Principles Underpinning Best Practice Management of the Damage Due to Pests in Australia

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Abstract: Principles contained in the 1993 publication "Managing Vertebrate Pests: Principles & Strategies" were developed during a review of past and current pest management practices. They were used to guide the development of a series of management guidelines for our major vertebrate pests – feral pigs, house mice, European rabbits, red fox, feral pigs, feral horses, wild dogs, and carp. The principles have been constantly refined through subsequent on ground experience in working with stakeholders to implement best practice management programs for pest animals. In this paper, we present what we now consider the seven principles that underpin best practice management of pest animals. They are:

1. A pest is human construct.
2. All key stakeholders need to be actively engaged and consulted.
3. Rarely can pests be eradicated.
4. Most pest management needs to focus on the outcome, reduction in damage, not just killing pests.
5. A whole-system approach is required for managing pest damage.
6. Most pest management occurs in ecosystems in which our knowledge is imperfect.
7. An effective monitoring and evaluation strategy is essential for all management interventions.

Together, the principles comprise the strategic approach to pest management. We explain the rationale behind these principles and illustrate them with examples.

Key Words: Australia, best practice, coordination, damage, eradication, evaluation, exotic animals, invasive species, management, monitoring, principles, strategic approach, vertebrate pest management, whole-of-system

Proc. 25th Vertebr. Pest Conf. (R. M. Timm, Ed.)
Published at Univ. of Calif., Davis. 2012. Pp. 300-307.

BACKGROUND

In 1991, the then Bureau of Rural Sciences (BRS) initiated a critical review of past pest management in Australia. Before 1990, the main focus of pest animal management in this country was to reduce the number of pests to as low a level as practicable, and if possible to eradicate them. Of course there were other strategies besides just killing animals, such as creating barriers and destroying the habitats occupied by pests, but the main focus was on dealing with the pest – less so on achieving production or conservation outcomes from managing pests. The BRS review concluded that despite concerted effort over many decades supported by strong legislation requiring land managers to continually suppress and destroy pests, all those animals that were considered to be well-established pests in 1900 were still pests in 1990 (e.g., European rabbit *Oryctolagus cuniculus*, red fox *Vulpes vulpes*, and rodents) (Braysher 1993). Subsequently, BRS published a report on the principles and recommended a strategic approach to managing the impact of pest animals (Braysher 1993). Other authors have since suggested similar principles (Thomas and Reid 2007, Melzer et al. 2009).

The background principles that Braysher (1993) comprised were:

- Consistency with the principles of ecologically sustainable development;
- Adoption of beneficiary pays;
- Managing the inherent variability of land management systems;
- Defining the role of various policy instruments to ensure the desired management goals are met;
- Involving all major interests groups in the ownership of pest problems, and in planning and implementing management programs;
- Managing total grazing pressure; and
- Consideration of animal welfare.

BRS then developed a series of national guidelines for several of the major pests in Australia, based on the principles and strategic approach (e.g., Saunders et al. 1995). To date, guidelines have been developed for feral horses, rabbits, foxes, wild dogs, feral pigs, feral goats, rodents, pest birds, and carp (see www.feral.org.au).

The effectiveness of the strategic approach and the national pest animal guidelines were then tested through a series of workshops with landholders and relevant agencies to develop pest management programs to address local pest problems (Braysher 2004). Based on the workshops and an evaluation of pest management programs that were developed through them, Braysher and Saunders wrote PESTPLAN, a Guide (Braysher and Saunders 2003a) and Toolkit (Braysher and Saunders 2003b) to assist land managers to develop and implement

effective, best practice programs to manage the damage due to pest animals. Around the same time, the National Vertebrate Pests Committee commenced development of an Australian Pest Animal Strategy (APAS) (NRMMC 2007). In 2003, with support from the Commonwealth Government and the Invasive Animals Cooperative Research Centre (IACRC), the University of Canberra developed and implemented an accredited diploma level course that aimed to give managers the skills and capacity to develop and implement effective integrated plans to manage the damage due to pest animals based on current best practice.

Given the significant developments since the initial principles and strategic approach were identified, it is now time to revisit and refine the principles that underpin strategic management of the damage due to pest animals. In essence, the strategic approach promotes coordinated action that aims to reduce the damage due to pests to an acceptable level with the desired outcomes of enhanced production, and environmental and social benefits from effectively managing pests. A diagrammatic representation is shown in Figure 1. The strategic approach has been endorsed nationally in the Australian Pest Animal Strategy (NRMMC 2007) and by relevant state and territory strategies (see NSW DPI 2008, Department of Natural Resources and Mines 2002, Environment and Sustainable Development 2011).

In this paper, we focus on the principles that underpin strategic management of the damage due to pest animals; namely, definition of the problem, and the development and implementation of an effective plan to manage the damage. As such, we assume that the strategic management will also be based on current best knowledge of the biology and behaviour of pests, the application of the most current approved management practices based on recently endorsed codes of practice and the associated standard operating procedures (Sharp and Saunders 2005), and a sound understanding and application of ecological principles (Krebs 2008).

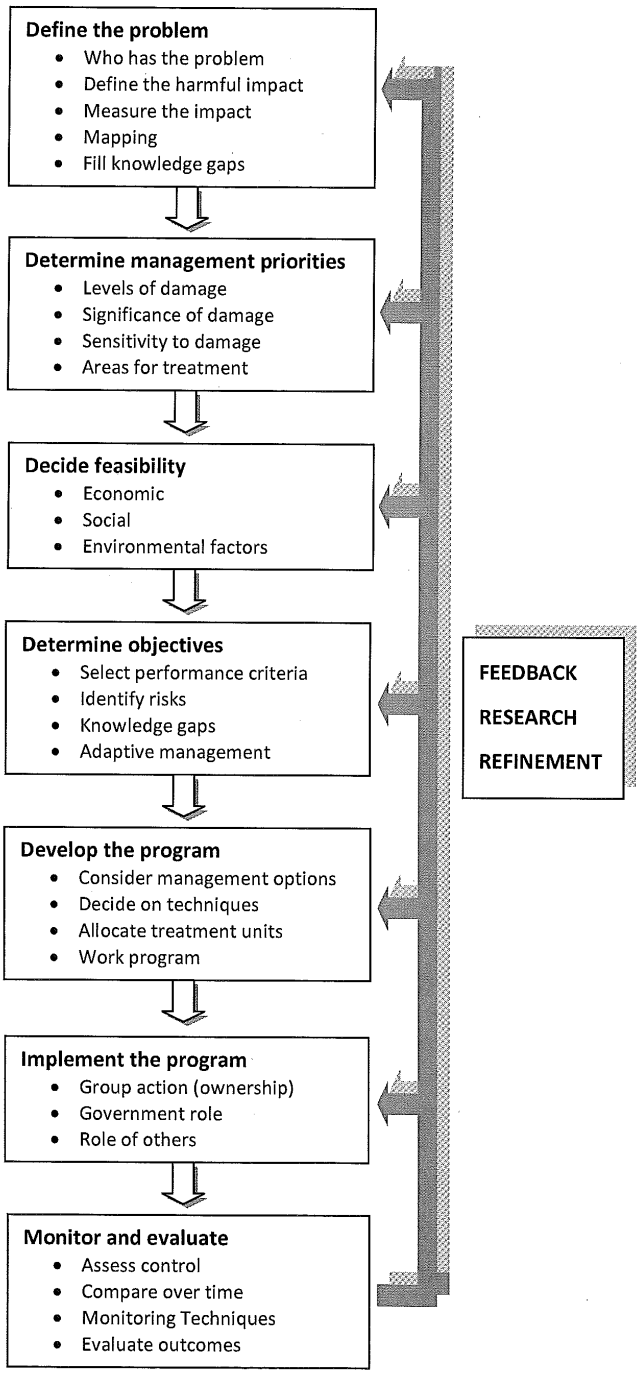

Figure 1. The strategic process (after Braysher 1993, Braysher and Saunders 2003a,b. Also see Olsen 1998, Fleming et al. *In Press*)

THE PRINCIPLES

Most of the original principles that were identified by Braysher (1993) still apply. However, this paper aims to present them in a more logical order and in a manner that more closely relates to the APAS and nationally endorsed approaches. The seven principles are:

1. A pest is human construct

The term 'pest animal' is generally used to describe an animal that conflicts with human interests. Such an animal may be destructive, a nuisance, smelly, noisy, out of place or simply not wanted. A more precise and workable definition is *those animals that cause more damage than benefits to human-valued resources and social well being*. A pest may be an animal that was originally introduced and spread by humans to new lands – this is particularly the case in Australia. It might also be a native animal such as a kangaroo, possum, or parrot within its native distribution.

It is important to note that people decide whether an animal is a pest, and what is a pest to one person may be a valuable resource to another. For example, a feral pig might be worth AUD$100 at the point of sale, where it is processed into game meat for the European gourmet market, and viewed as a valuable resource by the haunters and meat processors. Others believe that feral pigs are a menace to the environment and agriculture and should be controlled regardless of their value. Alternatively, an introduced animal such as a trout may be seen to be a serious pest to native fish in upland native streams but a valued resource in a recreational fishing lake. Indeed, trout are stocked annually in Australia, having legal take

limits and closed seasons to protect breeding fish. The pest status of an animal can even vary with the same observer. For example, some banana growers in Queensland view feral pigs as a major pest when banana prices are high but as a welcome guest when prices are low, as they clean up fallen fruit that can be a disease source to the crop. Because the attitude of different groups and individuals to the pest status of an animal is so variable, these varying attitudes can determine the success or failure of a pest control program. This is especially important where landscape management programs need to be coordinated and involve a range of land holders with varying attitudes, as is the usual approach for managing widely established pests such as exotic carnivores. If several landholders within the landscape will not cooperate and actively block management, such programs become ineffective.

Because the pest status of an animal varies with the location, land use, and with those that are concerned with the benefits and damage that they cause, it is essential to consult fully with those concerned with the pest, with the results, and with other consequences from managing them. This leads to the second principle.

2. Actively engage and consult key stakeholders

As shown above, differing opinions on whether a given animal is a pest or not, can inhibit or constrain effective management. When trying to flesh out the dimensions of a pest problem, it is important to determine who has the problem, the extent of the damage believed to be caused by the pest, and what stakeholders want to do about it. Understanding the varying attitudes toward the pest animal within all key groups and individuals is essential, as they can constrain the techniques and strategies that can be used to manage the pests' impact. This is a two-way process where both the understanding of the landholder towards the pests and how to manage them is valued equally to that of others, including Government agencies that regulate pest management (Olsen 1998; Braysher and Saunders 2003 a,b; Fleming et al. *In Press*). It requires active and open consultation and developing trust between the parties. Too often, pest management programs are developed and implemented in a top-down fashion by Government employees. Consequently, there is often little ownership of the program by those most concerned. Building trust between divergent individuals and groups can be a difficult and time-consuming process, but it is essential. It may also require increasing the understanding of some individuals and groups about the pests, the damage that they cause, and how the pests should best be managed (Fleming et al. *In Press*). In other words, we need to build their capacity to understand and deal with such a complex issue. Where tensions are high and opinions strongly divided, it can help to use a professional facilitator to work with the groups to help develop a common or agreed approach. An essential part of the process is to establish who the beneficiaries are from management and ultimately, who should pay. The *nil tenure* or *cross tenure* approach has been useful in reducing conflict and reaching decisions on cost sharing (Fleming et al. *In Press*). In essence, it involves developing a joint understanding about the damage that pests cause, how they move throughout the landscape, and where best to implement management using a map with no tenure boundaries. The tenures can be added at the end and be used to negotiate cost sharing.

3. Rarely can pests be eradicated

Eradication – that is, 'the complete and permanent removal of a pest', is incredibly difficult to achieve, except on islands and under special conditions on mainland environments. An example of the latter is when pest numbers are small and they have not fully established or where the populations are isolated and easily controlled (Myers et al. 2000). Once a pest has become established and is widespread, eradication is rarely possible. To further illustrate this, no established pest has ever been eradicated from mainland Australia despite intensive effort, huge monetary expenditure, and powerful legislation mandating action to reduce pest density.

There are six criteria – three that are essential and three that are desirable, which can be used to evaluate whether eradication in any given situation is possible (Bomford and O'Brien 1995). They are:

Essential

A. The control operation can remove the pests faster than they can reproduce. This seems obvious but it is difficult to achieve in practice. Many pest populations have a high natural rate of increase. For example, a pair of rabbits in an outside enclosure in the Australian Capital Territory, without supplementary food and water, increased to 184 individuals in 18 months (Williams et al. 1995). Furthermore, as the density of a pest declines, it takes progressively more time and more expense to locate and remove the last few animals.

B. Immigration can be prevented. If animals can recolonise an area from nearby populations, or by escape from captive populations such as domestic herds of goat and pigs, elimination of the pest will be temporary at best. Usually, this criterion can be met for islands but is very difficult to achieve on the mainland.

Immigration to a local area may be prevented where fencing and control creates a perfect barrier. An example is the successful campaign to prevent the common starling (*Sturnus vulgaris*) from crossing the Nullarbor Plain to south-western Australia. However, this is expensive. It costs the Western Australian Government approximately AUD$2.5 million each year to eliminate the 1,000 or so starlings annually that attempt to migrate into the south-west. Given the damage starlings could cause to crops and native species, this is probably money well spent.

C. All reproductive individuals are at risk from the available techniques. It is not necessary to remove all pest animals at the first attempt. However, all reproductive or potentially reproductive members of the pest population must be able to be taken by the techniques available. This is rarely possible, in part because there is only a limited armory of techniques. If, for example, some animals become trap-shy or avoid poisoned baits, then those animals cannot be removed and eradication will not be achieved. Trap-shyness and bait-avoidance, and resistance to poisons, are common causes of failure in pest animal control programs.

Desirable

D. The pest can be monitored at very low densities. If the animal cannot be detected at very low densities, then there is no way of knowing whether all animals have been eliminated. However, most population assessment techniques cannot detect animals at very low densities. The difficulty in meeting this criterion is illustrated by the attempts to remove rabbits from Phillip Island, a small oceanic island off the east coast of Australia. A small population of rabbits was found on the island two years after it was thought that all of them had been removed (Coyne 2010). This is not an uncommon experience with eradication programs.

E. The socio-political environment supports eradication. Even when all the technical problems can be overcome, social and political factors may prevent successful eradication. Community attitudes may oppose killing large numbers of animals on moral, emotional, or cultural grounds. Political factors may see the withdrawal of funds from the program before eradication is achieved, either because of the high cost or because some influential groups do not believe that foxes are present in Tasmania.

F. The high costs of eradication can be justified. Eradication is expensive. The program to eradicate foxes from Tasmania is estimated to cost in excess of AUD$27 million, while the U.S. National Park Service spent in excess of US$3,175,000 to eradicate feral pigs from Santa Catalina Island (Schuyler et al. 2002). It might be assumed that land managers act in an economically rational manner. However, pests seem to evoke strong emotional responses to the extent that management aims and expenditure are often far from rational. The resource being protected also has to have a monetary value allocated to it in order to determine whether eradication is economic. Yet, the monetary value of conservation and biodiversity is difficult to assess.

If most pests cannot be eradicated, then the focus turns to the next principle.

4. Most pest management needs to focus on the outcome, reduction in damage, not just killing pests.

Damage caused by pest animals can be social, economic, environmental, or a combination of these. When developing a management plan, it is important that the damage caused by pest animals is clearly defined, with the focus of the management plan being on reducing this damage to an agreed acceptable level. The success of the management plan is measured against this outcome, not based on the numbers of animals remaining (Hone 2007). However, it needs to be recognised that it is not always possible to measure accurately the reduction in the damage due to pests. Consequently, the reduction in pest animal density is used as a surrogate measure for the likely reduction in damage. The question then becomes "how much effort and resources should be devoted to management?" But the cost of pest removal increases significantly as the density of the pest decreases (Figure 2). This leads to the next principle, consideration of the other factors that influence the outcome from management, and where should the available resources be allocated to get the best return.

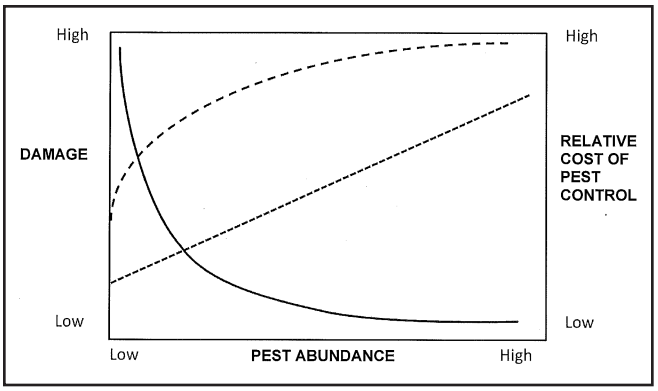

Figure 2. The relationship between pest abundance and the cost of controlling pests (solid line) and two potential relationships between pest abundance and damage (dashed lines). Note that even at low or nil pest abundance damage still occurs but is from other factors rather than pests.

5. Whole-system approach to managing the damage due to pests.

If we accept the principles in points 1 to 4 above, we are led to the concept that the focus of pest management planning needs to be on the desired outcome(s). Pests are but one of several factors that can influence the outcome (e.g., enhanced lamb production or conservation of a native wildlife community). A land manager needs to decide where to use limited resources to achieve the best outcomes (e.g., pest management, weed management, habitat management, better genetics of the ram to achieve a higher twinning rate, better ewe nutrition to reduce lamb mortality, or a combination of these).

Figure 3 illustrates the whole system approach to land management. It places pest animal management in the context of sustainable land use. The successful management of pest animals is influenced by a number of factors, such as the biology and behaviour of the pest and the affected wildlife, availability of control techniques, the interests of a range of social groups, and cost/benefits. By placing pest animal management in the context of sustainable land use, land managers gain a better understanding of the effect that pest animals have on a given system. This whole system approach enables the development of a pest management plan that is outcome-focused rather than concentrating on the pest itself. For example, the aim of a fat lamb enterprise would be to maximize their annual lamb production. Fox predation can have a significant impact on this, but is not the only factor – ram fertility, climatic conditions, food quality, disease status of ewes, and cover for newborn lambs also play a significant role. Pest animal management is an important component of sustainable land use, but it needs to be considered along with other factors that influence the desired management outcome.

There are similar examples for conservation systems. Malleefowl (*Leipoa ocellata*) are predated by foxes (Priddel 1990, 1991) and in a study designed to demonstrate

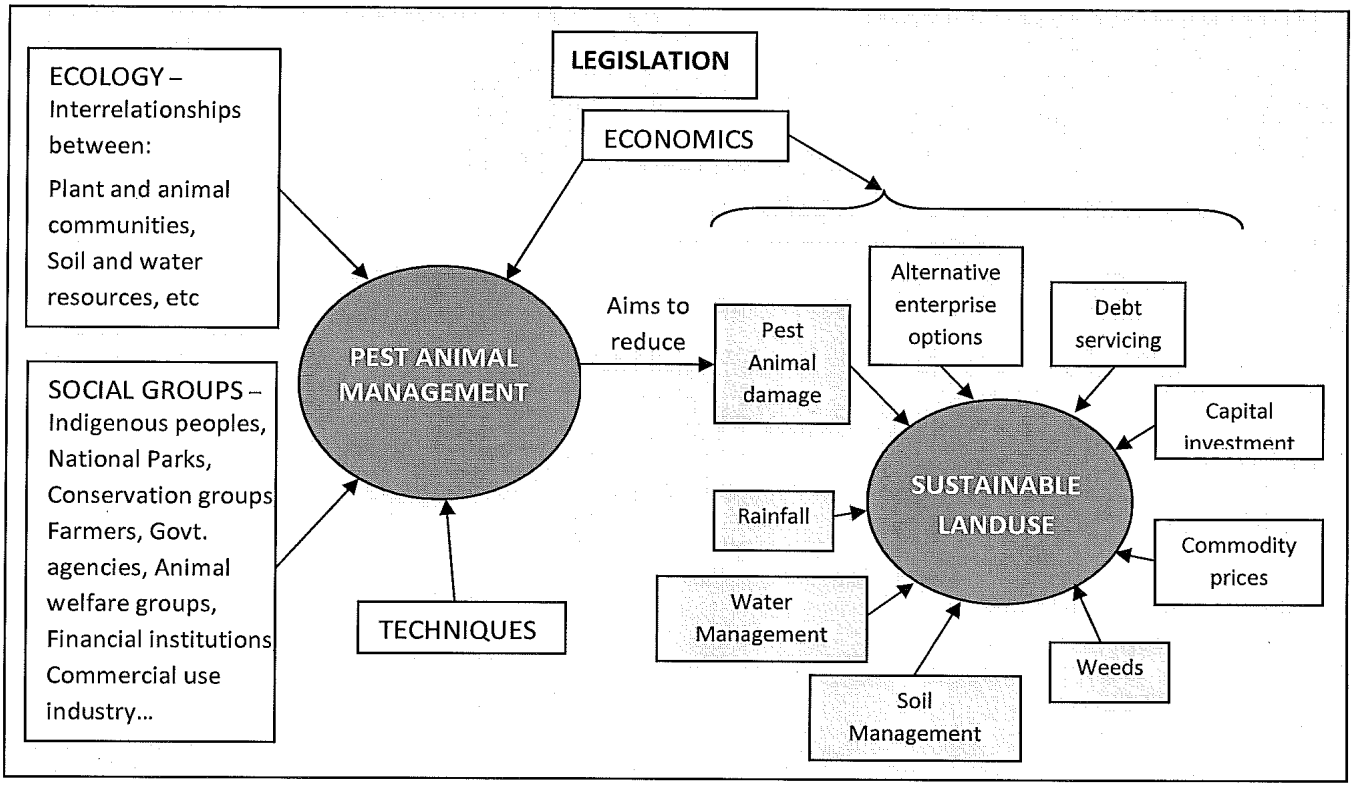

Figure 3. Pest management is only one of several factors that need to be managed for sustainable land use.

the damage foxes cause to this bird, there was little recovery in Malleefowl numbers following extensive poisoning of foxes. A later study showed that although foxes were important predators, Malleefowl did not increase, because the necessary food for chick survival was not available. Therefore, as well as the essential reduction in fox predation, it was necessary to manage grazing by domestic stock, feral goats, and rabbits to recover the native grass and their seeds on which the chicks fed.

An important potential benefit from increasing the profitability of an enterprise based on a natural resource system is that more resources are likely to be available to manage the base resource better.

6. We are operating in a system where our knowledge is imperfect.

Identifying the individual elements that play a role in whole-system management is the first step towards formulating a management plan. However, understanding and quantifying the elements that affect pest animal management and sustainable land use and conservation is complex. Our understanding of these complex and dynamic systems is imperfect. Consequently, we do not know how all of the system operates and how it will respond to management intervention. For example, in the North-east Atlantic marine food web (Link 2002 quoted in Krebs 2008), it might be assumed that if the density of a top order predator such as seals were significantly reduced, desirable fish species lower in the food web such as cod would increase (Figure 4). However, there are many interactions between the various species in the food web. It would be naive to assume that fewer seals would automatically result in more cod. It is often difficult to predict the outcome of management even in relatively simple systems. Bowen Island is an approximately 10-hectare island at the entrance of Jervis Bay, south of Sydney, Australia. It contains populations of little penguins (*Eudyptula minor*) and three species of shearwaters that breed in burrows on the island. There was also a small population of rabbits on the island. In 1980, one of the authors (Mike Braysher) eradicated rabbits from the island to increase the availability of burrow habitat for the native penguins and shearwaters. Unfortunately, the rabbits had been keeping in check exotic kikuyu grass. Once the rabbits were removed, kikuyu spread rapidly, inhibiting the access of penguins to their burrows to feed their chicks. Subsequently, an ongoing program has been required to minimise the spread of kikuyu.

The consequence of this is that we need to take a risk approach to management. This can take several forms: making decisions about how to best manage a particular pest situation; or assessing the risk of new animal imports to determine whether they may become a pest. One solution is to treat management as an experiment – to take an adaptive approach to management (Olsen 1998, Walters and Holling 1990, Fleming et al. *In Press*). This helps managers gain a better understanding of the system by appropriately monitoring the changes due to management and evaluating the results against the stated objectives for the program (Keith et al. 2011).

7. An effective monitoring and evaluation strategy is an essential component.

Because we cannot be certain whether our management intervention will achieve the desired outcomes, it is essential that we monitor the result of the intervention

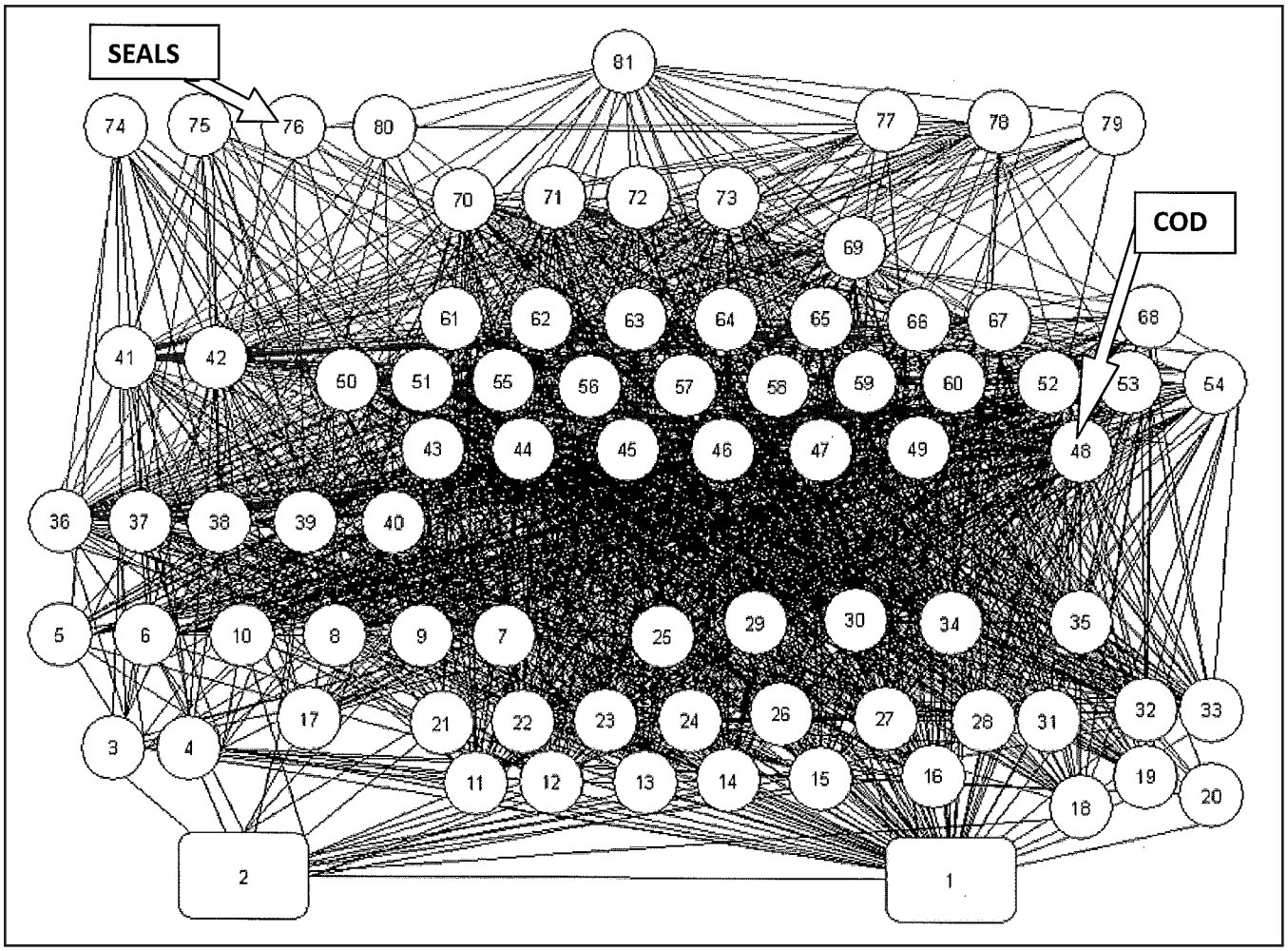

Figure 4. Complex food web from the north-west Atlantic Ocean (Link 2002 quoted in Krebs 2008) (Note: seals = 76, cod = 48)

and compare the results against the stated outcomes (as objectives) so as to evaluate them and the program. However, pest managers often fail to implement an appropriate monitoring and evaluation program. This can have serious consequences. For example, until the mid 1990s in Queensland, it was common to bait individual properties to reduce stock losses from wild dogs. In an experimental study, Allen and Gonzales (1998) showed that such practices could actually increase the loss of calves several-fold. They reasoned that limited baiting destroyed the social structure of wild dog packs. Young dogs would quickly invade the poison site, and unlike the pack which would take kangaroos and some stock sufficient for their needs, young dogs undertook surplus killing. Allen and Gonzales (1998) therefore recommended that broad scale coordinated baiting, and not property-based baiting, was necessary to manage stock losses effectively.

In another study, Tobin et al. (1993) showed that failure to monitor the results of trapping rats on macadamia crops in Hawaii missed the impact of rats on nut yield. Farmers noticed that the introduced black rat damaged developing nuts, removing up to 15% of the nuts. Consequently, they embarked on expensive culling of rats, primarily using traps. In order to understand the problem better, the U.S. Department of Agriculture set up an experiment to measure nut yield from plantations where rats were trapped and those there was no rat trapping. While trapping reduced damage, surprisingly there was virtually no difference in yield from the protected trees compared to the unprotected.

Subsequently, Tobin et al. (1993) mimicked rat damage to the developing macadamia nuts by artificially removing nuts at various stages of development. They showed that trees could fully recover loss of individual nuts in the developing crop up to 150 days after seed set. This is not surprising, as most fruit trees produce a similar weight of fruit and often larger and better quality fruit when excess developing fruit is removed. Thus, although rats were damaging developing nuts, they were not affecting the yield; rather they were pruning the excess fruit. An appropriate monitoring program would have revealed this, resulting in significant savings to the producers.

There are many additional reasons for developing and implementing an effective monitoring and evaluation program. They include:

- To provide feedback to those involved in the program and to maintain their engagement.
- To determine the efficiency of the program and how it might be made more efficient.
- To satisfy funding agencies and to justify

continued funding and to seek additional funds.
- To determine whether the pest actually caused the damage or to determine other factors were significant or more important.
- To obtain information for promotional material.
- To increase understanding of the impact of the pest and use it to refine future management.

However, we need to recognise that monitoring can be very resource-hungry. It is not possible to monitor everything, so priorities need to be set. It is important determine what data to collect, when, where, how often, and exactly how to collect the data. Some monitoring data, such as assessing the satisfaction of recreational fishers about the results of management, may be relatively easy to obtain. Other data, such as determining the initial population size of the carp population and how it changes as a result of management, or the breeding success and recovery in native fish populations, require specialised methods and hence more effort and cost – and are very difficult to determine.

CONCLUSION

In this paper, we have described the evolution of pest animal management in Australia and the underlying principles that need to be considered when designing and implementing programs to mitigate damage. While the focus has been on managing vertebrate pests, we contend that very similar principles apply to managing weeds and invertebrate pests. Also, we believe this evolution will continue as new techniques and strategies become available.

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