DEVELOPING AN IMMUNO-CONTRACEPTIVE METHOD FOR CONTROL OF FOXES:

THE LIKELY IMPACT ON THEIR WELFARE.

(Draft)

by

A.N. Start and M. Bradley

for

The Cooperative Research Centre for Biological Control Of Vertebrate Pest Populations

May 1996

1. INTRODUCTION

The purpose of this document

Man interacts with other animals in many ways. Some are passive or incidental. Others, intentional, are as varied as husbandry of domestic stock or control of species we regard as pests. Animals, like people, feel and respond to stimuli, including discomfort and pain. Therefor it is morally (and legally) incumbent on us to avoid inflicting unnecessary and avoidable discomfort when interacting with other animals.

The aim of the VBC is to develop effective methods for the control of vertebrate pests. Currently work is focused on the European red fox, the rabbit and, recently, the mouse in Australia. Thus the staff of the Centre interact with animals on a daily basis and the results of their research will have far reaching effects on animals in Australia. However the VBC's **Mission** recognises the need for control to be humane. It reads:

To develop more effective, more humane, species specific methods of control of Australia's vertebrate pests so as to protect the natural environment and enhance efficacy of agricultural production.

The humane aspect is further amplified in the principal strategy statement which reads in part:

The primary aim is to induce sterilisation that is humane and does not compromise the social status of affected animals, nor jeopardise the fecundity of any other species.

The reasons for seeking to control foxes in Australia have been well stated elsewhere (Saunders *et al.* 1995 provide an excellent summary). This document briefly outlines the justification for their control and then examines, from the welfare point of view, the likely long term impact of success on animals at individual and population levels (including non-target species where that is relevant) and compares those with the effects of other methods. It also outlines the treatment of animals that are used in the research work of the CRC and the procedures in place to ensure that research involving animals is necessary, acceptable and as humane as possible.

Its purpose, then, is to demonstrate that the objectives of the VBC with regard to animal welfare will be met by successfully implementing immuno-contraception as a control method and to present, openly, the protocols for the treatment of animals used in the development of the new technology, demonstrating steps that are taken to ensure that any distress which is caused is not avoidable and is minimised so as to be as humane as possible.

2. WHY CONTROL FOXES?

2.1. *The fox in Australia*

2.1.1. *The predator*

Foxes are primarily predators although they will seek carrion and sometimes take plant food such as fruit. They are astonishingly catholic, hunting berries and insects in some circumstances but they take lambs, poultry, rabbits and native vertebrates when available. Native vertebrates include mammals, birds, reptiles and frogs. Their

versatility enables foxes to hunt prey species to extinction provided they can access alternative food sources.

2.1.2. *Introduction of the fox*
Foxes were introduced from Britain for hunting with hounds as early as 1855. Although there seem to have been several introductions the first known feral populations established in Victoria in the early 1870s. There were further translocations from those populations but foxes also spread rapidly of their own accord and by 1893 they had attained sufficient pest status to attract bounties in some areas of that State.

2.1.3. *Spread over Australia*
Foxes were apparently well established on the Coorong of South Australia by 1888 although it is not certain whether they had dispersed naturally from Victoria or whether there had been additional introductions to South Australia. In any case they had reached the Western Australian border by 1911 and Geraldton on the west coast some 400 km north of Perth by 1925. They were reported in the south west Kimberley by the late 1930s. In eastern Australia foxes had moved north into New South Wales by the 1890s and reached Queensland by the first decade of this century.

It has been suggested that their spread in many areas followed closely on that of the rabbit. Certainly rabbits are a major food item in Australia as well as in their native Europe. Today foxes are well established and abundant wherever there are substantial rabbit populations but they are also common in some areas devoid of rabbits such as the arid Pilbara coast of WA.

2.2. *Fox impacts*
2.2.1. *Loss of native fauna*
Australia has the world's worst history of mammal extinction in the last two hundred years. We have lost 18 mammal species. Many more that used to occur on the mainland, often across the continent, are now restricted to off-shore islands or survive as endangered species in tiny fragments of their former ranges. There have also been serious declines in other classes, notably ground dwelling birds and even some reptiles such as larger pythons which prey on native mammals. The scale of fauna losses, not to mention the ecological processes they used to drive, are only now becoming apparent.

Several hypotheses have been put forward to explain this disastrous record. Undoubtedly many interacting factors have played a part but there is increasing evidence that implicates foxes as one of the most important of these factors. For example:

The fauna has remained substantially intact in many areas free of foxes. These include the wet/dry tropics and off-shore islands, including Tasmania where there are feral cats and most of the other disturbers that are often suggested as causes of fauna decline. Indeed many more mammals that were once widespread on the mainland would be extinct if they had not survived on islands free of foxes.

Many species are recovering in the shelter of fox control. Examples are Woylies (Brush-tailed Bettongs) *Bettongia penicillata*, Numbats *Myrmecobius fasciatus* and

Chuditch *Dasyurus geoffroii*. All three used to occur from about the Great Dividing Range westward across the deserts of central Australia to the west coast. Early this century the bettongs sold in Adelaide "by the dozen for about ninepence a head for (greyhound) coursing on Sunday" (Wood Jones 1924). They had vanished from SA twenty years later. In the last hundred years or so all three species retreated westward until woylies and numbats survived only in two small Nature Reserves and one small area of State Forest in south western WA. Even there they almost vanished. Chuditch persisted in more extensive areas of the jarrah forest though their numbers dwindled to an estimated total population of 6000 animals.

All three species have been the subjects of Recovery Plans in which the principal actions are protection from foxes and translocation to areas where foxes are controlled. The Numbat and Chuditch Recovery Plans are still being implemented. The Woylie Plan concluded in 1995 and this species has recently been removed from the National and Western Australian lists of threatened/endangered species. Using the current IUCN criteria they are in a category of *Lower Risk* than any of the *Threatened* categories but remain in the sub-category of *Conservation Dependent*. The change in status has been the direct consequence of fox control and translocation to areas where foxes are controlled. The *Conservation Dependent* status recognises their dependence on continued fox control.

2.2.2. *An agricultural pest*

Foxes have been regarded as agricultural pests since at least 1893 when bounties were introduced in parts of Victoria. A State-wide bounty system was introduced there in 1949 but abandoned in 1977 when up to 100,000 bounties were paid and the system was seen to be ineffective. Other States have also had bounty systems. However the real cost of damage by foxes has not been well established. Sheep are undoubtedly the most severely affected farm stock but it was thought that losses to foxes were probably not great. Recently there is evidence that the impact of foxes through loss of lambs, particularly twins, has been significantly underestimated. Aside from being predators of sheep foxes are certainly of nuisance value to rural communities because of their predation of poultry and of some economic significance to the growing small-holders who keep "boutique" livestock.

2.2.3.*A Rabies vector*

Rabies is not yet present in Australia. However it is present in north America and in Europe where 85% of reported cases are from foxes. The introduction of rabies to Australia would be a catastrophe. There is always a risk of introduction. Once here foxes would probably be the most serious transmitting agent of the pathogen and so a reduced fox population would significantly improve the practicality of containing and eradicating rabies if it should ever get here.

3. HOW ARE FOXES CONTROLLED NOW?

3.1. *Control by nature*

There are many ways by which fox populations are affected in nature. Some of these are natural, caused by interacting environmental factors. Eg predator-prey population cycles associated with wet and drought years; even juvenile mortality as young animals disperse in search of vacant territory. Others are indirectly consequent on human actions. Eg outbreaks of Rabbit Calici Disease (RCD) or Myxomatosis (both

introduced to Australia) or poisoning of rabbit populations. All these events remove important food sources and the subsequent declines in fox population often involve distressing events such as starvation. Even where human actions such as these indirectly cause suffering to foxes, it is unlikely that concern for fox welfare would alter the actions. Only eradication of foxes could prevent the continual recurrence of distress from adverse environmental factors. Permanent population reduction would reduce proportionally the number of animals that suffer in these circumstances.

3.2. *Control by man*

In all parts of Australia where there are foxes people catch or kill them as pests, for their pelts, for "sport" or (to a very limited extent) for research. The methods vary widely in their effectiveness and humaneness. The worst circumstances occur when people use inhumane methods that are unnecessary (Eg hunting with hounds) or ineffective (Eg steel-jawed traps to control populations). Scientists in the CRC account for a considerable proportion of the foxes taken for research but the VBC does not take foxes for any other purposes although CALM and Agriculture Western Australia (AgWA) in WA and the Department of Agriculture in NSW have operational fox control programs. Saunders *et al.* (1995) discuss the effectiveness and humaneness of various methods used to catch or kill foxes. Briefly they include:

3.2.1. *Traps*

Many trap types have been used to catch foxes but steel-jawed traps have probably been the most common. Thankfully, they are little-used now because they are inhumane, costly, time-consuming and inefficient.

Victor Soft-catch traps have been widely used in NSW and WA in fox research, including VBC projects on fox ecology. It is imperative that they do not injure foxes; they are used to catch the animals alive so that radio collars can be fitted before release, or for other work requiring healthy, live foxes. Their use by VBC scientists has been sanctioned by respective Animal Experimental Ethics Committees. They would not be effective for fox control except very locally.

3.2.2. *Riding with hounds and other forms of dog-hunting*

There are hunt clubs in many parts of Australia. Their objectives are "sport" and this form of hunting is not useful as a fox control measure nor can it be regarded as a humane way to kill foxes.

3.2.3. *Shooting - pest control and pelt trade*

Foxes are shot in most farming areas of Australia. Professional shooters seeking fox pelts usually use high powered rifles with telescopic sights. They are very experienced and they can not afford to lose wounded foxes. Their operation is probably quite humane. The industry is substantial and up to 500,000 pelts per year have been exported from Australia. However professional hunters harvest a sustainable resource. Reduction of fox numbers would be disadvantageous and their activities can not be regarded as a useful fox control method. VBC research staff do on occasion shoot foxes to obtain samples. In all cases experienced marksmen using high-powered rifles do the shooting.

Many rural residents shoot foxes. Most operate opportunistically with a variety of firearms and skill levels. Some marksmen may shoot humanely but others not so. Specific control objectives may be met (Eg. protection of lambing paddocks or poultry pens) but broad acre control is not usually achieved. It is almost impossible to police inefficient shooters who operate inhumanely.

3.2.4. *Den fumigation*
Den fumigation is not widely used and would not be useful as a broad-acre control method. Nevertheless, depending on the gas used and the concentration level in the den, it may be a relatively humane method.

3.2.5. *Poison. 1080 (Sodium mono-fluoroacetate)*
1080 is widely used to control a variety of pest vertebrates in Australia. In many areas it is the most common method of controlling foxes. In eastern Australia it is available commercially as FOXOFF (Applied Biotechnologies, Victoria.). and is usually distributed manually. In WA it is usually injected into dried meat baits which are available to landholders through AgWA. Baits can be distributed from the ground. However CALM, which now baits about 0.9 million ha routinely (and has announced an expansion to about five million ha) for conservation purposes in State Forests, National Parks and Nature Reserves distributes most baits from aircraft at a rate of 5 per km^2. Where safety issues require alternative methods the toxin can be inserted into chicken eggs and buried. This is costly and time consuming.

The substance 1080 occurs naturally in plants, notably members of the genus *Gastrolobium* (Fabaceae) which is a common component of the flora of south western Australia. The native fauna of the south west has acquired a very high level of tolerance to 1080, so much so that granivores and herbivores can include these plants in their diets. This tolerance means that the fox baits are toxic only to introduced fauna. It is this target-specificity (enhanced by the dried meat bait medium which is not attractive to most animals) that allows such extensive safe use of 1080 in WA. 1080 is used in VBC fox ecology projects where it is necessary to achieve reduction in populations over large areas.

Effects of poisoning in dogs include a latent, asymptomatic period up to two hours followed by hyper-excitability, barking and panting. That gives way to convulsions with continuation of barking and panting until death from respiratory failure up to two hours later. It has been suggested that extreme central nervous system stimulation even in anaesthetised animals could indicate that the convulsions are not a response to or symptomatic of severe pain or suffering.

3.2.6. *Poison. Cyanide*
Cyanide poisoning is the most humane and effective method available for scientists needing to sample fox populations where it is not necessary to obtain live animals. It causes death very rapidly and is considered to be the most humane of the toxins commonly used to kill foxes. It is used by VBC scientists to sample fox populations because the carcases can be retrieved since the foxes do not move far from the bait station before dieing.

Cyanide is not used as a control method for foxes because there are problems of user safety, the risk to non-target species, bait distribution and manufacture (salts rapidly decomposes to volatile hydrogen cyanide in the presence of moisture; baits used to sample fox populations enclose powdered cyanide salt in brittle wax capsules that are coated with an appetising attractant).

3.2.7. *Poison. Strychnine*
Strychnine was once commonly used in rural communities for controlling pest vertebrates including foxes. Death usually occurs within an hour of the onset of symptoms but it is regarded as a very inhumane toxin and there is a 1991 recommendation from a working group of the National Consultative Committee on Animal Welfare that its sale in Australia be banned. It would not be an effective method for broad acre control of foxes because of the difficulty of preventing poisoning of non-target species and because it would probably not be acceptable to the public.

4. THE LAW AND RESOURCE ALLOCATION

4.1. *Foxes as pests*

4.1.1. *Federal Legislation and resource allocation.*
The Endangered Species Protection Act 1991 administered by the Australian Nature Conservation Agency (ANCA) lists fox predation as a "Key Threatening Process". Accordingly ANCA has a statutory obligation to prepare a Threat Abatement Plan (TAP) which will provide a National framework for controlling the impact of foxes on threatened species. ANCA will have responsibility for its implementation on Commonwealth lands. Responsibility for implementation on State and Territory lands will reside with the State and Territory Governments. A draft TAP for public comment is nearly ready for publication.

ANCA, through its Invasive Species (formerly Feral Pests) Program, allocates money to the States and other organisations for the development and implementation of feral pest control. That program contributes substantial funding to both the VBC Reproduction Program and the VBC Ecology Program for work on foxes.

The Bureau of Rural Resources has also allocated funds to fox management and in 1995 made a significant contribution to fox control at the National level by publishing a fox control manual (Saunders *et al.* 1995).

4.1.2. *State Legislation*
The fox is regarded as a pest species in all mainland States although Departments of Agriculture and farmers do not allocate as much resource to its control as they do to many other vertebrates such as rabbits, dingoes, pigs or goats. This probably reflects the view that the fox is of less economic significance than other pest species. In some States (Queensland, South Australia, Victoria, Western Australia) there are statutory obligations to control foxes, but they are seldom enforced. The fox was deleted from the list of Declared Noxious Animals in New South Wales because of the acknowledged difficulty in enforcing legislation requiring control.

However, with the increasing awareness of the environmental impact of foxes, there is an increasing investment in fox control for conservation purposes by State conservation agencies and rural communities. This is most marked in Western Australia where the Department of Conservation and Land Management (CALM) is routinely baiting foxes on about 0.9 million ha including the northern jarrah forest, an area over 500,000 ha. CALM has announced plans to increase this area to about five million ha in the near future. Control for conservation purposes is gathering momentum in most other States and Territories but to varying degrees.

4.2. ***Animal Welfare***

There are several levels at which the activities of the VBC and its scientists are regulated.

4.2.1. *Welfare legislation*

In all States and Territories of Australia there is legislation for the Prevention of Cruelty to Animals. The Royal Society for the Prevention of Cruelty to Animals (RSPCA) is the best known advocate for animal welfare and its inspectors have powers under legislation to enforce the relevant regulations and to prosecute. The treatment of foxes is covered by this legislation.

4.2.2 *Animal Experimentation Ethics Committees (AEECs)*

The control of ethical issues pertaining to the use of animals in research within Australia is governed by the **Australian Code of Practice for the Care and Use of Animals for Scientific Purposes** prepared by the National Health and Medical Research Council, the CSIRO, and the Australian Agricultural Council. The current edition was published in 1990.

Adherence to the Code is not currently enforced by law everywhere, but its adoption by Australian research organisations is nearly universal. The Code prescribes the structure of Animal Experimentation Ethics Committees (AEECs) which are charged with responsibility for scrutinising all scientific research projects **"to ensure the humane care of animals used for scientific purposes"** (Page 1. Purpose of the Code). The AEEC membership must include, amongst others, a person with qualifications in veterinary science or experience and qualifications to provide equivalent expertise; a person (who is not an employee of the researching institution) with demonstrable experience and commitment to animal welfare, usually selected on the basis of membership of an animal welfare organisation and a person, preferably not an employee of the institution, who has not conducted experiments involving animals. Thus there is strong input from outside the research institution.

Each of the institutions participating in the research of the VBC has an AEEC constituted under the provisions of the Code and all scientific projects involving the use of vertebrate animals are submitted to one or another of the Committees.

4.2.3. *Public Issues Panel*

The VBC has established two expert panels that meet with the scientists and the Board each year. One is a Scientific Panel. The other is a Public Issues Panel. The Public Issues Panel comprises senior representatives of peak non-government organisations and federal agencies with special concerns about the environment and animal welfare

including the Australian and New Zealand Federation of Animal Societies (ANZFAS) and the Australian Conservation Foundation (ACF).

While these Panels meet formally with the Board only once per year, Members are encouraged to and frequently do liaise with the Director and other members of the VBC on any matters which are of interest or concern to them. It is expected that they will inform their respective organisations of the activities of the VBC and convey the views of their members to the VBC.

4.2.4. *Public Review*
Before the release of any biologically-vectored immuno-contraceptive to the environment there is a statutory requirement for scrutiny and approval by the Genetic Manipulation Advisory Committee (GMAC). It is standard practice for proposals submitted to GMAC to be released for public comment.

5. HOW WILL THE NEW WAY WORK

5.1. *The concept*
Immuno-contraception would prevent reproduction by inducing an immunological response by an animal to proteins involved in fertilisation or implantation, thus preventing pregnancy. By targeting species-specific proteins to elicit the immunological response the system can be made species-specific in its effect. This will make it environmentally safe to other organisms. The proteins could be delivered either in baits or by infection of the target species by genetically modified organisms such as viruses or bacteria that would express the genes encoding the proteins. The infectious agents could be non-transmissible and delivered in baits or host specific contagious organisms that will spread naturally through the target population. The latter would be ideal because bait delivered systems require repeat distribution of baits so that economic factors would severely limit the extent of the area covered.

5.2. *Physical effect on individuals*
Immunological activity is a natural daily process which causes no pain or distress. A bait delivered protein would therefor not cause any discomfort to an animal that ate a bait - in fact it would get a palatable morsel to eat!

Delivery by genetically modified organisms could affect the infected fox if the vector induces pathological symptoms. The ideal would be to use a readily (perhaps sexually) transmitted but benign vector. At present the VBC has not identified possible candidate vectors for foxes. Until potential candidates are identified and their pathological effects are investigated it is not possible to speculate on the distress that may be endured by foxes infected by vector organisms. If a potential vector is identified, these aspects will be reviewed.

5.3. *The effect on social factors*
Immuno-contraception would prevent either fertilisation or implantation. It would not interfere with gamete production or gonad function. It is therefor fundamentally different to sterilisation induced by chemical or physical interference with the gonads. Hormonal interference would be limited to processes associated with pregnancy and lactation. Therefor it is probable that there would be no influence on social activity like establishment of home ranges, den sites or interaction with mates. It is not known what

effect failure to raise a litter has on a vixen that was successful in establishing a den and attracting a mate. However this situation occurs in nature.

5.4. *The effect on interactive (predators and prey) species*

Foxes are not known to have natural predators in Australia although there is circumstantial evidence of interaction between foxes and dingoes. Reduction of dingo numbers may allow foxes to increase. The mechanism by which this happens is unknown. It has also been suggested that cats may increase where fox numbers are reduced

Widespread reduction of fox numbers protects prey populations and allows them to increase or, at least, prevents their decline. This is usually the objective of fox control for conservation and agricultural purposes. Control of fox numbers where rabbits are the principal prey item may allow an increase of rabbit numbers to the limit of food availability (assuming foxes are a limiting factor and that alternative predators such as feral cats do not increase to replace foxes as predators). In many situations that would precipitate a demand for additional rabbit control measures. Where foxpopulations are reduced for conservation purposes, increase in native fauna, including recovery of endangered species, will occur.

The implications for rabbit welfare would be difficult to anticipate if a self-disseminating, biologically-vectored immuno-contraceptive system for foxes were to be introduced before effective control of rabbits is achieved. In fact it is likely that a self-disseminating immuno-contraceptive for rabbit control will precede one for foxes. Even if a bait delivered system for foxes is available before rabbit control is possible, it is unlikely that there would be any advantage in baiting foxes in areas where rabbits are prevalent and the principal diet of foxes.

6. USE OF FOXES IN VBC RESEARCH

Foxes are used by VBC scientists for ecological studies of wild animals and for reproductive and micro-biological studies in the laboratory.

6.1 Taking wild foxes

It is necessary to catch or kill wild foxes for various purposes. Depending on the circumstances methods may involve trapping live animals, shooting and poisoning with cyanide or 1080. The welfare aspects of each are discussed in Section 3 and all projects requiring catching or killing of foxes are subject to the approval of Animal Experimentation Ethics Committees described in Section 4.2.

Live foxes are required for ecological studies (most commonly those involving radio-telemetry) or for replenishing captive stocks. It is important from welfare and scientific perspectives that the animals are not physically injured. Although it is not possible to avoid stress associated with capture and handling, this is minimised by frequent checking of traps and prompt handling by experienced staff.

Shooting or cyanide baiting are used where it is necessary to sample wild populations but live capture is not essential. Both methods are humane and carcass recovery is assured. Where it is necessary to reduce fox populations over large areas 1080 is used because shooting and cyanide poisoning are impractical or unacceptably dangerous to people or non-target animals.

6.2 Captive foxes

The successful development of immuno-contraceptive methods for controlling fox populations has necessitated the establishment of a captive fox colony for immunological trials and fertility testing. The colony has been maintained for five years at the CSIRO Division of Wildlife & Ecology site, Canberra. Housing arrangements were inspected and approved by the Division's Animal Experimentation Ethics Committee at the outset of the project and annual renewal of AEEC permits are subject to repeat inspections by the committee.

The animal facilities manager is a qualified vet. He oversees day to day operations, deals with animal health issues and supervises the two officers responsible for the care and management of the colony. The latter are also trained in procedure for collecting blood samples from the animals. Blood samples are obtained routinely for assaying hormonal and other biochemical compounds. When necessary the foxes are euthanased by established veterinary procedures.

The colony holds about 120 foxes of each sex. Each fox has a subcutaneous, electronic identification tag. Cages include logs for climbing, viewing and sunning, as well as sheltered breeding boxes. Comfort is important because the research requires that the foxes breed in the cages. The animals are held as pairs, one pair per cage, for approximately 10 months of the year. Surplus foxes are held in large outdoor enclosures which approximate the size of a tennis court. The foxes are fed a varied diet of wet and dry commercial dog food supplemented weekly with fresh meat. They have water *ad lib.* All animals are vaccinated against the common canid diseases, and regularly dosed against heart worm.Natural mortality within the colony is very low.

6.3. Ecological Studies

Ecological studies invoke many techniques. Some such as the monitoring of fox activity by tracks left on sand-pads are non-intrusive. Others involve some temporary or light intrusion. Eg spot-lighting. Radio-telemetry is a standard technique useful for a variety of studies. Radio transmitters are built into collars and fitted round the foxes necks. The collars must be comfortable so as to not interfere with the normal activities of the collared foxes. Radio-tracking of wild animals is now a well established procedure used world-wide, often for management of critically endangered species. The initial capture may be traumatic but subsequent tracking is carried out remotely. Some studies may require killing of foxes. Issues associated with capture or killing are described in Sections 3.2.1. and 6.1. All projects involving wild foxes are subject to approval of Animal Experimentation Ethics Committees irrespective of the level of intrusion.

7. IMPLEMENTATION OF THE NEW METHODS

The development of an effective bait-delivered immuno-contraceptive method for fox control will require the following steps.

- Demonstrate oral bait immuno-sterilisation.
- Field trial immuno-sterilisation by bait.
- Determine the level of sterility required to reduce populations.
- Determine the effect of sterilisation on behaviour.

Eventual release into the field will be the culmination of a series of closely regulated and critically assessed steps independently supervised by GMAC. There will be opportunity for public input to the process. If it is possible to locate suitable biological vector candidates for a self-disseminating system for fox control it will be necessary to review this document to incorporate information about any pathological effects of the vector candidate.

8. DISCUSSION

As long as foxes are common and widespread in Australia recurring, natural situations such as drought will cause fluctuations in prey availability and so distress, particularly social stress and starvation, amongst foxes. This may be more prevalent on our continent than in their native habitat because Australia has a very erratic climate which can cause huge fluctuations in prey populations, particularly rabbits.

Rabbits are also pests and so people will take action to control them. Man-induced reduction in rabbits (eg. by poisoning) will expose foxes to the same stresses. Myxomatosis is now an endemic factor which causes periodic rabbit population crashes. RCV is established in wild rabbits and (whether or not it is sanctioned for release as a control agent) it is likely to spread, causing episodic high mortality in rabbit populations. Given normal epidemiological patterns of lethal diseases it is unlikely that these diseases will reduce rabbit populations to a new, low, stable level. Thus they will exacerbate the wide fluctuations in prey availability and episodes of distress to foxes.

In any case the fox is considered a pest. People employ many methods to control it. None of the available methods result in permanent reduction with one application (except exclusion fencing which is very costly and only realistic where protection of small areas is essential). Therefor all methods require repetition at regular intervals. Thus the collective distress caused to foxes will not diminish with time.

As a general rule effective fox control over small areas requires frequent repetition because the rate of reinvasion will be rapid. (Eg. protection of rock wallaby populations on granite outcrops in Western Australian agricultural areas requires monthly baiting.) Substantial benefits derive from control over large areas if subsequent reinvasion through the boundary zone and prevention of population recovery in the core area can be achieved. The benefits include collectively less distress to foxes because there are fewer animals in the area which is subjected to follow-up control operations. There will be more effective protection of prey species, and there will be fewer animals killed by foxes. Furthermore there are economic advantages to scale. Repeat operations can be reduced (Eg. from monthly to bi-annual baiting in the core).

There is some degree of distress associated with all the available methods for killing foxes. However there is considerable variation between methods and to a lesser extent too the skills and ethics of the operators.

Traps are ineffective except very locally and then their effect is short-lived because reinvasion is rapid. Those most commonly used, steel-jawed traps are very cruel.

Shooting can be humane but is not usually effective because professional shooters want to harvest a sustainable resource and landholders usually shoot opportunistically to protect local values. In these circumstances reinvasion is rapid. Fumigating dens may be humane but it requires a lot of time to locate dens and is probably of little value as a long-term or broad-acre method. There are no known fox-specific pathogens that would be effective control agents.

Poison, then is the last remaining conventional option. Of the three toxins most often used, there are severe problems with the operator safety, manufacture, distribution and non-target risks of the most humane, cyanide. Strychnine has many of the same problems, particularly the risk to non-target species and is, in any case, considered so inhumane that a responsible non-government organisation has recommended that its sale in Australia be banned.

In many areas poisoning with 1080 is the most widely used control method. In Western Australia it is used for control over very large areas, with the advantages that accrue to welfare, efficacy and economics from that. However the unique levels of tolerance to 1080 in that area facilitate operations at a scale that would probably be impractical elsewhere. It is not clear how much pain is suffered by foxes that are dieing from 1080 poisoning; it may be relatively humane. However it would be preferable too have a control method that could be certain to cause little or no distress.

The short to medium-term goal of the VBC for foxes is to develop a bait delivered immuno-contraceptive that will be capable of reducing a fox population sufficiently to significantly improve protection of domestic animals and allow native prey species to recover. Because the system will prevent reproduction by stimulating an immune response to gametes it will not affect hormonal effects except those associated with pregnancy and lactation. In this way it will differ significantly from sterilisation by disrupting or destroying gonads. Thus immuno-contraception is likely to have little if any effect on social activity of treated foxes and it will not cause any discomfort or pain. Because it will be species-specific and non-toxic it will be safe to handle and benign in the environment. Although it isn't expected to be effective in small areas where immigration and emigration will swamp the effect it will be safe to apply baits over large areas in all parts of Australia from aircraft.

The long term ideal is to use a self-disseminating immuno-contraceptive system that will persist in wild fox populations with minimal need for reintroduction. Ideally the vector will be transmissible (perhaps sexually transmitted) and benign in so far as disease symptoms are concerned. However suitable vectors may be difficult to locate If a candidate is discovered, the animal welfare implications should be examined when details of its pathological effects are known.

9. REFERENCES CITED.

Saunders. G., Coman, B., Kinnear, J. and Braysher, M. 1995. *Managing vertebrate pests: Foxes*. Australian Government Publishing Service, Canberra.

Wood Jones, F. 1924. *The Mammals of South Australia*. Part II. Government Printer. Adelaide.