackling the issues described previously. Decision making is reliant on the ability to communicate and manage knowledge. Expert knowledge cannot aid anyone if it is not communicated in an effective way and excellent decisions cannot be made without good knowledge management.

We believe that there are five main options that could be considered to improve the problems discussed above and the applicability of a modelling project for aiding decision makers.

- Develop Australian standards for modelling
- Educate the decision maker
- Educate the modeller
- Get a knowledge broker
- Put together a decision support system

3.1. Develop standards for modelling

As far as we are aware, there are no accepted Australian Standards for Modelling. Standards or guidelines could help establish 'best practice' procedures for modelling, ranging from data collection, setting up modelling parameters, model calibration and validation and the use of modelling results. Standards or recognised guidelines would provide a framework for developers to document modelling work while guiding decision makers assessing modelling projects.

There have been some attempts to encourage consistent, high quality modelling work. Catchment Hydrology CRC have worked to include discussions of data inputs, uncertainty and model calibration as well as providing uncertainty visualisation tools within most of their catchment modelling products.

Guidelines for water quality modelling in tidal areas were produced by the Scottish EPA (Singleton 2002) and this document discussed different model types, data requirements, model calibration and model validation. Also, the International Association of Hydraulic Engineering and Research published guidelines for developing procedures for reporting on model validity, many years ago (Dee 1994) but these kind of guidelines have not been implemented in Australia.

In a survey of catchment model developers, Catchment Hydrology CRC found that 100% of respondents would consider adopting standards in their work if they became available (Weber et al. 2004).

A society that administered the standards could also provide a useful framework for decision makers to find modelling support. A summary of pros and cons are included in Table 1.

Table 1: Pros and cons for developing standards

Pros	Cons
1. Decision makers have guidance to ensure modelling work is of a high standard 2. Modellers can have guidance to ensure their work is to a high standard 3. Administering body would be a good 'initial contact'.	1. Modelling is highly technical (difficult to develop standards that apply to all) 2. Decision makers have very little time available to learn technical details 3. Modellers and decision makers may not agree with standards 4. Innovation could potentially be reduced and choices of modelling approach limited

3.2. Help the decision maker

Decision makers using predictive information may not be experts in modelling. In a survey by the Coastal CRC of government decision makers, only 17.5% of respondents had formally studied modelling while 24.6% of the respondents believed they had acquired skills through experience in modelling (Tilden 2005). The people targeted in this survey were natural resource managers working for organisations frequently dealing with models.

Decision makers need to understand the basic concepts of modelling before they can become aware of the possibilities and limitations of predictive science. They also should not be oversold on their expectations of what modelling can provide. We suggest that it is the responsibility of the modeller to ensure that expectations are reasonable and that the model can deliver as promised. As Bellinger (2004) stated:

> Modeling [sic] and simulation is a discipline to promote a deeper more complete understanding of how things work. If one expects the discipline to provide answers they will tend to believe the results which a simulation provides, and find that it leads them to all kinds of problems for the answers are not correct, they are only indications.

Some people have tried to help decision makers by providing training courses in modelling software. However, managers often have limited time and do not require the fine detail that is often provided in these technical courses. We believe basic modelling training (eg. *modelling 101* type courses) to be beneficial and (from our experiences) this option has been received positively by most government decision makers. Some pros and cons for aiming to help the decision maker are included in Table 2.

Table 2: Pros and cons for helping decision maker

Pros	Cons
1. Decision makers can network, make contacts with modelling experts 2. Decision makers can learn what modellers need from them to produce better models	1. Courses may be difficult to tailor to attendees 2. Decision makers may not be able to prioritise training due to time restrictions

3.3. Help the modeller

It is often assumed that modelling clients should be encouraged to learn more about modelling. We ask whether it should be the other way around. Should not modellers be ensuring that the limitations, problems and deficiencies of their models are explained? Is this possible?

Educating modellers has support from decision makers who feel that modelling work is often done in an ad hoc or narrow-focussed way. Possibly the main issue here is problem definition. Modellers often want very specific and logical problems to solve. However, decision makers are often so overloaded they do not provide enough time to describe the problems in enough detail. We suggest that modellers need to formulate good questions to obtain what they need from the decision maker in terms of technical detail, while ensuring that they are not oversimplifying the policy or legislative needs behind the decision makers' objectives. Some pros and cons are provided in Table 3.

Table 3: Pros and cons for helping modellers

Pros	Cons
1. Modellers can work to ensure their predictive science applications are suitable for real-life problems	1. Understanding policy or legislative requirements is very difficult 2. Many modellers have little training or experience in interacting with decision makers

3.4. Get a knowledge broker

A knowledge broker can provide a valuable communication and mediation link between modellers and decision makers. Government departments traditionally had knowledge brokers in their ranks—experienced scientists who could negotiate between the science and the management. However, science within government is being supported less, resulting in little scientific research being funded or outsourcing of this work. This highlights the need for effective communication between those administering projects and those completing the work. With improvements in technology and new policies to manage the environment, there is often a great need for someone to act as an intermediary to communicate what is going on.

Having a knowledge broker involved in an assessment project from the beginning can provides valuable opportunity for open communication between decision makers (and

more broadly, stakeholders) and modellers fulfilling a project. And if a human knowledge broker is effective, the success rates of understanding and collaboration may be higher than in the case of technology-based 'knowledge management' such as user manuals or journal papers. Wilson (2002), Hildreth and Kimble (2002) and Bellinger et al. (2004) promote 'a shift from simply capturing and leveraging knowledge to supporting learning and the sharing of knowledge'. Pros and cons for using a knowledge broker are highlighted in Table 4.

Table 4: Pros and cons for using a knowledge broker

Pros	Cons
1. Broker can implement effective networks between decision makers and modellers 2. Broker can provide a quick interpretation or advice for a problem 3. Valuable to have an effective communicator rather than relying on inexperienced communicators to share their research	1. Hard to find and support (salary) 2. If not a good broker situation may be worsened—may result in bad communication and greater problems 3. The knowledge broker may impose their own biases and values

3.5. Develop a DSS

Decision support systems (DSSs) have been around since the 1960s, when Information Technology researchers began to build DSSs predominantly for financial planning (Power 2003).

DSSs can aid a decision maker by providing organisation of 'expert' or tacit knowledge, relevant information or documents (explicit knowledge) and decision checklists and heuristics (a combination of tacit and explicit knowledge, potentially). According to Power (1999) DSSs 'support, rather than replace, managerial judgment and their objective is to improve the effectiveness of the decisions'. From a government agency's point of view, having a DSS available at all times so people can access relevant and expert knowledge within short regulatory timeframes, is more efficient than repeatedly calling on experts to provide this basic information.

According to Lockie and Rockloff (2005), 'in the coastal zone environment, spatial decision tools have been particularly popular as means to promote consistent decision-making, evaluation of coastal development alternatives, and to ensure ecological sustainability.

The Coastal CRC's *Modelling, Monitoring and Management Interfacing for Waterways (3M) project* is developing a DSS that will hold a mix of documented information and expert guidance for setting up water quality monitoring and modelling projects. We believe that products from the four preceding approaches for improving communication between managers and modellers can be included in a DSS. Some pros and cons for developing a DSS are included in Table 5.

Table 5: Pros and cons for developing a DSS

Pros	Cons
1. DSS provides a knowledge management system that is available at all times 2. The DSS can provide a first 'port-of-call' relieving pressure on organisational 'experts'	1. Difficult to satisfy all stakeholders with one tool 2. Runs the risk of being ineffective if not supported by stakeholders 3. Needs to be maintained, upgraded periodically

3.6. Conclusions

In conclusion, modelling is a field that is highly complex yet one that has much potential to inform decision makers. This paper has discussed some of the problems affecting the use and acceptance of predictive science applications. We would like to encourage both modellers and decision makers to work to remove the 'cone of silence' which often exists within the process of developing and using models as decision tools.

We believe that issues of uncertainty, although very important in the management context we exist in, should not prevent the use of modelling information. Communicating modelling limitations and resisting the urge to oversell models is encouraged. We also propose the need for quality assurance guidelines in Australia.

Until Australian standards for modelling are developed, combinations of mutual education and knowledge broking are important options for ensuring that modelling projects deliver what decision makers need and modellers receive adequate guidance. Exchange of knowledge through formal and informal means: training sessions, decision support systems, user manuals, or a person employed as a knowledge broker, can all help deliver these outcomes.

4. ACKNOWLEDGMENTS

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