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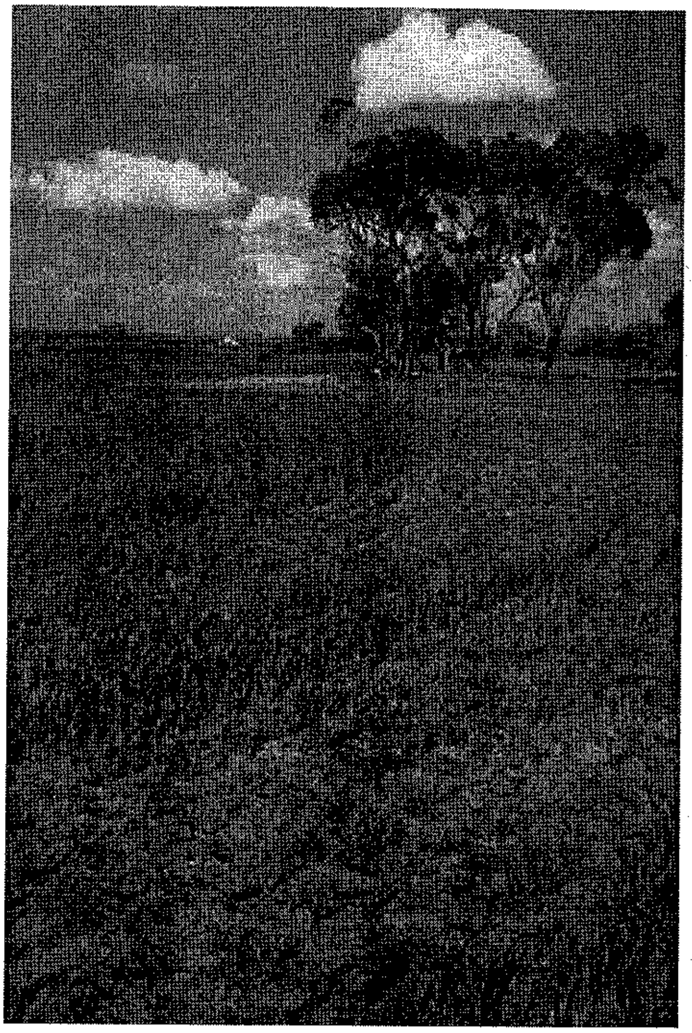
CONTENT



Damage caused by rabbits

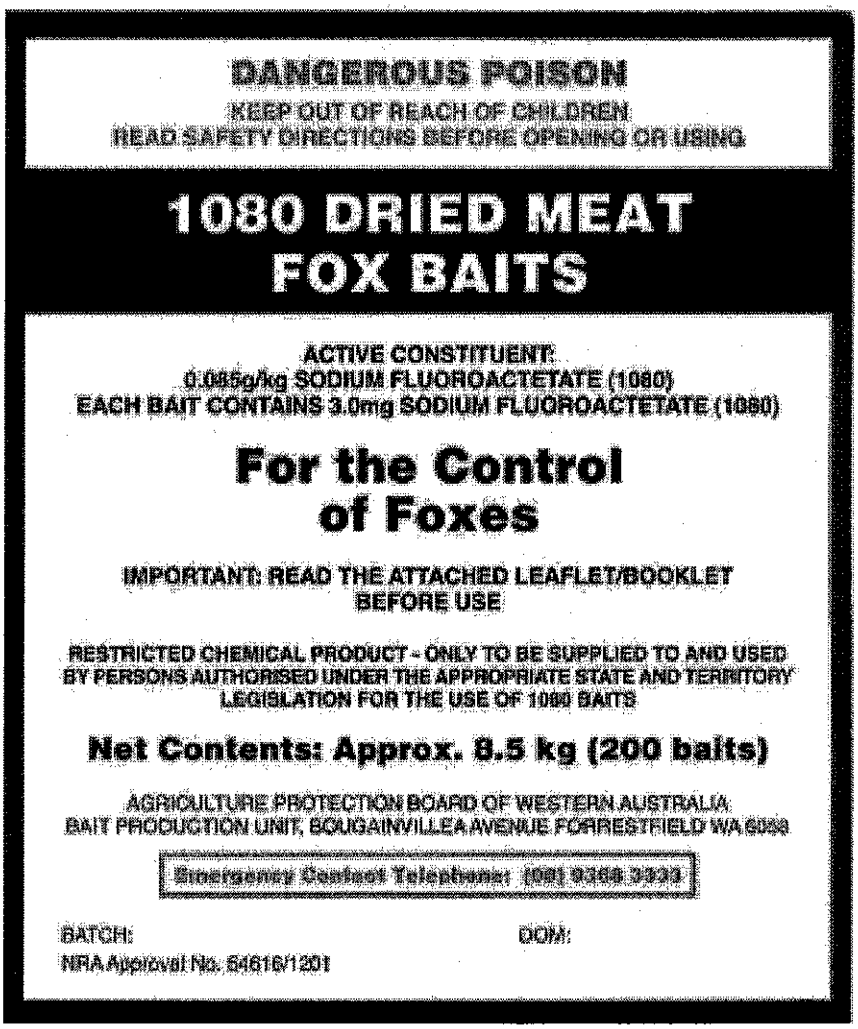
EXECUTIVE SUMMARY

Fluoroacetate, the active ingredient of 1080, occurs naturally in toxic plants in Australia, South Africa, and South America. Manufactured 1080 underpins most vertebrate pest control programs in Australia and New Zealand. Fluoroacetate occurs naturally in about 40 plant species in Australia with most of these plants restricted to the south-west of WA.

1080 was introduced to rabbit control programs in the early 1950s and therefore has a long history of proven effectiveness and safety in Australia. There have been few reported problems associated with human safety, environmental persistence, bioaccumulation or impact on populations of non-target species.

In particular, 1080 baits are a critical component of integrated pest management programs for rabbits, foxes, wild dogs, and feral pigs in agricultural, forestry and conservation areas of Western Australia.

For example, the broad-scale control of foxes using 1080 meat baits was introduced into management programs of the conservation estate in Western Australia in 1994 with the *Western Shield* program commencing in April 1996. Baiting activities in conjunction with recovery plans for the Woylie (*Bettongia penicillata ogilbyi*), Southern brown bandicoot or Quenda (*Isoodon obesulus fusciventer*) and the Tammar wallaby (*Macropus eugenii*) have so greatly improved the conservation status of these species that they have been removed from the State and Commonwealth endangered species lists. One of the significant contributing factors to the decision to de-list these species was the increase in the number and size of populations in mainland WA, principally in areas subject to government funded fox control programs which utilise 1080 baits. Moreover, 1080 is still an important component of management programs for reducing the impact of European rabbits on agricultural production and conservation in WA, having been used for this purpose since the early 1950's.



Sample label used on 1080 packages

1080 (*SODIUM FLUOROACETATE*)

GENERAL BACKGROUND

- Fluoroacetate, the active ingredient of 1080, occurs naturally in toxic plants in Australia, South Africa, and South America. Manufactured 1080 is used to control introduced mammals in Australia and New Zealand. Fluoroacetate occurs naturally in about 40 plant species in Australia with most of these plants restricted to the south-west of WA. These plants mostly belong to the genera *Gastrolobium* ('Poison peas') with one species of *Acacia* ('Gidgee'). Although usually in biological insignificant quantities, the ability of plants to synthesise fluoroacetate is reasonably widespread, and fluoroacetate can also occur at very **low** concentrations in tea leaves and guar gum, a common constituent of a variety of food-stuffs.

- *Sodium fluoroacetate* (and hence 1080) is a relatively stable molecule which is highly soluble in water. However, 1080 starts to break down at temperatures around 110 °C. 1080 is readily leached from baits, but accumulation in, or contamination of, soil or the environment does not occur because a number of fungi and bacteria (at least 24 different species) are able to degrade 1080 into harmless by-products.

- *Sodium fluoroacetate* is a broad-spectrum poison that acts by interfering with the energy-producing tricarboxylic acid cycle (TCA/Krebs cycle) in the mitochondria. Thus poisoned animals are not able to meet all their energy needs. However, fluoroacetate itself is not toxic as it must be converted to a second compound (fluorocitrate) within an animal to exert its toxic effects. This happens in the TCA cycle. As different animal groups convert the fluoroacetate to fluorocitrate (the ultimate toxin) at different rates, and as the effect of the fluorocitrate produced varies between groups, there is a wide variation in the sensitivity of the different animal groups (Families). This is summarised below.

- Canids are among the most sensitive, herbivores and birds are less sensitive, and reptiles and amphibians are relatively insensitive to fluoroacetate.

- Fish and other aquatic fauna (including invertebrates) are relatively resistant to 1080, and lethal concentrations would not be achieved even under intensive, standard aerial baiting programs. In any case, aerial baiting programs avoid watercourses, and 1080 breaks down rapidly under moist conditions through leaching and microbial action.

- The acute toxicity of 1080 has been determined for over 200 species/populations of animals, including birds, mammals, reptiles and insects (see Appendix 3). However, the toxicity of 1080 can increase once animals are forced to operate at temperatures outside of their normal body temperature range. 1080 can also have a chronic effect on many animals, such as a temporary reduction in their fertility.

- Because of the need for fluoroacetate to be absorbed and then converted to fluorocitrate, there is lag between the ingestion of 1080 and the appearance of signs of poisoning. In mammals, this lag is between 0.5 and 3 hours. Animals receiving small sub-lethal doses of 1080 may show mild signs of poisoning, metabolise and excrete 1080 within 1–3 days, and then recover. If an animal ingests a sub-lethal dose of 1080, toxin residues will not persist in meat, blood, the liver, or fat (as with some other pesticides; e.g. some anticoagulants, organophosphates).

- Production animals should not be exposed to 1080 baits and therefore residues in livestock are unlikely to occur.

- The mechanism of toxicity for naturally occurring fluoroacetate, and for 1080 in baits, is the same regardless of the origin of the poison.

- New Zealand is the greatest user of 1080 concentrate using around 2-4 tonnes of powder per year. In contrast, only 200 kg of concentrate is used in Australian pest control programs each year. 1080 baits have been used in New Zealand since the 1950s, largely for aerial baiting of introduced possums. Current 'sowing' rates are 3–5 kg/ha which equates to 4.5-7.5 g 1080/ha. This compares to around 0.000375 g 1080/ha used in many fox baiting programs in Australia.

TERMINOLOGY

Sensitivity: The toxicity of a particular toxin. This is usually measured as the amount of toxin per kg body weight. The Lethal Dose 50 (LD_{50}) is the most common measure of toxicity. This equates to the amount of toxin (mg) per kg body weight required to theoretically kill 50% of test subjects.

Susceptibility: Relates to the field/practical risk associated with the use of a particular toxin/pesticide. Susceptibility will depend upon a number of things including the sensitivity of different animals to a poison, the body weight ratio between the target and non-target species, the level of exposure to bait, bait placement, the method of baiting, and the time of year a baiting program is carried out.

Poison oat spreading

BENEFITS OF FLUOROACETATE AS A PEST ANIMAL MANAGEMENT TOXIN IN AUSTRALIA

- 1080 has a long history of proven effectiveness and safety in Australia having been used in rabbit control programs since the early 1950s. There have been few reported problems associated with human safety, environmental persistence, bioaccumulation or impact on populations of non-target species.

- 1080 has high efficacy with the potential to achieve rapid and high-level population knockdown for the main species it is used for in Australia (rabbits, foxes, wild dogs, and feral pigs).

- 1080 is generally target-specific in Australia due to relative tolerance of many native species, particularly when compared to canids. Target-specificity is further enhanced by careful selection of bait, its size, colour, bait material, and bait placement.

- 1080 has extremely low environmental persistence. However, 1080 can persist for several days in carcasses which can result in the secondary poisoning of foxes and domestic dogs. 1080 does not bioaccumulate.

- 1080 is metabolized rapidly in live animals and is usually excreted or detoxified within 1-3 days. Once excreted, or the 1080 exits the baits, it is readily broken down by microbial activity under moist conditions.

- 1080 has a reasonably rapid mode of action (compared with anticoagulants).

- 1080 is accepted as the most humane of the vertebrate pesticides currently available.

- 1080 has high-quality efficacy data to support both aerial and ground-baiting techniques against all the major vertebrate pests for which it is used.

- 1080 use in Australia is closely regulated by government agencies. Provision of 1080 is largely on the basis of a demonstrated need and clear guidance is provided on appropriate use in most States.

- In Western Australia, the use of 1080 has improved the conservation status of endangered native fauna through the control fox of populations (see Appendix 1).

- In Western Australia, 1080 is an important tool for managing rabbit populations with respect to agricultural production, tree plantation industry and conservation.

The potential risks associated with 1080 use (see Table 1b) can be managed by:

- continued government control over distribution and use;

- uniform State/Territory government policies on use;

- enhanced extension on 'best practice' use;

- use of appropriate bait material/size/colour and placement and toxin loading to minimise the non-target hazards (which are generally low at the individual animal level and negligible at the population level);

- precautionary approach and further research needed in the rare situation where 1080 use may pose a potential local threat to native species at the population level (e.g. quolls in some parts of eastern Australia);

- examining the potential for incorporating analgesics into canid baits to counter any perceived pain;

- developing alternative 1080 formulations or other toxins for feral pigs. 1080 can be highly effective for feral pig control over large areas, but relatively large amounts of 1080 are required (due to moderate sensitivity and large body weight) and the toxin provokes vomiting in many pigs.

There would be a range of negative consequences if 1080 was deregistered or its use became severely restricted. These include:

- lack of any effective method for broadscale control of fox and wild dog populations resulting in unacceptable agricultural and environmental damage. Restricting 1080 use for fox control in particular would seriously threaten the effectiveness of Commonwealth and State government recovery plans for endangered species. Any potential for minor direct effects of 1080 baits on native animal populations is insignificant compared to the predation and competition impacts caused by the introduced species which are managed with 1080. The loss of 1080 would almost certainly result in the extinction of native animals in Australia and New Zealand because no viable alternatives are available. 1080 is still also a very important component of rabbit control programs throughout Australia ;

- the loss of a critical component of integrated pest control programs for rabbits, foxes, wild dogs, and feral pigs;

- inevitable off-label use of other more harmful pesticides by frustrated landholders.

Table 1 (a) Advantages and Potential Disadvantages of General Poisoning for pest animal control in Australia

General poisoning	
Advantages	**Potential Disadvantages**
Widely accepted in rural and scientific community as a safe and essential tool in reducing the agricultural and environmental impacts of pest animals	Some non-target risks at the individual animal level and possibly at the population level may occur if these products are not used correctly. Thus there is a need for appropriate regulation and conduct of control programs according to uniform 'best practice' methods.
Potential for rapid initial knockdown of pest animal populations which can then be managed by lower level maintenance control. This 'knockdown' capability may be essential in the event of an exotic disease outbreak	Animal welfare concerns may be expressed by the general public.
Most cost-effective form of control over large areas for most vertebrate pests	
Aerial baiting allows control of pest animals in rugged country where there is limited vehicle access	
Offers a viable alternative to less effective and efficient forms of pest control such as shooting and trapping	

Table 1 (b) Advantages and Potential Disadvantages of the use of 1080 for pest animal control in Australia

1080	
Advantages	**Potential disadvantages**
Proven effectiveness and safety (long history in Australia with few reported problems associated with human safety, environmental persistence, bioaccumulation or impact on populations of non-target species)	Potential secondary poisoning risks associated with*: - Feeding on carcasses of poisoned animals - Feeding on vomitus of poisoned animals (mainly feral pigs) *However, there is a need to measure non-target effects at the population level (i.e. a net benefit is obtained)
Very effective - has the potential to achieve rapid and high-level population knockdown for the main species it is used for in Australia (rabbits, foxes, wild dogs, and feral pigs)	No effective antidote (some research into this is being undertaken in New Zealand)
Relatively target-specific in Australia due to the tolerance of many native species, particularly when compared to the high sensitivity of canids. Target-specificity is further enhanced by careful selection bait material/size/colour and bait placement.	May generate bait shyness if target animal gets sub-lethal dose in some cases. However, this has only been identified as a problem in New Zealand pest populations
Extremely low environmental persistence. 1080 is metabolized rapidly in animals and is readily broken down by microbial activity under moist conditions and/or in waterways	May not be the ideal toxin for feral pigs due to: - Large size of feral pigs relative to non-target species - Relatively high toxin loading of baits - Non-target risks of exposure to vomitus - Alternative toxins for feral pigs are being investigated. But none on the immediate horizon
Breaks down rapidly in baits under moist conditions (can also be a disadvantage if this results in sub-lethal poisoning)	N/A
Reasonably rapid mode of action, particularly when compared to the anticoagulants	Lack of an effective antidote
Is widely accepted as the most humane of the vertebrate pesticides in current use	Humanness in canids and feral pigs may be less clear but 1080 is generally accepted as being humane. Convulsions in canids do not necessarily indicate conscious pain; The potential of incorporating analgesics into canid 1080 baits as a preventative measure is being investigated
High-quality efficacy data exist to support both aerial and ground-baiting techniques.	

TOXICITY OF *SODIUM FLUOROACETATE* TO NATIVE SPECIES FROM DIFFERENT PARTS OF AUSTRALIA

In Australia, a key determinant of sensitivity of native animals to 1080 is the extent to which these species have developed a tolerance to 1080 through the ingestion of fluoroacetate, which occurs naturally in a variety of native plants. Of these plants, over 38 species are confined to the south-west corner of Western Australia. Others are found across northern Australia and central Queensland and Northern Territory. No fluoroacetate-bearing plants are known to occur in South Australia, New South Wales, Victoria and Tasmania. Because of the presence of fluoroacetate in these plants, tolerance to fluoroacetate has developed in most native animal species with evolutionary exposure to fluoroacetate-bearing vegetation. The sensitivity to 1080 is known for over two hundred native animal species or populations in Australia (for examples see Appendix 3). Within a species, this tolerance is most pronounced in those species indigenous to Western Australia. For example, possums from Western Australia have a LD_{50} of over 100 mg/kg whereas possums from areas without fluoroacetate-bearing plants have a LD_{50} of less than 1 mg/kg. Such tolerance allows demonstrable risk reduction to non-target species as a consequence of 1080 baiting programs. The situation is not as clear cut in areas without fluoroacetate-bearing vegetation, but with careful planning and execution, 1080 baiting programs can still be used safely and effectively in areas devoid of fluoroacetate-bearing plants.

It is useful to have a standardised measure of toxicity that allows comparisons between the different species. The median lethal dose (LD_{50}) is the most common measurement used to represent sensitivity, although these are not always available for rare or endangered species. These studies have revealed different sensitivities between animal groups and this often correlates with their phylogeny, and/or with their past exposure to fluoroacetate-bearing vegetation. For example, dogs and other carnivores are generally highly sensitive to 1080, herbivores and birds are less sensitive, and reptiles and amphibians are relatively insensitive to 1080. A variety of factors can influence sensitivity to 1080 within, and between, species. These include the level of exposure to fluoroacetate-bearing vegetation, the age of individuals, their breeding condition, inherited tolerance, body size, and metabolic rate. The determination of $LD_{50's}$ require studies on captive animals. LD_{50} estimates may not always reflect the absolute sensitivity to 1080 of the same animals living in the wild. Nevertheless, LD_{50} data provide a very useful component of the risk assessment procedures used to assess the possible hazards presented to native species by 1080 (see Appendix 3).

Body size of non-target species relative to that of the target species is also important in assessing their susceptibility during 1080-baiting programs. Ranking different animals according to the amounts of 1080 they would need to ingest to receive a lethal dose provides a useful basis for evaluating the potential risk faced by non-target animals from field-based control programs (see Appendix 3).

Non-target animals (both native and introduced) can be exposed to 1080 either directly by eating baits intended for pest animals (primary poisoning) or through the scavenging of tissues from an affected animal (secondary poisoning). Susceptibility of non-target animals and/or populations will also depend upon a number of other factors including their sensitivity to 1080, their body weight ratio relative to the target species, the level of exposure to bait, bait placement, the method of baiting, and the time of year at which a baiting program is carried out. Ultimately, the degree of risk can only be determined by measuring responses of non-target populations during actual 1080 baiting programs. That is, do native animal populations show an overall net benefit from pest control programs which utilise 1080. Although a number of these studies have been conducted, it would be prohibitively expensive to consider all of the above variables matched with all species at potential risk and in all geographical areas of Australia. Those studies that have been conducted have indicated that no significant detrimental effects have occurred in non-target animal populations. This suggests that risk assessments based on sensitivity alone tend to overestimate the real risk faced by non-target animals in the wild.

HUMANENESS OF 1080

Although 1080 is generally accepted as being humane, there is some debate regarding this claim, particularly from the animal welfare lobby. Much of the argument against 1080 is based upon the time from ingestion to death. However, this is not appropriate because the key issue is the time from when signs of poisoning first appear to death. This can be as short as 1-2 hours in many species, and is usually less than 12 hours. Furthermore, this argument is based upon data from published toxicity trials aimed at determining the LD_{50}s etc for 1080. It is accepted that the response of animals to 1080 is more rapid and pronounced with increasing dose level, but the lag phase associated with 1080-intoxication is not less than 0.5 to 2 hours. All 1080 baits/programs are designed such that the target species ingest around 2-3 lethal doses. Thus using the time to death generated from toxicity trials is not a valid estimate of what would happen during a pest control program.

Cyanide has been proposed as an alternative to 1080, but this toxin is not target specific and is only likely to be applicable for use with canids. Similarly, the incorporation of analgesics in baits has been proposed as a means of reducing animal welfare concerns. However, although this approach has some merit, the target specificity of the added chemical would need to be determined for both the analgesic alone and in combination with 1080. That is, it would need to be determined that the use of analgesics had no unintended detrimental effects.

The following is a précis of an article by Dr Graham Gregory from 'Humaneness and Vertebrate Pest Control', the proceedings of the seminar held 27 March 1996, pg 62-64, Ed. P.M. Fisher and C.A. Marks, Report Series Number 2, Dept of Natural Resources and Environment, Victoria'

There is increasing public concern that poisoning with *sodium fluoroacetate* (compound 1080) is inhumane. People unfortunately witnessing the death of a family pet in what appeared to be in a painful and terrible manner further enhance this concern. Dr Gregory considers that users of 1080 need to be more informed about the humane aspects of 1080 so that they may respond to these concerns. He has reviewed relevant literature in an attempt to explain the relationship between 1080 poisoning and associated pain.

Fluoroacetate is converted within the body to fluorocitrate which blocks the TCA (Krebs) cycle or the process that provides energy to the cells. Energy reserves are depleted and cellular function is impaired, resulting in gross disorders of organs and organ systems. In herbivorous animals the major effect of fluoroacetate is in the cardiac system while in carnivores it is in the central nervous system.

Symptoms of poisoning where the heart is involved include progressive lethargy and in some cases a sudden convulsive seizure followed by death. Squeals occur during the convulsions while the animal is unconscious. It is reported that squeals and convulsions in rabbits did not unduly disturb nearby rabbits and rabbits nearby did not associate this activity with fear or pain. Convulsions seen in wallabies and rabbits are thought to occur when the animal is unconscious and feels no pain.

Where the central nervous system is involved, the symptoms of poisoning in dogs includes the sudden appearance of hyperexcitability and abrupt bouts of barking followed by alternating convulsions and running movements. Breathing becomes rapid and laboured and death occurs after repeated and prolonged convulsions of the respiratory centre. These symptoms are very distressing to an observer and are interpreted as expressions of pain.

The symptoms of fluoroacetate poisoning in dogs relate to similar conditions in humans. No pain has been reported in human patients as a result of 1080 poisoning. Williams in 1948 became poisoned while mixing 1080 powder. He reported tingling sensations around the mouth and nasal passages extending to the arms and legs with spasmodic contractions of the involuntary muscles prior to unconsciousness after 2.5 hours with no recollection of pain at this time.

Electroencephalographs of dogs dosed with 1080 have displayed cerebral dysrythmias identical to those found in *grand mal* and *petit mal* epileptic seizures. Also, 1080 poisoning is likened to hyperinsulinism where in each case the cause is a depletion of energy in cells. Hyperinsulinism leads to mental disorientation, convulsions and loss of consciousness. There are enough similarities between 1080 poisoning, epilepsy and hyperinsulinism in humans to conclude that the symptoms to the central nervous system caused by 1080 poisoning in dogs are not associated with pain.

Fumigating rabbit burrows

PERSISTENCE OF *SODIUM FLUOROACETATE* IN BAITS UNDER A RANGE OF ENVIRONMENTALLY RELEVANT CONDITIONS

The persistence of *sodium fluoroacetate* (1080) in baits can be variable, and will depend upon the prevailing environmental conditions and the type of bait used.

As 1080 is highly soluble in water, it is readily leached from bait material. Released 1080 is readily trapped by cellulose/humus material in the soil. 1080 is also readily degraded by over 20 different species of soil micro-organisms. A number of independent studies have demonstrated that there is no evidence of 1080 persisting in, or contaminating soil or waterways in Australia or New Zealand.

Predator (meat-based) baits

In temperate Australia, most 1080 predator baits are likely to become non-lethal within 2-8 weeks depending upon the amount of rainfall and soil temperatures. In arid Australia, bait longevity is often much longer than this, and some baits may remain toxic for 8-12 months. However, the longevity of the toxin in the bait is only half the story when considering 'environmental persistence' or potential non-target risk. The rate at which the baits are taken by target species will determine how long baits remain in a particular environment. Irrespective of the bait type, many (> 60%) predator baits are usually taken in the first 10-12 days after bait-lay, and around 80% of baits are generally taken within about 3 weeks. Few baits are likely to remain after 12 weeks. Furthermore, most states and territories recommend that any untaken baits are collected at the end of a baiting campaign and destroyed by either deep burial, or incineration. However, caution is always urged because a small number of baits are likely to remain after, or could be relocated during, a predator control program, and these baits may well be lethal to domestic dogs.

Preparing meat baits

Control of Herbivores (grain-based and carrot baits)

Because 1080 is highly water soluble, even small amounts of rainfall (6 mm) often renders the baits used in rabbit control programs non-toxic. In fact, even moist soil or heavy dews can result in much of the 1080 being leached from the baits. Hence, the recommendation that 1080 rabbit baits not be laid if rain is forecast. It needs to be remembered too that 1080 degrading soil microbes will also influence the persistence (longevity) of 1080 in these baits. Further, it is recommended that any bait trail remaining at the end of a control exercise should be covered with soil before paddocks are re-stocked. Soil microbes would rapidly degrade the 1080 in the buried baits to harmless by-products.

Secondary poisoning

The persistence of 1080 in target species killed during control programs is also an important component of the 'persistence of 1080 in baits'. To date, 1080 has been shown to have a relatively short half-life (2-3 days) in the tissues and plasma of affected animals. This suggests that the potential for unintentional effects on native animals during 1080-based pest control programs as a result of secondary poisoning should be low. This has, in fact, been supported by those field studies undertaken, and by the lack of substantial reports of any non-target native species having been affected via this route. Whilst 1080 is comparatively rapidly eliminated from living animals, it may persist in carcasses for several weeks where it will break down more slowly and could pose a risk to dogs. Trials investigating the level of 1080 residues in 1080-poisoned, wild rabbit carcases are underway.

SUMMARY OF CONTROLS FOR THE SUPPLY AND USE OF 1080 IN WESTERN AUSTRALIA

In Western Australia, the control of use of 1080 products is governed by the Poisons Act 1964 under a specific Section 24 Notice of the Poisons Act, the Poisons (Section 24) (Registered Pesticide 1080) Notice 2000. This Notice outlines the conditions imposed on sale, supply, use and possession of 1080. The Notice refers to written instructions which is the *Code of Practice on the Safe Management and Use of 1080* issued by the Department of Health in July 2000.

The Code of Practice elaborates on the procedures that are required for handling products containing 1080 and identifies training requirements. It outlines the processes for authorising a person to use 1080.

Authorisation to use 1080 is based upon a risk assessment undertaken by the approving agency (Department of Agriculture (DAWA) or Department of Conservation (CALM)) and has to be undertaken before approval is issued to supply or use 1080.

The Risk Assessment is undertaken by trained officers and includes: a detailed application by the proponent; is undertaken by an appropriately trained officer; assessment that the method and type of bait to be used are appropriate for the species to be controlled; and takes into account the need to minimise the potential risk to human health and non target animals (native and domestic).

An approval to supply and use 1080 is given after a risk assessment indicates that the use of 1080 presents an acceptable potential risk and the level of training required for persons to use or posses 1080 is appropriate. The approval may also stipulate additional conditions for a given baiting program.

ALTERNATIVES TO 1080 IN WESTERN AUSTRALIA

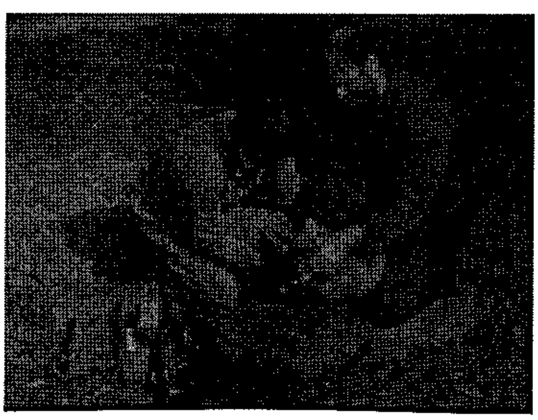
The most effective pest control programs are those which use an integrated approach where all appropriate techniques are utilised, and which cover the largest area possible (i.e. include neighbouring properties). However, at present, there is no escaping the fact that 1080 underpins most vertebrate pest control programs for control of exotic vertebrate species in Australia, and that 1080 is often the only available practical option. Good coordination between rabbit and fox control programs will also improve the effectiveness of fox control campaigns. For example, using 1080 to reduce rabbit numbers not only reduces the availability of food for foxes, but it also results in the secondary poisoning of some foxes as they feed on 1080-poisoned rabbits.

Foxes and rabbits

Trapping, shooting and fencing

These options can be a useful adjuncts to control programs, particularly for small holdings (< 100 ha). For example, rabbit-proof fencing can provide a viable option for virtually eliminating the impact of rabbits on many holdings used to produce horticultural crops, and the cost of fencing can be quickly recouped when high-return crops are involved.

A well planned shooting program can be used to mop-up those rabbits remaining after a baiting campaign has been carried out. Organised fox shoots can also remove a considerable number of foxes, however, because the area covered is generally small, which often results in rapid



Attaching a tracking collar to a fox

reinvasion by foxes, such shoots seldom result in a reduction in the overall level of associated damage.

Unfortunately, on their own, none of the above techniques offer viable options for broadscale control of vertebrate pests.

Fumigation

Fumigation of rabbit warrens and fox dens may be an option for localised control. Phosphine (e.g. Phostoxin®, aluminum phosphide) and carbon monoxide are available for this purpose. However, these options are not really suitable for broadacre control programs.

Virally Vectored Immunosterility (VVIS)

A Cooperative Research Centre (Vertebrate Biocontrol CRC) was established in 1992 to examine the possibility of reducing the fertility of introduced foxes, rabbits and house mice. The Agriculture Protection Board / Department of Agriculture was a founding member of the original CRC which ran for 7 years, and is also a partner in the renewed CRC, the Pest Animal Control CRC, when the VBCRC was renewed for a further 5 years. The aim of the CRC is to develop target specific naturally spread immunocontraceptive agents for each target species. This is to be achieved by modifying a specific virus for each target species such that it fools the target species into mounting a immune response against its own reproductive tissue thereby preventing successful reproduction. These agents may be also delivered in a bait in some instances (e.g. foxes).

However, unfortunately and perhaps not surprisingly, this task has proven far more difficult than anticipated. Although considerable progress has been made, and the potential mechanisms for inducing the infertility have been identified, considerable work still needs to be undertaken (e.g. ensuring these agents only affect target species, final delivery mechanisms, effectiveness in the field) before any of these products are likely to become available for use in vertebrate pest control programs in Australia. It is anticipated that it could be 5-10 years before any product could be considered for general release.

Furthermore, it needs to be remembered that these products are likely to involve genetically modified organisms, so even if successfully developed, the regulatory authorities and the general public may not agree to the release of such control agents. In any case, Virally Vectored Immunosterility (VVIS) is not expected to replace the need for existing control techniques, but rather, it is envisaged that VVIS will augment current options thereby resulting in a reduction in the frequency and level of poison baiting required to reduce the impact of vertebrate pests.

Foxes only

Strychnine

Although strychnine has been used to control foxes in the past, it is no longer registered for this use in WA. Strychnine is not target specific, and there is some concern about its humaneness. Strychnine is also bitter tasting so masking agents need to be used (e.g. sugar). Bait shyness is also a recognised problem with strychnine baits. Strychnine is not an option for fox control in WA.

Cabergoline

If administered around day 14 of pregnancy, cabergoline has been shown to cause abortions, and death of post-natal cubs in foxes. However, such administration is generally only effective around 25-40% of the time, and it is ineffective in some canid species.

Cabergoline may also cause some canids to vomit which may well result in the development of bait aversion. To be effective, cabergoline would need to be administered (by baits?) to the same vixens year after year. Cabergoline is not registered for fox control in Australia, and only a small number of research trials have been conducted regarding its effectiveness. It is also expensive, and it is one of the main drugs used to treat Parkinson's Disease in humans.

Rabbits only

Pindone

Pindone is one of the first generation anticoagulants. Both water soluble and water insoluble pindone products are registered for controlling rabbits in Australia. However, because of some concern regarding non-target impacts, it is recommended that pindone only be used in WA where the use of 1080 is not practicable. For example, in urban areas where 1080 can not be used, and in the winter months when wet soils and rainfall may make the use of the water soluble 1080 products impractical. Unlike 1080, there is an effective antidote for pindone (administration of vitamin K) if domestic animals are inadvertently poisoned.

Recent research also suggests that the anticoagulants may not be as humane as first thought, as death in some medium-sized animals (> 2 kg) appears to result from starvation as the animals become less mobile and are therefore are unable to feed normally. Pindone is known to be toxic to kangaroos, bandicoots, wedge-tailed eagles and possibly some parrots. Pindone may also affect the reproductive output of domestic animals.

Despite these concerns, pindone products provide a useful adjunct for rabbit control programs in WA, provided these products are used according to the label and, where appropriate, mechanisms are put in place to reduce the risk to non-target species. However, where possible, 1080 should remain the first choice for rabbit control programs.

Ripping and harbour destruction

If undertaken correctly, ripping can be an effective means of rabbit control. However, it is generally a fairly expensive option and warren-ripping may not be suitable for all areas (e.g. conservation estate, rocky areas, areas prone to erosion). Harbour destruction has less appeal in WA because many rabbits shelter in areas of native vegetation. Nevertheless, the removal of rock and stick piles, and other man-made rabbit habourage on-farm will reduce the available shelter for rabbits. Remember also, that many rabbits in WA live above-ground and, therefore, may not be affected by a warren-ripping program. Warren-ripping and harbour destruction will work best if they are incorporated into a baiting program.

Burrow destruction

Biological control

The myxoma virus (myxomatosis), and more recently, Rabbit Haemorrhagic Disease Virus (RHD) have been introduced into rabbit control programs in Australia. Both diseases can be highly effective in controlling rabbits. However, neither disease is effective in controlling all rabbits all the time. This particularly true of RHD in high rainfall areas where the disease has had little effect on rabbit numbers. This is now believed to be due to the presence of a non-pathogenic RHD-like virus which gives the rabbits cross immunity to RHD.

Past lessons with myxomatosis indicate that, ultimately, attenuation will develop in these viruses (i.e. they become less lethal), and rabbits will develop some resistance to these diseases. As this occurs, the availability of a wide variety of techniques (e.g. 1080, pindone, ripping) will be crucial for maintaining the sustained long-term effectiveness of rabbit control programs in Australia. Spanish (arid areas) and European (wetter temperate areas) rabbit fleas have been introduced into Australia to improve the transmission of myxomatosis by insect vectors.

APPENDIX 1

Extract from the publication

'THE BENEFITS OF 1080 PREDATOR CONTROL IN WESTERN AUSTRALIA, WESTERN SHIELD, FAUNA RECOVERY AND MONITORING', January 2002, by Peter Orell and Peter Mawson, Western Australian Department of Conservation and Land Management

Changes in Conservation Status of Critical Weight Range Fauna as a Result of *Western Shield* Baiting Program.

Broad-scale fox control using 1080 meat baits was introduced to conservation estate in Western Australia in 1994 with the *Western Shield* program commencing in April 1996. Baiting activities in conjunction with Recovery Plan actions for the Woylie (*Bettongia penicillata ogilbyi*) so greatly improved the conservation status of this species that it was removed from the State and Commonwealth endangered species list in 1996 (Morris *et al.* 1996). This was the first, and to date only, time that any native mammal species had been de-listed as a direct result of conservation actions. The continued lower risk conservation status of this species is entirely dependent on broad-scale fox control programs using 1080 baits.

In 1998 the Southern brown bandicoot or Quenda (*Isoodon obesulus fusciventer*) and the Tammar wallaby (*Macropus eugenii*) were also removed from the endangered species list in WA. One of the significant contributing factors to the decision to de-list these species was the increase in the number and size of populations in mainland WA, principally in areas subject to government funded fox control using 1080 baits.

A number of other native species occurring in WA are rapidly approaching population levels that will allow them to be considered for de-listing as endangered species. In nearly all cases the existence of large areas of conservation estate that support very low densities of foxes is a major factor contributing the improving fortunes of these species.

The cessation of broad-scale fox control would undoubtedly lead to an increase in fox numbers in large parts of southwest WA and an immediate decline in the numbers and populations of many species of native animals. Until alternative exotic predator control techniques become available there is no alternative but to continue to apply 1080 baiting programs to targeted areas.

APPENDIX 2

Extract from the publication

'SUBMISSION, REVIEW OF THE USE OF 1080 IN AUSTRALIA', January 2002 by Ray Fremlin, Forest Products Commission, Western Australia

The Forest Products Commission (FPC) of Western Australia (previously the Department of Conservation and Land Management and the Forest Department of WA) uses 1080 (*Sodium fluoroacetate*) poison for the control of rabbits in newly established eucalypt and pine plantations.

The FPC manages a plantation estate exceeding 100 000 hectares. This estate has been increasing at a rate of between 6000 and 8000 hectares each year for the last 10 years. The total plantation estate in Western Australia exceeds 250 000 hectares and has been expanding at an average rate of 25 000 hectare per annum for the past 6 years. All new plantations are established on cleared farmland where the likelihood of rabbit infestations is high. Whilst the rate of expansion of Blue gum plantations is likely to fall, the rate of expansion of other plantation species is likely to increase as deployment of plans to address salinity and greenhouse gas emissions take affect. The net effect is for the plantation estate to increase at approximately the current rate for the foreseeable future.

Rabbits cause significant damage to newly established plantations in Western Australia. An effective, safe method of controlling this pest is essential to the continued expansion of the plantation estate.

Integrated with other methods of control, 1080 provides the most cost effective and safe method of controlling rabbits in Western Australia. The native wildlife of Western Australia has a high level of tolerance to 1080.

Fencing and the use of Pindone® offer effective alternatives to 1080. However, fencing is too expensive to be considered, except in exceptional circumstances, and the use of Pindone® increases the likelihood of native wildlife being poisoned.

Other control methods used alone, or in combination, do not have sufficient impact on rabbit populations to provide crop safety. Biological control methods do not provide the certainty that is necessary for plantation managers.

The system used by FPC to procure and lay 1080 baits is rigorous and provides a high level of occupational and environmental safety. It is suggested that the level of training be increased for people who lay and monitor baits to ensure that secondary poisoning is minimised.

There is currently no program to systematically control foxes on private property. The Western Shield Project managed by the Department of Conservation and Land Management will not achieve its potential unless the program can be expanded onto private property. The FPC is considering an initiative to form a collaborative with District Landcare Groups to address the problem. Any decision to withdraw or limit the use of 1080 will add considerably to the cost of fox eradication, reduce the efficiency of any program and alternative strategies may increase the likelihood of unwanted events occurring.

APPENDIX 3

THE APPROXIMATE LD_{50} VALUES FOR 1080 (ADJUSTED TO 100% PURE 1080) FOR A RANGE OF AUSTRALIAN NATIVE SPECIES WHOSE CURRENT OR FORMER RANGE INCLUDES AREAS WITH FLUOROACETATE-BEARING PLANTS

Species	Common name	Mean adult body Wt. (kg)	LD_{50} (mg/kg)[A]	Amount for LD_{50} (mg)	Approximate amount of bait for an LD_{50}				
					6 mg Dingo baits (No. of baits needed)	3 mg Fox baits (No. of baits needed)	Conventional oat bait @ 670 mg/kg (g of bait mix)[B]	One-shot oats @ 0.5% mix[C]: g of bait mix required[C]	One-shot oats @ 0.5% mix[C]: No. of poisoned one shot oat[C]
Anas supercillosa	Black Duck	1.100	18.4	20.24	3.37	6.75	30.21	100	4.5
Antechinus flavipes	Yellow-footed Antechinus	0.050	11.8	0.59	0.10	0.20	0.88	20	0.1
Aquila audax	Wedge-tailed Eagle	4.850	9.1	44.18	7.36	14.73	65.95	200	10.0
Barnardius zonarius	Port Lincoln Parrot (28)	0.179	10.8	1.93	0.32	0.64	2.89	20	0.4
Bettongia lesueur	Burrowing Bettong	2.000	13.8	27.60	4.60	9.20	41.19	140	6.1
Bettongia penicillata	Woylie	1.350	115.0	155.25	25.88	51.75	231.72	700	34.5
Chenonetta jubata	Wood Duck	0.820	11.8	9.64	1.61	3.21	14.38	60	2.1
Corvus bennetti	Little Crow	0.380	12.8	4.88	0.81	1.63	7.28	40	1.1
Dasycercus crisiticauda	Mulgara	0.115	*4.8*	0.55	0.09	0.18	0.83	20	0.1
Dasyurus geoffroii	Western Quoll (Chuditch)	1.390	7.1	9.80	1.63	3.27	14.63	60	2.2
Dasyurus hallucatus	Northern Quoll	0.600	7.1	4.23	0.71	1.41	6.31	20	0.9
Dromaius novaehollandiae	Emu	39.500	102.0	4029.00	671.50	1343.00	6013.43	17920	895.3
Falco berigora	Brown Falcon	0.440	*30.1*	13.23	2.20	4.41	19.74	60	2.9
Isoodon auratus	Golden Bandicoot	0.469	8.4	3.94	0.66	1.31	5.87	20	0.9
Isoodon obesulus	Southern Brown Bandicoot	1.000	18.8	18.80	3.13	6.27	28.06	100	4.2
Lagorchestes hirsutus	Rufous Hare Wallaby (Mala)	1.370	*35.3*	48.29	8.05	16.10	72.08	220	10.7
Lagostrophus fasciatus	Banded Hare Wallaby	1.700	106.2	180.54	30.09	60.18	269.46	820	40.1
Leipoa ocellata	Malleefowl	1.800	94.0	169.20	28.20	56.40	252.54	760	37.6
Macropus eugenii	Tammar	7.000	9.4	65.80	10.97	21.93	98.21	300	14.6
Macropus fuliginosus	Western Grey Kangaroo	40.500	47.0	1903.50	317.25	634.50	2841.04	8460	423.0
Macropus irma	Brush-tailed Wallaby	8.000	7.1	56.40	9.40	18.80	84.18	260	12.5
Macrotis lagotis	Bilby	1.650	14.1	23.27	3.88	7.76	34.72	120	5.2
Notomys mitchelli	Mitchell's Hopping Mouse	0.050	*50.9*	2.55	0.42	0.85	3.80	20	0.6
Ocyphaps lophotes	Crested Pigeon	0.204	23.5	4.78	0.80	1.59	7.14	40	1.1
Parantechinus apicalis	Dibbler	0.070	*35.3*	2.47	0.41	0.82	3.68	20	0.5
Perameles bougainville	Western Barred Bandicoot	0.220	8.5	1.86	0.31	0.62	2.78	20	0.4
Phaps chalcoptera	Bronzewing Pigeon	0.294	37.6	11.05	1.84	3.68	16.50	60	2.5
Phascogale calura	Red-tailed Phascogale	0.053	16.5	0.87	0.15	0.29	1.30	20	0.2
Phascogale tapoatafa	Brush-tailed Phascogale	0.173	*9.0*	1.55	0.26	0.52	2.31	20	0.3
Platycercus icterotis	Western Rosella	0.060	70.5	4.19	0.70	1.40	6.26	20	0.9
Polytelis anthpoeplus	Regent Parrot	0.180	11.8	2.11	0.35	0.70	3.15	20	0.5
Pseudomys albocinereus	Ash-grey Mouse	0.027	*50.9*	1.38	0.23	0.46	2.05	20	0.3
Pseudomys hermannsbergensis	Sandy Inland Mouse	0.012	38.5	0.45	0.08	0.15	0.68	20	0.1
Pseudomys nanus	Western Chestnut Mouse	0.038	*50.9*	1.91	0.32	0.64	2.85	20	0.4
Pseudomys occidentalis	Western Mouse	0.043	*50.9*	2.19	0.37	0.73	3.27	20	0.5
Pseudomys shortridgei	Heath Rat	0.073	*50.9*	3.69	0.62	1.23	5.51	20	0.8
Puprpureicephalus spurius	Red-capped Parrot	0.114	23.5	2.67	0.44	0.89	3.98	20	0.6
Rattus fuscipes (Max Tolerance)[D]	Southern Bush Rat	0.145	73.3	10.63	1.77	3.54	15.86	60	2.4
Rattus fuscipes (Min Tolerance)[D]	Southern Bush Rat	0.145	22.2	3.22	0.54	1.07	4.80	20	0.7
Setonix brachyurus	Quokka	3.150	37.6	118.44	19.74	39.48	176.78	540	26.3
Sminthopsis granulipes	White-tailed Dunnart	0.028	*11.9*	0.33	0.05	0.11	0.49	20	0.1
Tiliqua rugosa	Bobtail Skink	0.350	800.0	280.00	46.67	93.33	417.91	1260	62.2
Trichosurus vulpecula	Brush-tail Possum	3.000	117.5	352.50	58.75	117.50	526.12	1580	78.3
Tyto alba	Barn Owl	0.322	*21.8*	7.01	1.17	2.34	10.47	40	1.6
Varanus gouldii	Sand Goanna	1.350	47.0	63.45	10.58	21.15	94.70	300	14.1
Varanus rosenbergi	Rosenberg's Goanna	1.550	235.0	364.25	60.71	121.42	543.66	1620	80.9
Zyzomys argurus	Common Rock Rat	0.043	*6.8*	0.29	0.05	0.10	0.43	20	0.1
INTRODUCED SPECIES									
Canis familiaris	Dingo/Wild Dog	14.5	0.11	1.60					
Felis catus	Feral Cat	4.4	0.35	1.54					
Homo sapiens	Human	80.0	2.00	160.00					
Oryctolagus cuniculus	European Rabbit	1.6	0.40	0.64					
Sus scrofa	Feral Pig	55.0	1.02	56.10					
Vuples vulpes	European Red Fox	6.5	0.12	0.78					

A LD_{50}s in *italics* were estimated from the appropriate ALD according to Calver *et. al.* (1989), Australian Wildlife Research 16, 625-638.
All LD_{50}s have been standardised to the amount of pure 1080.

B This conventional oat bait is mainly used for controlling rabbits (trails), and also for feral pig control (bait stations).

C Not all oats in a One-shot bait mix contain 1080, but rather, 1 oat in 200 (unpoisoned) oats contains 4.5 mg of 1080. Thus any animal needs to ingest approximately 20 g of bait mix to ingest one poisoned oat.

D A range of populations have been tested from WA, and these values represent the minimum and maximum LD $_{50}$ recorded.
Shaded areas indicate those species which may be exposed to 1080 as they are known to, or are likely to, ingest a particular ba it based upon known food preferences. Unshaded areas indicate those species which are unlikely to, or can not (lack the dentition), ingest bait or are unlikely to be exposed to 1080 baits.