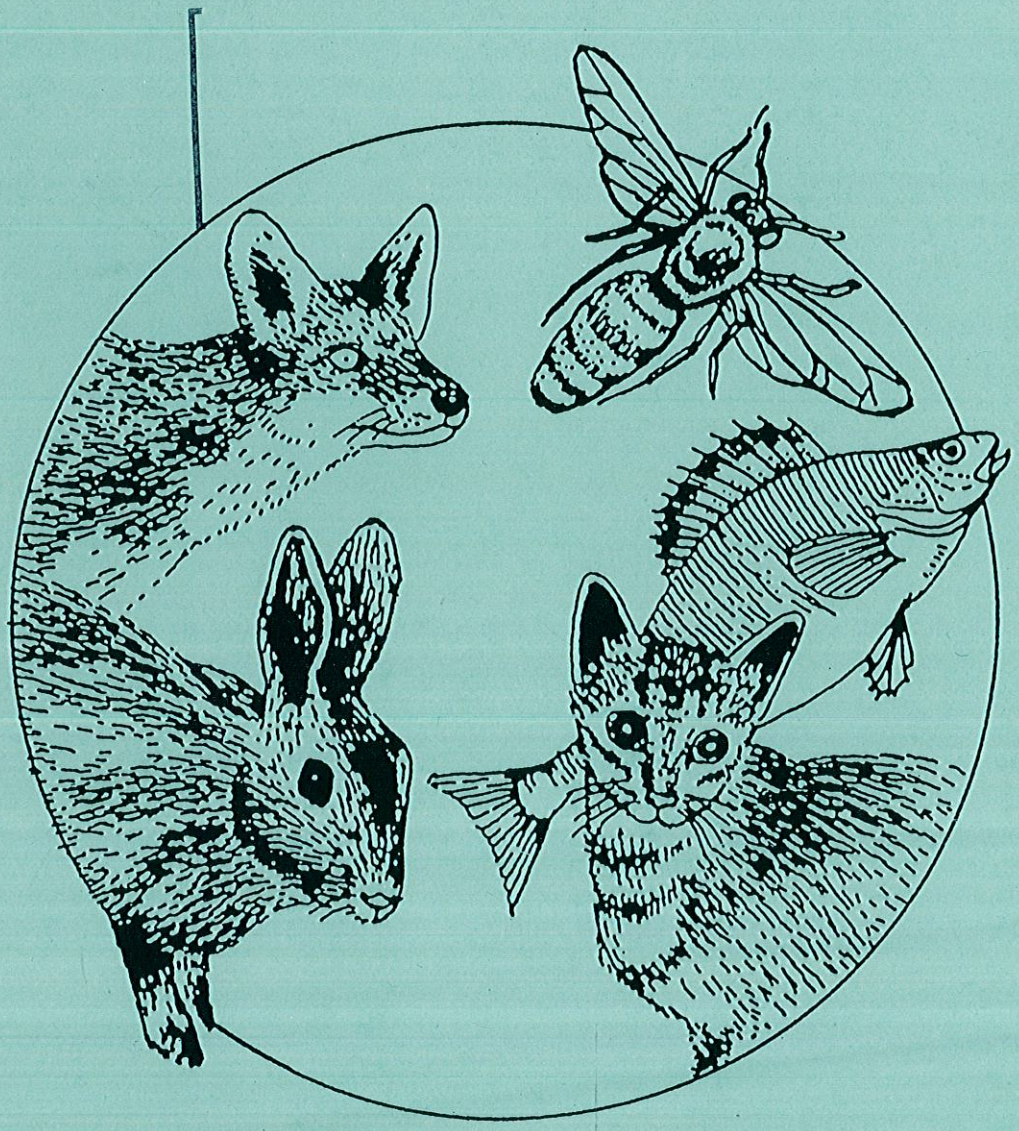
IMPACT AND CONTROL OF FERAL ANIMALS IN SOUTH-WESTERN AUSTRALIA

PROCEEDINGS OF A SEMINAR WITH WORKSHOPS



Conservation Council of Western Australia

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PROCEEDINGS OF A SEMINAR WITH WORKSHOPS

held at
Edith Cowan University, Churchlands Campus,
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Edited by
R. Siewert, N. Robinson and P. Horwitz

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PREFACE

These are the proceedings of the Feral Species seminar held in Perth in November 1993. The proceedings include the formal talks and, most importantly, the outcomes of the workshops. We feel that the recommendations of the workshops are particularly important as they are the result of discussions of interested community members, scientists, land managers and representatives of government bodies.

The Conservation Council was extremely pleased with the seminar and the positive response it generated in the community. The Council is committed to ensuring the implementation of a package of the recommendations from the workshops.

The Council would like to thank the many people who contributed to the success of the seminar. We would especialy like to thank the convenors, Margaret Robertson and June Lowe, without whose committment the seminar would not have occurred.

We are most grateful to our sponsors, the Gordon Reid Foundation for Conservation (a Lotteries Commission funding initiative) and Edith Cowan University, whose generous assistance made the seminar possible, and the Australian Nature Conservation Agency for providing assistance in printing these proceedings.

Beth Schultz
President
Conservation Council of Western Australia.

FEDERAL GOVERNMENT'S POLICY ON FERAL ANIMAL CONTROL PROGRAMMES

John Hicks
Director, Wildlife Management Unit
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The Minister shares your concern about the impact of feral animals.

At the commencement of her new term as Environment Minister, she set priorities for the next three years. Progress in feral animal management is one of those priorities.

It's one of those issues where conservation and agricultural interests converge. Feral animals directly threaten our endangered species and are a major cost to our primary producers.

Fox predation threatens species like the western swamp tortoise, numbat, woylie and mala. Without effective fox control these endangered species will not recover.

While a variety of factors, including habitat damage, may have contributed to their decline, we know that, through fox control alone, the populations of some endangered species can increase more than five-fold over five years in suitable areas.

Feral cats have also frustrated recovery attempts for endangered animals.

Rabbits, even at low densities, are having a major impact on our rangelands by preventing regeneration of shrubs and trees. They are changing the landscape as surely as bulldozers but on a longer time scale.

On Phillip Island, a small island half way between Australia and New Zealand, rabbits effectively converted lush sub-tropical rainforest into a lunar landscape.

Feral animal impacts on primary production are high. Rabbits cost the pastoral areas of South Australia alone more than $17 million each year. Recent research using ultra sound techniques suggests that lambing losses due to foxes may be quite significant in some areas. The Commonwealth recognizes the damage caused by feral animals and a number of recent initiatives have reflected this.

While the Minister understands that the prime responsibility lies with the States and Territories because of their land management responsibilities, the Commonwealth can help through coordination activities, by preventing the introduction of new pests to Australia, by investigating new biological control techniques that have national significance and through funding and labour market programs that provide assistance for improvements in control.

Of course the issue goes further than Governments, be they State, Federal or local. Effective, sustainable feral animal management will only become a reality if there is strong, coordinated action at grassroots level with individual landholders working cooperatively.

The Minister wanted to tell you about some recent Federal initiatives on ferals. In the 1992/93 Budget, the $1.5 million a year Feral Pests Program (FPP) was introduced.

This grew from the Endangered Species Program (ESP) which started in 1989. The FPP aims to reduce the impact of feral animals on native species, particularly in areas important for the recovery of endangered species.

Then, in the PM's Statement on the Environment in December 1992, funding for the FPP was increased by $700,000 a year and a complementary new $1.2 million a year program (the Vertebrate Pests Program - VPP) was established.

While the FPP has a focus on the impact of feral animals on native species and the natural environment, the VPP has a focus on the agricultural damage caused by these animals. There is a close coordination between the two.

The importance of feral animals was further recognised in the Endangered Species Protection Act which Mrs Kelly introduced into Parliament last year.

Under the Act, four feral animals are listed as key threats - foxes, feral cats, feral goats and rabbits. The Commonwealth has an obligation to prepare, in consultation with the States, Threat Abatement Plans for each of these species The Plans will eventually guide funding priorities under the FPP.

Now a few details in the Feral Pests Program, of which WA is getting the lion's share. In 1993/94 it will receive 39 per cent of the $1.2 million allocated to State agencies under the Program.

That's partly due to the pioneering work undertaken by Western Australians like Jack Kinnear, on the impact of foxes on endangered mammals and the development of cost effective aerial baiting techniques. Western Australians like Jack blew the whistle on the foxes.

This is a reflection of the project managment skills of CALM which has developed some of the best project proposals. It is also because W.A. has endangered and vulnerable species which have shown that they respond quickly to the removal of foxes.

Tonight, the Minister is announcing Feral Pest Program funding of $1.8 million over the next three years for continued work on improving fox control techniques. Some $675,000 of this will be allocated to CALM to improve baiting techniques and contribute to the development of biological control.

This continues the CALM work funded by the Commonwealth, at a cost of $400,000, over the last three years.

Funds will also go to the CSIRO to continue biocontrol research on the development of immuno-contraceptive agents in foxes.

These activities are coordinated within the Vertebrate Biocontrol Centre, which also receives $1.85 million this year from the Commonwealth Cooperative Research Centre Program.

The Minister believes that the work being done by the Vertebrate Biocontrol Centre is exciting and innovative and at the cutting edge of biotechnology.

Understandably, there can't be any guarantees that it will be successful but so far, it is going well.

An effective immuno-contraception techniques for foxes and rabbits would obviously have advantages from a humane perspective as well as reducing feral

animal damage in those large areas of Australia which we can't reach for conventional control.

But while such agents have the potential to deliver great rewards, they take time to deliver. Meanwhile we need to strategically apply and improve conventional techniques to conserve our threatened wildlife and we need to have other strings to our bow if the biocontrol approaches don't work or take longer than expected.

We can't afford to sit back and wait for a techno-fix.

So the Minister was pleased to see that CALM and ALCOA recently announced broad-scale fox baiting on half a million hectares of Jarrah forest. It is good to see the results of research work, which the Commonwealth helped fund, find their way into such broad-scale application so quickly. And the baiting will also complement the ongoing CALM research the Commonwealth is helping to fund.

I will be talking tomorrow and will provide details of the Commonwealth programs. However one thing I have learnt about feral animal management is how difficult it is to eradicate a pest. I helped remove the last rabbit on Phillip Island in February 1986 and again in February 1988.

The campaign by ANCA to eradicate the rabbits from Phillip Island took 3 years.

For most of mainland Australia, eradication is not really an option, and the Minister believes we need to look at cost effective ways to manage the impact of feral animals. This requires careful planning and coordination.

The Minister stresses the need to work cooperatively on major environmental problems like feral animals. Take the biocontrol initiative for instance. WA CALM, the FPP, the WA Agriculture Protection Board and CSIRO are all in it together.

At the local level, grass roots support and coordination is vital for effective feral animal management. If landholders can coordinate their efforts, sustained reduction of impact of feral animals is possible. The Minister emphasises we need to work together.

Mrs Kelly congratulates the WA Conservation Council for bringing you all together to focus your energies on how we can better reduce the impact of feral animals. On her behalf I have pleasure in declaring this seminar open.

AN OVERVIEW OF THE IMPACT OF FERAL PREDATORS AND COMPETITORS ON AUSTRALIA'S ECOSYSTEMS

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Australia's Feral Animals

This paper tries to give a context for the specialist papers that follow. It covers some basic facts about Australia's feral animals, and then discusses what we know about feral animals and their impacts, and whether we are acting the right way. The factual questions are: What are Australia's feral predators and competitors, and why are they here? Are any more to come? Have they really had any impact? How do we know?.

I am going to discuss mainly feral **vertebrate** species, because they are what I know best; but we need to remember that there are many more feral species of invertebrates than vertebrates. However, we can apply the principles that we learn from the vertebrates to any other feral animal species, and even some feral plants.

Feral species or populations, strictly defined, are once captive or domestic animals that have gone wild; but we commonly extend the term to mean any introduced species with self-sustaining wild populations. Note that they do not have to be foreign, non-Australian species; they can be Australian species or sub-species established outside their natural range.

About 24 exotic mammal species have established breeding populations somewhere in Australia out of 30 exotic mammal species released. Several Australian mammal species, having been moved from their native range, have established wild populations in other parts of Australia. Similar numbers of exotics (and again, several native) bird species and at least 15 exotic fish species are established in the wild; but so far one exotic frog and one (maybe two) reptile species. Why the differences? Our 19th-Century forebears, who did most of this transporting and releasing, thought that many mammals, birds and fishes were either useful, or good companion animals, or worth hunting, or aesthetically pleasing; they were less keen on reptiles or frogs. We have different representations of taxa because people view them differently, not because some are intrinsically more likely to became feral than others.

The simple lesson from this is that feral animals, in large part, are a product of people's attitudes towards animal species. Most feral animals are established in Australia either because people wanted them to be, or did not strongly enough not want them to be. The feeling that feral species should be discouraged began to emerge about 100 years ago and has been expanding steadily since then.

However, attitudes change slowly. Cane toads (Bufo marinus) were introduced as late as the 1930's because someone thought that they were useful (they weren't). There are still people who want to introduce foxes to Tasmania. People are still releasing aquarium fishes into tropical streams and wetlands, and sport fish into southern rivers. Indeed, releasing trout into streams is still a socially acceptable thing to do, the last fling of the Acclimatisation Societies that were established under royal patronage 130 years ago.

The mobility of modern people and their intentional pets or unintentional animal cargoes is an on-going threat. Whether as pet cane toads travelling to Canberra or Perth, or marine invertebrate larvae in the ballast water of ships, the mobility of these human-transported organisms outstrips our ways of stopping them.

Impact of Feral Animals

Out of this array of feral vertebrate species, what generalisations can be made about their impacts?

Feral predators and competitors are commonly blamed for general environmental degradation, and specifically for the range reduction or extinction of native species. Yet rarely has any impact been unequivocally confirmed, let alone quantified. We need to ask why we know so little about their impacts.

One immediate problem is that we do not blame non-feral, introduced animals for their impact to anything like the same extent. We blame feral goats, but not domestic sheep; feral buffalo, but not domestic cattle; feral horses, but not domestic horses; feral cats, but not domestic cats; and feral dogs, but not dingoes. We are, in a nutshell, not always very logical; and that may mean that we do not always seek the management of ferals as sensibly as we might.

Classification of Classes of Impacts

A simple categorisation of types of impacts can help us to understand how problems arise, and how to resolve them.

Impacts can be **direct, indirect,** or **human-induced.** In the first, feral organisms interact directly with native species. I can think of three kinds of direct impact. The least widespread are: (a) the impact that cane toads may have by poisoning some native predators that eat them; and (b) the genetic contamination of pacific black duck (Anas superciliosa) by hyridisation with mallard (Anas platyrhynchos) and of dingoes (Canis familiaris dingo) by domestic dogs (C.f.familiaris).

However, genetic contamination is a growing threat, again as a result of human-aided mobility of animals. If native animals taken from one part of Australia, escape (or are released) and become feral elsewhere, the chances are that they will introduce new genetic material to the local, genetically distinct, population of their species. For example, if pet galahs (Cacatua roseicapilla) were transported from eastern Australia to Perth and there escaped, they would introduce eastern Australian alleles to the Western Australian galahs with which they could freely interbreed. Similarly if re-introduction programs "restore" wild populations of native animals with stock not originally from the release area, new genetic material will be released to that environment. That will matter little, unless wild conspecifics are still living at the release site.

The most important (and ecologically least understood) direct impact is **predation.** The most frequent accusations are directed at red foxes (Vulpes vulpes), cats (Felis catus), black rats (Rattus rattus), and feral dogs; but in addition feral pigs (Sus scrofa) are accused of eating eggs and nestlings of waterbirds and turtles, trout of eating native galaxiid fishes, and Gambusia of eating eggs and larvae of native fishes and frogs. Feral ferrets (Mustela putorius furo), of which colonies are said be to established in the northern surburbs of Perth and near Launceston in Tasmania, could be a bad threat to

native wildlife if they became widely established.

The **indirect impacts** encompass habitat modification, and competition for food and other resources.

Impact through habitat modification occurs when a feral animal's way of life alters the physical or biological environment for native species. These impacts could have either negative or positive effects. For example, feeding by European carp (Cyprinus carpio) supposedly makes the water turbid, suppressing light levels and hence primary production that would support native communities of plants and animals. Pigs, rabbits (Oryctolagus cuniculus), horses (Equus caballus), water buffaloes (Bubalus bubalis), cattle (Bos spp), sheep (Ovis aries), goats (Capra hircus) and camels (Camelus dromedarius) all dig up soil or wallow or make tracks that can induce soil erosion that will consequently affect communities of native species. Some are blamed for soil compaction; some for pugging; their effects may be beneficial for some native species but detrimental for others (Braithwaite et al. 1984).

Exotic herbivorous mammals are particularly blamed for destroying vegetation cover, either by removing standing vegetation, or suppressing plant reproduction and establishment. They thus change vegetation structure or floristics, eliminating some native plants, and depriving some native animals of shelter and food (e.g. Neave & Tanton 1989). We tend to ignore the fact that native and domestic herbivores also alter the vegetation communities within and upon which they live.

Competition between feral and native species for food does not occur every time one species eats a food that the other one might eat. Strictly speaking, competition occurs only when the resource being used is limiting the numbers of the species. Competition is very difficult to prove. However, the extent of removal of vegetation by some feral mammalian herbivores, such as rabbits or goats, (or domestic ones such as cattle or sheep), is so great that it is bound to leave insufficient to support natural densities of native herbivores that depend upon that vegetation. It is harder to be sure that the same is true of competition for food between feral and native predators or insectivores.

We know least about the long-term change to plant community composition brought about by feral herbivores feeding on or trampling the vegetation. Many changes happened before we had any records of the vegetation, so the extent of the change is unknown. Even reversal experiments (removing the ferals) may not tell us much if the seedbank for the original plants has long gone.

Competition for shelter is often said to occur between some feral hole-nesting birds, such as European starlings (Sturnus vulgaris) or common mynas (Acridotheres tristis), and the many Australian birds that nest in holes in trees. Similarly, goats are accused of competing with rock-wallabies (Petrogale spp.) for use of rock shelters; and on some oceanic islands rabbits are said to compete with seabirds for nesting burrows. Demonstration of these competitive effects is lacking.

The final class of impact I have called **human-induced** because it arises from what we do to the feral species rather than from the feral species itself. Attempts at pest control can have unwanted side effects upon non-target native animals...what the US military might call collateral damage. In the bad old days of widespread use of strychnine, a range of native species were reported to be poisoned as well as the targeted rabbits or dingoes. Even now, 1080 (sodium monofluoroacetate) may pose a threat to some non-targeted animals, either

directly or through secondary poisoning; and rabbit and dingo-trapping can still kill native mammals and birds. Warren-ripping can be very destructive of soil structure, if poorly planned or carried out.

Some human-induced impacts may be worse than we suppose, in some circumstances devastating. Our major uses of poisons are not against vertebrates, where their application can be quite specifically targeted, but against invertebrates and plants, where poisons are relatively unspecific.

We still understand little about their impact upon native communities of invertebrates and plants. However, some ecologists sample whole communities (on a very small scale) of invertebrates by applying insecticides; they at least believe that these poisons have the ability to kill indiscriminately all the invertebrates that they are studying, providing a dead sample of the whole community.

I foresee these human-induced impacts of feral species as major threats. We give human life such priority that much is justified, almost without question, if human health or wealth is at risk. If malaria or rabies entered Australia it would be a brave Minister for the Environment who said too insistently, 'Watch what you are doing with that insecticide or those fox-baits'.

Extent of our Knowledge

We cannot discuss the impact of feral animals fully because we are ignorant in two areas: we are ignorant of the ecology of the feral animals and the communities in which they occur; and we are ignorant of the interactive processes within ecosystems. Among these processes are the "impacts". Without understanding these interactive processes, even when we see two species interacting, we cannot tell whether either is having a significant impact upon the other's chances of surviving.

For example, rabbits and kangaroos might feed in the same area upon the same grasses. Yet unless we know whether the supply of that grass affects either birth rate or mortality of the kangaroos, we cannot say that rabbits, by eating those grasses, are having an impact on the kangaroos.

Another example: anyone who watches cats can see them kill lizards, birds and small animals. David Paton (1990, 1991) has estimated the annual numbers of birds taken by cats. His figures grimly suggest that suburban cats in a year typically take as many birds as are present at any one time. Yet no-one has shown that cats have held down the density of any bird population, except on islands. The Action Plan for Australian Birds (Garnett, 1992) lists the cat as a "reason for decline" of threatened bird species 26 times; but its listing as a threat is called "speculative" 23 times, and "confirmed" only thrice.

We do not always know what feral or even native vertebrates there are in an area, or their numbers and whether those are changing. We do not usually understand the process of change even when we can see it happening. The result is a history of argument among scientists and the public about the impact of feral animals upon our native communities.

However, in the past 15 years many surveys of mammals, birds and reptiles (and sometimes of amphibians) have been conducted, producing anything from simple statements, such as the probable numbers of feral pigs in Australia (13.5 million; Hone 1990) to complete distributions of whole Classes, like the RAOU's Atlas of Australian Birds (Blakers et al.1984).

Particularly important studies have looked at **changes** in populations or communities through time. Some, like the annual aerial surveys of kangaroos (conducted for ANCA to determine culling quotas), follow current changes. Others reconstruct past distributions by interpreting old records or collecting oral history especially from knowledgeable Aboriginal sources (Burbidge et al. 1988; Tunbridge 1991). Such studies show us the scale and rates of change in our native fanua.

Indeed, we worry about the native fauna mainly when we notice that their status today **differs** from that in the past. We know that many mammal species have gone extinct or have disappeared from most of their former ranges, surviving only on islands or as isolated colonies. We can also tell roughly **when** many of these changes occurred. We notice **patterns** in the disappearances, for example that most of the species that have disappeared have weighed somewhere between 35 and 5,500g, and almost none have been bats or arboreal mammals (Burbidge and McKenzie 1989). And we can contrast the fragility of the mammal fauna with the robustness of the Australian bird fauna. The few extinctions of birds have been from islands, although a number of mainland species have suffered reductions in range. The reptile and amphibian fauna are almost intact, although several frogs are now causing concern, especially (in contrast to birds and mammals) some rainforest ones.

Knowing that changes in fauna and populations have occurred, we naturally want to know a **cause.** And that is where we run into the next major barrier of ignorance. In simple terms, we do not know **for sure** the **cause** of change in the population status of any of these species.

This is partly because population status is the outcome of processes (of recruitment into the population and death or emigration from it) that are affected by many environmental factors; and partly because it is difficult to detect the effect of any one of those factors against the background of effects of all the others.

The only two ways around the second problem are either to carry out experiments that vary one factor at a time, looking at its effects alone, or to look at so many situations that statistical analyses can detect the influences of any one environmental factor amongst the influences of all the others.

Such experiments are rare, and I will mention some later; and analysis of variance has yet to be widely applied to explain changes in native communities.

We more commonly use a simple correlative approach, particularly since maps of past and present distributions of mammal species have been published.

Any armchair biologist can now compare maps of former and current distributions of bilby (Macrotis lagotis) (for example), and wonder what has caused the change. They can try fitting maps of possible causal agents. And sooner or later they will convince themselves that the difference between the two bilby maps is best explained by invasion of one part of its former range, but not the other, by rabbits or foxes (or whatever their fancy settles on).

This approach is exploratory and makes us think. Of course it takes only one factor at a time, but that can be improved by GIS techniques that allow you to overlay as many factors as you can map. You can even give it some time dimension: you could overlay a map of how **long** rabbits have been in each area, to see whether length of exposure to rabbits were relevant.

The weakness of the approach is that many of the possible detrimental factors are themselves correlated. Take an eastern example. Surveys of North-Western

NSW and adjacent South-Western Queensland show that the mammal faunas now differ strongly across the border, although they, and the vegetation, would have been the same before the arrival of European pastoral land-use 150 years ago. That part of NSW has lost all its mammals between 50g and 5kg, its dingoes have been eliminated, and it is full of sheep, red kangaroos (Macropus rufus), rabbits and foxes. That part of Queensland still contains some of the critical-weight-range (CWR) mammals, carries lower densities of red kangaroos, good numbers of dingoes, few foxes, no sheep, and plenty of rabbits and cattle.

What we now see are two areas differing in **sets** of variables; but you could not pick any one variable (say the presence of foxes) and say that it was the principal cause of the changes to the wildlife community, because the occurrences of foxes, sheep and rabbits are all correlated. Ultimately the differences derive from a difference between sheep-keeping in NSW and cattle-keeping in Queensland. Perhaps the different feeding styles of sheep and cattle produce differences in vegetation floristics or structure. Perhaps it is a difference in the density of watering points. I personally think that it results from elimination of the dingo from sheep country and its persistence in cattle country. Dingos suppress foxes; where foxes flourish, CWR mammals disappear. But can the correlations **prove** that? The answer is: No, they can't.

If this sort of arguing is done formally and fully by correlation analysis of complete enough data sets, it can tell us a lot. But if it is merely the basis for bar-room argument, it is extremely misleading.

It fails when the factor whose effect you want to detect is not known to vary spatially. Take the example of the feral cat. Many people believe that the feral cat has been a disaster for Australian wildlife. Yet if you tried to use correlation to show a causal link between feral cat distribution and the disappearance of wildlife species you would fail. Until recently, the best map of feral cat distribution (Strahan 1983) showed that cats occurred everywhere, and no one knew whether their densities varied over their range or had changed through time. As a result there was no variation in cat occurrence or density to relate to the presence or absence, or disappearance or persistence, of any native wildlife that had not gone totally extinct. With that lack of resolution in the data, you could not pin any blame on the feral cat. If the cat is to blame, it must have its effect only in interaction with other factors.

As an aside, let me say that in a recent workshop on The Impact of Cats on Native Wildlife (Potter 1991) representatives from every State and Territory said that cats were bad but they had no specific data to prove it. As one speaker admitted: "most assessments are based upon suspicion, supposition and superstition without much substantiation." (Copley 1991).

I repeat that the problem with uncontrolled observation is that the factor you are interested in is not the only one that varies, and many of them vary together.

The simple message is that all of Australia has been subjected to many ecological changes since European settlement, and feral animals are only some of those changes. Simple techniques of correlation analysis are not always good enough to demonstrate the impact of feral animals. And we must beware of trying to make ferals alone shoulder the blame.

Experiments

Experimental evidence for impacts avoids many of the problems associated with correlative evidence. In ideal circumstances, an experiment can hold constant

all the factors except the one or two that you most want to look at. You can vary those and see what effects their variation has.

Such experiments to look at the impacts of feral animals have rarely been set up formally. Experiments can either introduce, or remove, feral animals and look at the responses of the ecosystem.

Experimentally introduced trout induced a fall in numbers of the native galaxiid fishes in streams; Lake & Marchant (1990) assumed that this resulted from predation by trout upon the galaxiids. This induced result paralleled a " natural" experiment in which the mountain galaxias (Galaxias olidus) disappeared as trout invaded a stream, but persisted upstream of a waterfall that the trout could not climb.

Such "natural" experiments are common in Australia. Feral species that are still spreading present opportunites to monitor what happens to communities during invasion.

The results do not always bear out common assumptions. For example, a study (Freeland & Kerin 1988) of cane toads invading the south of the Gulf of Carpenteria concluded: "B. marinus had no observable impact on the patterns of habitat and food use by the native species of frog, or on the species compositions, equitabilities and population sizes of native frog communities active during the dry season...The absence of a measurable impact of B. marinus indicates that effects of habitat variables (e.g. rainfall, cattle grazing, vegetation composition etc.) may be of such magnitude that any effect due to B. marinus is trivial by comparison." There was also no effect of cane toads as predators.

As well as by its addition during invasions or purposeful introductions, the effects of a feral species can be shown by its **removal.** Jack Kinnear and colleagues (Kinnear et al. 1988, and this volume) removed foxes around some rock-wallaby colonies, while leaving foxes around others. They demostrated convincingly that foxes can play a determining role in the population processes of such rock-wallaby colonies. Such experiments are the best unequivocal evidence we could ask for that foxes suppress the population densities of some native mammal species.

The impact of rabbits upon vegetation, and on wildlife using that vegetation has been shown in a few removal experiments; yet in some no effect of removal of the rabbits could be found.

A significant fall in rabbit density following widespread control allowed Olsen & Marples (1992) to show that wedge-tailed eagles (Aquila audax), brown goshawks (Accipiter fasciatus) and whistling kites (Haliastur sphenurus) had suffered a decline in food availablility. This is experimental evidence for the positive impact of a feral animal upon natives: rabbits had been supplying food for the native raptors.

Experiments are valuable and we must look for opportunities to do more. Every time that the spread of a species is being monitored, we have the chance to treat the spread as an experiment. Every time a feral species' density is artificially lowered by control, we can gain another experimental insight into its impacts. Public groups, Landcare groups and local naturalists can contribute by taking part in full-scale surveys and monitoring of communities with and without feral animals.

Systems Ecology, Population Processes, and Management

Experiments demonstrate the impact (or lack of it) of the feral species in particular circumstances. They are a good start, but may not apply to all circumstances. For example, we could easily show experimentally that cats can have a severe impact on bettongs on an island; yet that does not mean that cats would similarly affect a bettong population on the mainland.

Any animal population exists as part of an interactive system. For as long as the population's birth rate matches or exceeds its mortality, it will persist. Most can survive fluctuations in both those rates.

We see a negative "impact" from a feral animal when it affects the balance of these processes so that they no longer maintain a population of a species. This always means that deaths and emigration from the population come to exceed births and immigration into it. Emigration is almost never the problem; the other three are.

We tend to focus on excessive death rates, because disease or predation have an abrupt and therefore noticeable effect. We tend not to notice that too few births are occurring. A population consisting of long-lived adults may take so long to disappear that we do not notice the process beginning.

A lack of immigration is more important in Australia than almost anywhere else. Because of natural fluctuations in rainfall and primary productivity, and in the incidence of fire, many of Australia's land animals persist through "bad" times as small scattered populations in refuges. When good times return, they expand from these to re-populate the now-suitable habitat by immigration. Anything preventing that immigration will prevent the community reforming.

Usually the barriers to that reforming are forest clearing, draining of wetlands, flood-mitigation works on rivers, and other forms of habitat destruction. But feral animals may create the "bad" conditions, or make them last longer or occur too frequently, or make immigration from refuges impossible. In this way feral animals can contribute to the impoverishment of remnant patches of habitat by preventing immigration between patches.

Animal communities on islands have proved very sensitive to feral animals. Cats or black rats destroy nests and chicks of ground or burrow-nesting seabirds, and rabbits destroy their nesting habitat. Such communities are vulnerable because immigration to them (to replenish the population after any period of heavy impact from the ferals) is slow or impossible.

Very simple communities are, in theory, also vulnerable to impact from ferals. Being simple, they lack alternatives: predators do not take the pressure off one diminishing prey species by switching to another; competing herbivores do not have a wide enough choice of plant species for each to select a separate diet; and so on.

Australia's simplest terrestrial vertebrate communities are on islands, in deserts, or in alpine areas and Tasmania. Communities in the alps and Tasmania have not yet suffered greatly from feral animals; those on islands and in deserts may have done.

Ideally management would be based upon an understanding of how interactions within an ecosytem affect the population processes of the component species.

Unfortunately, systems ecology has rarely reached that level of refinement, too little funding is devoted to it, and it sounds too complex to have strong appeal.

People like black-and-white directives for what to approve of and what to do. "Bilbies good; foxes bad. Therefore kill foxes; save bilbies" seems to be about as complex a message as the media feel the public can handle. The idea that killing foxes might release rabbits that then might compete with bilbies for critical drought foods is too complex to swallow.

Some scientists feel that they have to play the media game. A recent interview (in the Australian 26/8/1993, by Julian Cribb) quoted a scientist as saying: "Every fox-skin coat saves a bilby". This is self-evident nonsense. The vast majority of foxes shot for skins will live in the south-east of Australia so far from bilbies that their deaths will not relieve predation pressure upon bilbies one bit.

Such woolly thinking comes from poor problem definition. The scientist (a nutritional physiologist, not an ecologist) has effectively said: foxes kill bilbies, therefore killing any foxes will prevent bilbies being killed. The processes, the circumstances and the systems have been totally ignored. The idea is about as well focused as the national kangaroo cull as a cure for local pasture damage, or proposals for selling cockatoos overseas as a cure for a farmer's bird problems on his crops.

Feral animals (or plants) have their impact because they affect processes within systems. Until we pay more attention to systems ecology (which has been in decline these past 20 years; Shorrocks 1993), we will produce ad hoc solutions to poorly defined problems.

I admire the Federal Government's Feral Species Programme and am delighted to see it being funded, albeit meagrely. I pray that it will avoid the fox-and-bilby trap. I think it admirable that the ecology of feral pests should be researched, and that ways of controlling their populations should be sought. But I would like to see each project investigate the role of that feral organism in the interactive processes of a specified system.

In other words, I hope that the programme will seek more than just the quick techno-fix for each pest problem, and will invest in the longer-term safety of a deeper understanding of the processes within native Australian ecosytems.

Western Australia's Position

Western Australia is relatively fortunate, compared with the rest of the continent, and is in a unique position to serve the conservation needs of all of Australia. Some feral mammals, such as the rabbit and the fox, reached Western Australia later than the Eastern States. Consequently, their impacts have progressed less far, and remnant populations of some species that have disappeared from the rest of their ranges (e.g. numbat (Myrmecobius fasciatus)) have persisted long enough in WA for remedial action to be taken. The Western Australian government also has an impressive record of working actively to exclude invasion by other feral species, including birds such as starlings.

Excellent research has been conducted on feral species and means for their control by the Agriculture Protection Board and the Department of Conservation and Land Management. Co-operative efforts between these agencies and other land-managers have led to larger and more co-ordinated efforts to control feral mammal populations in WA than in any other State.

The widespread natural occurrence of sodium monofluoroacetate ("1080") in

plants of the genus Gastrolobium in WA has led to the evolution of a degree of immunity to this poison in native mammals. As a result, 1080 can be used for the control of exotic mammals more safely in WA than in the Eastern States.

Western Australia is also fortunate to have many off-shore islands which have not been invaded by feral mammals, predators in particular. Some of these islands have preserved native species which have otherwise been gravely threatened on the mainland. Maintenance of these islands, eradication of predators from others, and the use of feral-free islands to conserve populations of threatened mainland species, are all ways in which Western Australia can contribute to Australia's efforts to conserve its native wildlife in the face of threats from feral predators and competitors.

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FERAL PREDATORS: THE IMPACT OF THE FOX AND THE FERAL CAT ON NATIVE WILDLIFE

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Introduction

Basically this presentation will consist of a series of slides illustrating the kind of evidence we have which incriminates feral predators as threats to medium-sized marsupials. However, before the show begins I would like to briefly discuss how predators damage wildlife populations, and the problems we face in actually relating this damage to predators.

Feral predators can damage wildlife populations in a number of ways; here I will focus on two damaging actions:

1. Predators can over harvest their prey.
   As a result of this process, a prey population will decline and it may become extinct due to predation alone. In the case where a predator makes a prey species rare, then the risk of extinction increases greatly because of other causes and interactions.

2. Predators can greatly affect the living space and the distribution of a prey species. Predators can force prey species to live in refuges in order to survive. Refuges afford protection from predators and food is generally nearby; prey numbers are low. Such areas are not necessarily typical of a species' habitat requirements.

However if we are not aware of this predation effect, we may be mislead into believing that refuges are truly representative of a species' habitat requirements and so we manage the habitat accordingly. Such management practices are likely to be inappropriate.

In Australia, two avenues of research are open to conservation biologists; they can elect to ignore feral predators (and the predation process in general) or they can perform research whereby feral predators are controlled. If feral predators are having a significant impact, the results and conclusions of the latter will be markedly different from the former (i.e. no predator control). The onus is on the researcher to justify his or her approach.

Predation: Establishing Cause and Effect

To demonstrate that predators are causing damage to native wildlife is not easy. Ideally, in studying the impact of foxes on a prey species in a nature reserve, we would like to collect this sort of information:

> One would like to have a complete record of every kill for each and every fox (and/or cat). To add to this difficulty, we would also like to simultaneously monitor the changes in numbers of prey and predator over time - a tall order indeed.

Carrying out the above is a very formidable task. If we could do this we could then predict unequivocally the damage caused by a predator and whether it is truly a threat. There would no room for disputes.

It is doubtful that this will ever be done without advances in radio-telemetry.

Attempts to develop such telemetry have been encouraging, but funds are currently lacking. It should be pursued. A valuable spin-off of this technology would be in the area of disease transmission by ferals and the implementation of microbial-aided fertility control of feral pests.

Predator Removal Studies

Fortunately we can gain some insights regarding the damage that predators do by removing them. Let us assume that the fox is doing damage, so why not get rid of it? If the fox is the culprit, the damage to wildlife populations should stop. Wildlife will increase and utilise areas away from refuges.

However we lose certainty; the downside to predator removal is that the evidence one collects is not as conclusive as one would like for it is indirect. Thus different interpretations and conclusions can be derived from such data. Indeed one prominent overseas academic dismisses predator-removal experiments as trivial.

So without an apology, I am going to present some trivia. I will show you some slides illustrating the response of some marsupial populations following the removal of feral predators particularly the fox. I leave it to you to form your own interpretations and conclusions.

However, before we have a look at these slides, a few words about how we remove foxes. We are able to remove foxes by laying 1080 poison baits. The baiting procedure is the product of much research by the APB and CALM. The baits are target specific for foxes and feral cats and do not pose a risk to native wildlife or the environment. I won't dwell on this contentious subject further because of time limitations. Additional information can be found in articles published in CALM's *LANDSCOPE* magazine and on poster displays.

[A series of slides were shown that illustrated dramatic increases in medium-sized marsupials following removal of the fox.]

The Feral Cat

So far my discussion has focused on the impact of the fox. The fact is that we have two exotic predators at large over much of Australia and this greatly complicates things. Indeed the faunal responses that we have observed may well be due to the joint control of both the fox and the feral cat. This is a limitation inherent in predator removal experiments; the removal technique at this stage is not selective enough.

I am not aware of any feral cat removal experiments comparable to the fox studies. However, circumstantial evidence abounds: feral cats have been shown to be damaging predators of rufous hare-wallabies, burrowing bettongs, golden bandicoots, rock-wallabies and just recently, bridled-nailtail wallabies. Feral cats

are linked to the extinction of mammals on Dirk Hartog Island and the Montebellos.

However unlike the fox, there is an absence of pattern. Wherever the fox is present the fauna has declined, but this is not invariably so for the feral cat. Tasmania is fox-free but has feral cats yet the fauna is intact and relatively abundant. Likewise for Kangaroo Island. Locally, Garden Island supports a high-density tammar wallaby population in the presence of feral cats. Cats have been resident on Rottnest probably since settlement, but we still have quokkas in abundance soliciting handouts as any visitor to the island will testify.

There is no doubt in my mind that the cat is a threat, but clearly more research is needed regarding the impact of cats on native fauna. It is pleasing to note that research programs are underway across Australia thanks largely to the Australian Nature Conservation Agency (ANCA).

Concluding Remarks

In closing I would like to make these points.

I would like to acknowledge the financial support provided by ANCA. This support has been forthcoming despite the fact that some respected scientists have adopted the view that the case against feral predators is not all that convincing.

The control of predators by baiting should be viewed as a holding action. What we really need is wide area control but this can be achieved only by some form of biological control. Biological fertility control research is in progress in Australia. It must be appreciated that biological control research is high risk research and failure cannot be ruled out; we must realise that it needs to be pursued and supported until a solution is found.

Meanwhile it is important that we identify the full range of the fauna at risk because of predation and these species should be made secure from feral predators. This means that traditional control methods must be maintained, improved and expanded, and made as cost-effective as possible.

If we don't do this then we will surely lose much of our medium-sized marsupials, the malleefowl and perhaps other ground dwelling/nesting birds. In ecological terms, the feral predator-prey relationship is an unstable one signifying that the fauna has not reached an equilibrium or balanced state even after 80 years of exposure to the fox and even longer for the cat. In other words, the extinction light is still on, and we must switch it off.

FERAL BEES: THEIR POTENTIAL EFFECT ON THE NATIVE INSECT FAUNA

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Australia's most abundant feral animal

The honey bee, Apis melifera is perhaps the most abundant and obvious feral animal in Australia. Its effect on the native fauna has been the subject of debate for decades (Pyke 1990), with the beekeeping industry maintaining that its effect is minimal, a position accepted by public opinion, while natural historians contend that the impact of bees on natural ecosystems is severe. This paper concerns the interaction between feral and hive bees with native insects. The discussion has two main parts. First, I emphasise how the introduction of any foreign organism will have both beneficial and detrimental effects on the natural ecosystem; for after its introduction the ecosystem will never be the same. I build a case, more easily recognised by those involved in agriculture, where the introduction of "beneficial" organisms has a marked and often dramatic effect on the target commercial species. This is Biological Control, and there are many very successful examples in Australia of its implementation. I argue that the introduction of Apis melifera may have had no less effect than many of these agents.

The second is to highlight the sensitivity of the invertebrate community to any form of change. The effects of altering the balance of species within an invertebrate community can be compared with the more obvious effects of vertebrate feral animals on the native mammal fauna. But insect biology is poorly understood, seldom recorded and has little to no political influence. Few care about an extinct insect, particularly species that are small, or so poorly coloured as to avoid public or even scientific scrutiny. In this paper I describe a simple experiment that demonstrates how feral bees exclude at least three insect species from a limited nectar source in the late summer in a reserve close to Perth. I suggest that if repeated, this experiment, because its protocol is simple and is easily controlled, could be used to build up a case for the eventual management of feral bees.

Biological Control - the necessary introduction of non-native insects

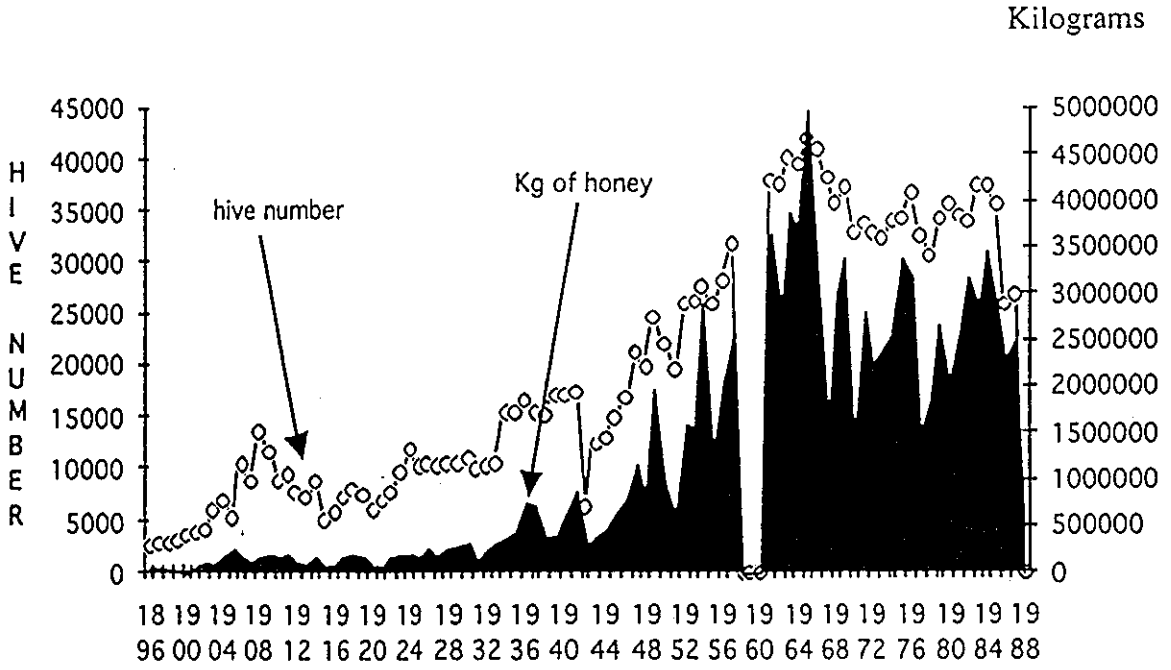
The introduction of any biological controlling agent demands, in today's ecologically sensitive political arena, extensive research as to its possible side effects on man's economy. The worst case scenario would be for the introduced organism to escape from its initial use and become feral, perhaps decimating a national investment. Commercially available beneficial pathogens are screened, as are insects that reduce the impact of weeds or the outbreak of pestiferous insect species. Indeed, screening is so exhaustive that it may be years before the final release is made and in some cases this is never achieved. The reasons for this are plain and there are salutary examples of beneficial organisms themselves becoming pests.

No such sensitivity belonged to our early migrant forebears. Animals, including invertebrates were introduced for pleasure, sport or commerce and it was assumed that anything native was of less value. Yet, strangely, the fundamental concepts of Biological Control were far from novel and the impact of introduced organisms on pest species was well known to agriculture and science. Indeed the

introduction of controlling organisms was a more usual and effective means of insect control than the use of insecticides, which only really began to dominate agriculture after the second World War.

The hive bee, Apis melifera, was part of this seemingly innocent list of introductions during the middle of the 19th century, and the number of hives has increased in Western Australia ever since (Manning 1989 Fig 1). But hive bees swarm, and unless there is strict control over the domestic or commercial hive, the swarms become feral. These swarms form new nests is tree hollows and refuges of gardens, reserves and National Parks. Over time they lose the carefully nurtured genetic stock of the professional apiarist and they are, in essence, wild. Strangely, the impact of feral bees on our native biota has hardly been measured and one reason for this is that unlike the release of present day Biological Agents, where the onus of proof is on the releasor to demonstrate no deleterious effect, with the feral bee, the onus of proof of impact is on those concerned with, and responsible for, the native system. For example, Rob Manning, Research Officer and apiarist with the Western Australian Department of Agriculture, states (Manning 1989) that "unlike other exotic feral animals such as rabbits, pigs, goats, starlings and cane toads, honey bees have few physical effects on the environment that are visible and measurable." The assumption of those in the industry is that the effect of bees is minimal.

Fig 1. Honey production (Kg) and productive hive numbers 1896 - 1987. (1958 - 1960 no available data). (After Manning 1989)



Recognition of the adverse impact of introduced plants and animals on the natural biota is beyond question, and this workshop has been formed to examine such issues. For example, few would now defend the presence of the fox or goat or rabbit as a natural part of our ecosystem. But such a view was not current thirty years ago where, for example, the press, in the same paper as that describing the opening of the Tutanning nature reserve in Pingelly (see Kinnear, this volume, for a discussion on fox eradication in this reserve), records with great sensitivity

the relationship between a young boy and his pet fox. Now we are aware of the terrifying effect of such animals on our native fauna and we have no hesitation in applauding their removal. Perhaps in twenty years time, such basic arguments as developed in this essay will be unnecessary and steps will have been taken to manage feral bees.

Experimental studies of the interaction between Apis melifera and our native insect fauna are surprisingly rare in this State (e.g. Douglas 1977; Wills et al. 1990), although studies have been carried out in the Eastern States of Australia (Goebel 1987, Sugden & Pyke 1991) and New Zealand (Donovon 1980). There have been a number of studies quantifying the effect of feral and hive bees on the pollination system of many of our native plants (e.g. Bell 1985; Wills et al 1990), but few have targeted species with the view of measuring changes in the reproductive effort of affected insect species.

Current ignorance of WA's insect fauna

One reason why so few studies have been carried out on the effect of feral and hive bee on our native insects is that we know so little about our endemic fauna. The public are invariably surprised when told that one quarter to one third of our native invertebrate fauna is undescribed. Indeed in certain, less worked groups, this proportion may be as high as 80% and government concern for such a precarious position is such as to downgrade our national effort in regard to taxonomy. Museums are receiving less and less of the national research budget and CSIRO's Australian National Insect Collection in Canberra has received such severe cut backs in recent years as to make its function, as a repository and identifier of our native insects, almost unworkable. Yet major developments take place that involve the modification or reduction of native vegetation and invariably decisions are based on the potential impact on the vertebrate fauna. As a consequence, policies formed by land managers, often with the best of intentions, are established on guess work, and those non-scientists making the economic decision claim that it is up to the biological scientist to say otherwise. But even recognition of our vertebrate fauna, as having any value along side economic development is only a recent political phenomenon. For example, our biological understanding of one of the symbols of conservation in WA, the Numbat, has only been possible through a funding program established in the last decade.

The examples of insect/insect interaction, and insect/plant interaction referred to below are at the other end of the spectrum of biological ignorance. These insects have been hardly worked, poorly described and they have no public image. Yet they are as much part of our native fauna as the Numbat.

How sensitive is the natural system - managed changes

The insect fauna of Western Australia not only has a high degree of endemism but has been separated from the rest of the world for millennia. As such, we may reasonably assume that it is fragile and therefore sensitive to disturbance and perturbation. It is also reasonable to expect that because of the high number of localised species, often existing on islands of remnant vegetation, the stability of these long evolved relationships can be easily disturbed. But in Australia and other countries, the introduction of Biological Control agents have had dramatic effect on target organisms, and in some cases, where studies have been carried out, such managed introductions have impacted on the native fauna. If successful Biological Control agents can have such a catastrophic impact on target organisms, it is reasonable to assume that the introduction of a large, aggressive insect such as the hive bee will have an equal impact on the native ecosystem. It has been the dominant user of nectar for over a century, and sadly we have no

good records of its effect. I provide two simple scenarios of the possible impact of insect management on largely unknown insect species.

Manipulation through Biological Control

Based on experience of insect Biological Control, a few hundred minute parasitoid wasps brought in from California could alter the economics of citrus, lupin or clover within a few years. Where these crops form part of a major horticultural industry the effect can be measured in millions of dollars. One classic case is the control of Californian red scale in California at the turn of the century (Debach and Rosen 1991), where scale insects, once abundant on fruit were brought under control within a season. This form of biological control, as part of an essential horticultural industry must be considered beneficial. But these wasp parasitoids may also attack native scales closely related to the target species. Such scales, in the natural ecosystem, would have no economic value, and indeed may not even have been described by science. The effect of these secondary infections will therefore go un-noticed, largely because no one has studied the native scale fauna. Further, the native scale will have its own species of wasp parasitoid, and this species, under competition from the useful introduction may also become locally extinct. Again, nobody will know and few will care, and therefore, for sound economic reasons there will be two local extinctions. Evidence of local extinction of native parasitoids is reasonably well documented in regions of the world where introduced fruits, such as citrus, have local indigenous plant species with their own naturally occurring control systems (Debach and Rosen 1991).

Disturbing a natural ecosystem - the Jarrah Leaf Miner

In Western Australia, the native Jarrah Leaf Miner has a suite of natural controlling agents ranging from minute parasitoid wasps to birds (Mazanec 1987). Zan Mazanec (CSIRO) has documented the influence of a guild of 8 parasitoids on populations of Jarrah Leaf miners for over 20 years (Mazanec 1988), and it would appear from his researches that where these "controlling" agents are removed, population number may reach outbreak proportions (Mazanec 1974). The Jarrah Leaf Miner is an important ecological component of our forest system and because it can have such a devastating effect on trees has come under considerable scrutiny. But the biology of the controlling agent is hardly known and at the time of Mazanec's study many were undescribed.

We do know that for a female parasitoid wasp to lay her eggs she first must take in carbohydrates usually in the form of nectar. These carbohydrate sources are usually flowers within the understorey of the forest, but we have no idea as to which flowers are important and no understanding of the influence of removal of the understorey on such organisms. Parasitoids, like many predators are rare and it could be that forest management by periodic burning, or even the presence of feral bees competing with nectar sources within this depleated understorey, may prevent these wasps from feeding (Mazanec 1988). The onus of proof will continue to be on the entomologist to make a case against a well funded industry or government body.

These two examples reveal a possible impact of the most basic form of disruption. But these examples cannot be used as counter evidence in the debate regarding the possible control of feral bees; the evidence is unsubstantiated and therefore must be dismissed. At best these two examples infer that the presence of any foreign organisms within a balanced ecosystem will disrupt it, leading to the exclusion of some species with which it competes either directly, or indirectly through biological interactions with other associated organism. There is a compelling need for experiment.

The following experimental approach tests the degree to which feral bees displace native insects from a flower source. The experiments are simple and easily repeated by workers with the most basic of skills. These simple experiments can be achieved by the classroom teacher with little to no knowledge of the insect world.

An experiment

Surprisingly, it is extremely easy to test hypotheses regarding the impact of one organism on another. The most basic ecological experiments, carried out with the minimum of resources, will tell the experimenter something about the biology of the system. I illustrate this with a simple exercise carried out by a group of students from the department of Zoology at the University of Western Australia.

Native insect displacement from a restricted nectar source.

Mere changes in insect abundance may have little to do with the presence of bees. Insects, foraging for nectar will show species' specific activity patterns that may vary during the day. Most show preferred foraging times that will depend on the weather, allowing insects to fly within certain temperature limits, and on the plant, when it is producing sufficient nectar in a form accessible by the insect. Virtually all diurnal insects show different levels of flight activity during the hours of sunlight and so estimating the activity of nectar feeding insects around a flower source may be compounded by changes in deil activity. Following this pattern and assessing abundance against, say the presence or absence of bees could lead to erroneous conclusions. Insect numbers may decline, not because of the presence of bees but that it is coming to the end of a species' flight activity. It is important then to design an experiment that caters for this change in relative abundance.

The study site, used for this experiment, was at the Harry Waring Marsupial Reserve at Jandakot, south of Perth, Western Australia. The experiments were carried out in March when flowering on the reserve was low and nectar sites few. The reserve is dominated by Banksia/Eucalyptus marginata woodland with a varied understorey of Astartea sp. Boronia crenulata and Pultenaea reticulata. The low spreading Leucopogon propinquus, which was the target species for these experiments, produces, between February and June, masses of small bell shaped flowers. These flowers were the only nectar source observed within a 100m radius of the experiment.

The bush used for study was therefore isolated and 1.5 m tall. It was shaded by Banksia before mid-morning and again in late afternoon. Insect foraging activity was rare during these times and so observations were carried out between 11.30 and 15.15 over six days. The experiment was repeated the following year with a slightly altered format. One year's data are presented in this discussion. Air temperatures were close to 30^{0}C and days were sunny and warm.

Initially, all pollinating species of insect were noted and sub-sampled over the entire period of study until recaptures of the same species no longer occurred. The collected insects formed "voucher" specimens and were later identified to the lowest taxonomic level. For the purpose of the experiment, however, the names of individual insect species are not necessary.

Feral bees were removed by aspiration. An aspirator, or pooter, is a glass tube into which insects may be sucked through a long piece of rubber or pvc tubing. A second tube leading to the mouth is covered with gauze to prevent the experimenter inhaling the insect. In this way insects can be removed from the plant with minimum disturbance. In the case of feral bees, recruitment from the hives is slow as bees signal to their nest mates the best sites of nectar. They do this

by remembering the locality of the site in relationship to the sun/sky, then fly back to the hive and pass on the geographic information, such as its direction and distance, to other foraging bees. If they are prevented from returning to the hive, fewer and fewer bees attend the site, and eventually the nectar source is only visited by occasional foraging scouts. Bees, so collected, were retained in a cage for the duration of the day, and then released. After the initial removal, further removal of bees need only take place each 30 minutes.

The experiments were conducted over 4 days where the weather conditions were similar between days. During the first count on the first day, all insects visiting the plant were identified from the voucher specimens and counted. Counts were also made of feral bees. On the following day, feral bees were removed and again counts of visiting insects were recorded within a 30 minute period. This paired sampling was repeated over 3 days.

Results

If bees had no influence on the foraging activity of native insects, then the counts of insect abundance of each species would be similar: there would be no significant difference in mean (n = 3) visitations. Table 1 shows data from one year's sample over 6 days.

When feral or hive bees are excluded from a limited nectar source during the middle of a late summer's day two species of native bee, Campsomeris sp. and Nomia sp. increase in numbers at the plant. In addition the number of an unknown species of Diptera also significantly increases. Notably, the mean number of nectar feeding insects remained remarkably constant over the three days (a feature of the repeated experiment the following year). This implies that each flower-bearing plant has a finite load for nectar feeders.

Many insects were present at the site in low numbers and variation in the number of individuals of these rare species visiting the site varied between each sample. There was no significant difference between the control, when bees were allowed to the site (3 days), and the experimental exclusion (3 days). Other genera, such as Bembix are large insects and it may be reasonable to expect that size may have been one factor in between species difference in response to bees. Although not carried out as part of these experiments, such an hypothesis is testable. The numbers of Bembix appears unaffected by the presence of feral bees.

Figure 2 Visits to Leucopogon propinquus by two species of Hymenoptera before and after removal of feral Apis melifera. (Nomia sp. before: dark stipple; after: light stipple; Campsomeris sp. before: absent; after black)

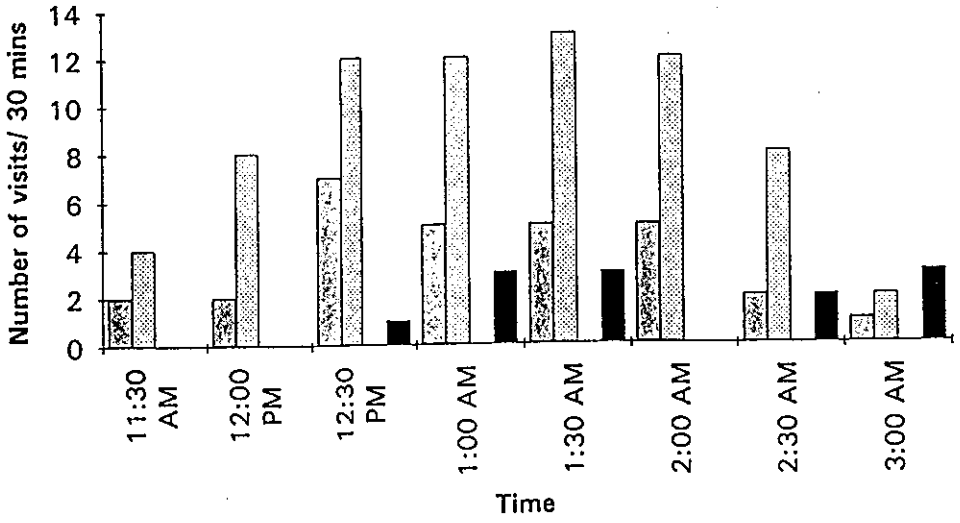


Figure 2 shows the variation in flower use over time by two species, Campsomeris sp. and Nomia sp. Clearly foraging activity changes over time, and therefore by sampling each 30 minutes while removing feral bees data can be collected on visits before and after bee removal. As indicated above, Nomia is strongly influenced by the presence of bees on each sampling period. Campsomeris, which appears to be completely excluded from the plant by bees is present during the afternoon, albeit in low numbers.

Discussion

Two features of this experiment are worthy of comment within the current debate. First, is the extraordinary diversity of hymenopteran fauna present at this nectar source. These insect were the "macro" foragers and only those that could be captured easily by a pooter were scored. There were others, far smaller and the biology of all these species, both hymenopteran and dipteran is hardly known. We have also excluded the day-flying micro-Lepidoptera. Wills et al (1990) found that 70% of the 51 autumnal flowering species in the Northern Sand Plain, an area recognised as a bee-keepers reserve, were visited by both native and honey bees. The most abundant species of Hymenoptera in this situation were species of the genera Leioproctus and Hyaleus but no records were kept of other visiting insects.

The second, unequivocal conclusion from this particular experiment was that at least three species of insect are excluded from the nectar source by feral bees. But when nectar flows are significant, competition for nectar sites may be weak, and hence any evidence of exclusion may not be so obvious. It is therefore important to carry out these experiments when nectar sources are low; the criterion for competition is that the resources for which participants are competing must be limited, in quality, quantity, space or time. For example, Sugden and Pyke (1991) found no appreciable effect of competition with feral/hive bees on the reproductive ability of the native bee Exoneura asimillima in the Eastern states of Australia. In this case, there was no evidence that nectar sources were limited and they conclude that any lack of evidence may be attributable to the abundance of nectar.

The experiments carried out at the Harry Waring Marsupial reserve were on nectar sites that were rare and apparently under extreme competition between species. This is the most compelling evidence that bees, subject to low food sources will be under severe pressure to obtain sufficient carbohydrate to survive.

The energetics of foraging

Why should insect forage, and just how far can they forage? Metabolic consumption during flight is significant, and therefore insects, like any other highly mobile organism will apportion, or budget, energy between flight activity and the amount of sugars it can take on board. Insects that actively forage, in order to build up reserves for developing eggs, or searching for mate and oviposition sites, will use energy. Deprived of this energy, they may use sub-optimal egg laying site or may never find their mates. Their numbers will be reduced as the nectar sources become more difficult to use. In certain areas plants that have coevolved with their insect partners are removed, these flower-dependant species may die out. Where these insect species impact, perhaps as predators on other insects, the biological equilibrium may be disturbed and we could see the manifestation of this disturbance in outbreaks of plant-damaging species.

Honey bees by comparison are robust, have a wide acceptance of flower types and above all have the ability to store honey. When nectar is abundant, competition for nectar sources may be unusual, but many insects are abundant during the long hot and dry summer months when only certain species of flowers are

available and so nectar sources may be highly restricted. It is during this time that we should be examining the interaction between hive/feral bees and the native fauna they may displace.

Should we exclude bees from reserves and parks

This emotive debate has ranged for many years and it is reasonable to suggest that National Parks should be cleared of feral animals and this includes bees. Matthews (1984) suggests that the opening of parks to the apiary industry is no different from opening reserves to cattle or sheep. The argument is reasonable and politically acceptable if not rather impracticable. But what happens to the flora once the bees have been removed? We have little idea as to the historic effect of the introduction of bees to these areas, and we hardly know what species of insect are present today. We certainly cannot speculate on what may have been removed by over 100 years of feral intrusion, and so without the original pollinators certain plants may loose their hold in some plant communities.

Experiments are possible that test hypotheses regarding the presence or absence of pollinators on local plant species' abundance. The most basic data could be collected on the reduction of species number within selected plant communities. King's Park is contemplating the removal of feral bees as part of its management program. This affords those with money to invest in conservation an opportunity to test a number of hypotheses; it has the mark of a classical experiment. Botanists with an understanding of pollination may be able to target certain native plant communities or species that appear dependant on the hive/feral bee for pollination. Could these species survive without this introduced pollination? Again we may hypothesise that the removal of the common pollinator will reduce the levels of abundance of certain species while others become more abundant. But native pollination-dependant species will die out altogether because the original pollinator, to which the plant species was co adapted, has been lost in time.

At another level, funds could be made available for education. School children could carry out simple natural history experiments, similar to those described above, designed by a coordinator and supervised by the teacher. Such experiments may identify species of insect that are affected by feral bees. This would add to our knowledge of insect pollinators across the state and in many different habitats. I have shown how three species of native insect appear excluded from one plant, Leucopogon propinquus. These insects may not be heading for extinction, but the prospect is there, and for the inquiring mind, the educator can set the seeds of an awareness that feral bees are indeed feral and that they may impact on other organisms. The take-home message for the student may be an awareness of nature, but it may also cause a shift from considering Apis melifera as a benign friend to a realisation that this introduced animal has modified our ecosystem, perhaps in much the same way as the sheep, cattle, rabbits or even the fox.

Acknowledgments: This paper is delivered by an entomologist with no direct involvement in the feral bee debate. I am therefore grateful for the many who have provided ideas and papers before and after the workshop. To Rob Manning who kindly wrote me concerning issues raised at the workshop and for providing me with considerable information on the position of the beekeeper in WA. I would thank Alan Kendrick whose student researches in 1983 have finally found the light of day, albeit in a form he would not have envisaged.

Table 1. Mean number of visits of all insects over 3 days where feral bees were excluded and over 3 days when all insects were allowed to visit Leucopogon propinquus (Data from student field project - acknowledgement to Alan Kendrick: all identifications were carried out with thanks to T. Houston.) (Significance: * = $p < 0.05$; ** = $p < 0.01$; NS = Not Significant.)

Pollinating insect	Mean (n=3) No. Visits - Control	Exclusion	sig. t test
Apis melifera (Apidae - Hymenoptera)	204	Excl	
Nomia sp. (Halictidae - Hymenoptera)	89	206	* *
Campsomeris sp (Scoliidae - Hymenoptera)	2	43	*
Megachile sp (Megachilidae - Hymenoptera)	4	4	NS
Leioproctus sp (Colletidae - Hymenoptera)	2	0	NS
Ephutomorpha sp (Mutillidae - Hymenoptera)	4	0	NS
Bembix variablis (Sphecidae- Hymenoptera)	15	21	NS
Prionyx globosus (Sphecidae - Hymenoptera)	3	6	NS
Tachytes sp (Sphecidae - Hymenoptera)	0	4	NS
Tachyspex sp (Sphecidae - Hymenoptera)	25	9	NS
Spp? (Bombyliidae - Diptera)	1	0	NS
Spp ? (Syrphidae - Diptera)	4	4	NS
Diptera (sp 1)	39	65	*
Diptera (sp 2)	8	5	NS
TOTAL	400	367	

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TRANSLOCATED AQUATIC SPECIES IN SOUTH-WESTERN AUSTALIA: a review and some prescriptions

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Introduction

The south-western part of Australia is remarkable biogeographically, being characterised by a high diversity of endemic plants. To a certain extent the same could be said for aquatic species[1] (while for some reason the actual diversity of aquatic species appears to be low compared to other temperate climates in the world [Bunn and Davies, 1990], endemism is high). For natural distributions, most of the frogs and fish, all the freshwater crayfish, most of the caddis flies, mayflies and stoneflies, all the temnocephalan flatworms, for instance, that are found in South-Western Australia, are found nowhere else (although their close relatives are found in the south-eastern part of Australia)(Allen 1982; Dean, 1987; Hynes and Bunn, 1984; Main, 1965; Riek, 1967). The aquatic fauna support the notion that the south-western part of Australia is ecologically distinct. In addition, like the other elements of the biota, even within the south-west we find patches or areas where endemism is even more localised. The extreme south-western coast is an excellent example, like the region around Walpole.

There is every reason why south-western Australia should be like that, from an aquatic point of view. It is a region incorporating the coolest and wettest part of the driest half of the continent. The region does not share surface or subterranean water with any other part of Australia; it has been isolated from similar climates in South-Eastern Australia by desert. Deserts usually present a formidable barrier to aquatic animals; only species which have resistant stages in their life cycle or can disperse long distances can move between the two areas.

There are two implications of this for the translocations of aquatic species. The first is that the south-west has had a period of time for species to evolve into unique and valuable ones in the Australasian context. The second is that up until 3-400 years ago (since the Dutch) the assumption is that the aquatic fauna was relatively stable in terms of new arrivals. Boats and motorised transport have changed all of that, so that we now have an assemblage of introduced aquatic species as well.

Known Translocations of Aquatic Organisms

Species have been moved from other continents, other parts of this continent, and other parts of the south-west, to have free release and establish feral populations. Some have been introduced intentionally but no longer, some

1 In this paper I will deal mainly with issues and examples from aquatic habitats in inland areas, but the issues covered should be applicable in a broad sense to estuarine and marine conditions.

continue to be intentionally released, and some other releases have been accidental.

Table 1 shows some of the known examples of freshwater species which have established themselves in the south-west. Some of these species will be dealt with later in the paper, but briefly one which needs highlighting here is the snail Limnaea columella which is causing agricultural concern because it is the introduced host of the sheep and cattle liver fluke.

TABLE 1. Freshwater organisms introduced and now established in South-Western Australia

(Sources Austin 1985, Cannon unpubl., EPA 1992, Ponder pers. comm., Williams, 1980, Allen 1982)

Species		Place of origin
FRESHWATER FISH		
Goldfish	*Carassius auratus*	Asia
Redfin Perch	*Perca fluviatilis*	Eurasia
Brown Trout	*Salmo trutta*	United Kingdom
Rainbow Trout	*Oncorrhynchus mykiss*	North America
European Carp	*Cyprinus carpio*	Eurasia
Gambusia	*Gambusia holbrooki*	South America
Tilapia	*Oreochromis mossambicus*	East Africa
FRESHWATER CRUSTACEA		
Yabbie	*Cherax destructor* group	Eastern Australia
FRESHWATER MOLLUSCA		
Snail	*Physa acuta*	Europe
Snail	*Limnaea columella*	
OTHER FRESHWATER INVERTEBRATES		
Flatworm	*Temnocephala minor*	Eastern Australia

Table 2 shows those marine and estuarine species which are known to have been translocated and become established; the list is undoubtedly underestimated. With the exception of the brine shrimp which has aquarium/aquaculture origins in WA, there is almost no doubt that all of these species have arrived by one of two related mechanisms, either by carriage and then release in ballast water of large ships, or as part of a fouling community on the hulls of boats which have sheltered in our ports and estuaries.

In Table 3 I have included examples of native species which have been moved out of their range, and the importance of this will be outlined below.

TABLE 2. Marine and estuarine organisms introduced and now established in South-Western Australia

(Sources: EPA 1992, Lawrence 1993, Pollard 1990, Slack-Smith and Brearley 1987, Wells and Bryce 1993)

Species		Place of origin
MARINE FISH		
Japanese Goby	*Tridentiger trigonocephalus*	Japan
Sobaity sea bream	*Sparidex hasta*	Arabian Sea
MARINE CRUSTACEA		
Brine Shrimp	*Artemia salina*	N. Hemisphere
Barnacle	*Megabalanus tintinnabulum*	
Barnacle	*Megabalanus rosa*	Japan
Isopod	*Sphaeroma serratum*	
Isopod	*Paradella dianae*	America
Isopod (sea lice)	*Cirolana hardfordi*	USA
Shore Crab (European)	*Carcinus maenas*	Europe
Pear Crab	*Pyromaia tuberculata*	Eastern Australia
MARINE MOLLUSCA		
Nudibranch	*Gadiva quadricollar*	
Nudibranch	*Polycera hedgpethi*	USA
Asian Bag Mussel	*Musculista senhousia*	Asia
OTHER MARINE INVERTEBRATES		
As yet unspecified hydroids and ascidians from fouling communities.		

TABLE 3. Examples of endemic freshwater organisms deliberately translocated within South-Western Australia.

Species		Purpose
Marron	*Cherax tenuimanus*	Aquaculture
Koonacs	*Cherax preissii*	Aquaculture

Impacts of Feral Species in Aquatic Waterways

The impacts of feral species in aquatic waterways can be extreme; translocations of organisms may lead to a loss of genetic diversity, bring with them other species, alter habitats for native species, cause massive biomass shifts, alter community structure, and eliminate other species. These impacts lead to degradation of aquatic systems and loss of aquatic values.

Genetic Implications

The genetic implications of translocations are at least two fold. If an introduced species is represented by more than one strain and if interbreeding occurs between strains, the locally adapted hybrid *can* have a vigour which gives the introduced species the capacity to colonise areas where previously it couldn't. This has happened in South-Eastern Australia with strains of the European Carp

(Arthington 1991). Alone it is a valid reason to prevent further translocations of feral species already found in South-Western Australia.

Another consequence is that of "genetic pollution". Of potentially serious consequences is the translocation of marron within its range. This species has a natural distribution in the extreme south-west of Western Australia (Morrissy 1978) where it occurs in permanent waters. Its suitability for aquaculture has resulted in it being translocated widely within Western Australia (and incidentally to just about every other continent). In the mid 1980s two distinct forms of marron in South-Western Australia were identified as subspecies (Austin 1986, unpubl.). One subspecies is endemic to the Margaret River system, and the other is more widespread and appears to be the form which has been translocated so extensively. The concern raised stems from the likelihood that if within state translocations continued unabated then the two forms would interbreed and significant genetic and morphological variation would be "lost, or made unavailable" by hybridisation (Horwitz 1990). Sadly the circumstantial evidence indicates that this is already occurring in Margaret River.

Introduction of Other Species
Another impact is that of the introduction of other species with the translocated individual. These include pathogens (diseases), parasites, symbionts, and other incidental species. The principle behind this notion is that translocations never occur in isolation; you can never introduce just the individual animal and any animal will bring with it a host of passengers. Possibly the most serious of these are diseases. At least two feral species in the south-west have the potential to bring with them diseases we do not want; goldfish can harbour the bacterium Aeromonas salmonicida, causing goldfish ulcer disease. Redfin perch harbour epizootic haematopoietic necrosis virus which is pathogenic to native species and commercial species as well. Both of the diseases are in Australian populations already (Arthington 1991, Langdon 1989).

Other aquatic organisms arrive this way too. The temnocephalan flat worm Temnocephala minor is widespread on the yabbie from Eastern Australia. This has now been isolated from marron in marron farms in Western Australia and also from marron being bred in Japan. Such incidental and symbiotic translocations are serious if they can be implicated in the fitness of hosts in their new environment or if they spread and become pests in their own right.

Alteration of Natural Habitats
Some species are known to physically alter the habitat, and the most pronounced of these is the European carp which can move sediment and alter vegetation patterns.

Alteration of Community Structure
The *Trophic cascade theory,* or the *theory of biomanipulation* when it is applied to manage waterways, is based on the principle that food webs are irrevocably linked and altering one component can have ripple effects throughout the community. For instance in a simplified aquatic food web phytoplankton are eaten by the zooplankton which are eaten by the fish. If a fish which eats zooplankton were to be released, it might proliferate and lead to a decrease in the amount of zooplankton. This then means that phytoplankton can proliferate and in some cases this is exactly what we don't want, particularly when the phytoplankton are blue green algae and the water body is nutrient enriched. *Biomanipulation* aims to increase zooplankton numbers by getting rid of plankton eating fish directly or by introducing a predator which will eat fish. Redfin perch and Gambusia have both been implicated in phytoplankton blooms

in South-Western Australia because they eat zooplankton but detailed evidence for these effects have not yet been established.

There are other implications of considering ferals in the context of food webs. Gambusia was introduced into Australia from South America to control mosquitoes; it is now resident more or less throughout the south-west, and abundant in some lakes on the Swan Coastal plain. In Lake Jandabup, for instance, Kim Richardson and I conservatively estimated that some 20 million fish were in the Lake in November 1992. Assuming that the average weight of these fish was 0.5 g, then this represented 10 tonnes of Gambusia. Applying the rule that 90% of biomass is lost as energy as you go from one trophic level to the next, this means that the ten tonnes represents one tenth of the food which the fish have eaten. So this batch of Gambusia have consumed 100 tonnes of invertebrates and zooplankton in Lake Jandabup. To a lake without a native fish this must be considered to be a significant impact on an aquatic community.

Elimination of native species
This can occur either by competition for space or food, by aggressiveness, or by predation. It has now been conclusively demonstrated that trout have eliminated native fishes from water ways in South-Eastern Australia and trout are principle offenders in the demise of Australia's two most endangered galaxiid fish. Locally it has been hypothesized that a causal connection exists between the presence of redfin perch and the decline of native fish. For instance Pen and Potter (1992) demonstrated that under certain extreme circumstances in the rivers of the south-west predation by Redfin perch could result in threats to the conservation of indigenous fishes. Likewise, Hutchinson (1991) demonstrated a substantial range expansion of redfin perch in the Murray River at the same time as range contractions of native fish species. The circumstantial evidence for these effects are substantial, even if the mechanisms of the interactions (and the role of habitat disturbance, see below) are not entirely understood.

The Control of Feral Aquatic Species

There are two components to the control of feral species: the *prevention* of more invasions, a difficult task in its own right, pales into insignificance next to the *eradication* of existing species.

The prevention of more invasions
Three documents are important to us when deliberating over whether to continue the practice of introducing aquatic species into South-Western Australia. They are the IUCN's position statement on translocations of living organisms (1987), the European code of practice and manual of procedures for marine and freshwater organisms (Turner 1988), and the Western Australian Fisheries Department's recently released Discussion Paper (Lawrence 1993). From these I've taken three key concepts which I consider to be important in the prevention of unwanted or inappropriate introductions.

1. *There should be no distinction between species proposed for introduction into a natural ecosystem and those proposed for enclosures*

Adopting this concept is important because escape of aquatic organisms from enclosures (be they aquariums, tanks, dams or sea cages) is inevitable. There is so much evidence from South-Western Australia, the rest of Australia and the rest of the world to support this. This means that any translocation should be examined in the context of the damage it could do in the natural environment. The international community is here placing the onus on those who make decisions to provide thorough and convincing argument that their actions will not have significant adverse environmental consequences.

The second important concept is that before any consideration is given to a translocation, a search should be made for a suitable indigenous species.

2. *Always investigate indigenous species first; if they can be used the risks of producing any of the associated impacts would be (entirely) negated.*

An outstanding example concerns the introduced brine shrimp Artemia now found in some of our salt lakes most notably those on Rottnest. In Western Australia we have endemic to our state a number of species of our own brine shrimp Parartemia which is receiving very little attention.

Thirdly, if it is deemed *absolutely* essential that the species *must* be imported, and if its predicted impacts are determined to be minimal when (not if) it escapes, then

3. *Stocks are to be imported as fertilised eggs, broodstocks should be developed from these eggs in a quarantine station.*

This is to make absolutely sure that no other passengers are brought in with the species.

The Western Australian Government should be urged to adopt these three principles in their code of practice.

The Fisheries discussion paper briefly outlines recommendations for interstate and intrastate translocations. At the moment any importation requires a permit or license to be issued by the Fisheries Department. Controlling translocations between states is an interesting issue because it raises the spectre of the Constitution. States **do** control the movement of organisms on the grounds of disease management or ecological protection, and according to most Fishery legal advisers this would constitute reasonable regulation for environmental protection rather than being discriminatory and protectionist in the trading sense under the Constitution.

But regulation and enforcement should only occur with other forms of prevention.

Illicit translocations by uninformed or naive persons, or persons deliberately flouting the laws can be minimised by an education programme. The need to regulate has to be approached delicately; if regulations are perceived as unnecessary and/or unenforceable they may cause a counteraction and actually lead to a proliferation of the spread of species. This is perhaps where the Commonwealth has a role to play. Where conflict exists between the states, the Commonwealth could resolve the issue in favour of the most cautious approach adopted by one or other of the states.

The aquarium industry has an enormous role to play in preventing the release of aquarium animals, made all the more important given the fact that the industry has been blamed for the presence of several introduced species in the south-west, typically occurring when owners tire of their pets and release them into neighborhood wetlands. They must see it as their duty to educate and to urge responsible behaviour from those buying their stock, and even to repurchase unwanted stock to prevent release of aquarium fish. To do so would be in the best interests of their industry. The Fisheries Department has to be proactive in this regard, setting conditions on licences, like attendances at education workshops.

Education programmes may also help explode myths surrounding the value of introducing some species (like introducing Gambusia for mosquito control; this fish has now been deemed unsuccessful in mosquito control).

Prevention by education (and in this case agreement as well) is relevant to the problem of ballast water discharge or fouling communities (as demonstrated by the arrival of species in the Swan River and in other Southern Australian estuaries). The example of the Asian Bag Mussel in the Swan Estuary is an interesting one. In 1983 one specimen was found at Blackwall Reach; by the time Mrs. Shirley Slack-Smith of the WA Museum had published an article on the mussel in 1987 it had succesfully established itself throughout the mid estuary and when we reassessed its distribution last year we found that its occurrence had been consolidated and it was carpetting some areas particularly along the Perth Esplanade. The concern currently being raised by the spread of the northern hemisphere sea star in the Derwent Estuary Tasmania, and in the same estuary the spread of toxic dinoflagellates which can poison humans if they ingest affected sea food, is further evidence that we should be scrupulous in ensuring that ballast water is not exchanged in or near port, and that hull fouling communities are not present on boats.

Another important area concerns sanctioned translocations, those undertaken with Government approval or by the government. The public need to carefully monitor the activities of government departments and check these sanctioned releases. There are many examples. Trout stockings continue at specific locations in South-Western Australia despite the fact that they have been implicated in the demise of native fish **and** they predate heavily on aquatic invertebrates, **and** no assessment of the conservation status of their prey has been formally undertaken by the Department that arranges for their release, **and** when other fish of recreational importance in inland waters are available (ie redfin perch).

A similar example concerns the current thinking within the Fisheries Department on the issue of yabbies. Their movement east (and north) of the Albany Highway will be approved despite the fact that no impact assessment has been done. There is now ample evidence to suggest that yabbies will escape dams and circumstantial evidence is starting to come in of their impacts in natural ecosystems. The endemic species the koonac has some advantages over the yabby, yet there is an almost blind allegance by authorities and by farmers: yabbies are working well. Again, the Fisheries Department has to lead here, and not react solely to fishfarmer's wishes. It has to initiate high quality research, disseminate the results, make broodstock of indigenous species easily available, educate the farmers and investigate methods of replacing yabbies with koonacs.

One serious problem with sanctioned translocations is that they create the mind set that the issues aren't really that serious at all; they are an obvious area where we need to tighten up our approach.

Control, Eradicate or Do Nothing?

Aquatic systems in South-Western Australia have been greatly altered; we are threatening the native biota with an impressive variety of processes, and obviously some areas are more disturbed than others. Feral species must be viewed in the context of these altered ecosystems. We may have to be very careful in our management of feral species in disturbed systems since we are dealing with species which are *embedded* in a non-native landscape, a landscape perhaps with its own stability. It is not beyond the realms of possibility that in *some rare* circumstances, to remove introduced species from these landcapes may destabilise ecological communities to result in equivalent or more serious ecological probems. This means that attempts to eradicate species must be part of

a carefully designed experiment with controls and replications, so that other factors which may affect the abundance of the introduced species are held in check as well, and if something does go wrong we might have a way of working out what it was or how it happened.

Eradication programmes are going to be expensive (except for one which I outline below); for this reason we should have clear guidelines for establishing which species have priority for control. *Ad hoc* eradication programmes are dangerous. Two priority areas I can think of for aquatic organisms are firstly those species causing economic damage, secondly those species which are, or have the potential, to cause ecological damage in relatively undisturbed areas.

For some species the eradication is easy in practice; for instance hunting and fishing can deplete populations dramatically, and in the case of some threatened species overfishing is the main process causing endangerment. The effects of overfishing are clear and unequivocal. So, for recreationally fishable species like the yabby, redfin perch and trout, at least, eradication may be possible through environmentally sensitive harvesting/fishing at the appropriate times of the year. The public I'm sure would want to be involved in this; licencing conditions could be rewritten for the purpose and size and bag limits removed. I find it a particular irony that we are regulated so that we are forbidden to take too many feral species **out** of our waterways.

As appealing as this solution might sound, sadly the reality here is that lobby groups like recreational fishers and aquaculturalists will object unless given crystal clear reasoning or benefit. These objections are going to be felt most acutely at the level of the Minister's ear, indicating that for the control and/or eradication of some species the issue is as much a social policy question as it is an ecological one.

For other species like the aquatic snails we **can** investigate biological control which shows some promise but these are expensive operations and unless it can be demonstrated that the species is causing serious economic or environmental problems government funding for such an operation is going to be absent.

Chemical means of control are available for some species but are **only** viable options for controlling confined populations like those in a dam or very localised outbreaks.

Sadly, though, there will be some species that we cannot eradicate or control, as much as we might want to. Under these circumstances perhaps we should count our losses, and reluctantly adopt them as our own or use them to educate and highlight how best not to do things in the future.

Epilogue

If we believe that feral aquatic species are a serious problem then we should no longer sanction the live export of South-Western Australian species. The management of our fauna should not only maintain the integrity of our own ecoregion, but also ensure that species native to the south-west are not the causes of biotic alterations elsewhere on the continent or the planet.

To return to where I started this paper perhaps the solution in both the longterm and short-term is to promote amongst South-Western Australians a sense of ecoregionalism, a reverence for things in our immediate area, rather than <u>longing</u> for species which were never a part of the landscape.

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LATEST DEVELOPMENTS IN THE BIOLOGICAL CONTROL OF FERAL ANIMALS IN AUSTRALIA

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Introduction

This paper is a summary of the keynote address presented at the first day of the Feral Animals seminar, and as such it does not contain the relevant citations usually associated with a formal scientific publication. Its purpose was to provide the audience with a background as to what biological control is, its associated problems which need to be overcome before it can be used, its advantages and disadvantages, advise on which Australian species are being considered for biological control and what methods are being considered for these species, and finally, place biological control in context with the more conventional control techniques currently in place in Australia. While this paper's emphasis is on the biological control of vertebrate pests, many of the principles discussed are relevant to other species and to most conventional control strategies currently in use.

What is Biological Control?

Put simply, biological control is the use of one species to control or regulate the abundance of another different species which is usually, or about to become, a serious pest. Biological control agents can be a predator, a disease or pathogen, or a competitor which effects the abundance of the target species. I am sure everyone is familiar with the spectacular success of the cactoblactus moth in controlling prickly pear in Australia since the 1950's. The myxomatosis virus was also introduced into Australia around this time to control rabbits. However, the concept of biological control dates back much earlier. The Chinese first became aware of its potential several hundred years ago when they introduced predator ants to control insect pests (eg scale insects) in their citrus orchards. In more modern times, biological control techniques, such as parasitic insects, have been used to control many species of plant weeds (e.g. prickly pear, Paterson's curse, water hyacinth, Salvinia) since the early 1900's.

What is it then that makes scientists and wildlife managers alike believe that biological control has much potential for assisting with the control of many of our vertebrate pests in Australia? You must remember, of course, that most vertebrate pest species are not native to Australia but rather have been deliberately or accidentally introduced. While it is a complex issue, one of the main factors is that a lot of our vertebrate pests lack many of the diseases, parasites, predators and competitors that they coexist with in their native homelands. For example, many Australian populations of the European rabbit and the House mouse have only around 50% of the diseases and parasites of their overseas counterparts. In the absence of their natural competitors and predators, it is no wonder that many pest species have

run rampant across most of Australia. It is important to remember, however, that it is extremely unlikely that any biological control agent will totally eradicate its target species. The best that can be achieved is to reduce the abundance of the target species to a much more manageable level.

Compared to the current conventional control techniques which generally need to be implemented on at least an annual basis, once released, biological control agents usually only require occasional monitoring to ensure they are working effectively, and consequently, are generally thought to be more cost effective in the long term.

Some Problems to Overcome

Before any biological control agent is considered for release we must be sure of its "environmental safety". Biological control agents must be target specific; that is, they must only affect the specified target species and have no deleterious effects upon any non-target species. Biological control agents also need to be able to compete favourably with other similar organisms in areas where they are intended for release. If this does not happen, then they are unlikely to persist, and control of the target species is unlikely to occur.

The continued long term success of any biological control agent can not always be guaranteed. Most animal species, or at least their populations, are dynamic and as such, they are continually responding to the new challenges they face in their ever-changing environment. Thus the "life span" of a given biological control agent is not necessarily never-ending and this can result in a finite period (usually many years) during which the control of the target species can be achieved adequately. An example here is the rabbit viral disease, myxomatosis, which since its introduction around 40 years ago, has become less effective in controlling rabbit populations in many areas of Australia. The virus is evolving towards a less lethal form and some rabbit populations are developing a degree of genetic resistance.

Any pest control program needs to develop a holistic approach. How do they affect non-target species? What happens to an ecosystem when the abundance of a given species, in our case vertebrate pests, becomes suddenly and considerably reduced. In some areas of Australia, rabbits are a major prey item of wedge-tail eagles, and when rabbits are abundant these eagles are often able to raise a second clutch. Thus, it can be seen that developing suitable control programs for our vertebrate pests is a complex task.

Regulation of Biological Control Agents and Associated Research

The general public and other interested bodies have a valid concern that any research into, or the release of, biological control agents is well regulated. To this end, in Australia there is a regulatory body known as the Genetic Manipulation Advisory Committee (GMAC) whose role is to oversee all research involving genetically modified organisms, and the release of "new" organisms into the environment. Had the GMAC been in place at the time when cane toads were introduced into eastern Australia, then this introduction is unlikely to have taken place. These days, the review process for introducing exotic species is much more

rigorous. Furthermore, all of the initial research of any exotic organism which is being considered as a potential biological control agent and which is deemed to present a theoretical or potential hazard to the Australian public or ecosystems, must now be undertaken in high containment laboratories.

The general public, through their politicians or other relevant bodies, can have considerable input into whether a biological control agent should or should not be released. For example, public opinion against the effects of the myxomatosis virus on rabbits was one of the major reasons as to why myxomatosis has not been introduced to New Zealand to control rabbits. Thus it is possible that some future biological control agents may be successfully developed but never released because of unfavourable public concern.

Some Advantages and Disadvantages of Biological Control

Some of the advantages and disadvantages of biological control agents are provided in the following table.

Advantage	Disadvantage
- Usually permanent management of target species.	- May not always out compete local "varieties".
- No harmful side effects because of target specificity.	- Can NOT guarantee 100% safety.
	- Can NOT be recalled once they are released.
- High cost benefit ratio as usually self replication and naturally spread.	- Initial cost ($) can be high. Need political commitment.

The main points here are that although biological control programs may be costly to set up initially, in the long term, if efficacious, they are likely to provide better cost benefit ratios than do many (most?) conventional control programs currently used for controlling vertebrate pests. A 100% safety guarantee can not be given for any biological control agent (or indeed any control technique), and once they are released biological control agents can not be recalled. Thus the general public, politicians and regulatory boards etc must ultimately decide whether the "risk" factor is within acceptable levels.

Australian Feral Animals and Biological Control

a) Rabbits

Myxomatosis, European rabbit fleas, and Spanish rabbit fleas
Myxomatosis was introduced into Australia in the 1950's to control the European rabbit. Despite some loss of its effectiveness, myxomatosis is still an important

component of rabbit control strategies in most areas of southern Australia. Originally, the lack of suitable vectors for transmission from rabbit to rabbit restricted the effectiveness of this viral disease (myxomatosis is spread on the mouth parts of specific fleas and mosquitoes feeding on infected rabbits). To overcome this problem, the European rabbit flea was introduced into Australia to improve the transmission of the disease. However, this flea does not survive in arid environments. Thus, a new flea, the Spanish rabbit flea, which can readily survive in arid areas has been recently released in South Australia and Queensland following extensive research trials in South Australia. The Spanish rabbit flea is likely to be released for trials in Western Australia in the not too distant future. The release of the Spanish flea is expected to improve/increase the spread of myxomatosis in arid Australia.

Rabbit haemorrhagic disease (RHD)
This a different viral disease of rabbits that has only recently (>1984) appeared in native rabbit populations in China and Europe. Infected adults die within two days but for reasons unknown, rabbits less than 4 weeks of age are not effected by the disease. Its effect on Australian rabbits and on several species of native Australian animals has been investigated at the high containment Australian Animal Health Laboratories at Geelong, Vic. Because of the encouraging results obtained from these trials, a restricted field release of RHD (now know as Rabbit Calicvirus Disease) is about to be undertaken on an offshore island in South Australia. If this is successful, we are still looking at at least five years before RHD is likely to be released on the Australian mainland.

b) House Mice

Capillaria heptica, a nematode parasite of mice, is being investigated by the CSIRO for its potential to regulate mouse populations by decreasing the body condition of mice, particularly breeding females, such that the breeding performance of mouse populations is reduced. This would help in the control of mouse plagues which occur regularly in eastern Australia. Pen trials have been conducted to determine its effect on house mice and on non target species. Restricted field releases are now under way in Queensland and Victoria to examine the effects of C. hepatica on free-ranging mouse populations.

c) Fishes

To my knowledge there is very little research being undertaken in Australia on the biological control of fishes. Furthermore, biological control of fishes is not considered to be a popular option because of difficultly of restricting any such agent to its target area in an aquatic environment.

d) Cane Toads

It is interesting to note that most researchers and wildlife managers consider the introduction of cane toads into Australia to be more akin to the introduction of the European rabbit, rather than an attempt at biological control. This is because the necessary research into the effects of these toads on their target species (the cane beetle) and on non target species was not rigorously undertaken, and because there

were few regulatory processes in place at that time. Had this been the case, then cane toads would not have been introduced because they provide little control of their intended target, the cane beetle.

The CSIRO is currently undertaking a study of the ecology and biology of the cane toad in South America (its native habitat) and are particularly looking for potential biological control agents (e.g. diseases, parasites).

e) Natural Predators

Given the current trend away from the use of chemicals in pest control, the use of natural predators as control agents has much appeal. However, the role of natural predators in vertebrate pest control programs is a complex issue. Because of the dynamics of predator-prey systems, the abundance of predators will always lag behind that of their prey. Thus at high prey densities at least, predators alone are unlikely to provide satisfactory pest regulation (control). Predators will simply become satiated and will not be able to eat enough pest animals to significantly effect their overall numbers. However, at low to moderate prey densities, birds of prey have been shown to be able to regulate abundance of house mice and it has been suggested that birds of prey are an important component of this system. Any landuse patterns and pest control programs should be undertaken such that they have minimal effects on natural predators.

f) Fertility Control (rabbits and foxes)

In 1992, a Cooperative Research Centre for the Biological Control of Vertebrate Pest Populations was established. The founding partners were: the Agriculture Protection Board, WA: Conservation and Land Management, WA; the Division of Wildlife and Ecology, CSIRO, ACT; and the Australian National University, ACT. The major emphasis of this CRC is to examine the possibility of developing a naturally spread fertility control agent for rabbit and fox populations in Australia. The Centre has around 40 research scientists, plus their support staff, examining various aspects of this program. Controlling fertility has much intrinsic appeal because it is aimed at decreasing the birth rate rather than increasing death rates, but it is also more difficult to achieve.

For two main reasons, the initial emphasis of the program is aimed at rabbit and foxes: 1) These two species have by far the greatest adverse impact on the environment and on agriculture in Australia. 2) Because the biology and ecology of these two species is so intimately linked in Australia, it would be unwise to implement an increase in the control of one species but not the other.

The method of fertility control being examined is one which will fool each target species into mounting an immune response against its own specific reproductive proteins in their egg or sperm. This will result in the prevention of conception as the sperm and egg will no longer be able to recognise each other. The agent used to induce this response is likely to be a host specific virus which will only effect the target species, and which will spread naturally. The host specific viruses will need to be modified in the laboratory so that they can induce the immune response necessary to prevent conception in the target species. The whole process is known as virially vectored immunosterility. The myxomatosis virus is the likely candidate for

rabbits, but a virus suitable for use with foxes is yet to be found. The myxomatosis virus only infects rabbits and no other Australian native or domestic animals. Fertility control of both free-ranging (e.g. horses) and captive (e.g. deer) mammal populations has been achieved previously using chemicals which need to be administered on a regular basis. If developed, naturally spread fertility control agents should generate much greater cost benefit ratios compared to the chemical mediated techniques.

Before a naturally spread sterility agent is considered for release, we have to provide satisfactory answers to many questions. For example, we need to demonstrate that we can induce a sufficiently strong immune response to cause infertility in most of our target species which become infected with the agent, we need to illustrate what level of fertility control is required to cause population declines in our target species, we need to also show that the fertility control agents are indeed target specific, and we need to understand how our modified viruses will compete with similar organisms already present in Australia. Thus there are four main programs in this CRC: Ecology, Reproduction and Immunology, Virology, and Education.

Because of all these complex issues, it is generally accepted within the CRC and the Federal funding body, that our changes of ultimately releasing a naturally spread fertility agent for rabbit and foxes are small. However, the "spin offs" from this program are considerable. The research programs are generating a considerable amount of information which will ultimately lead to improvements in existing conventional control techniques (e.g. improved/modified techniques for fox baiting, a better understanding of rabbit and fox biology). If fertility control is successfully implemented for rabbits and foxes, then the benefits to Australia would be considerable. It is also worth noting that the concept of successful fertility control is generic: that is, it could be adapted for other vertebrate pest species such as house mice and feral cats.

Biological Control and Conventional Control in Context

Conventional control refers to those strategies currently used to control our vertebrate pests, and can include: poison baiting, trapping, shooting, barrier fencing and scaring devices. It is important to realise that biological control will not provide a magical solution to our vertebrate pest problems. At best, it will allow us to get our pest species down to a more manageable level. There will always be a need for conventional control techniques. The best strategy is one which integrates all our available options. Any control strategy needs to be humane as possible, and this is an added advantage of fertility control over existing techniques as less animals would need to be killed. We will always need to be looking towards the future, and continue to develop and refine our control strategies. Clearly, the management of our pest species is a complex issue which requires input from all relevant bodies and the general public so as we can ensure we preserve as much of our natural heritage as possible. This can only be done if we remain vigilant and are prepared to consider alternative options.

A Suggested Framework for Discussing the Problem of Feral Animals

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1. Introduction

The problem of feral animals is extensive, significant and persistent.

Although the extent of the problem is well documented, the significance of the problem is not generally appreciated by the community at large. The problem is usually seen as one of economic cost or as a heritage issue: i.e. ferals are causing us to lose our unique fauna. Without wishing to denigrate these aspects, I would argue that there are two other levels at which ferals impact that make them a much more significant issue:

i. the effect that ferals have on ecosystem functions and
ii. the effect that ferals have in inhibiting corrective land management strategies.

These two levels and the implications they have for ecological sustainable development make the problem of feral animals a keystone issue for land management.

The problem of feral animals is neither new nor unique to Australia. Given the significance of the problem, I am suggesting an approach that focuses on the persistence of the problem. In other words, let's look at why the problem has not been solved already? Perhaps this will help point us to practical solutions.

Feral animals are a complex problem. The persistence of the problem indicates that it has many dimensions and is not easy to solve. By analysing the factors affecting the persistence of the problem of feral animals a multi disciplinary approach can be taken: the social and economic factors can be addressed as an integral part of the problem.

There is obviously not time today to go into all the factors involved, but it is hoped the framework presented here will help make the workshop sessions to follow, more focussed and productive.

2. The Persistence of the Problem

The factors affecting the persistence of the problem may be summarised as:

i. the context in which the problem persists;
ii. the complexity of the problem; and
iii. the conceptual domain in which the problem is investigated and solutions are devised.

i. The context of the problem

The context of the problem can be seen in terms of the biophysical and the socio-cultural domains.

Biophysical
The Australian continent has many unique attributes that make the feral problem particularly significant. For instance, the absence of ungulates before European settlement affected the evolution of the flora.

The scale of the problem is vast. The area of Western Australia is 2.5 million square kilometres with a population of 1.7 million people.

Socio-Cultural
In socio-cultural terms, five broad types of responses to the problem can be delineated:

- Ignorance and/or hubris of the problem
- Loss of indigenous species
- Economic costs of 'pests'
- Concern for the regenerative capacity of the ecosystem
- The impact of feral animals and invasive plants on the implementation of land management strategies.

There are many reasons behind these different responses, but it is clear that the general level of awareness of the problem is low.

Demographic
The relatively short time in which the feral problem has become significant is largely a socio-cultural phenomenon. For instance, the activities of the Acclimatisation Societies and their attempts to alter the indigenous ecological balance have had an enormous impact.

Less than half the population were born in Western Australia, around 30% were born overseas. This indicates a general lack of community awareness of the ecological history of Western Australia and a general lack of experience of environmental changes first hand. It does not imply that those born here have superior knowledge or understanding.

The vast majority of the population live in an urban situation.Australians live in a culture that has low awareness of the vital nexus that exists between environment and cultural well-being.

Education
There has been no major emphasis in the education system on ecological awareness. In terms of finding solutions, it is clear that a major educational push for the whole community is required.

ii. The complexity of the problem
The complexity of the problem ranges from the problems of defining 'pest', finding acceptable and effective means of control, to governmental policy and co-operation, community awareness and understanding.

The complexity of the problem can be addressed in a four tier structure that reflect the various aspects that inhibit solutions:

- the ecosystem level,
- the management and control level,
- the policy and responsibility level and
- the understanding and awareness level.

Each of these levels has a diversity of issues and conflicts that impede the implementation of simple solutions.

The Ecosystem/Species Level
The extent and diversity of the problem itself.

The Management/Control Level
The problems of finding viable, practical, ethical and safe methods of control and management of the pests.

The Policy/Responsibility Level
The legal, political and administrative jurisdictions and responsibilities for the problem. This level involves:

- the perception of the problem: the dichotomy of agricultural and environmental weeds; the methods, ethics, limits and funding of scientific research;
- the 'vertical' interactions of government: Federal, state, local & community;
- the 'horizontal' interactions of government: responsibilities and jurisdiction within and between government departments and agencies;

The Cultural/Understanding Level
The political, scientific and community awareness of the significance of the problem.

iii. The conceptual dimensions of the problem
The concepts underpinning the problem affect the way in which policy is developed. The conceptual domain 'colours' the way in which the problem is perceived and thereby affects the 'viability' of particular solutions. Different perceptions and costings of the same problem can result in different strategies being considered as 'viable'.

Analytical tools, concepts and scientific methodology
The analytical tools, methods and concepts used in the conventional prognosis of the problem need to be critically assessed. This means close scrutiny of the disciplines of Ecology and Economics in particular. From an epistemological perspective, it is clear there are several conceptual and theoretical weaknesses in both disciplines that need to be addressed.

Scientific methods and analytical tools affect how the problem is investigated and understood. The way scientific results are communicated to the general community (or not!) have a profound impact on the persistence of the problem. For instance, the emphasis of ecologists tends to be on the invading species, not on the ecosystem being invaded. Attention tends to be fixed on finding common attributes of invading species rather than on assessing the causes that allow ecosystems to be invaded.

Administrative structures and the political domain
Feral animals and invasive plants are not politically attractive. They are an expensive problem that will take a long time to resolve. They are beyond the horizons or resources of any one generation, let alone any one parliamentary term. The tools needed for politicians to address such complex and persistent problems over such a time frame are not part of everyday political life. The lack of adequate theoretical and policy frameworks capable of dealing with the problem is a major constraint in Australia. This impacts on the institutional structure and the way in which problems are handled. It is an area that requires research.

a. Interactions among governments
Feral animals are a problem that affects federal, state and local governments. Relations among these levels is a complex political issue in itself. A vast amount of energy goes into trying to get governments and agencies to work together.

b. Interactions within governments
Issues of inter agency disputes, lack of co-ordination between institutions within and across State and Territory borders, and lack of uniform management planning and research arrangements all contribute to an unsatisfactory system .
Demarcation problems within and among departments inhibit constructive and effective management. Jurisdiction, competition for funds and 'bureaucratic territoriality' are examples of demarcation problems. The upshot is that there is no co-ordinated management of the problem of feral animals and invasive plants. Given the significance of the problem, this is a major issue.

c. Administrative structures and change
The role of bureaucracy must also be considered in terms of the capacity of this organisational form to initiate and execute solutions with the requisite speed and flexibility. The bureaucratic structure was developed to 'normalise' procedures, not initiate solutions . As it stands, the problem easily defies the bureaucratic mode.

In bureaucracy, stability, security and uniformity of response are key elements of the success of bureaucratic procedures. Risk minimisation, rationalisation and expedience are the default modes of operation. It is not a question of criticising bureaucracy per se, but rather a recognition that it may not necessarily be the ideal vehicle for initiating solutions to such complex problems.

Bureaucrats have the contemporary political reality to deal with. Those trying to 'work within the system' to bring about change spend a great deal of energy trying to get around constraints within the system. For activist bureaucrats, small failures can have inordinate consequences. The result can be an unwillingness to take responsibility or respond quickly to change. This leads to a degree of inflexibility and the overall result is a disturbing inertia amongst government departments that is not warranted by the gravity of the situation.

3. Conclusion: Toward Action

Ferals are a keystone issue that must be resolved, not just because they cost us, nor because they are destroying part of our heritage, but because they are affecting the health and wellbeing of our ecosystems and, thereby, our social and economic wellbeing.

It is hoped that the brief framework presented above will allow the various components of the problem to be discussed in a constructive way so that resolutions can be a step towards solution, not merely an addition to the 'wish list'.

"Understand your enemy" is an old military adage that could be applied to the problem of feral animals in Western Australia. Ferals are a complex issue that needs to be addressed with due respect. The solution is not just a question of more resources and more research. More of the same is not enough and will not do. The way of dealing with the problem has to change. The ferals are more cunning, adaptable and quicker than our policy making and research procedures. We will always be behind if we wait for definitive research conclusions to come from our scientists, or comprehensive strategies to come from our bureaucrats. Despite their good intentions, their tools and methods are not up to it on their own.

The problem of feral animals needs to be addressed as a strategic issue: they are inhibiting corrective land management activities. A strategic approach

acknowledges the complexity of the problem and the need for clarity to get a full understanding of the problem. A realistic assessment of our existing tools, resources and processes is needed.

What is missing from the above is the action dimension. That is what the workshop sessions are for today. Solution requires a well informed, broad based community effort. Good luck!

(I would like to acknowledge the support given by the Gordon Reid Foundation for Conservation to undertake the research of the problem of feral animals in Western Australia.)

POLICY ISSUES AND STRATEGIES REQUIRED

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Introduction

A poem by Ogden Nash

> There was a young lady from Niger
> Who went for a ride on a tiger
> They came back from the ride
> with the lady inside
> and a smile on the face of the Tiger!

Often we intervene in situations and find that we are forced to continue to intervene. We are caught by our own tiger. This analogy applies to the introduction of feral animals to this continent as well as some of our attempts to control those animals. We need to look at the objectives and the consequences of our actions before we leap on the tiger.

This paper outlines various issues associated with feral animal control which concern people associated with the conservation movement. It briefly examines the objectives of feral animal control, direct and indirect approaches to the problem and proposes some general principles for policy and strategy development.

The central message is that we need to take a more holistic or integrated approach to the management of our natural systems if we wish them to survive.

Objectives

We need to clearly examine the objectives of programs to control feral animals before we address policies or strategies. Objectives will vary between people, organisations and even between members of conservation groups. I propose this general definition:

> **The objective of feral animal control is the preservation of our unique native species and systems.**

I believe this reflects the intent of this conference. It encompasses the clinical and anthropocentric motive of maintaining the biodiversity of this planet and the more spiritual or philosophical approach of respecting the intrinsic value of life and the right of all species to survive.

The next step is to examine whether the control of feral animals will achieve this objective. If feral animals were the only major threat then this would be an effective strategy. However, there are many processes which threaten the survival of these ecosystems and a strong possibility that other disturbances increase the impact of feral animals. It is important to recognise that it is the "impact" of feral animals on native populations that is the problem. Therefore the aim when addressing ferals is to control their impacts which may or may not be best accomplished through direct control of the animals themselves.

Clearing, fragmentation, grazing, inappropriate fire regimes and many other processes threaten these systems. In many cases the threat from these processes is as great or greater than that posed by feral animals. Addressing feral animals in isolation will not, therefore, achieve this objective. It is a simplistic approach to a very complex problem.

Integrated management of these ecosystems should lead to more efficient control of the impacts of feral animals and will ensure that the species we are currently protecting will have a habitat which will support natural populations over the long term. If we do not take the approach of protecting the system as well as the species then we should accept that wild populations are destined to disappear.

Current Approaches

Most current strategies are limited to the direct control of feral populations. The Department of Conservation and Land Management (CALM) has targeted threatened species and the success of their programs has been measured by the growth in populations of these selected species. CALM's fox baiting program has been very successful and has recovered many small marsupials from the brink of extinction. Their intention to expand the program to other areas is applauded.

Coordinated projects in fox baiting involving land holders, the Agriculture Protection Board (APB) and CALM have also yielded results in the Albany Shire. Mandy Kurnow, project officer for Land Conservation Districts in the Albany Shire, has presented a poster on this project at this conference. This provides an example of how feral management could be expanded beyond reserves by involving other land managers.

Future Strategies

While foxes are clearly the major threat to small populations in disturbed habitats, it does not follow that they are the sole cause of the situation. Indeed Burbidge and McKenzie (1989) were unable to link species population declines to this or any other single process. The policy implications of this finding are that we need to manage the system and not individual elements. If we wish to prevent further population declines among other species then we need to manage and monitor their environments.

Direct control measures are essential for threatened communities, but we also need to ensure that other species do not suffer the same fate. A sensible approach would be to manage communities so that they do not become vulnerable.

Indirect approaches to feral animal control involve recognising the role of disturbance as a precursor to invasion.

Dr Richard Hobbs (1989) and other authors have noted that there have been few attempts to assess the effects of disturbance on the invasibility of communities although some (e.g. Fox & Fox 1986) have concluded that some form of disturbance is often a necessary precursor to invasion of communities. Obviously there is a need for research in this area.

The political sensitivity of topics such as prescribed burning and logging has prevented a clear examination of the impacts of these activities on the ecosystem or the interaction with impacts of feral animals

The impacts of all human activities need to be examined clearly. We, as a community, may well decide to continue those activities. However we should clearly assess consequences or costs of those activities and set aside adequate areas to conserve natural systems.

In the interim it would be sensible to follow the precautionary principle and disturb systems as little as possible. However we are immediately faced with a dilemma: does the removal of feral animals from highly disturbed systems represent a further major disturbance?

To deal with this possibility I suggest separate approaches to disturbed and relatively undisturbed ecosystems.

Relatively undisturbed regions such as D'Entrecasteaux or Fitzgerald River represent our best hopes of preserving healthy natural ecosystems without intensive management. We should therefore give priority to research and management of these ecosystems. The control of the impacts of feral animals would form part of the integrated approach to management. These regions would have a prime objective of preserving natural ecosystems and therefore disturbing activities would not be compatible uses. The following strategies would be appropriate:

- Commercial activities such as exploration or seed collection would be banned from such areas,

- Fires would be limited to the frequency required by the ecosystem,

- Limit recreational activities by area and level, and

- Control of introduction or expansion of exotic species would be given priority in these areas.

In highly disturbed areas such as state forests and remnant vegetation different strategies are applicable:

- Continue direct control programs and co-ordinate the activities of government agencies and land holders,

- Undertake ongoing programs of co-ordinated management of natural ecosystems including feral animal control,

- Take an ecosystem approach to management, recognising the interactions at all levels and between land uses, and

- Monitor the health of the ecosystem, not just individual species, and adapt management accordingly.

General strategies that apply to all areas are:

- Recognise the need for greater education and understanding of natural ecosystems among government agencies such as Department of Agriculture and land managers, and

- CALM officers need to become more involved with land managers so that this education can be achieved. Their expertise also needs to be more available to land managers who currently undertake their own feral control measures. CALM advice could make such activities more effective.

Conclusion

The purpose of this paper was to discuss the concerns of the conservation movement and suggest policies and strategies.

The conservation movement would like to see policies that address the management and health of the entire ecosystem.

The following strategies are suggested as elements of this approach:

- Greater emphasis on ecosystem management as distinct from species management,

- Co-ordinated, monitored and adaptive management of these ecosystems which involve government and communities and are co-ordinated across ownership boundaries,

- Research into ecosystem dynamics and the impacts of all types of disturbance,

- Minimise disturbance of intact systems by banning commercial activities and undertaking integrated management that includes feral animal control, and

- Greater education of land managers, including government officers on the topic of ecology.

Integrated management can only occur on the ground level therefore a central component of this approach is community education and involvement. The landcare structure and/or the local government structure provides a ready-made vehicle for such programs.

If we are to extract ourselves from the jaws of this tiger we need to put more effort into creating stable, healthy systems and not limit our activities to emergency room type management that targets only endangered species.

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PREFACE TO THE WORKSHOPS

The purpose of the workshops was to generate ideas, enthusiasm, and document key recommendations for action to address the issues and problems of feral animals in the South-West. The Conservation Council of Western Australia is committed to ensuring implementation of the results.

A suggested format for the workshops was a pre-briefing session, by an informed member, followed by a brainstorming session to identify the issues and problems. These were then to be categorized under a) community awareness and participation, b) government policies and regulatory measures, c) inter-departmental and community co-ordination and liaison, and d) ecosystem management. Further discussion was then to focus on formulating action plans and recommendations.

The above format was generally applied although some, rather than formulate action plans, produced a list of issues or problems to be tackled by others, such as lobbyists or researchers. Others produced recommendations or policies to be adopted rather than action plans.

The aim of presenting pre-briefing notes is to provide the reader with a contextual framework to interpret the workshop findings. In some cases pre-briefing notes were combined with the 'issues and problems' section to remove obvious duplication of information.

The proceedings were transcribed during the workshops in note form, and later prepared for publication from those notes. The editors have added the words in italics, in an attempt to make the document more readable and more easily understood by those with no previous knowledge of the subject. This overall process may have resulted in some minor loss, or misinterpretation of information presented at the workshops, but it is hoped that this is minimal.

How to cite workshop proceedings:

For example:

Workshop: Invertebrates (1994). In: Impact and Control of Feral Animals in South-Western Australia. Proceedings of a Seminar with Workshops (eds. R.Siewert, N.Robinson and P.Horwitz) pp. 55-58. Conservation Council of Western Australia, Perth, WA.

INVERTEBRATES

1. Pre-briefing Notes

1.1 Origins of introduced invertebrates

No systematic survey has been undertaken to determine this. Most introduced weeds and invertebrates however, came from Europe and the Mediterranean and also many from South Africa. America and Asia are generally not sourced.

1.2 Number of species

In general we do not know how many species of introduced invertebrates there are, but there are certainly many. For example, of 160 species of aphids only about 20 are native, and one estimate of springtail populations found that only 3.2% were native.

1.3 How they were introduced

Insect introductions tend to be accidental which is in contrast to weeds and vertebrate pests which were mostly introduced deliberately.

1.4 Ability to predict introductions

Experience in predicting which insects will survive on weeds has shown a low accuracy. Accuracy of prediction for agricultural pests is also low and for environmental pests it is zero.

1.5 Impacts

The CSIRO biological control programme introduces insects all the time. Also agriculture's dependence on introduced bees will increase with crops such as Canola. But we do not have any sound information on the impact of these introduced invertebrates *and there are many questions that are unanswered, such as:*

- What was the impact of Argentine ants?
- What is the fox *(i.e. predator on native species)* of the invertebrate world?
- What are the pests causing great damage?
- What are the major grazers which could affect agricultural systems?
- What has been the impact on the natural food webs - especially in the soil and litter?
- What is the impact on the whole ecosystem?

1.6 Control Programmes

These are mostly chemical programmes although a sterility programme *was used* on fruitfly and there has been success with biological control against orchard pests which reduces the need for chemical control. Successful programmes *have been conducted for instance* on the codling moth.

1.7 A suggested definition of feral invertebrates

"Insects in the wrong place," but excluding biological control agents.

2. Issues and Problems

2.1 Species

The topic species include:

- Grazers: feral bees, Meditteranean snails and slugs, leaf blister saw fly, autumn gum moth,
- Predators: European wasp, paper wasp,
- Pollination ecology: feral bees, butterflies, wasps, Argentine ants, moths,
- Competitors: feral bees, Argentine ants,
- Recyclers: cockroaches, slaters.

2.2 Ecosystem Management

The impacts on ecosystems of the above groups of species include:

- Bee hives on the edge of parks causing problems *(e.g. displacing native pollinators in nature conservation areas)*,
- Loss of biodiversity,
- Loss of plant productivity,
- Change in the reproductive capacity of plants leading to altered community survival,
- Altered flora and fauna communities,
- Displacement of native species (e.g. by feral bees),
- Altered gene flow,
- Reduction of population size of some species and an increase in others,
- Change in speed and/or efficiency of nutrient recycling,
- Change in soil structure.

2.3 Other Community Values and Interests

Introduced invertebrate impacts on the community include:

- Altering aesthetic values,
- Becoming a nuisance *or creating discomfort (i.e. European wasp)*,
- Providing economic benefit, *e.g. honey from bees,*
- Causing economic loss, *e.g. agricultural pests.*

3. Recommendations

3.1 Management Policy

1. *Management policy to:*

   - Prevent new problems,
   - Eradicate at an early stage where possible (which requires

monitoring/surveillance and rapid response),
- Consult with industry.

2. As honey bees are likely to be the most important feral invertebrates in the South-West of WA, effort should be focused on this species *and it should be* used as a model for management. (*It was* concluded that bees should be excluded from nature reserves.)

3.2 Ecosystem Management

This is a suggested protocol for examining feral invertebrate ecosystem management issues using the feral bee as an example.

1. Required information includes:

   - The distance and conditions under which bees will swarm and travel,
   - The 'recolonisation rate' for areas,
   - A method of readily finding hives (known methods could be trialled),
   - Location of apiary sites (registered and unregistered). Industry can provide this data,
   - Location of feral bees populations.

2. Design a 'removal' experiment with selected sites all in the same area. Sites should be:

   - Selected to minimise variables between sites,
   - In an area worked by commercial apiarists,
   - Discrete from each other.

3. Design a 'correlation' experiment to compare native pollinators and feral bees on one group of native plants e.g. Davesia. This could be completed quickly (i.e. a Masters project).

4. Apiarists' needs should be considered when planning revegetation and catchment management (which is happening). The industry needs to prepare an information kit.

3.3 Community Awareness and Participation

1. Increased awareness by children of feral invertebrates and the problems they cause could be achieved through primary school curricula. The Australian Association of Environmental Educators could take a role in this.

   For example a feral bee poster kit to target 8 to 12 year olds, could provide information on where bees come from, types of bees and types of hives (i.e. managed and feral colonies), and school nature excursions could involve searches for feral hives (and plotting their location), and for other pollinating insects.

2. Wider community awareness could be achieved through demonstration projects to show the impacts of feral invertebrates, such as the feral bee and Argentine ant, in natural systems.

3. The public should also be encouraged to report the location of hives to local

shires and council rangers or environment officers who would collate the information, seek advice and take appropriate action.

3.4 Interdepartmental and Community Co-ordination and Liaison

Co-ordinated research is required *into feral bees* and invertebrates generally. *It is therefore recommended:*

1. A bibliography of feral invertebrate studies be prepared. This could be a project for a library studies student. The Commonwealth may be approached for funding.

2. A research panel be established which would involve all interested parties (for example, the Bee Consultative Committee research sub-committee within CALM) to develop and conduct research projects into the role of feral bees in existing ecosystems.

3. A research project be conducted involving relevant government departments, industry and community groups. The concerned parties would include CALM, APB, Department of Agriculture, advisory committees (e.g. NPNCA and SLCC), conservation groups, LCDCs and industry associations.

   The project would require a steering committee with representatives from each group. This committee would design the research outline, appoint the researcher and seek funds from sources such as the Honeybee Research and Development Council (5c/kilo levy), the Commonwealth Feral Program, and CALM (in the form of support only).

   There is a need for a pilot demonstration project. Although there are at least 3 projects done in other parts of Australia, they do not study all the desirable points.

   Principles for the management of operations would come out of the results of the research project.

   To start the whole project, the published results of this conference are to be used to initiate work on this study, either by lobbying the Bee Consultative Committee or directly to Government.

3.5 Legislation

It is recommended that current legislation which controls the introduction of exotic invertebrates, is maintained and extended.

WORKSHOP

AQUATIC FAUNA

1. Pre-briefing Notes

1.1 Origins of Feral Species

Feral aquatic fauna originate from several sources, including:

- *Released* ballast water and fouling communities *from interstate and international ships,*
- The aquarium industry, *i.e. escapees and unwanted pets released into water-ways,*
- Aquaculture, *i.e. escapees from ponds, tanks and sea cages,*
- Attempted pest control, e.g. Gambusia *were introduced with the aim of controlling mosquitoes,*
- Government action,
- Recreational fishing, *e.g. trout were introduced to South-West WA.*

1.2 Nature of Impact

The impacts of feral species on ecosystems are various and include:

- Genetic *changes,* e.g. *interbreeding to produce* hybrids
- *The introduction of* passenger species and disease, e.g. crayfish plague *is caused by an introduced* fungus *which parasitises crayfish,*
- Habitat alteration, e.g. carp disturb sediments,
- Trophic cascade, e.g. biomanipulation,
- Elimination of native species *through predation or competition.*

1.3 Nature of Control Programmes.

These include:

- Biological control, e.g. triploid breeding (*this produces* xxx chromosome *individuals which are sterile*),
- Chemical control, e.g. rotenone, copper compounds and some others,
- Complete removal by fishing,
- Drying lakes.

1.4 Regulation

The following principles should be adopted:

- Recognise the inevitability of escapes,
- Always consider indigenous species first,
- Only introduce fertilised eggs,
- Establish an inter-departmental committee for broad-based assessment of feral aquatic issues.

1.5 Education

To minimise the extent and impact of introduced fauna:

- Educate the aquarium industry,
- Educate the fish-owning public,
- *Encourage the public to* adopt and monitor their own local region.

2. Issues and Problems

2.1 Ecosystem Management

Issues of concern include:

- The introduction of species,
- The translocation of species regionally, nationally and internationally,
- The export of species,
- Ecological sustainability,
- Habitat maintenance and catchment management.

There may also be conflicts of interests *between the environment and issues such as* recreational fishing and other economic and social *values obtained from water-ways.*

2.2 Public Awareness

There is a lack of public awareness *of issues concerning feral species.*

3. Recommendations - General Principles and Guidelines

3.1 Objectives

We recommend that the following objectives be embraced:

1. To achieve the principles of ecological sustainability as they apply to endemic aquatic ecosystems.

2. To adopt as the priority (in aquatic feral species management), the minimization of the impact of feral species on relatively undisturbed systems.

3.2 The Current Situation

We recognize that:

1. Introduced exotic species generally have a detrimental effect on natural ecosystems.

2. There is an ethical conflict in translocation of endemic species.

3. The South-West eco-region is unique and should be conserved.

3.3 General Principles

We urge the state government departments to adopt the following principles:

1. There should be no distinction between species proposed for introduction into a natural ecosystem and those proposed for enclosures, as it is generally acknowledged that escape is inevitable.

2. Always investigate indigenous species first; if they can be used the risks of associated impacts of feral aquatic species would be (entirely) negated.

3. If importation is deemed absolutely essential and if the predicted impacts are determined to be minimal when the species escapes, then stocks are to be imported as fertilised eggs, and broodstocks should be developed from these eggs in a quarantine station.

4. An inter-governmental committee should be set up to operate under the precautionary principle to:

   a) oversee the implementation of the above principles,
   b) undertake an ongoing review on the status of aquatic feral species.

5. To initiate on-going review with respect to the above principles.

4. Recommendations - Specific Issues

4.1 Ballast Water

1. We recommend that Federal and State Government take action to deal with an urgent need for complementary international, national and state legislation regarding the discharge of ships ballast water.

2. We recommend the CEPA, the Western Australian EPA, the Marine and Harbours Department and the Australian Quarantine Information Service, draft the required legislation.

3. The Australian Federal authorities need to establish and implement procedures for exterminating foreign marine organisms in ballast prior to release into Australian waters.

4. There is a need to establish baseline data and monitoring programmes for all coastal areas, covering both ports and off-shore rigs - initially to determine benthic fauna, etc., and identify any introductions which have occurred.

5. Maritime unions should be involved in the development of education programmes for ships' personnel.

6. The public need to be informed of the effects of ballast water on local marine ecosystems.

4.2 Recreational Fishing

(Not in order of importance)

1. Because of the detrimental effects on aquatic ecosystems, NO further introductions or replenishments for recreational fishing of any non-endemic species should be permitted.

2. Research should be undertaken by recognised agencies into recreational use of endemic species, e.g. black bream and catfish.

3. Remove size and bag limits on recreational introduced fishes in all waterways, with the aim of fishing out the current stocks.

4. Provide positive information (with input from conservation groups) regarding the control of feral aquatic species, to be produced and distributed throughout the community.

4.3 Education - Public Awareness

1. Use existing programmes, such as Ribbons of Blue, to promote public awareness of endemic aquatic fauna, eco-regions and the impact of feral species.

2. Educational programmes, through environmental interpretation, should facilitate personal experience of the endemic aquatic ecosystems.

BIRDS

1. Issues and Problems Identified during Pre-briefing and Brainstorming Session

1.1 Categorization

Feral birds in the southwest can be categorized as follows:

- Widespread exotics, e.g. turtle doves, pigeons,
- Isolated populations of exotics, e.g. white swans, pheasants,
- Exotics which threaten to invade, e.g. starlings, sparrows (there is much evidence of their effects),
- Eastern States species, e.g. kookaburras, lorikeets,
- Native species that have extended their range and population numbers, e.g. galahs, corellas,

1.2 Impacts of Feral Birds

These include:

- Environmental: *they may compete with native birds for food and nesting sites resulting in displacement of native species,*
- Economic: *they may become pests to farmers by, for example, consuming large amounts of grain,*
- Health: *some feral birds have a potential to carry human diseases.*

1.3 Lack of research

Much is still to be learnt about the impacts of feral birds. It is possible that their indirect impacts are greater than their direct impacts. It is claimed that kookaburras and lorikeets have some impact yet there is a lack of information and research in this area.

1.4 Future Problems

Potential future problems identified included:

- Invasion of exotics from the Eastern States *(e.g. starlings and sparrows),*
- Escape of aviculture birds (this is regarded as inevitable - not IF but WHEN).

1.5 Control

In most cases, the power to prosecute rests only with the government departments who have the power to determine what species are "pests".

It was implied that current government controls were unco-ordinated and insufficient.

1.6 Education and Community Awareness

More effort is required to bring peoples' attention to the impacts of feral birds and how they can help the situation.

2. Recommendations

2.1 Ecosystem Management

1. Maintain existing control programmes.

2. Target species with small populations (e.g. the red-browed firetail and long billed corella) *for control.*

3. There is a need to monitor, assess and control new species coming into Western Australia via the pet industry. This factor is particularly relevant for birds and fishes. These groups of animals are still being purposefully introduced.

2.2 Research

1. More research is required generally, for example on kookaburras, lorikeets, starlings and sparrows, galahs and other species in the wheatbelt.

2. Species need to be categorized according to their impacts, such as:

Impact: Significant	Type of Impact
starling	Pest in urban areas
sparrow	Aesthetic
galahs	Increasing numbers & range expansion
ringnecks	Increasing numbers & range expansion
little corellas	Increasing numbers & range expansion

Impact: Unknown
red-browed firetail
kookaburra
long billed corella
rainbow lorikeet

Impact: Negligible
laughing turtle dove
spotted turtle dove
chestnut breasted mannikin

From the above, priorities for research and management can be determined.

3. Research may be carried out in conjunction with a community education programme (see below).

2.3 Community Awareness and Participation

1. The aims of education/awareness campaigns are to:

- Encourage aviculturalists to:

  - Consider native birds as pets rather than keeping exotic birds, e.g. the painted button quail (a native), instead of the Japanese quail,
  - Support legislation against the introduction of new species,

- Educate school children and the general community on the impacts of feral birds, and

- Using the appeal of colourful, native birds to promote tourism and visits to the country by city people, and encourage a 'sense of place' - i.e. the south-west is a unique part of Australia.

2. Select one species, such as the rainbow lorikeet, as the focus of an education/research programme. This species is feral, very visible, its population appears to be expanding, it is in the metropolitan area and very little is known about it. It would be very suitable as a schools project integrated into an existing environmental education package.

   The direct goals of the project would be to accumulate information on the distribution of lorikeets, population size, movements and also feeding and nesting.

   The indirect goals would include community education, e.g. attitudes of bird keepers and firming of legislation against introduced species.

   The question of what control measures are environmentally and ethically acceptable could be incorporated and aired during the project.

   It should be set in a time frame, e.g. 2 years initially, and involve as many people as possible.

2.4 Policies and Legislation

1. There is no need for special legislative structures for birds. However discrete policies for managing feral, introduced and native pests are recommended.

2. Expand the APB committee structure to consider ferals generally in an agricultural and environmental light.

3. Legislation pertaining to management should facilitate licensing of private contractors for feral species control.

4. Private citizens should be allowed the right to prosecute environmental vandals.

2.5 Co-ordination and Liaison

It is necessary to establish better liaison between government departments (APB and CALM) and non-government organisations (e.g. RAOU). A board should be set up comprising the APB, CALM, and statewide public representatives to look at all feral and pest species. *This group would:*

- Co-ordinate co-operation between all states,

- Introduce a uniform ranking system *for feral species,*
- Attract better funding,
- Gather information from all sectors (statewide).

WORKSHOP

THREATENED SPECIES

1. Pre-briefing Notes

Many native species are threatened because of introduced species. *In dealing with this situation however,* the lack of information clearly defining the problem is obvious.

Some of the information that we do have includes the distribution of the last remaining WA populations of marsupials such as the bettong (Bettongia penicillata). Other previously widespread species, are now only found on offshore islands that are free of feral species. These include the western-barred bandicoot and rufous-hare wallaby.

There has been an increase in the bettong population after fox baiting in Tutanning Nature Reserve and a similar occurrence with numbats in Dryandra State Forest.

Evidence of feral species' impacts on avifauna is variable but some of the species identified as at risk include the malleefowl and ground parrot.

Exotic herbivores (è.g. goats, sheep and rabbits) have an impact on flora. It is essential therefore to continue work in order to prevent other introduced species, such as starlings, becoming established.

2. Issues and Problems

2.1 Community Awareness

Community awareness *of how introduced animals have contributed to native species becoming threatened* is limited. Where it exists, people do not know how to become involved in the protection of native species.

The lack of community involvement stems in part from elitism and poor communication within and between government departments.

2.2 Ecosystem Management

The lack of co-ordination in government departments hinders an integrated approach *to ecosystem management.*

2.3 Government Interaction

- Entrenched positions are getting in the way of co-operation,
- Upper levels of government departments are not as co-operative as on the ground levels,
- Government department jurisdictions need to be rationalised. This also applies to local government,

- Differences between community and government issues need to be clearly understood and distinguished from each other,
- Government tends to hijack initiatives of private enterprise,
- Due to government funding shortages, private sponsorship is needed for projects.

3. Recommendations

3.1 Community Participation, Awareness and Education

The aims of community participation, awareness and education programmes should be to:

1. Overcome historical European biases *which favour associations with non-native species. Strategies may include:*

   - Promoting the "Easter Bilby" instead of the Easter Rabbit,
   - Promoting political correctness *when referring to feral species,*
   - Promoting the use of Aboriginal names: for example, using the name 'chuditch' and not 'native cat',
   - Investigate the possibilities of utilising native animals in the pet trade and on hobby farms.

2. Involve individuals or community groups in practical ways - for example:

   - Encourage groups to adopt endangered species e.g. Busselton camps and ring-tailed possums,
   - Identify opportunities for individuals and community groups to adopt local species.

3. Provide formal environmental education and training, and resources, such as:

   - Teacher training and resources giving priority to in-service teacher training (statewide), involving threatened species,
   - Give curriculum priority to threatened species and feral animal issues,
   - Increase CALM's involvement in education,
   - Continue support of Earth caretakers programmes,
   - Use and support native animal carers,
   - Convert school camps to staffed environmental education centres,
   - Support LCDC education programmes,
   - Set up community-based native animal sanctuaries for environmental education.

4. Heighten media awareness of threatened species by:

   - Appointing a communications person - perhaps someone from the threatened species network,
   - Linking stories/articles to human interest,
   - Creating an award for threatened species journalism, e.g. a landcare award,

3.2 Co-operation and Communication - Between Government Departments, Industry and the Community

Co-operation and communication could be achieved by:

1. Promoting integrated management for endangered species (i.e. networking) at all levels.

2. Facilitating community awareness of section 2 *(i.e. Problems and Issues).*

3. Encouraging industry involvement *in managing threatened species and heightening community awareness by:*

   - Using industry's resources to optimum efficiency,
   - Promoting commercial opportunities, and
   - Providing tax incentive for use of local endangered species images.

4. Encouraging a regional and local approach.

3.3 Ecosystem Management and Research

1. *The objective of management is to* increase populations and range of endangered species. *To achieve this* fauna surveys, re-introductions and monitoring of population recoveries need to be undertaken.

2. *Management should also* integrate feral control with other aspects of land management across all land tenures.

3. Research findings should be widely disseminated, including to community groups and farmers.

WORKSHOP

BIOLOGICAL CONTROL

1. Pre-briefing Notes

Ideal biological control agents are target specific (not an option for aquatics without extensive research), *and their population rises and falls in response to the same changes of the target species' population, i.e. their* population is dynamic. *However they often* compete with similar existing organisms.

Research has concentrated on rabbits, house mice and cane toads, *and it is directed towards the* introduction of new viruses and the study of the spread of diseases, and disease vectors.

Fertility control *is also being investigated. This involves* fooling the target species to mounting an antibody response against an introduced virus in order to prevent conception. *Ideally the virus would* spread naturally and be target specific.

Consideration is also given to the humane death of animals from viruses and diseases.

2. Issues and Problems

2.1 Ecosystem Management

In using bio-control the following should be considered:

1. Determining the effects of bio-control on:
   - Local, natural and internal ecosystems,
   - Non-target species,
   - Target species (i.e. humane considerations).

2. Assessment of the effectiveness of control, i.e. the damage, not the density, *should be evaluated.*

3. The long term effects, including:
   - Development of resistance *to the control agent by the target species,*
   - *The effectiveness of* existing control techniques,
   - *The emergence of* new virus strains.

4. The rigour of testing, *i.e. are the* safeguards *sufficient.*

2.2 Other Community Values and Interests

Consideration needs to be given to parties with an interest in feral animals. These include:

1. Aboriginals: *feral species may be an important* food source.

2. Industry: *commercial interests in feral species include:*

   - The fox fur trade,
   - Agriculture (positive),
   - The rabbit industry *which utilizes* fur and meat.

3. Recreational interests: *for example trout fishing and fox hunting.*

2.3 Legislation and Administration

Legislative and administrative processes for release *of bio-control agents need examination. These include:*

- Policies *formulated* as a result of public pressure to have priority,
- Co-ordination and liaison between agencies, departments, and *other* organisations.

2.4 Public involvement and Awareness

Community misconceptions and urban bias *need to be addressed.*

2.5 Attracting resources for research

There is a low chance of success of attracting resources *from the* Commonwealth and State agencies unless the problem species has a high public profile.

3. Recommendations

3.1 Policy

The following recommendations are to be adopted regarding the use of biological control agents:

1. Biological control, as one of the tools which can be used to reduce the impact of feral animals, be integrated into WA's feral management strategy.

2. National guidelines*be prepared* to indicate where biological control approaches are appropriate.

Guidelines to include:

- The impact of feral species on biodiversity and sustainable primary production,
- The cost effectiveness of other available controls,
- The likelihood of success of bio-control.

Bio-control only to be used after rigorous testing to ensure target specificity.

It should also undergo rigorous Commonwealth assessment using the Quarantine Act, Wildlife Protection Act, GMAC, and Environmental Protection (Impact of Proposals) Act (used in parallel rather than sequentially). Concurrence of actions across states is also required.

3. Independent scientific review bodies to be maintained. These include for example, the Co-operative Research Centre (CRC) and the Vertebrate Bio-Control Centre (VBC) (which is audited by an independent 'Scientific Advisory Panel').

4. *Following bio-control measures* independent scientific research to assess

damage mitigation to be conducted (i.e. the economic and/or ecological benefits following biological control should be evaluated, rather than just counting carcasses).

A long-term monitoring process to be put in place to continually assess the effect of the bio-control agent and to detect any increase in resistance by the target species. Contingency plans should be developed to deal with these problems, e.g. with respect to fertility control, the need to target more than one reproductive protein.

Monitoring should be nationally co-ordinated and involve state agencies, local government, LCDC's, and community groups (e.g. Ribbons of Blue).

5. Modify Commonwealth legislation to prevent accidental or deliberate export from Australia of biological control agents. Also ensure that Commonwealth legislation is adequate to prevent accidental or deliberate import of biological control agents into Australia.

6. Educate and legislate against the consumption of species which are being biologically controlled (if necessary).

3.2 Ecosystem Management and Research

1. Synchronise control of linked feral species *(e.g. foxes and rabbits).*

2. Predict and manage for the effects upon linked native species.

3. Encourage through funding, University research on links between target species and others within the ecosystem (e.g. the link between wedge-tailed eagles and rabbits).

4. Research and develop methods of managing accidental releases, e.g. vaccines *for released viruses.* The accent should be on preventative measures.

5. Involvement of WA agencies in national research on development of bio-control should continue.

6. Consideration should be given to the effect of the bio-control agent on the target species. This includes:

- Directing research towards fertility control rather than towards mortality-causing agents,
- Where fertility control is used, the disseminating agent is to cause minimal disruption/pain to the target species,
- If a mortality agent MUST be used, it must cause minimal (i.e. length of time and degree) pain and suffering to the target animal,
- Pre-release testing of the bio-control agent should be carried out in a manner which avoids unnecessary interference with the target animals.

3.3 Public Involvement and Awareness

1. Encourage involvement of stakeholders (including Aboriginals, industrial organisations and the public), in the development of policies, guidelines and plans at national and state level, e.g. public interest panels such as the VBC.

2. Increase public awareness of the seriousness of feral animal impacts, the role of bio-control and the issues related to bio-control methods should be

increased. This could be achieved through:

- The education curriculum (teachers in-service, advertising the availability of resources),
- Television (current affairs, science and special interest programmes, co-production as in television soaps e.g. "Flying Doctor"),
- Special events such as Environment Day,
- Children's stories,
- Public workshops,
- Newsletters,
- Information leaflets, using outlets such as libraries and shopping centres,
- Expansion of volunteer programmes via the APB, CALM and CSIRO, plus newspaper advertisements.

3.4 Attracting Resources

Timing is important when attempting to attract resources: e.g. in South Australia funds are made available for mouse research following mouse plagues.

Strategies for attracting resources include:

- Informing all politicians to gain inclusion of feral bio-control issues on the political agenda,
- Putting in place appropriate levies such as the Grains Research and Development Corporation levy on grain for mouse research, and levies on the recreational use of national parks,
- Seeking corporate sponsorship,
- Holding special events for fund raising.

WORKSHOP

RABBITS

1. Pre-briefing Notes

Background

Rabbits originated in the Iberian Peninsula of North Africa and moved from the Mediterranean into Europe. Rabbits were later introduced into Great Britain from Europe as a food source.

Following colonisation by Great Britain, rabbits were introduced into Australia. Several attempts between 1788 and 1829 were made before the rabbit first became established. Early introductions were generally deemed to have failed due to the use of domesticated rabbits. Introduction of wild populations from Britain was successful.

Once established the wild rabbit multiplied rapidly and spread quickly. This was aided by movement of people who frequently took along a number of rabbits during journeys to new areas. These were released to provide future food sources, repeating the process first seen in Great Britain.

The rabbit population spread into northern areas of Australia successfully colonising arid areas. This northward spread was eventually halted and is generally attributed to the dry conditions. Populations later retreated to a line further south of their initial radiation with the northern limit generally recognised as the Tropic of Capricorn. The lower south-west of WA was infiltrated only slowly by the rabbit.

Populations built up to very high numbers due to the absence of natural predation and disease. Rabbit population growth was eventually checked by the introduction of myxomatosis but this was not as successful in WA as it was in the Eastern States.

Rabbits had become a major agricultural problem and the use of strychnine and phosphorus had proven ineffective. Introduction of the poison sodium fluoroacetate, known as 1080, widely used in Russia, was to prove highly effective. The combination of myxomatosis and 1080 was successful and rabbit populations fell to much lower levels.

The rabbit is very susceptible to the 1080 poison whereas most marsupials (in WA) are resistant due to their co-evolution with Gastrolobium and Oxylobium, genera found only in WA. These plants produce fluoroacetate, which acts in the same manner as 1080 with the result that native species can withstand up to 200 times the levels of poison required to kill non-resistant, introduced species. (Stock species such as sheep and cattle are not resistant for the same reasons and must be protected from accidental ingestion of the 1080 poison.)

Application of 1080 is undertaken by baiting with grain. The procedure involves the 'training' of rabbit groups to accept unpoisoned grain for a period until they are habituated to its availability. Grain is then spread with a proportion of poisoned grains mixed in. Each grain with poison contains a lethal dose. This method overcomes the problem of behavioural changes which reduces the baiting effectiveness, is less labour intensive, and allows much larger areas to be baited. Following large population reduction due to 1080, supplementary techniques may then be used to control rabbit numbers.

Eastern States of Australia use baited carrot rather than grain. Better results following use of grain have been obtained in WA for reasons which are not quite clear. Certainly grain is less bulky and requires less labour. Carrots do not lend themselves to the 'one-shot' baiting technique. 1080 has led to much better reduction and control of rabbit populations.

The main concentrations of rabbits are along the coast with Geraldton, Albany and Esperance being targeted for control programmes. Rabbits thrive in sandy soils and are very difficult to control in these habitats. Areas where soils are heavier have resulted in greater success in rabbit control. Wild rabbits can live above ground but must have warrens, usually in low scrub.

In dry harsh areas rabbits must have access to vegetation with > 55% moisture content to survive. Perennial grasses are a good source of moisture. Native vegetation can also be a source but rabbits generally lose weight. The promotion of perennial grasses in the Blackwood catchment area has neglected to take into account the potential increase in rabbit numbers due to the improved supply of moisture from this introduced grass. Rabbits love Guildford grass bulbs and can eat these exclusively.

Feral animals are an old problem and we need to re-assess our approach and possibly find alternative methods. This may be through a greater understanding of the interactions between rabbits and the ecosystem and with other feral animals. Perception of the problem of rabbit damage is much higher in WA than in the Eastern States.

The Urban Situation

The presence of human populations makes the use of poisons such as 1080 unacceptable due to its toxicity to mammals and the lack of an effective antidote. The use of Pindone has problems due to its lack of target specificity. Pet rabbits are not a problem as they are extremely unlikely to survive, (recall the initial failed introductions of the rabbit to Australia). Farmed rabbits are held in very strict security and are unlikely to escape. The security is very much in the farmers interests as he needs to protect his investment from predation.

Understanding of rabbit control in urban areas is inadequate. A process of education and awareness of the problem and methods employed would improve this.

2. Issues and Problems

2.1 Control Measures

1. Poisoning

   This is used initially to reduce a population to low levels so that other control methods can be utilized. Complete target specificity is the ideal goal but is not achievable. Poisons include:

   a) Sodium fluoroacetate (1080): this is used by providing undosed, feed grain over five days to attract rabbits, then removing any remnant grain and replacing it with poisoned grain. This can kill 90 - 100% of the population. Alternatively a 'one-shot' feeding with poisoned grain, laid out in a single operation, can kill over 50%,

   b) Pindone: this is an anti-coagulant which works very effectively over a five day period. The disadvantages are that native fauna are susceptible

to it and so it cannot be used where local species, e.g. kangaroos, may injest it. Other negative aspects are that a large volume of grain must be laid and it is more expensive.

2. Ancillary Controls:

a) Shooting: this is useless as it disrupts the behaviour of the rabbit population

b) Trapping: this includes:

i Jaw traps - there are objections to these on humane grounds due to the pain they inflict,

ii Cage traps - these are labour intensive as they must be laid out and baited with frequent follow up to remove captured fauna.

c) Warren ripping: this removes the rabbit refuge and is best done only once but very efficiently. It must be avoided in bushland areas.

d) Fumigation of warrens: this is an alternative to warren ripping in bushland.

e) Blasting of warrens: this has variable results but is largely ineffective.

f) Netting: nets can be electric or normal. They provide a discrete area in which to work, can be used selectively and may be relocated (although this is time consuming and hard work). Electric netting is easy to install, and can utilize various power sources but is twice the price of normal netting. The nets should have an 'apron' section which is buried to prevent burrowing under. An additional precaution is to combine netting with poison to improve kill rates.

g) Laying of poison trails:

i A disc cart is used to cut a groove in which poison grain is laid *Another groove is cut* alongside to prevent covering by loose soil,

ii Spray spreading of poisoned grain. Rabbits will find the grain but larger animals will not.

2.2 Ecosystem Management

1. *The environmental and economic* cost of rabbit damage.

2. A positive impact of rabbit eradication is that the native flora will be less heavily predated, and will allow regeneration of habitats for native fauna.

3. Negative impacts of eradication are the likelihood of an increase in other feral herbivores (e.g. goats and pigs) and in some native species possibly resulting in over-population (e.g. the western grey kangaroo). Rabbit predators may also switch to native fauna as an alternative food source or be reduced in numbers by lack of prey.

4. Control in one area in isolation from other feral animal control programmes could produce unforeseen and possibly detrimental results.

5. Control methods may themselves be damaging to ecosystems, e.g. ripping of warrens or bulldozing of bush to 'eliminate' the rabbit problem on a particular property.

6. Concern about the impacts of baits and poisons on non-target fauna.

7. Consideration should be given to the possibility of transgenic control.

8. Overgrazing land by farm stock pre-disposes land to degradation by rabbits.

2.3 Community Awareness

1. Public perceptions about rabbits include:

   - Rabbits form a continuous population rather than separate and sporadic colonies,
   - Total eradication is not possible,
   - The problem is too big,
   - Scrubby coastal land is worthless and therefore not worth protecting from rabbit impacts,
   - There is also a lack of understanding by the public of the damage caused by rabbits and of control techniques. Farmers however do perceive value in rabbit control.

2. Ethical issues include the welfare of rabbits.

2.4 Interdepartmental and Community Co-ordination and Liaison

1. Co-ordination of control programmes is needed within districts. This involves planning, goal setting, local involvement, and communication between all participants.

2. The metropolitan area may act as a reservoir for rabbit populations if action is not taken in conjunction with country area eradication programmes.

3. Landcare programmes need to include the rabbit problem in the planning process.

2.5 Government Policies

1. There is a lack of political support *for feral animal control.*

2. There are conflicts of interest in land use in the metropolitan area *which may aggravate the feral animal problem.*

3. Rabbit farming and commercial use of rabbit products (i.e. rabbit-felt hats), is seen as legitimizing the rabbit's existence.

4. Levies on rabbit products may provide financial support to offset costs of control programmes.

3. Recommendations

3.1 Ecosystem Management

It is recommended that the following ecosystem management principles be adopted:

1. Ecosystem management should include the recognition of agricultural land and bushland, metropolitan areas as well as country, and individual reserves and private properties. This applies at national, state, and local levels.

2. Control programmes need to be integrated with other species, e.g. rabbit and fox programmes should be connected but may not necessarily be carried out at the same time.

3. Co-ordination of baiting must involve all neighbouring properties, and all interested departments with effective communication and co-operation between them. This would prevent a reservoir of rabbits surviving which would allow re-population to occur.

4. Control techniques need careful assessment for each individual situation, e.g. 1080 bait trails in paddocks, fumigating burrows in bushland. Baits should be target specific to reduce the effect on native populations, e.g. birds. Animal welfare must also be a continuing theme or principle in all activities.

3.2 A demonstration project

A demonstration project should be conducted with the aim of:

1. Increasing community awareness and education with particular emphasis on the cost of control and lack of control of rabbit populations.

2. Promoting community co-ordination and liaison, and both public and private involvement in the generation and implementation of solutions.

3. Demonstrating the above ecosystem management principles.

The project should be conducted as follows:

1. Select a single sub-catchment (approximately 50,000ha) in the wheatbelt.

2. Use the landcare movement to disseminate ideas, knowledge and methods. Involved parties may include the EPA, Department of Agriculture, CALM, Shires, OCM, APB, WAFF, CLTO, LCDC and other interested community groups.

3. Methods of control may include fumigation, trapping, poisoning and ripping, and the target should be total eradication of rabbits in the catchment.

4. Monitoring should take place before, during and after the project.

   Before any control methods are used, rabbits are counted along 2km transects. This is undertaken three nights in succession to provide improved sampling accuracy.

During the period of control, counting (as above) is to be repeated every 6 months. (A winter and summer survey will provide an improved picture of rabbit population.)

Post-eradication, all sightings in the area are to be reported.

Sightings are to be recorded and mapped detailing soil types, position in the land form and catchment. The damage caused by rabbits could then be demonstrated by comparing this treated catchment with an untreated one.

5. Possible sources of funding may be from the parties involved in the project, landowners and a NLP grant.

WORKSHOP

URBAN CATS

1. Issues and Problems Identified during Pre-briefing and Brainstorming Session

1.1 Definitions

There are three types of cat: domestic cats (pets that are dependent on people), stray cats (abandoned pets often found in rubbish tips and alleys that are indirectly dependent on people), and feral cats (animals that are totally independent).

The problems associated with cats can also be split into three categories: those concerned with domestic cats, stray cats, and feral cats.

1.2 Issues

These relate to:

- Noise, defecating, fighting, trespassing, stray tomcats, digging,
- Sterilisation,
- Diseases that affect cats and other health problems,
- Predation on birds and other wildlife,
- Cat welfare,
- Dumping of unwanted pets in particular areas.

1.3 Action required

Attention needs to be given to:

- Legislation to make owners responsible, e.g. sterilisation of cats,
- Work on a strategy *to overcome the problems.*

1.4 Education

Public education is required because:

- People do not realise a problem exists with predation on native wildlife, competition with native carnivores and the risks to wildlife of the diseases carried by cats,
- People do not realise a problem exists with the welfare *of cats,*
- People may not want to know,
- There may be community resistance to sterilisation,
- Myths *exist amongst the general community,* e.g. that a cat needs to have a litter before sterilisation,
- Ownership responsibilities *may not be clear.*

2. Recommendations

2.1 Ecosystem Management and Research

1. The aims of ecosystem management are to reduce:

   - Predation pressure on native (endangered) species to enable the maintenance of population viability,
   - Competition with native carnivores,
   - *The risk of* disease *spreading from cats to native species and humans.*

2. *Further research is required to:*

   - Collect data relevant to control options *and measure the success of* current strategies,
   - Define areas where feral cats are a problem,
   - Conduct manipulation experiments (there was some disagreement about necessity of further research in this area).

3. Control measures need to target all feral species in concert for a given area. Some feral cat control methods include:

   - Euthanasia,
   - Sterilisation,
   - Culling programmes,
   - Specific exclusion areas.

   (Establishing specific exclusion areas (i.e. places were cats cannot go) involves identifying areas where ferals are to be excluded and incorporating them into town planning schemes and council by-laws. Such areas may include buffer zones between reserves and residential areas. Alternatively exclusion could be in time rather than space by imposing a curfew.)

2.2 Education

The aim of an education campaign may be to:

- Encourage native animals as pets,
- Educate the public to produce a groundswell for legislation,
- Emphasise the protection of native fauna and not, killing cats,
- Promote responsible cat ownership,
- Inform of the ramifications of dumping,
- Gain public acceptance of an euthanasia programme,
- Increase awareness of cat diseases affecting humans and other animals.

An example of an education campaign is given:

Aim:

- To promote responsible cat ownership.

Target Audiences:

- Cat owners,
- Children (schools/other),
- Vets and staff,
- General public,

- Media,
- Council staff,
- Pet shop owners,
- Breeders,
- Politicians,
- Conservation movement,
- University Courses (Environment),
- Animal welfare groups.

The message:

- A cat can be a delightful pet if responsibly managed,
- Otherwise it can be a menace,
- Education on problems of unwanted cats.

RESPONSIBLY MANAGED CATS (Benefits to people):

- Companionship,
- Cats can improve human health,
- Provide a sense of well-being to owner,
- Assists children with behavioural problems,
- Child development,
- Need for less regulation if cats are well managed,
- Less neighbourhood conflict,
- Less destuction of wildlife,
- Reduced veterinary fees,
- Fewer unwanted kittens.

RESPONSIBLY MANAGED CATS (Benefits to cats):

- Health (disease, injury reduction, diet),
- Companionship,
- Prevent unwanted pregnancy (stress),
- Safety.

RESPONSIBLE CAT OWNERSHIP CONSISTS OF:

- Community awareness that there is a problem,
- Is a cat the right pet for me?
  - cost,
  - living environment,
  - time to look after it,
  - personalities (person/cat),
- Where do I get the right cat?
  - animal shelter,
  - breeders (registered),
- What should I do to look after my cat?
  - sterilisation,
  - feeding,
  - immunisation,
  - accommodation (shelter, litter trays),
  - companionship,
  - confinement with outside runs,
  - identification,
  - registration,
  - bells/mirror.

Message can be promoted via:

- Pet shops.
- Labels on pet food,
- Certificate to identify cat owner,
- Companion cat club/shows,
- Packages (training),
- Scientists (in their communications or teachings),
- Notices on reserves 'Don't dump cats, take them to a welfare centre'.
- Community papers,
- Professionally produced video for media (e.g. TV), schools, community resource centres,
- Posters, tour as a "road show" to pet shops, shopping centres, schools, clubs, youth hostels,
- Handouts, e.g. Council offices (with rates notices),
- Phone-in information lines,
- Radio talk-back shows.

2.3 Government Policies and Regulatory Measures

1. *The following regulatory measures should be considered:*

   - Registration of all cats (e.g. microchip registration),
   - A $15 fee for registration of sterilized cats and a higher fee for unsterilized animals,
   - Curfews or confinement in selected/sensitive areas,
   - Fines and/or removal of cat for non-compliance with regulations.

2. Legislative changes should include:

   - Allowance of selected native fauna to be domesticated by giving CALM the authority to licence commercial, native animal breeders (e.g. so cats can be replaced by quolls),
   - The introduction of bounties paid on cats not registered or in remote areas only,
   - Penalties for dumping unwanted animals,
   - The declaration of feral cats as vermin.

3. The following services should be provided:

   - A 'put-down' service for cats and kittens by councils, or a rate reduction for cat-free households. (Ethical methods should be used for euthanasia of cats),
   - A mobile vet service to sterilise/kill cats,
   - Registered pet shops selling kittens at a price incorporating the pre-paid cost of sterilisation by a pre-organised veterinarian.

4. Further research and development *of control methods.*

2.4 Interdepartmental and Community Co-ordination and Liaison

It is recommended that:

- One department should deal with cats, dogs and companion animals,
- Administration *requires greater* co-operation *between departments,*
- A co-ordinated approach to education is needed,
- Pet education in schools should be promoted,
- Education comes before legislation *(in order to gain public support for changes),*

- Veterinary practises should take a bigger role *in educating the public and in cat control,*
- A shire should be selected as a test case *for a control programme.*

2.5 Funding

Possible sources of funds include:

- Federal government subsidies for euthanasia,
- A tax on pet food,
- State and Federal funding for research and development,
- Private sponsors.

WORKSHOP

FERAL CATS

1. Issues and Problems Identified during Pre-briefing and Brainstorming Session

1.1 Definitions

Domestic cats are pets that are dependent on people. Stray cats are abandoned pets found in rubbish tips, etc. and are therefore indirectly dependent on people. Feral cats are totally independent of people for survival. It is possible however, for a stray or domestic cat to become feral periodically.

1.2 Community Participation and Awareness

The community needs to be made aware of the impacts of feral cats on native fauna, and their participation is needed to find solutions to the problems.

Education campaigns need to consider cat lovers' emotions but focus on gaining public acceptance of control measures, such as voluntary euthanasia, and of gradually replacing cats as pets with other animals.

1.3 Policies and Co-ordination

Co-ordinated control strategies need to be set in place. Funding is required and some legislative changes.

1.4 Ecosystem Management

The main issues relating to ecosystem management include:

- The logistics of implementing control programmes in such a large country,
- Maintaining specific exclusion areas,
- Further research into cat ecology is needed in order to develop effective control methods, such as biological control.

2. Recommendations

2.1 Community Participation and Awareness

The feral cat problem is not a problem just for conservation and land management agencies, but is a community problem which needs community participation for solutions. *Therefore, recommendations are to:*

1. Promote an awareness of the uniqueness, diversity and beauty of our native fauna. This should be done at the regional level by:

   - Local community-based interest groups promoting local fauna by regional surveys, eco-tourism, school curricula, television programmes, newspapers, workshops, field days, and "fauna watch",
   - Government agencies co-ordinating activities and providing some funding, logistical and technical support.

2. Promote awareness of feral cat impact and mitigation, by:

   - Local community, local groups and government agencies demonstrating the impact of feral cats on regional fauna through collecting data on cat kills, circulating scientific articles, posters, videos, public talks, seminars, school curricula, and organised control programmes (e.g. trapping and shooting),
   - Highlighting the connection between dumping of unwanted cats and the impact of these animals on the environment.

3. Create an awareness of pet ownership responsibilities.

4. Provide incentives for communities, farms etc., to control feral cats, and provide rewards for new and inovative ideas.

5. Sources of funding include government grants, corporate sponsorship, licence fees for domestic cats and a tax on pet food.

6. Community based groups and individuals should lobby government and politicans for action and funding.

7. Educate the public. This is needed before government legislation to get the public 'on side'. *The following methods may be used:*

   - A professionally produced video to go on air on prime time TV and to schools,
   - Posters at vets, pet shops, schools, clubs, Youth Hostels Association,
   - Use a quoll *(chuditch)* to show cuddly native animals,
   - Show cats killing, e.g. a blue wren,
   - Handouts in Council offices and included in rate notices,
   - Members of the public to ring in about native animals to talk back shows.

2.2 Policies and Co-ordination

It is recommended that:

1. Penalties be imposed for dumping of unwanted animals. The RSPCA could implement this.

2. Euthanasia *be made readily available* by establishing a mobile veterinary service at regional centres.

   State and Federal Government subsidies for voluntary euthanasia could be provided through a Cat Tax, registration fees and a tax on pet food companies.

   An education campaign should be conducted to gain public acceptance of euthanasia.

3. Other control measures that may be utilised include:

   - Restricting ownership,
   - Imposing curfews,
   - Identification of areas to specifically exclude cats (e.g. reserves),
   - *Create cat-free* buffer zones between nature reserves and residential areas,
   - Owners to be registered via local or state governments,
   - Pay bounties on feral cats in remote areas or specific areas excluding urban residential areas,

- Declare cats as vermin.

4. Funding be made available from state and federal governments for:

   - A euthanasia programme,
   - A sterilization programme,
   - A research and development programme,
   - Culling programmes,
   - Education programmes.

5. Pet shop owners *should help to* educate the purchasers of kittens, and only *be allowed to sell* sterilized animals.

6. Replace cats with quolls by changing legislation to allow people to keep quolls as an alternative pet.

2.3 Ecosystem Management

It was decided that control options needed developing and refining to be more effective, but in the meantime the following strategies should be adopted:

1. *Concentrate on* areas where cat control is most critical. *These areas are likely to have* threatened fauna and they should be accessible and predator-free (and able to be maintained in this way).

2. Collect information on feral cats for future biological control work.

3. Persist with the methods available. These include:

   - Fencing: this is only suitable for small areas and the geography needs to be considered,
   - Baiting: the development of a bait type is under way,
   - Shooting: this is dependent on visibility but is good for collecting specimens,
   - Trapping,
   - Biological control: this has potential for the use of diseases such as feline enteritis. Feline herpes could be examined. Sterility may not be an option due to the longevity and low density of cats.

4. Manipulation experiments to prove feral cats' impact on the native fauna are difficult to do at this stage as we can't establish and maintain cat-free areas.

5. Apply control to all species (e.g. rabbits, foxes, cats, and rats), at the same time.

WORKSHOP

FOXES

1. Pre-briefing Notes

Foxes were introduced from England in the 1860s to provide sport in Victoria. They spread quickly and reached WA early this century, and within about 25 years they had colonised most of WA except for the northern wet tropics. This distribution was reached by 1930 and appears to be stable.

Associated with the spread of foxes are faunal declines especially medium-sized marsupials such as wallabies, possums, bandicoots etc.

A bounty system was operative in WA between 1928 and 1956. If such a control procedure were to be effective for controlling foxes, then one would expect to observe a reduction in fox numbers - hence bounty payments should have declined at some stage. Such was not the case because even though the bounties paid fluctuated and declined in some years, the payments increased overall. Accordingly, there is no basis for suggesting that bounties would be an effective conservation measure.

Long term research programs have demonstrated that removal of foxes by baiting results in population increases of medium-sized marsupials. To date nine species have increased in response to fox removal, often dramatically. Faunal translocations (e.g. numbats, rock-wallabies, woylies) have been successful under predator control.

Meat baits containing 1080 are very effective and safe for native fauna. This is due to careful bait design which takes advantage of the fact that the WA native fauna has co-evolved with endemic 1080-producing species of vegetation (Gastrolobium spp.). This co-evolution has produced a 1080 tolerant faunal community.

Farm dogs and cats are highly susceptible to 1080 baits and are thus at risk if they venture into a baited area. Occasionally, birds such as large ravens are reputed to carry baits onto farmland thus increasing the risk. Baits can be buried if this is a problem.

Different baiting regimes are currently under investigation by CALM in order to determine the most cost-effective baiting strategies. Smaller areas of the conservation estate (e.g. wheatbelt nature reserves) need to be baited more frequently than larger areas (e.g. national parks) because foxes rapidly colonise smaller areas.

The creation of buffer zones around nature reserves by extending fox control to adjacent farmlands maybe a useful measure as this would likely slow the rate of colonisation by foxes into a core baited area. Reasearch is needed here.

2. Issues and Problems

2.1 Research

More research is needed into the relationships between foxes, their prey and other feral animals, and also into the methods, frequency and timing of control procedures.

2.2 Education and awareness

There is a lack of awareness within the general community in general, of the threats to native animals by feral predators.

2.3 Funding

Current funding is spent on research and implementation *(of control) by the public sector* (CALM and APB) *and the private sector* (e.g. Alcoa and farmers).

Costs associated with fox control are mostly due to labour and transport, but also include the cost of baits.

Increased funding is needed.

2.4 Legislation and bureaucracy

Legislation is required to tackle the problems of feral animals which result in threats to native wildlife.

There is a need to streamline government bodies and bureaucracy *concerned with feral animal control.*

2.5 Co-ordination

A co-ordinated approach is needed for the control of feral foxes, cats and rabbits.

Public education of feral animal problems also needs to be conducted in a co-ordinated manner.

3. Recommendations

3.1 Research

1. A clear statement is needed of the minimum amount of control required and the amount of damage that is acceptable. This can be assessed by asking the public how much control it wants and from current scientific knowledge.

2. The optimum baiting regime for an adequate prey response needs to be defined. This is currently under way but should be expanded to include national parks. (Faunal increases will enhance the tourist value *of natural areas* and demonstrate the benefits of predator control to the public.)

3. A synopsis *is required* of suitable methods of control for different situations (e.g. large reserves, small reserves, urban).

4. *Further research is required into* the life span of 1080, and a comparison of the different methods of delivery and necessary dose rates in the field.

5. Research into biological control should continue until a solution is found.

6. Fox/rabbit/cat dynamics *should be studied. This should include the* effects of fox control on rabbit populations. A study of cat and fox dynamics may produce more valuable information.

7. Research *should be conducted* into the effectiveness of exclusion fencing.

8. *Assessment* of the impact of foxes, investigation and refinement of control methods in urban areas is needed.

9. Research and development is required in order to lower the cost of bait production.

10. Investigation is needed to determine how the public can assist in control.

11. The Conservation Council can help to promote public awareness of research.

3.2 Education and Awareness

Educational campaigns with both urban and rural target audiences *should aim to:*

- *Address* the perceived community issues that are preventing progress,
- *Inform of* the impacts of feral animals on native mammals (through information from CALM on what we have lost, defined area by area),
- *Inform of* the environmental safety of 1080 (particularly to urban audiences),
- *Emphasise* fox damage as opposed to poison damage,
- *Promote* the conservation ethic (caring about wildlife),
- Increase public support in order to increase political commitment.

Each campaign should define the desired educational outcome and select an appropriate mechanisms for its promotion. Depending on the target audience this may be via:

- The media (print and radio),
- Newsletters,
- Ecological studies in schools,
- Meetings with shire councils,
- Seminars.

3.3 Funding

Increased funding is needed to provide:

- On-going *research and control rather than agencies being dependent on* one-off grants,
- *Specifically for* on-going biological control research,
- Education programmes,
- Subsidies to end-users for the cost of baits,
- Baiting in CALM reserves and national parks which would lead to increased fauna and to increased public awareness,
- LCDCs or other similar bodies (not government departments) with resources for feral control.

Possible sources of increased funding include:
- Parties who benefit from feral control, such as farmers and wildlife observers,
- Corporate *donations in the form of* research support,
- *Donations from* mining companies,
- World Wildlife Fund,
- *Fund raising by* 'Friends' groups,
- Eco-tourism (e.g. charging entry fees into national parks),
- Lobbying political parties for increase in federal funding.

3.4 Legislation and Bureaucracy

It is recommended that a single agency responsible for feral animal control, be established by incorporating existing government departments into one body (rather than creating a new one). A strong governing body such as this should be able to over-ride existing, individual Acts in each department, and provide a streamlined, less bureaucratic service. *It is suggested that* heads of departments meet to co-ordinate the creation of a central control agency.

It is also suggested that an inter-departmental committee with community representation, be established to oversee all feral animal control. It would refer directly to state/federal government ministers (e.g. environment or agriculture). LCDCs are a great example: they have a cross-sectional membership from different departments and all levels of the community. Other examples are 'Friends' groups and advisory councils. Administrative and financial support *should be provided* for such a body.

3.5 Co-ordination

It is recommended that co-ordination of feral fox, cat and rabbit control *be undertaken* on a regional basis.

A 'feral officer' should be employed by the 'Feral Governing Body'.

Co-ordination could be achieved by the proposed inter-departmental body setting up a subcommittee to deal with:

- Education,
- Research,
- Funding,
- Legislation and bureaucracy,
- Measurement of results,
- Monitoring.

Note: It is important to keep sponsors informed to ensure continued commitment for funding. It is also important to provide feedback for field operators.

WORKSHOP

OTHER FAUNA

1. Pre-briefing Notes

'Other fauna' that have an impact on the environment include pigs, rats, mice, ferrets, goats and humans.

Pigs

Most of our knowledge of 'other fauna' relates to pigs. They are found in forests from Perth to Walpole, around Northampton and in the Kimberley.

Most people think that pigs are a problem because they affect farmers (for example, by carrying diseases such as foot and mouth), spread dieback, alter vegetation and habitats, and have the potential to attack people. They also provide benefits however, such as hunting, meat (which is sold illegally) and food for crocodiles.

Control methods for pigs include trapping (costly), shooting (aerial shooting in Kalbarri has had limited success), hunting with dogs (by licensed or voluntary hunters), and poisoning with 1080 or other poisons (although the high body weight of pigs and their tolerance makes this difficult). Control techniques need some refinement.

Priorities or hot spots for control are farms and neighbouring properties. It is necessary to remove 80 - 85% of animals for control programmes to be effective. While an outbreak of foot and mouth can elicit an immediate response of money from the government, this can be short-lived and continued control is not a priority.

A control plan needs to retain a flexible approach, i.e. a variety of control techniques. The focus should be on location of pig populations and methods of control.

Human involvement in pig control comes from opposing two sectors of society: one sector is trying to eliminate/control pigs while the other sector is perpetuating the problem by releasing pigs in different areas.

2. Issues and Problems

2.1 Species

The species that present current problems were identified as ferrets, pigs, goats, rats, and mice.

Those that are expected to present problems in the future problems include llamas, alpacas, deer, dogs, and zoo species (such as palm squirrels).

2.2 Ecosystem Management

The impacts of feral animals on ecosystems include:

- The introduction and spread of disease,
- The introduction of insects *or other small or microscopic commensal, symbiotic or parasitic organisms,*
- Displacement of native species,
- Catchment degradation and pollution.

Factors to be considered when controlling feral animals include:

- Sources of introduction(e.g. accidental and deliberate introductions of domestic and commercial animals, pets, and abattoir and circus escapees),
- The lessons learnt from historical events (e.g. ferrets may become as big a problem as rabbits),
- Maintaining feral free ecosystems on islands,
- Humane treatement of ferals,
- An understanding of species and food chains *is necessary,*
- The effect of control on the ecosystem *(e.g. if a feral predator (cat) is controlled, will a feral prey (rabbit) population increase and create greater damage?),*
- Assessment of short-term control measures versus on-going control,
- Control burns may be used as a management tool for herding,
- Preventing native species becoming feral in other communities,
- Resources are currently limited for ecosystem management and total reliance cannot be placed on government,
- Consideration should be given to the assistance that can be gained from land-care groups, wider community groups and volunteers,
- It must be recognised that many non-native species have commercial value and those parties with vested interests must be considered.

2.3 Communication and Education

These issues include:

- The need to increase awareness of problems created by feral animals and prevent further introductions,
- Encouraging the use of native species as pets and for commercial purposes where possible,
- The need to develop ecological ethos, guardianship and participation within the community,
- Dissemination of scientific findings.

2.4 Legislation

Legislation should facilitate greater control of domestic and feral species, and *allow* increased utilization of native species *where the alternative exists to introduce new species to an area.*

3. Recommendations

3.1 Communication and education

- *An education campaign should define:*

  - Which animals are feral,
  - What impact they have,
  - What the alternatives *are for control.*

- Target audiences include:

  - LCDCs,
  - Politicians,
  - Local government,
  - Professionals *(e.g. farmers, animal breeders).*
  - Vets and vet schools,
  - Animal owners,
  - School children,

- Information may be disseminated via:

  - Government Departments (i.e. CALM and APB),
  - Community based networks (e.g. newspapers, TV),
  - Schools,
  - Individuals.

3.2 Legislation

Current legislation is adequate *although it may* require refinement.

3.3 Liaison

Liaison between governments, community groups, conservation groups and farmers *should be* improved.

3.4 Ecosystem management

It is recommended that a task force be set up with representatives from CSIRO, APB, EPA, Department of Agriculture, CALM, and the Conservation Council *to manage feral species. Its objectives for various species may be as follows:*

1. Ferrets:

   - Total elimination within 5 years. (They are already a declared species.)

2. Pigs:

   - Control rather than eradication (an 80% reduction can probably be achieved),
   - A combination of control methods may be used,
   - A task force for pigs alone should also be established with representatives from CALM, WAWA, APB and other land users,
   - Initiate a unified data base within 3 years.

3. Goats:

   - Maintain current *control* programme,
   - Remove all populations, particularly from islands.

4. Rats & mice:

   - Initiate research at universities and colleges to look at diets of rats and mice,
   - Review options for control without affecting native rodents.

5. Squirrels:

   - Total eradication.

6. Other:

   - No new pet species should be introduced.

GLOSSARY

Abbreviations

AAEE	Association of Australian Environmental Educators
ANCA	Australian Nature Conservation Agency
APB	Agriculture Protection Board
CALM	Conservation and Land Management
CEPA	Commonwealth Environmental Protection Agency
CLTO	Community Landcare Technical Officer
CRC	Co-operative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWR	Critical Weight Range
EPA	Environmental Protection Authority (in Western Australia)
ESP	Endangered Species Programme
FPP	Feral Pests Programme
GIS	Geographic Information System
GMAC	Genetic Manipulation Advisory Committee
LCDC	Land Conservation District Committee
NLP	National Landcare Programme
NPNCA	National Parks and Nature Conservation Authority
OCM	Office of Catchment Management
RAOU	Royal Australian Ornithological Union
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SLCC	Soil and Land Conservation Council
WA	Western Australia
WAFF	Western Australian Farmers Federation
WAWA	Water Authority of Western Australia

Definitions

Translocation is the movement of living organisms from one area with free release in another. The three main classes of translocation can be defined as follows:

> **Introduction** of an organism is the intentional or accidental dispersal by human agency of a living organism outside its historically known native range.
>
> **Re-introduction** of an organism is the intentional movement of an organism into part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe.
>
> **Re-stocking** is the movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat.

Feral species are those which have escaped or have been released, and have reverted to their wild states as opposed to their domesticated, commercial or selectively-bred states.

Biological invasion is a general phrase used to denote the biological processes associated with the movement of organisms from one area to another to colonize that area (either by their own means of dispersal or by human intervention).

Eco-region is a region characterised by its biological similarities.

APPENDIX 1

SOME OF THE OUTCOMES OF THE INTRODUCTION OF FOREIGN ANIMALS INTO AUSTRALIA

Mike Hill

The introduction of foreign animals into Australia has contributed significantly to the decline of native species of flora and fauna. This practice has also had a dramatic effect on the social and economic fabric of Aboriginal society.

Many species of flora and fauna used in the diets of Aboriginal people have either disappeared, become rare and are protected by legislation or are contaminated by disease. The creation of nature reserves is designed to protect flora and fauna stocks in areas where agriculture has meant vast tracts of land being cleared for those purposes.

In WA there has recently been the creation of nature reserves, national parks and marine parks. These ecosystems have been created to protect flora and fauna from the further ravages of land clearing, human interference and for the identification and protection of rare and endangered species. It is within these areas that most Aboriginal communities pursued their traditional subsistence food gathering and hunting.

Legislation has been introduced to prevent people taking species which are protected including those that are the staple diet of Aboriginals. A major contributing factor for legislation for protection of these places is the impact feral exotic animals have had on native species.

Sheep and cattle have robbed the Aboriginal people of their homelands. Sheep and cattle are primary industries but they are also the primary reasons why Aboriginal people were dispossessed and brought to the brink of their destruction.

The taking of food for subsistence reasons not only ensured a healthy diet but as particular species of animals are an integral part of ceremony, ritual and mythology, then not being able to have right of access to them has meant a serious decline in traditional practices which, as an example, has led to the serious impediment of the natural progression of passage of rites.

Every foreign animal that has been introduced into Australia has made an impact on the negative side more so than the positive. Being the great survivors they have become renowned for, Aboriginal people have used some of the introduced species to positive effect on their culture and lifestyle.

The dog and cat have replaced the dingo and the possum and other native species as domestic pets. The horse has made a valuable contribution to the economy of Aboriginal people living in places such as the Kimberley or the Northern Territory. The crocodile is now part of the mythology of Aboriginal culture in areas where they occur.

The kookaburra is an Australian native, however they were introduced into WA. This bird is responsible for the destruction of eggs and various reptiles in this state.

Australia is truly a multi-cultural society and some of the baggage that comes

with different cultures making Australia home also comes with them. Different farming practices are being tried such as the alpaca and red deer. The impact that these animals have on the environment is not yet visible unlike the feral goat and pig who have their presence felt in the Pilbara and forest areas of the south-west of Western Australia.

Introduced animals in Australia has led to a dramatic decline in the health standards of indigenous people in Australia. This practice has also seen the dispossession, dispersion, and dysfunction of a once healthy, culturally and spiritually intact society. It has also upset the delicate balance of nature particularly in our more fragile ecosystems.

We need to ensure that Aboriginal people obtain the right to pursue their traditional diets and we must introduce or strengthen existing controls of effectively reducing the impact that these animals are having on native species.

Managers of the national estate need to be more innovative and do more. The role of Aboriginals in protection of native flora and fauna and the control of introduced feral animals is an area that needs further exploration.

APPENDIX 2

CAT CONTROL TASK FORCE

The Hon. Paul Omodei
State Minister for Local Government

This seminar provides the opportunity to share information and ideas, as well as identify action required on the issue of feral animals.

In August this year I announced plans to draft special legislation to tackle problems associated with feral, stray and domestic cats.

This in part resulted from concern expressed by local governments from across the state about councils' lack of power to deal with an increasing cat population causing havoc to wildlife and roaming neighbourhoods unchecked.

Councils currently have recourse to The Dog Act to deal with canine problems, but have little ability to take action on cats, due to the lack of specific legal controls.

I have asked the Department of Local Government to consider the options for cat legislation and make recommendations on preferred legislation. A Peak Advisory Body with representatives from a number of key organisations has been formed to help in this task. They include, the Department of Conservation and Land Management, the Western Australian Municipal Association, the Cat Welfare Society (Cat Haven), the Animal Welfare Advisory Committee, the Royal Society For the Prevention of Cruelty to Animals and the Municipal Law Enforcement Officers' Association.

This committee has been asked to provide expert technical and practical information on cat issues during the public consultation period and critically assess the public comments received.

It will also comment on the practicality and feasibility of options being considered for inclusion in the draft bill and suggest alternative options where appropriate.

Several hundred submissions have been received and are now being analysed. The submissions cover a range of matters including the problems cats create between neighbours and also the wildlife issue.

Quite a number indicated support for registration and sterilisation subsidy.

If any cat management strategies are to work effectively they must be accompanied by a comprehensive, positive public education program. Such a program should make people aware of the responsibilities of cat ownership and the problems cats cause in the community. The education program should be aimed at:

- Cat Owners
- School Children
- Pet Shop Owners
- Breeders, and
- Animal Wefare Groups.

It is anticipated that the discussion paper and recommendations will be

prepared and available for public comment within the next few months. I am sure you will all be interested in the outcome.

Finally, thank you for inviting me here today. I trust the remainder of your program is rewarding and you take up the challenge presented in solving the problem of feral animal control.