20. Adaptive management of Malleefowl

Keynotes: Dr Joe Benshemesh, La Trobe University, Victoria, and Dr Michael Bode, University of Melbourne

Joe Benshemesh\(^1\), Michael Bode\(^2\)
\(^1\) Department of Zoology, La Trobe University, Bundoora, 3086 Australia
\(^2\) Department of Botany, University of Melbourne, Parkville, 3010, Australia

Abstract

Adaptive management (AM) is a pragmatic process of ‘learning by doing’ that takes an experimental approach to management and evaluates the effectiveness of management actions through continuous monitoring. Its main aim is to reduce uncertainties in management while simultaneously taking effective remedial action.

Such uncertainty certainly exists in how to best manage Malleefowl populations. For example, two separate studies have recently examined the national Malleefowl monitoring data and shown that fox control, the most widely used management intervention for Malleefowl, does not increase Malleefowl populations. This illustrates that we don’t know as much as we thought we did, and highlights the need for better ways of identifying management practices that are beneficial and effective. Our uncertainty in what constitutes effective, reliable and cost efficient management is also likely to increase as result of climate change.

Rather than allow our uncertainty to become an excuse for inaction, an AM strategy allows both management and learning to proceed at the same time. It uses an ongoing flow of monitoring data to test current management beliefs and propose interventions that balance immediate population benefits with future learning.

While simple in principle, dealing with numerous issues simultaneously requires sophisticated mathematics, and successful implementation requires a high degree of collaboration between scientists, managers and the community.

We explain how we envisage AM working for Malleefowl conservation and outline the process. We have applied for ARC funding to develop an AM strategy for Malleefowl across its range and if successful, believe that this program can capitalise on the species’ extensive and ongoing research and monitoring programs, improve both the efficiency and transparency of Malleefowl conservation, and provide renewed purpose and focus to the management and monitoring community.

Introduction

Conservation management is faced with two conflicting demands. One the one hand, threatened species and ecosystems need to receive immediate life-support. Populations are declining, ranges are contracting, and threats are increasing and multiplying. Managers needed to begin management decades ago, with double their current budgets. On the other hand, most ecosystems are very poorly understood, and scientists and managers aren’t entirely sure what should be done to conserve them. On closer inspection, many of the ecosystems and species we thought we understood, we hardly understand at all. For example, a recent analysis showed that tens of billions of dollars had been spent restoring degraded water systems in the USA, with no apparent benefit (Bernhardt et al. 2005). For conservation to proceed, managers need to improve their understanding of their ecosystems and species, while at the same time do more, immediately to preserve them. This is the conundrum of modern conservation.

Adaptive management offers a solution to both of these problems. Most people may have heard the term ‘adaptive management’ bandied around in management plans and it may well seem that everybody is doing it. Adaptive management is often called “learning by doing”,...
simply another way of saying that management will change (adapt) if observations show it's not working. However, in the ecological literature, adaptive management has a more specific meaning and relates to a large body of theoretical work that has developed the process of adaptive management (henceforth AM) to a high degree of sophistication (Holling 1978, Walters 1986, Walters and Holling 1990, McCarthy and Possingham 2007, McDonald-Madden et al. 2010). Rather than referring to any ad hoc means of learning from one's mistakes, formal AM has been refined into a package of mathematical techniques that help managers to experiment with and learn from their management while keeping the goal of conservation firmly in sight. The approach involves a repeated cycle of goal-setting and system modelling, carefully planned management interventions, monitoring of outcomes, and evaluation. During this final stage of the cycle, our understanding of the system is updated and management is adapted accordingly. AM is a rigorous scientific process, rather than an aspiration, and aims to balance the need for management actions now, with the equally important need to assess the success of these actions and gaining understanding of how the system works so that improved management can be planned for subsequent AM cycles. It is in this more formal sense that we use the term 'adaptive management' in this paper, rather than the more colloquial and loosely define sense.

Recently, in conjunction with colleagues Drs Brendan Wintle, Libby Rumpff (Melbourne University) and John Wright (Parks Victoria) we have developed a project that aims to implement formal AM to the conservation of Malleefowl. The project has gained the support of the National Malleefowl Recovery Team, state agencies and volunteer groups, and is backed financially by grants from mining offsets in Victoria and by Parks Victoria. The application is currently being considered for funding in the ARC Linkage Grants program, and if successful, we believe that this work will represent an important advance in the conservation of Malleefowl.

Here, we attempt to explain what AM and the pending project is all about, why it's appropriate for Malleefowl conservation, and how we envisage the project, if successful, will unfold.

What AM is

AM is a structured and iterative process of learning by doing that is highly pragmatic. Science has historically progressed by experimentation – each hypothesis is trialled in a limited, controlled setting. Early conservation management proceeded in a similar manner, testing alternative interventions and then applying those that worked at a larger scale. AM was devised because we rarely have the luxury of the time and resources needed for this approach. In AM, the experiment takes place during the management, with different actions taken simultaneously. In doing so, AM offers managers the benefits of both immediate action and learning. However, because it is multidisciplinary and holistic, and because it operates on a large ‘real world’ scale and over many years, AM requires a high degree of collaboration between all stakeholders, institutions flexible enough try multiple interventions, and managers confident enough to take calculated risks so that they and the management community can learn.

The basic idea (Figure 1) is that the process starts with a set of beliefs (or models) of how the ecosystem in question will respond to various management interventions. These beliefs are then tested by applying each of them at a large scale to different locations in the field while observing (monitoring) how the system responds. The approach sounds straightforward in theory, but in practice requires three key behaviours. First, the managers have to be willing to implement a number of different management actions, including those they don't think are the best option. This requirement can prove difficult for managers used to applying only the 'best practice'. Second, the managers have to closely monitor the results of their management in the different locations. While this may sound straightforward, ecological management is replete with examples of datasets that were collected but never analysed. Third, at some point the manager has to decide that enough has been learned, and that the best management intervention needs to be rolled out across the entire ecosystem. To do so, they have to trade-off the rate at which they're learning with the different performance of the management alternatives. The result is that we learn not only how good the management intervention is, but also how credible our initial beliefs were, and we adapt our management and beliefs.
accordingly. The cycle is then repeated with the updated beliefs and improved management interventions being tested in the real world. The AM process can thus be visualized as rapidly spiralling toward more effective management solutions as learning and improved management results from each AM cycle. This notion of constant improvement in management is important and provides a great advantage over other styles of management because it enables adaptability in a changing environment: if environmental conditions change, AM may spiral towards new solutions. Natural ecosystems are inherently complex and variable, and this is especially the case in today’s world where ecosystems have been severely disrupted due to human activities, species extinctions and introductions, and where the prognosis over the next few decades is for unprecedented environmental upheaval due to climate change.

AM is a simple and appealing concept that has its conceptual analogues in many disciplines. In fact, some scholars argue that a simple form of AM has been used for thousands of years by some pre-technological societies to alter their environment (Berkes et al. 2000): these societies tested ideas about the environment by undertaking actions, observed and recorded the results through story and songs, and codified practices through rituals and taboos, in a continuous cycle of assessment and improvement from which developed an effective understanding of their environment.

While the basic concept of AM may be old, it was only introduced into ecology and environmental management as a formal and sophisticated process, and the term coined, in the late 1970s (Holling 1978). In this modern and rigorous embodiment of AM, often termed ‘active’ AM to distinguish it from ‘passive’ forms that do not involve experimentation, mathematical modelling is used to encapsulate beliefs and prior knowledge. Statistics replaces intuition as the measure of effectiveness of management actions, and to assess the credibility of beliefs. Decision theory takes the place of personal judgement about when to stop experimenting and learning and only apply the best-practice intervention. These developments have greatly increased the power of the AM, while retaining its essentially intuitive structure and holistic nature, and AM is widely held up as the most logical and elegant framework for continuous improvement in natural resource management.

Our project aims to apply this formal and rigorous AM approach to Malleefowl conservation. We aim to use as many of the monitoring sites as possible – there are currently 113 monitoring sites across the continent registered on the National Malleefowl Monitoring Database- to provide a firm basis for learning at the appropriate scale and variety of contexts needed for Malleefowl conservation. In many ways, observing the responses of Malleefowl to management at 100 sites is equivalent to observing the responses at one site for a century, providing some idea of the potential power of the intended approach. Using multiple sites is vital for accelerating our learning about how best to manage Malleefowl, but also complicates matters and is the reason why mathematics and statistics are essential for interpreting the flow of data, designing interventions, and making the best decisions. In short, a simple AM program could be designed for a small number of sites, but would lack power and would require many decades to provide reliable results, whereas an AM program that is a powerful and relatively speedy in providing results requires many sites and the mathematical tools to deal with the complexity.

What AM is not

1. AM differs from the conventional scientific approach

AM is a process that integrates the often disparate approaches of management, research and monitoring in order to improve management of a process, such as the conservation of a species. Therein lies its first strength, and sets it apart from the conventional scientific approach.

By integrating science and management, AM allows management interventions to proceed even where there is insufficient information available to be sure about how effective the management may be. This is a distinct advantage in cases where some urgent action is considered to be essential, such as in the conservation of a declining species, because in AM the lack of information does not delay the beginning of management action.
In contrast, the more conventional approach to uncertainty in management is to postpone actions until appropriate scientific studies have been instigated and completed, thereby avoiding possible deleterious effects and potential wastage of funds. These are certainly valid concerns as funds are always limited, ecological systems are notoriously complex and well meaning management may backfire in reality (e.g. the recent removal of cats to protect wildlife on Macquarie Island backfired when the rabbit population consequently increased to levels that threatened the entire ecosystem (Bergstrom et al. 2009)). But experimental science can take a long time, and rarely provides certainty. In conservation, there is simply not enough time to wait before management needs to act at an appropriate scale: small-scale experimentation costs time and money that would often be better spent taking immediate action since we know that waiting may have serious consequences for the species or ecosystem in question. AM provides a simple (but not necessarily easy) solution. We do not have to wait for knowledge to accumulate before we manage: we can act now and learn from our actions as we go.

Another problem with the conventional approach to devising management solutions is that science is typically reductionist by nature and conducted at a small scale over a limited time. Transferring the findings of such studies to large scale situations is often problematic because the results are to a certain extent context- and scale-dependent. The findings of well designed scientific studies are highly relevant in AM in developing models and expectations, in planning management action, and in testing specific ideas or components, but because the process involves testing the effectiveness of management at a large scale, not everything hinges on such studies. Thus, AM offers a more holistic approach to solving a problem than the reductionist approach of traditional science, while still providing the rigour required to supply reliable answers to the questions it addresses.

2. AM is not “trial and error” management

AM is often misunderstood as simply learning from mistakes - trial and error management - but formal AM differs markedly from this more ad hoc approach. Trial and error management is a common approach whereby managers adopt what is considered as ‘best practice’, which is often based on opinions, anecdotal information, or implications of scientific studies that may be incomplete. Management continues implementing ‘best practice’ until it is felt to be inadequate for some reason, perhaps because observations or monitoring shows that the approach is not working. The management intervention may then be changed, or abandoned altogether, but rarely with much reflection on why the management did not work as hoped; whether it was the wrong option, or the right option applied at an inadequate intensity, for example. This change of approach therefore produces very little new information to guide future management decisions apart from the intuition of managers. Much of what is commonly (and loosely) regarded as AM is more appropriately regarded as trial and error. While trial and error does at least entail some flexibility, it’s not an efficient strategy and provides little opportunity for learning, leaving managers with little understanding of why the management action did not work, or what to try next.

AM differs from trial and error management in many ways, but perhaps the most fundamental difference is how it deals with uncertainty. Rather than applying what is regarded as ‘best practice’ and being disappointed (and a bit lost) if things don’t work out as hoped, in AM there is explicit recognition that there are many unknowns in developing effective management; the main goal of AM is to maximise management outcomes in light of these uncertainties. In some situations, AM may emphasise the benefits of learning and experiments, whereas in others ‘best practice’ may be preferred (perhaps because of strong prior beliefs, or time or budget constraints). Thus, in AM, learning is highly valued and is built into the very fabric of the approach. This is achieved by developing competing system models that distil alternative views into quantitative predictions about how the system will respond to management, and testing these models with interventions and monitoring.

A medical example of AM

In addition to conservation and natural resource management, AM has been applied to answer more familiar questions, including medical research. Imagine a group of people suffering from an inoperable cancer, being treated with three different varieties of chemotherapy, A, B, and C. These three different concoctions represent three proposed models of the human body and the
cancer – one of them will provide the best outcome for patients. Perhaps one of these types of chemotherapy, A, is thought to be the most effective based on animal experiments: the ‘best practice’ treatment. However, the two alternatives have not yet been sufficiently trialled for this to be 100% certain. Instead of consistently treating all the patients with the chemotherapy A, an adaptive manager would start by placing the majority of patients on chemotherapy A, with a smaller number on B and C, and would then start to monitor the three groups carefully. Based on their responses, the adaptive manager would update his relative belief in the three treatments, and may begin to switch patients from an underperforming treatment to a more successful one. The outcome of these patients to the change in treatment would also be monitored. Finally, as one of the treatments becomes clearly superior – but before he was 100% certain – the adaptive manager would place all the patients on the best treatment. At this point, the diminished potential benefits of learning more about the system (e.g., prior chance events reversed the treatment ranking) would be outweighed by the better predicted outcomes of putting all the patients on the best drug.

Is AM right for Malleefowl?

Malleefowl declines are well documented and the species is threatened by a range of factors (as outlined in the National Recovery Plan) and is clearly in need of improved management. AM is an appealing strategy for learning how to manage systems in a more efficient and effective way, but is it right for Malleefowl? We think it is for a number of reasons and we briefly outline these below:

Firstly, there is currently uncertainty about the effectiveness of management actions in reversing declines, and in the role of environmental factors. For example, although fox baiting is the most widely applied management action for Malleefowl conservation, two separate studies have recently concluded that, contrary to widely held expectations, fox baiting as currently practiced does not increase Malleefowl populations (Benshemesh et al. 2007, Walsh et al. (submitted)). Although this may not necessarily mean that baiting doesn't benefit Malleefowl at all, it does illustrate how little we know about Malleefowl management, and highlights the need for more efficient ways of identifying management practices that are demonstrably beneficial and effective. Climate change, and the long-term effects of fragmentation, will most likely amplify these uncertainties in the future and exacerbate local threats. The adaptive management approach embraces and provides a means of resolving such uncertainties.

Secondly, monitoring, which is a key ingredient in AM, is already in place and is providing consistent data on Malleefowl trends from over 100 sites across Australia. This extensive monitoring program has provided insights into Malleefowl population trends and management, but is currently under-utilised. Fortunately, the existing monitoring program provides a major leg-up for the development of an AM strategy for Malleefowl because the cost and difficulties involved in implementing suitably wide-scale and regular monitoring programs are precisely where many attempts at AM fail (Walters 1997, Possingham 2001, Stankey et al. 2005, Wintle and Lindenmayer 2008). Apart from providing an ongoing flow of monitoring data to test current management beliefs, the monitoring data collected in the past provides an excellent baseline for generating ideas and hypotheses within the AM framework.

Thirdly, while there is considerable and justifiable concern about the conservation of Malleefowl, the species appears relatively resilient compared with many other threatened species. Malleefowl still occurs over much of its uncleared range (Benshemesh 2007a), providing opportunities for replicating management treatments and controls (non-treatment sites). Moreover, the current network of monitoring sites, which would provide the core data necessary for AM, represents only a tiny proportion of the species range and varying management treatments at these sites to test the benefits of management actions and increase learning is unlikely to compromise the conservation of the species as a whole.

Fourthly, there is already a strong community involvement in Malleefowl conservation and an evident enthusiasm for collaboration with agencies, land managers, and scientists. Community volunteers organise and conduct most of the Malleefowl monitoring that occurs in southern Australia, often through the efforts of local contacts, while agencies manage these sites in varying ways. Close collaboration between communities, managers, scientists and other
stakeholders is a key ingredient in AM, and is already happening (as demonstrated in this forum), and will provide a firm basis upon which to design and implement an effective national program. Many attempts at developing AM have in fact failed due to social or political difficulties in bringing diverse stakeholders together; however, there is good reason for optimism within the Malleefowl community.

And finally, an AM approach would provide an organising framework at a national level with which to integrate Malleefowl research and management, improve conservation outcomes and efficiency, and involve all stakeholders. At the core of AM is a clearly stated, quantitative management objective. The process of debating and formulating this objective can itself provide unparalleled clarity to stakeholders, and focus to researchers. Any steps in this direction are highly desirable; even if AM stumbled at some unforeseen technical, social or political hurdle, we would argue that the exercise would nonetheless be of great value to Malleefowl conservation by bringing managers, scientists and volunteers together, and by providing the national monitoring program with a unified purpose.

Overview of how AM for Malleefowl will unfold
Careful planning is of critical importance in developing AM. It is during the design and planning phase that objectives are determined, models are constructed, experiments are designed, and suitable means of assessing outcomes and adapting management is systematised. The application we have before the ARC largely deals with this aspect of AM over a three year period, and it is a natural place to start an overview of how we envisage the development of an AM cycle (Figure 1) for Malleefowl.

The Design and Planning phase
Successful implementation of AM depends on the involvement of a broad range of people and groups, and it is important that these stakeholders collectively determine the appropriate objectives of the AM program. It is also important that stakeholders have an opportunity to contribute their understanding of how management may be used to benefit Malleefowl, and for those developing the AM strategy to understand exactly what management options may be acceptable at each of the potential study sites across the country. Given the large number of monitoring sites that are already providing data, and the great range of organizations and individuals that are already involved in Malleefowl conservation, this first step in developing an AM program is itself quite a challenge.

We intend to host a series of workshops with key stakeholders including managers, researchers, and volunteers, to identify management objectives. It will also be necessary to hold workshops to elicit and explore potential management options at specific sites. This will firstly involve documenting past and current management practices and perceived threats at each of the hundred or so monitoring sites across Australia. With this information at hand, the workshops will identify management and monitoring options at a site level and examine possible alternatives.

Workshops will also provide a means of collating the range of perspectives about Malleefowl ecology and management, augmenting information already available in scientific papers and reports, but also allowing the knowledge of experienced observers to be incorporated. This information from a variety of sources will be synthesized and represented in mathematical models that will attempt to encapsulate existing knowledge and the range of views that are held by managers, scientists and others.

Models occupy a vital and central role in AM, but are often misunderstood. In its simplest form, a model may just represent a concept, or idea, about how something might work. For example, the idea that "rain makes grass grow" is a simple conceptual model, as is "predation by foxes will undermine Malleefowl populations". Models are just simplified representations of expected relationships between ecological entities, and they are useful because they make predictions that can be tested in experiments.

Mathematical models are simply conceptual models translated into a different language, but mathematics' internal logic provides a much more powerful platform for prediction and
experiment, and has the advantage that assumptions about how the system operates are made very explicit, transparent and accountable.

While AM is simple in principle, dealing with numerous issues simultaneously requires sophisticated mathematics. In AM for Malleefowl, mathematical models will be used to encapsulate our current knowledge of the species’ population processes, the effects of threatening processes, and the ecosystem dynamics in general. These models will then be used to predict the benefits of implementing various management actions under the full range of environmental conditions, and the accuracy of these predictions will be tested in the field by the monitoring program. The models will also be useful as learning tools to determine which system processes are most amenable to management, and what critical uncertainties limit our ability to make good predictions, information that is essential for designing efficient management experiments.

Finally, the design and planning phase of AM will also require the development of a ‘decision support’ framework that uses the ongoing flow of monitoring data to test current management beliefs, propose interventions that balance immediate population benefits with future learning, and determine when the current level of understanding is advanced enough for experimental management to cease. Once again, sophisticated mathematics may be required, but it’s a necessary step if important and complex decisions are to be made objectively in regard to available evidence, and for these decisions to be thoroughly accountable.

With collaboration facilitated, knowledge synthesised and modelled, management options documented and explored, and a decision framework in place, the stage is set for the AM cycle to begin.

**Act/Manage**

While mathematical modelling is the primary tool for describing and synthesising what we know, management experiments are the primary tool for probing the system, and addressing any critical uncertainties (many of which will be determined through modelling). In the design and planning phase, realistic and acceptable management interventions will have been identified on a site-by-site basis in close collaboration with managers, and this cooperation must continue throughout the AM program. However, implementing management is essentially the province of managers: their commitment and faith in the process, and capacity to implement recommended interventions, will be paramount to ensuring the success of AM. As management interventions may take several years to show effects on Malleefowl populations, a long term commitment to the process is essential.

Extra resources for implementation will probably be required to reap the greatest rewards from the AM program; however, it would be mistaken to conclude that the adoption of an AM approach will necessarily require additional large investments in Malleefowl conservation. Much could be achieved by re-organising the existing funding and effort in a way that would provide both clarity of the benefits of interventions, and opportunities for learning. For example, rather than providing low level predator control over most Malleefowl populations, concentrating the effort on just a few sites would provide opportunities to examine the benefits of this intervention in a statistically meaningful way (Benshemesh 2007a).

**Monitor**

Monitoring is essential in AM and provides the feedback required to test the effectiveness of management interventions and the veracity of the models that suggested them. But it is also one of the most difficult steps to put in place due to the considerable logistic and cost issues involved in instigating an effective and appropriately wide-scale, on-going program. In the case of Malleefowl, such a system is already in place and is providing consistent data on Malleefowl trends from over 100 sites across Australia.

The AM project will build on the existing flow of data from the Malleefowl monitoring program. This program is largely undertaken by community volunteers, often supported by state agencies and NRM bodies. It has a long history, and although it was always intended as a resource for research and management (Benshemesh 1992), this goal has never been attained or even attempted at an appropriate scale.
While a major hurdle for most attempts to develop AM programs, monitoring is one of the least concerns in developing an AM program for Malleefowl due to the efforts of a large number of volunteers over many years and especially over the past five years. Substantial improvements in the monitoring program over the last few years (such as the introduction of national standards and protocols, a national and centralized web-based database, stringent and effective quality control, and more regular and rigorous data collection) have made the program more ready than ever before to provide high quality input into scientific approaches such as AM.

Nonetheless, the requirements of the AM program may necessitate some changes to the existing monitoring program. In particular, it is likely that the AM program will require additional data on the abundance of predators, competitors, and food resources (Benshemesh 2007b). Modelling may also highlight the importance (or otherwise) of other potential forms of monitoring, such as population turnover and recruitment of young into the adult population (Benshemesh 2007a). The need for such additional data, whether community based programs might be expanded to capture the extra information or other solutions need to be found, will be examined during the AM design and planning phase and involve extensive consultation with community groups, managers and researchers.

**Evaluate**

The framework for evaluating the effectiveness of management interventions will be prescribed in the design and planning phase of the AM project, as already outlined above. An important outcome of the ARC Linkage project will be to develop and pass on the tools and the structure of the AM framework to the National Malleefowl Recovery Team. By enabling the AM strategy to continue beyond the three year life of the ARC project, monitoring will allow management to improve and adapt for as long as the program continues.

**Conclusion**

We all want to get on with effective on-ground works that make a difference to Malleefowl conservation, rather than engage in endless research and monitoring. However important research and monitoring are providing information about the plight of Malleefowl and proposing remedial actions, in themselves these activities cannot alter the environment or affect Malleefowl directly.

On the other hand, ineffective management is a waste of time and money, regardless of how well intentioned it may be. Even worse, ineffective management may also distract us from the real issues by providing a false sense of security that appropriate actions are being taken. Without research and monitoring, management is blind and without direction.

AM provides the opportunity to combine management, research and monitoring in a way that creates a highly effective approach to simultaneously learning about, and also undertaking management of, an ecosystem about which there is much uncertainty. It is in the synthesis of management, research and monitoring that the greatest benefits are realised as the synergies between these activities are released. Despite its conceptual simplicity, AM is not the easiest path and its reliance on cooperation and collaboration among stakeholders, and a shared, long term vision provides ample opportunities for problems. Furthermore, it does not magically reduce uncertainty, nor does it mean that initial management actions will not be misdirected. However, it does provide the most effective approach to uncertainty in management, and it uniquely synthesises action and learning.

Walters (1997) identified several main classes of impediment to successful AM programs, including: problems arising from the treatment of the modelling phase; the cost and logistic problems involved in collecting long-term monitoring data; and social or political issues arising from self-interest and risk-aversion of stake-holders (particularly research or management organisations), and from disagreements over what outcomes were acceptable.
In regard to these issues and the development of an AM strategy for Malleefowl, we are very confident that the mathematical and modelling difficulties are tractable, while the problems involved in establishing long term monitoring program have in a sense already been solved. We are also optimistic that the social and political issues listed by Walters (1997), which include failures of implementation and lack of a shared vision, can be avoided by thorough consultation with all stakeholders and genuine collaboration and openness among all those actively engaged in the process. Our hope, and an enormous potential benefit of this project, is that a successful application of AM to Malleefowl will provide a template for the method’s application to other threatened species and communities. Of all the species on Australia’s lengthy threatened lists, Malleefowl provide one of the best opportunities for AM to be successfully implemented – a goal that has to a large extent eluded Australian conservation managers for the reasons outlined by Walters (1997).

AM provides a coherent and effective way forward for Malleefowl conservation and management, and in many ways represents the best possible use of the existing monitoring system, and the culmination of previous Malleefowl research and monitoring across the species’ range. By thinking carefully about the best suite of actions, AM can improve both the efficiency and transparency of Malleefowl management. By demanding that our understanding of the system be stated explicitly openly, AM can help to realise the value of unharnessed knowledge in the existing monitoring data and in the Malleefowl community. Finally, because AM stresses foresight and pre-emption, its application can help to provide renewed purpose and focus to the management and monitoring community.

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*Figure 1.* The adaptive management (AM) cycle.