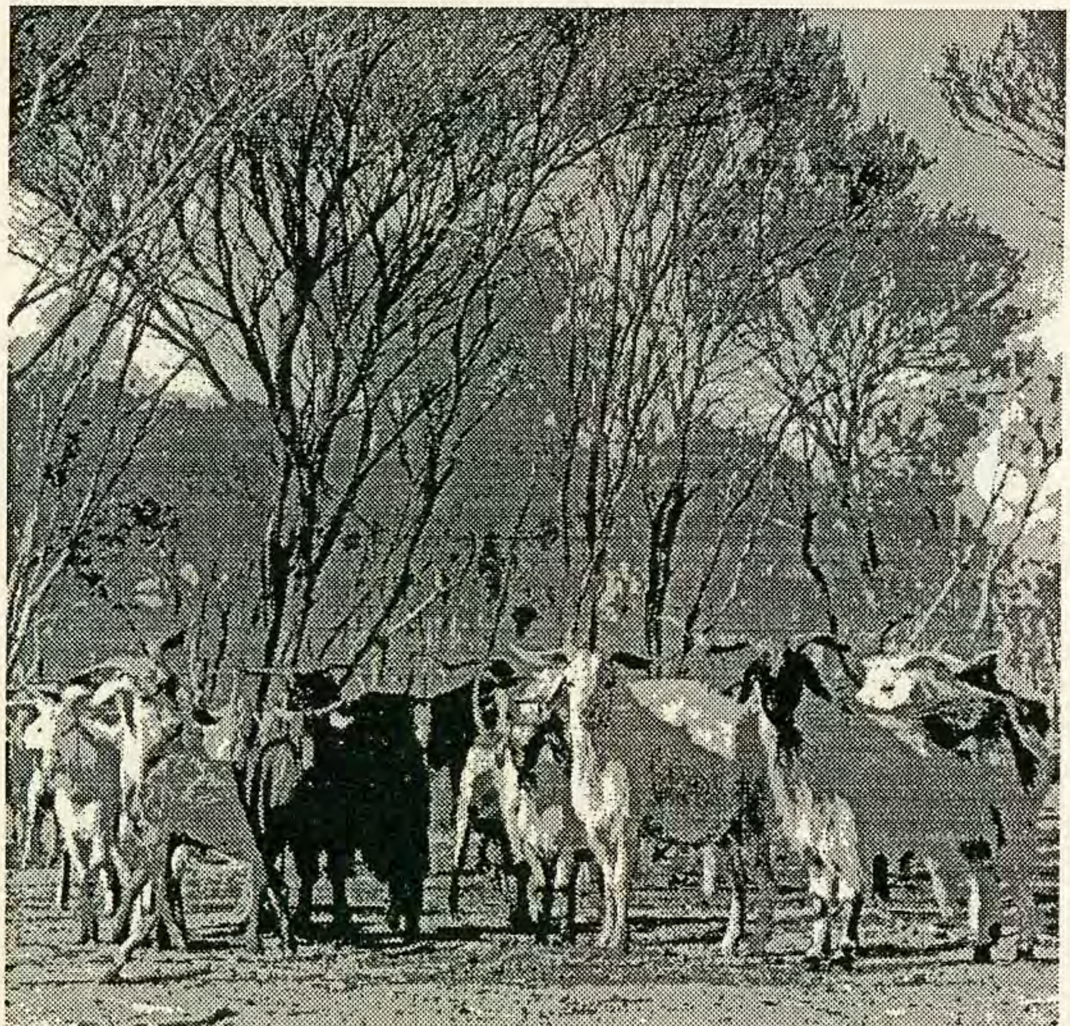
PUBLIC ENVIRONMENTAL REVIEW
EPA ASSESSMENT NO. 752

THE PROPOSED USE OF 1080 TO CONTROL FERAL GOATS IN WESTERN AUSTRALIA



MAY 1993

ECTION BOARD OF WESTERN AUSTRALIA

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PROPOSED USE OF 1080 TO CONTROL FERAL GOATS IN WESTERN AUSTRALIA

PUBLIC ENVIRONMENTAL REVIEW

INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

This Public Environmental Review (PER) for the proposed use of 1080 to control feral goats in Western Australia has been prepared in accordance with Western Australian Government procedures. The report will be available for comment until 9 August 1993.

Comments from Government agencies and the public will assist the EPA in preparing an assessment report with recommendations to Government.

Why Write a Submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public comments, unless confidentiality is requested, and may be quoted either in full or in part.

Why Not Join a Group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people), please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a Submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the PER:

- clearly state your point of view,
- indicate the source of your information or argument if this is applicable,
- suggest recommendations, safeguards or alternatives.

Points to Keep in Mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.
- Refer each point to the appropriate section, chapter or recommendation in the PER.
- If you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering.
- Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Continued. . .

Remember to include:

- your name,
- address, and
- date.

The closing date for submission is:
9 August 1993

Submissions should be addressed to:
The Chairman
Environmental Protection Authority
Westralia Square
141 St Georges Terrace
PERTH WA 6000

Attention: Ms K Wilson

CONTENTS

EXECUTIVE SUMMARY

In this Public Environmental Review, the Agriculture Protection Board of Western Australia (APB) presents its proposal to use the poison sodium monofluoroacetate (1080) to control feral goats in the rangelands of Western Australia (WA).

During dry periods of the year, the survival of feral goats depends on artificial water supplies provided on pastoral stations. During these periods, the APB proposes to temporarily poison drinking troughs used by feral goats with 1080. Trials have shown that four days of 1080 poisoning will reduce feral goat populations around water points by 70%. A poisoning technique has been developed which does not pose a significant hazard to people, native wildlife or pastoral stock.

The use of 1080 to control feral goats would have a positive environmental impact on the goat-infested rangelands of WA. The control of feral goats would reduce the grazing pressure on rangeland vegetation and reduce soil erosion. This proposal would not have any significant adverse environmental impacts.

It is expected that a small number of wild dogs, dingoes, foxes and cats would be killed either by drinking the poisoned water directly or from secondary poisoning by consuming poisoned goat carcasses. However, as all of these animals are pests in WA, and their removal would be beneficial in conserving native wildlife, this would not be considered to be an adverse environmental impact.

The APB makes 16 management commitments for the use of 1080 to control feral goats. These are designed to protect public health, native wildlife and pastoral stock. Management commitments are listed in Section 6.2 of this report.

CHAPTER 1 INTRODUCTION

This document describes the proposed use of the poison sodium monofluoroacetate, or 1080 as it is commonly known, to poison feral goats at artificial waters in the rangelands of Western Australia (WA) by the Agriculture Protection Board (APB). This document was prepared for the general public and Environmental Protection Authority (EPA) by the APB and the Department of Agriculture of Western Australia (DAWA).

The first chapter of this document provides a background to the problem of feral goats in WA and discusses the potential use of 1080 poison for their control. The WA environmental impact assessment process and how it applies to this proposal is then discussed.

1.1 FERAL GOATS IN WESTERN AUSTRALIA

Goats were introduced into Western Australia more than 100 years ago. The first documented release was in 1870, when the Victorian Acclimatisation Society exported 50 animals to Shark Bay (Long 1988). Goats were later introduced to inland areas for a specialty wool trade and for use as a source of meat and milk by early settlers, miners, and construction workers. By 1894 some 4,500 goats were present in WA and by 1905 they were reported to be established in small numbers in inhabited portions of the State. Later, large herds of goats were released from pastoral stations when the mohair industry collapsed. Through escapes and intentional releases goats soon became wild or feral in WA (Long 1988). Feral goats are now found over much of WA's southern rangelands.

Feral goats are very hardy animals which breed prolifically and can have very destructive grazing habits. Through their unmanaged grazing feral goats have caused considerable damage to the vegetation and soils of the rangelands.

In response to concerns of pastoralists, feral goats were declared vermin in 1928 under the Vermin Act (1918) and subsequently under the Agriculture and Related Resources Protection Act (1976).

In an attempt to induce pastoralists to reduce feral goat numbers, a 'commercialisation' policy was introduced in 1973. This policy allowed pastoralists to take advantage of the commercial value of feral goats by mustering and selling feral goats on their property.

Since 1973, over 2.5 million feral goats have been removed from WA, yet there has still been an increase in their population. In 1987 and 1990, the Australian National Parks and Wildlife Service (ANPWS) and CALM undertook an aerial survey of kangaroos in Western Australia (Southwell and Pickles, in press). During these surveys feral goat numbers were also collected and it was observed that goats were the most widespread and numerous of the large feral animals. When considering the data obtained from these surveys, there was a 64% increase in feral goat numbers over the 3 years, despite the removal of 560,000 goats which were commercially harvested.

In the past, between 60,000 and 245,000 feral goats were removed from the rangelands each year (G Pickles pers. comm.). Still this rate of removal allowed their numbers to increase. Because of feral goat's prolific rate of breeding, at least 70 percent of their population must be removed each year to keep their population at a constant level. The past level of removal was probably less than 20% of their population, which can be removed relatively easily. A much more intensive effort is required to markedly reduce their population.

In discussions with pastoralists through Pastoral Industry Liaison Committees and Land Conservation Districts Committees (LCDC), the APB and DAWA have been promoting the need to achieve feral goat eradication. Pastoralists have strongly supported the need for a more intensive goat control program. In February 1991 thirteen pastoral LCDCs met at Mt Magnet and agreed upon an objective to eradicate feral goats. As a result of this meeting, the Feral Goat Eradication Program (FGEP) was developed. The aim of this program is to eradicate feral goats, or to reduce their numbers to a very low level. The program is being implemented by pastoralists and is co-ordinated by the APB and DAWA through LCDCs.

Currently the APB and pastoralists co-ordinate their eradication efforts by forming control cells of neighbouring pastoral properties. The pastoralists of these control cells simultaneously muster and trap as many goats as possible, selling these to markets or shooting them. The pastoralists then undertake ground shooting to maintain pressure on the feral goat population. Once this stage is complete, and the feral goats are in low numbers, the APB attempts to shoot the remaining animals from helicopters.

The two-stage muster and helicopter shooting technique has proved to be very effective for most areas. However, in some situations, this form of control is not available or effective. These situations include: when stations are too far from markets to sell the mustered goats to subsidise the control program, where control cells are not working effectively because of social factors, where financial difficulties prevent stations from participating in the control program, and in some rugged areas where the terrain prevents some types of control work.

These problems have led the APB to investigate alternative forms of feral goat control. The most promising of these techniques is the use of 1080 poison to temporarily poison water troughs which feral goats use on pastoral properties. Because of the potential danger of this technique to native species, the APB has submitted this proposal to the EPA for environmental approval. This document describes the APB's proposal to use 1080 to control feral goats.

1.2 USING THIS PUBLIC ENVIRONMENTAL REVIEW

The principal objectives of this document are to provide the public with sufficient information about the proposal to make informed comment and submissions to the EPA, and to enable the EPA to adequately assess this proposal.

It was intended that this report be written in an open and friendly manner to enable members of the public to fully comprehend the proposal. With this in mind, the more technical information about this proposal has been left in the appendices of this report. This report also includes a glossary to provide meanings for the numerous acronyms and technical jargon that are used.

You will note throughout this PER that names and dates often appear in brackets at the end of sentences. This is the Harvard reference system for referencing the work of other authors. When something significant is stated in this report a reference will often be provided to substantiate the statement, e.g. 1080 occurs naturally in Australia (King 1990). In this case the reference is to an author who's surname is King and whose paper was written in 1990. With these details you would then go to the reference section at the end of this report and find the full reference for King's 1990 paper, which in this case is :

King, D.R. (1990). 1080 and Australian Fauna. Agriculture Protection Board of Western Australia, Technical Series No.8, pp.27.

With a full reference listing you should now be able to track down this paper and check up on the facts. The reference section provides a full listing of all references made in this document and also provides more details on how to use references.

If anyone has any difficulties in understanding any parts of this PER or would like additional information, the following DAWA and APB officers would be happy to help:

Malcolm Edgar, Rangeland Adviser
WA Dept. of Agriculture
PO Box 522
Carnarvon WA 6701
Telephone: (099) 41 1125 Fax: (099) 41 8334

Greg Pickles, Manager Feral Goat Eradication Program
Agriculture Protection Board
Baron-Hay Court
South Perth WA 6151
Telephone: (09) 368 3323 Fax: (09) 368 2958

Environmental impact assessment (EIA) as done by the EPA in WA, is a fairly long and complex process. So to explain how EIA works and to provide a context for this PER document the next section discusses the EIA process.

1.3 THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

With the increasing awareness of environmental issues during the 1970s, community demands led the Western Australian Government to develop an independent agency to provide advice on environmental matters. In 1986 the State Government established the Environmental Protection Authority under the Environmental Protection Act (1986).

One of the principal roles of the EPA is to assess the environmental impact of potential developments and provide recommendations and advice to the Minister for the Environment. The EPA undertakes different levels of impact assessment depending upon the environmental significance of the development.

The two principal streams of environmental impact assessment are: (i) informal assessment for proposals which the EPA feels pose no significant environmental impact and (ii) formal assessment for proposals with a potentially significant environmental impact.

1.3.1 INFORMAL ASSESSMENT

Informal assessment is done quickly through discussions with the proponent and the EPA to achieve an environmentally satisfactory conclusion. Although there is no formal public involvement in informal assessment, the EPA advertises it's decision regarding the proposed level of assessment in the Saturday edition of "The West Australian" newspaper in order to allow those who feel that the matter should be formally assessed to appeal to the Minister for the Environment within two weeks.

1.3.2 FORMAL ASSESSMENT

Formal assessment is a rigorous and more lengthy process incorporating a public review process. There are three levels of formal assessment depending upon the significance of the potential environmental impact.

The highest level of assessment is an Environmental Review and Management Plan, or an ERMP This level of assessment is reserved for proposals with a very high potential environmental impact. An example of ERMPs is Hamersley Iron's proposal to develop a mine and a railroad in the Karijini National Park. Currently only a couple of ERMPs are done each year.

The next level of assessment is a Public Environmental Review (PER). This level of assessment is used for proposals with a potentially high level of environmental impact. An example of a PER is the Main Roads Department's Roe Highway extension proposal. Presently the EPA would assess around 20 PER's each year.

The lowest level of formal assessment is a Consultative Environmental Review (CER) which is used for proposals with a potentially moderate level of environmental impact. An example of a CER is the proposed development of an LPG plant on Burrup Peninsula. Each year approximately 40 CER's are assessed.

After initial proposals are put up to the EPA, the EPA evaluates whether they require informal or formal assessment. If formal assessment is required, the EPA then sets the level of assessment. This 1080 feral goat poisoning proposal was deemed to warrant a Public Environmental Review, because of potential impact of 1080 on native species and because of the large area the proposal covers.

With the PER level of assessment set, the EPA then enters into discussions with the proponent, the APB in this case, to develop guidelines for the assessment. Guidelines set out topics or issues that the proponent must cover in it's environmental impact statement. The guidelines set by the EPA for this proposal are presented in Appendix 1.

With this done, the EPA sets a timetable for the assessment process. The PER assessment process usually involves an eight week public review period. During this period the PER document is made available to the public for a nominal charge and the public are invited to make submissions to the EPA.

Once the EPA has received all the public submissions, it puts all the issues raised to the proponent, who then responds to the public submissions. After this, and further discussions between the EPA and the proponent, the EPA assesses the proposal and releases its Report and Recommendations to the public.

The 1080 Feral Goat Poisoning PER Timetable

• public release of PER document	14 June 1993
• public submissions to the EPA close	9 August 1993
• issues raised put to the APB	30 August 1993
• APB responds to issues raised	20 September 1993
• EPA's Report & Recommendations are released	12 November 1993

For this proposal, the tentative date for the release of the EPA's Report and Recommendations is the 30th of October 1993. After their public release there is a 2 week period for appeals against the EPA's Report and Recommendation. If appeals have been made against the EPA's Report and Recommendations, the Minister for the Environment considers all appeals with advice being sought from the EPA's Chief Executive Officer. This process may take a few weeks.

The next step is formal consultation between the Minister for the Environment and the decision-making authorities (DMA), which in this case are the Minister for Primary Industries and the Minister for Health. The pesticide registration needs to be approved by the Minister for Health. The period in which the DMA's may respond to the conditions and procedures proposed by the Minister for the Environment is set at 2 weeks. If the DMA's do not respond within this period the Minister for the Environment's conditions and procedures become binding.

In addition to the EIA process, there are sometimes other statutory requirements that a proposal must meet before it can go ahead. The next section of this chapter discusses the other statutory requirements that apply to the 1080 feral goat proposal.

1.4 OTHER STATUTORY REQUIREMENTS

Besides the Environmental Protection Act 1986, under which the EPA operates, the only other statutory requirement that this proposal falls within is the Health Act 1911 and its associated Health (Pesticides) Regulations 1956.

The Pesticide Regulations regulate the registration and use of pesticides in WA. Under these regulations, applications to register pesticides for use must be approved by the Executive Director of Public Health acting on advice from the Pesticides Advisory Committee (PAC).

Under the Pesticides Regulations 1080 poison is registered for the control of a number of pest animals, however the use of 1080 to control feral goats is a new application of this poison and requires registration for this purpose.

In 1992 the APB submitted an application to register 1080 poison for the control of feral goats to the Executive Director of Public Health and the PAC. This application was reviewed by the PAC which then recommended that the application be assessed by the EPA before registration is approved.

In addition to the Western Australian pesticide registration process, the registration of 1080 for the control of feral goats must now also be approved under a new national registration scheme for agricultural and veterinary chemicals. Under this national scheme the Australian Agricultural and Veterinary Chemicals Council (AAVCC), assisted by the Federal Department of Primary Industries and Energy, evaluates new chemicals and new uses of existing chemicals to ensure that they work properly, are safe to use, and pose no substantial threat to the environment.

The federal legislation under which the AAVCC is to operate has not yet been passed by parliament, so until that time, a State-Commonwealth Government administrative agreement exists which require that the AAVCC first approves registration of a chemical before it goes through the State registration process.

How the registration process of 1080 will proceed is presently unclear. It appears, however, that the EPA's report and recommendations will be used by the AAVCC to assess whether 1080 should be registered for the use of controlling feral goats. If the AAVCC approves the application, the registration will be then be passed back to the WA Executive Director of Health and the PAC for approval.

It is estimated that EPA's Report and Recommendation will be made available by the 30th of October 1993. The AAVCC will then take some 4 to 6 months to evaluate the 1080 registration application. With the approval of the AAVCC and the Executive Director of Health, it is estimated that the registration of 1080 could be completed by January - March 1994.

It should be noted that the WA Pesticide Regulations restrict the manufacture and distribution of 1080 to the APB. The APB may then in turn supply the poison to trained officers of CALM, and preparations containing low concentrations of the poison to farmers and pastoralists trained in the use of 1080.

Currently 1080 is registered for controlling wild dogs, dingoes, feral pigs, foxes, rabbits and feral cats. Under the Pesticide Regulations there are specific regulations which control the use of 1080. If 1080 is registered for the control of feral goats, the Pesticide Regulations will be amended to include this new use and will incorporate a series of restrictions controlling its use.

1.5 1080 FERAL GOAT WORKING GROUP

The 1080 feral goat working group was developed specifically for this study. This group is made up of 21 people with a range of skills and experiences from the APB, CALM and DAWA. The members of this working group were:

Supervising Working Group

Neil Hogstrom, Msc.Agric.,
Chief Executive Officer (APB)

Greg Pickles, B.Sc. Agric. Sci.
Manager, Feral Goat Eradication Program (APB)
chairman of the 1080 feral goat working group

Dennis King, B.Sc., M.Sc., Ph.D.
Research Officer (APB)
research adviser of 1080 feral goat working group

Stuart Wheeler, B.Sc.(Zoo.), B.Sc.(Math), Ph.D.
Principal Research Officer (APB)
research adviser of 1080 feral goat working group

Ken Dean
Policy Officer (APB)
policy adviser of 1080 feral goat working group

Trial Working Group

Grant Norbury, B.Sc., PhD.
Research Officer (APB)
officer responsible for the trial design

Colin Holt, B.Sc.
Feral Goat Eradication Co-ordinator (APB)
officer responsible trial site co-ordination and trial implementation

Malcolm Edgar, B.Env.Sc.
Rangeland Advisor (DAWA)
author of the PER and officer for the Carnarvon trial

Danny Carlisle
Operator (APB),
Leonora trial

Terry Donnelly
District Officer (APB),
Carnarvon trial

John Websdale
Operator (APB),
Leonora trial

Arthur Pepper
Technical officer (CALM),
Peron trial

Ron Shepard, B.Sc.
Regional Officer (CALM),
Peron trial

Geoff Thomas
Feral goat eradication co-ordinator, (APB)
Leonora trial

Rex Walker
National Park Ranger (CALM),
Peron trial

Geoff Cahill
District Officer (APB),
Leonora trial

Mike Dowd
Regional Officer (APB),
Carnarvon trial

Simon Kniveton
District Officer (APB),
Carnarvon trial

John Russell-Pell
District Officer (APB),
Carnarvon trial

Jim Stevens
Regional Officer (APB),
Leonora trial

Mark True
Mobile Park Ranger (CALM),
Peron trial

CHAPTER 2
NEED FOR THE PROPOSAL

This chapter discusses the need for the use of 1080 to control feral goats. The first section describes the environmental impact that feral goats are having on WA's rangelands, followed by a discussion of the current feral goat control program, and its limitations. The final section describes possible application of 1080 poison to control feral goats.

2.1 THE IMPACT OF FERAL GOATS IN WA

The uncontrolled grazing of feral goats has had a significant impact upon much of WA's rangelands. It is estimated that the current population of feral goats in WA is in the order of one million animals (G. Pickles pers. comm.) and cover an area of 460,000 square kilometres (Southwell and Pickles, in press). The distribution of feral goats can be seen in Figure 2.1.

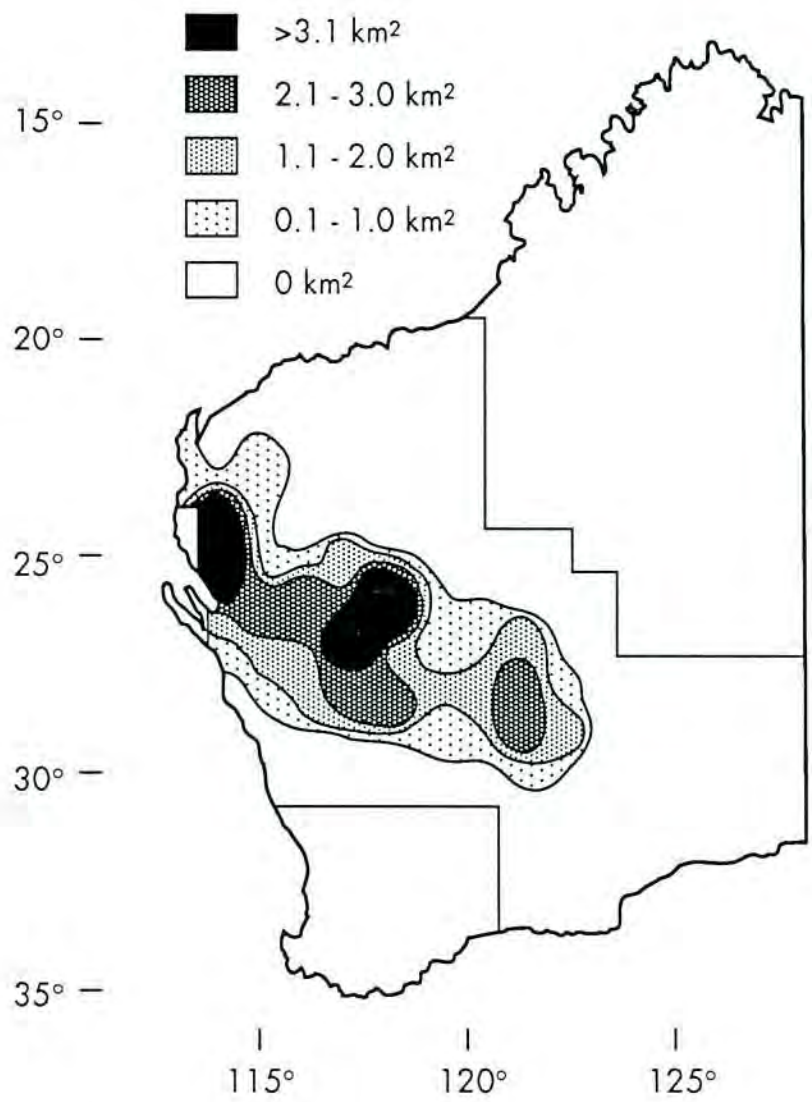

Figure 2.1 Distribution and density of feral goats in WA in 1990 (Number per km²) (Southwell and Pickles, in press).

Feral goats occur on some 270 pastoral stations in the southern pastoral region, and on average contribute 20% of the total grazing pressure on these stations, with sheep contributing 46% and kangaroos contributing 34%. The distribution of feral goats is not uniform, as can be seen in Figure 2.1. On some stations in the Upper Gascoyne, feral goats would contribute to more than 50% of the total grazing pressure, while on other stations their numbers are very low.

Through their unmanaged grazing, feral goats place substantial environmental pressure on rangelands; they cause vegetation degradation, they reduce the recruitment of important perennial shrubs and grasses, they delay the processes of regeneration, and they cause soil degradation. When feral goats are pressed for food, such as when they are grazing in degraded areas, their grazing habits can be very destructive. Figure 2.2 shows the impact of feral goats grazing on an Acacia shrub, where they have climbed into the shrub breaking down branches to feed on. Acacias and other perennial plants play a vital role in the rangelands, maintaining soil stability during the extended dry periods when annual and ephemeral plants have disappeared (Wilson and Harrington 1984).

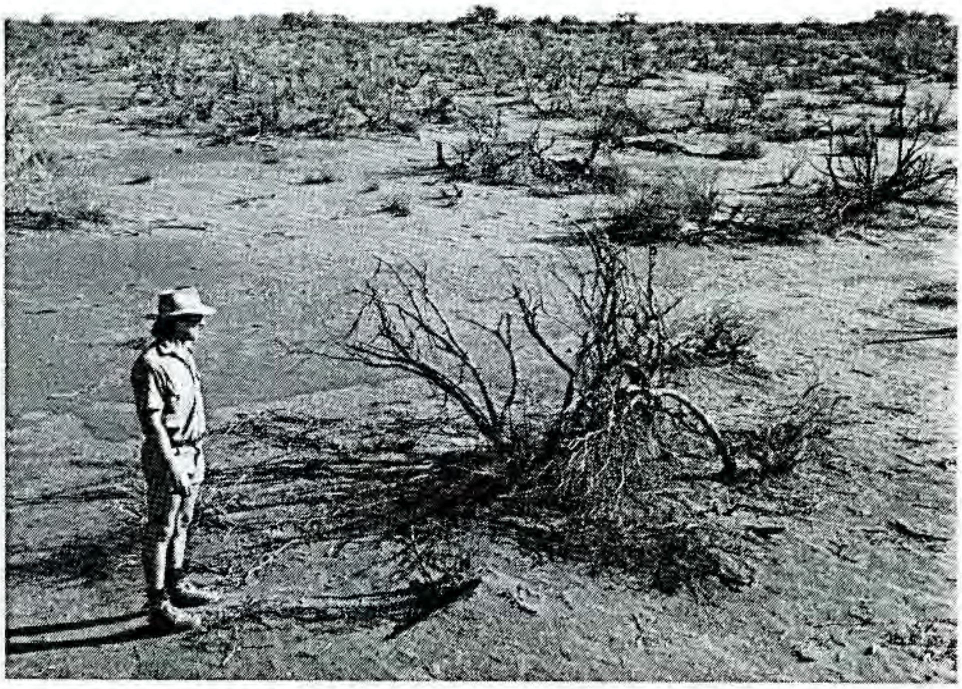

Figure 2.2 Feral goat damage to a Snakewood shrub *Acacia eremaea* north of Mt Magnet.

Feral goats also have a substantial impact on the pastoral industry. Feral goats compete with sheep for rangeland pastures, graze in destocked areas, damage fences and waters, use the limited stock water supplies during summer, and their control consumes much time and money. Last year it was estimated that pastoralists spent approximately $1 million on feral goat control, and this is money that the pastoralists can ill afford to lose during this time of economic crisis.

In addition, feral goats pose a severe threat to the future conservation of WA's rangelands. From a study on the environmental impact of feral goats in WA's rangelands (Fletcher 1991), we know that their rate of reproduction is not limited by the vegetation degradation they cause. This means that feral goat numbers can increase even though they are destroying the country which they use. This, combined with their very high rate of reproduction, means that the feral goat population could increase greatly and remain at high levels if they are not controlled. Such a population of feral goats could cause severe degradation to WA's rangelands.

In the event of an exotic disease outbreak, feral goats could act as a vector, spreading the disease throughout large areas of the State. An Australian Veterinary Emergency Plan

(Austvetplan) for controlling feral goats in such an event was written in 1990. This plan relies heavily on radio collared "Judas" goats being used to find feral goats and helicopter-based shooting. From what is now known on the behaviour of feral goats and with experience gained from the FGEP, it is unlikely that the Austvetplan would be effective and its implementation would be very expensive (King 1992). The best way that we can eliminate the possibility of feral goats acting as an exotic diseases vector is to eradicate them now.

In summary, the control of feral goats is of vital importance in conserving WA's rangelands. The importance placed upon the control of feral goats can be gauged by the size of State's Feral Goat Eradication Program, which is the topic of the next section.

2.2 THE FERAL GOAT ERADICATION PROGRAM

As discussed earlier, in 1991 the APB, DAWA, and 13 pastoral LCDCs developed the FGEP with the objective of eradicating feral goats, or reducing their number to a manageable level. This program was designed to run for 5 years. In 1996 the effectiveness of the program will be reviewed and an assessment will be made as to whether it needs to continue.

Under the FGEP the role of the APB is to co-ordinate and facilitate eradication work, while the role of pastoralists is to undertake the actual eradication work. However, the APB does undertake direct control work in helicopter shooting, and would also undertake 1080 feral goat poisoning. Under the FGEP, DAWA also assists the APB in their co-ordination facilitation role.

The FGEP had been running for twenty-one months, as of March this year, and during this time more than 814,000 feral goats have been removed. The program covers 272 stations, and 14 LCD's. The level of participation in the program is high with more than 230 of the 272 stations involved, and with some 53 control cells being formed. A summary of the 1991/1992 feral goat work is provided below in Table 2.1.

Table 2.1 Summary of 1991/1992 Feral Goat Eradication Program

Land Conservation District	Cells	Stations involved	Stations participating	Sold number	Sold % of total	Destroyed number	Destroyed % of total	Total number
NE Goldfields	7	28	28	70997	58	51668	42	122665
Kalgoorlie	5	28	22	20205	81	4817	19	25022
Sandstone	4	19	17	18558	89	2318	11	20876
Lyndon	5	22	20	16579	44	20773	56	37352
Gascoyne	3	10	10	31721	76	9860	24	41581
Shark Bay	4	14	12	16511	56	13012	44	29523
Non Aligned	1	8	8	20321	89	2597	11	22918
Upper Gascoyne	2	17	14	14654	66	7705	34	22359
Murchison	6	29	27	42978	59	29772	41	72750
Meekatharra	4	21	21	12688	38	20773	62	33461
Cue	1	11	11	4825	43	6508	57	11333
Mt Magnet	5	20	18	20017	89	2447	11	22464
Yalgoo	5	27	24	20612	69	9188	31	29800
Wiluna	1	18	5	0	0	1345	100	1345
TOTAL	53	272	237	310666	61	182783	39	493449

The 1992/1993 control program to March 1993 had removed 321,044 feral goats from the rangelands, with 210,932 being sold and 110,112 being destroyed. Table 2.2, next page, provides details of the 1992/1993 program.

Table 2.2 Summary of 1992/1993 Feral Goat Eradication Program up to March 1993

Land Conservation District	Cells	Stations involved	Stations participating	Sold number	Sold % of total	Destroyed number	Destroyed % of total	Total number
NE Goldfields	7	28	28	33344	53	29704	47	63048
Kalgoorlie	5	29	17	6760	50	6818	50	13578
Sandstone	4	19	10	16405	91	1643	9	18048
Lyndon	5	22	14	4402	40	6479	60	10881
Gascoyne	3	10	9	15553	69	6915	31	22468
Shark Bay	4	14	12	9758	60	6483	40	16241
Non Aligned	1	8	7	19927	89	2560	11	22487
Upper Gascoyne	2	17	12	19088	82	4101	18	23189
Murchison	6	28	26	34032	62	20553	38	54585
Meekatharra	4	21	20	11523	43	15383	57	26906
Cue	1	11	11	1024	26	2961	74	3985
Mt Magnet	5	20	20	22085	92	1940	8	24025
Yalgoo	5	27	23	17031	79	4564	21	21595
Wiluna	1	18	3	0	0	8	100	8
TOTAL	53	271	231	210932	64	110112	34	321044

The estimated cost of the program to date is \$3.7 million, with the government and the pastoral industry making equal contributions.

While the FGEP is progressing well, there are a number of problems which are currently limiting the program and which may be major constraints in the future. These include:

1. The financial downturn of the pastoral industry. The current wool crisis is severely limiting the amount of resources pastoralists are able to put into feral goat eradication work. Most pastoral stations can't afford to run their normal complement of staff and have only a skeleton staff to maintain their water points. This, together with a lack of cash, means it is increasingly difficult for pastoralists to undertake goat mustering, and to provide resources for helicopter-based shooting. The State government is also constrained by its limited budget and must maximise the effectiveness of every dollar spent.
2. Feral goats are still being viewed by some pastoralists as a long term resource rather than as a cost to the industry. Although there has been an increased awareness of the real cost of feral goats to the pastoral industry, some pastoralists still view feral goats as a form of income and don't want them eradicated. This situation has not been helped by the wool crisis which is making the idea of "farming" feral goats more attractive to some pastoralists. To achieve feral goat eradication the FGEP will need total support of all stations, otherwise the non-participating stations will act as refuges from which feral goats can spread.
3. Unavailability of some control techniques.

To address these problems the APB and DAWA is putting considerable effort into research and into the development of better communication and co-operation between all the parties in the FGEP.

One of the research projects the APB has undertaken is developing a method of using 1080 poison to control feral goats. With increasing economic pressures being placed on the FGEP the application of 1080 could have a valuable role to play in the program. The final section of this chapter discusses the potential application of 1080 to control feral goats.

2.3 POSSIBLE APPLICATION OF 1080 POISONING

The way in which 1080 would be used is to temporarily poison water troughs on pastoral stations during summer. During summer, and other dry periods, feral goats depend on the water provided by the bores and wells to survive. By poisoning water troughs during these times large numbers of feral goats can be destroyed. A detailed description of how feral goat poisoning would be done is provided in Chapter 4.

In feral goat eradication work there are generally two phases. In the first phase the bulk of the goat population is removed, usually by mustering and trapping, and in the second phase the remnant population is destroyed by shooting from helicopters or the ground. The second phase is called the "clean up stage". From the trial work done it appears that the most cost-effective application of 1080 would be in first stage control as a "knock -down tool". Using 1080 in the clean up stage is more expensive, as the cautious behaviour of the remnant feral goats makes them difficult to poison. However, as the population of feral goats is depleted the relative value of controlling the remaining feral goats increases, and this may offset the increased costs of 1080 control.

The best application of 1080 poison will evolve over time within the stringent environmental and safety controls detailed in this PER. It is presently envisaged that 1080 would be most useful in situations which preclude other forms of first stage control. These situations would include; where stations are too far from markets to be able to afford the transport costs, where stations are having extreme financial difficulties and cannot afford other feral goat control work, and in cases of rugged terrain which preclude most other forms of control.

It is also important to note that mustering and trapping operations during the feral goat eradication program is dependent upon relatively high prices being paid for feral goats in order to finance these operations. If there is a major decline in prices of feral goats, it is expected that there would be a corresponding decline in the amount of control work done. If this were to occur, the application of 1080 would become more valuable.

CHAPTER 3 EVALUATION OF ALTERNATIVES

This chapter describes the evaluation of alternative methods for feral goat control, and the ethical implications of their use. The first section discusses the conventional forms of control, namely mustering, trapping and shooting. The second section discusses the potential use of biological control, and the third discusses poisoning options. The animal welfare considerations of feral goat control and the use of 1080 are then discussed.

3.1 CONVENTIONAL CONTROL METHODS

Conventional forms of feral goat control include mustering and trapping goats for sale or destruction, and shooting feral goats from the ground and from helicopters. Control techniques, with the exception of helicopter-based shooting, have been used for decades in Western Australia, and now provide the principal methods for implementing the FGEP.

Since the development of the FGEP, the use of these conventional control methods has been enhanced. The major innovation has been the use of co-operative control cells, integrated with helicopter-based shooting.

Control cells are made up of a number of adjacent pastoral stations, usually about five. These stations co-ordinate their control efforts to achieve eradication throughout the entire cell. The co-ordination of control effort usually takes the form of combined musters, where pastoralists co-operate to undertake large mustering operations across station boundaries, and by undertaking simultaneous trapping operations. By doing these co-ordinated operations, stations in control cells prevent themselves from being reinfested by feral goats from neighbouring stations which haven't done control work. When cell work has reduced feral goat numbers to a low level, pastoralists can apply for helicopter-based shooting to destroy the remaining animals. In some cases, using ground shooting after cell work can keep feral goat numbers at low levels.

Through the use of control cells and LCDCs, pastoralists are able to pool their resources. With large-scale co-operative musters, the proceeds of goat sales are used to pay for the operation, and surplus monies are often used to underwrite future control work. Helicopters, which are now being used in mustering operations, are very expensive to operate, and it is necessary for LCDCs to underwrite their use if the mustering operation fails. Co-operative LCDC funding schemes are also necessary to financially support helicopter-based shooting.

Helicopter-based shooting is a complex operation undertaken by the APB with the assistance of LCDCs. Initially, cell control work must be done to reduce feral goat numbers to a clean-up stage. Helicopter-based shooting is not used as a first stage control technique because of it's high cost, and because it is unable to deal with large mobs of goats. After the cell work has been done, the APB and the LCDC undertake an aerial survey of the control area to ensure that the remnant goat numbers are at a sufficiently low level. If they are not, more cell work is done.

The shooting operation uses a spotter plane flying a grid search pattern at medium altitude to locate feral goats. Under the direction of the spotter plane, a helicopter flying at low altitude is used as a gun platform from which the feral goats are shot. The rifles used in these operations are ex-military semi-automatic rifles firing high power 7.62 mm hollow point ammunition. On average 2 rounds are used to destroy each goat. These powerful rifles are used to make the shooting operations faster and more efficient, and to minimise the suffering of the goats being shot.

Trained APB officers are used to undertake these shooting operations, as under WA's firearm regulations, pastoralists are not permitted to use high power semi-automatic rifles.

Conventional control techniques have many advantages. These include;

- they are target specific, in that they do not have an impact upon other species
- they have no significant residual environmental impacts
- they are relatively safe to undertake and do not risk the health and safety of the general public
- in many cases, where goat numbers are high, they are self-financing
- they are very effective in many areas and situations.

The limitations of these control methods, however, include;

- cost, especially when stations are undergoing financial hardship, and at medium to low goat densities which make control operations more expensive
- dependence upon feral goat markets to finance their implementation, and these markets having to be close enough to the control operations to overcome transport costs
- their dependence upon group co-operation and commitment from all pastoralists to be effective
- areas of rough terrain can prevent first stage control work being done.

Even with these limitations, conventional control techniques will probably remain the principal methods used for implementing the FGEP.

3.2 BIOLOGICAL CONTROL

Biological control is a term used for a wide range of pest control methods which exploit biological aspects of the pest species to control their populations.

Common forms of biological control are the manipulation of predator-prey relationships, or the use of parasites or disease organisms. Examples of biological control in Australia are the use of the myxoma virus to control rabbits and the use of the *Cactoblastis cactorum* moth to control the prickly pear cactus *Opuntia stricta* in eastern Australia (Krebs 1985). Both of these biological control programs have been very successful, however the use of biological control can be very dangerous if it is not handled correctly.

One disastrous example of biological control was the attempted use of the cane toad *Bufo marinus* in Queensland to control the greyback cane beetle. When released into the cane fields, the South American cane toad was not the slightest bit interested in the offending cane beetle and proceeded to eat almost everything else. The cane toad now poses a substantial environmental threat to much of tropical Australia, and ironically a CSIRO-led research team has now been formed to look at biological control for the cane toad.

The upshot of all this is that biological control needs to be painstakingly researched and exhaustively tested if it is to perform correctly. This scientific research, which usually takes years, is extremely expensive and may not result in a control method being developed.

The potential application of biological control for feral goats is severely handicapped as not all goats in Australia are feral. There are many agricultural industries which use domestic goats for the production of cashmere, goat's milk, and capretto (goat meat). A possible feral goat biological control program must not have an impact upon these domestic goat herds.

The use of natural or genetically engineered diseases would pose a substantial threat to domestic goat herds, and if there was a cross-species threat to Australia's sheep flocks the damage to nation's economy could be enormous. The use of predator-prey or parasitic relationships are also constrained by these factors. In the rangelands, the only significant predators of feral goats are wild dogs and dingoes. Unfortunately though, these predators have to be controlled by 1080 poison baiting, because of the enormous damage they do to the pastoral sheep flocks.

Given these substantial limitations, and the very high research costs and the time it would take before a biological control program could be implemented, the APB has not pursued this form of control.

3.3 POISONING OPTIONS

When discussing poisoning options there are two considerations. The first is the type of poison to use and the second is how the poison is administered.

In evaluating potential poisons there are a number of important criteria which the prospective poison should meet. These criteria include:

- ideally the poison should be toxic to the target species only. In practice, however, this is rarely achievable.
- the poison should have a low toxicity to native species relative to feral goats. This property can be used to target feral goats and reduce the poisoning risk to non-target species.
- the poison should have a low toxicity to humans relative to feral goats.
- the poison should be biodegradable, breaking down naturally in the environment.
- the poison should not accumulate in the environment and pose a continuing health risk to other animals or people.
- the poison should be water soluble and tasteless so it can be used to poison the drinking water of feral goats.
- the poison should provide a relatively humane death for feral goats.

Potential poisons which were evaluated for feral goat control included 1080, arsenic, cyanide, pindone and strychnine. The toxicological properties of these poisons are listed below in Table 3.1.

Table 3.1 Properties of various poisons

Poison	Low toxicity to native animals relative to goats	Low toxicity to humans relative to goats	Readily bio-degradable	Non bio-accumulative	Tasteless & water soluble	Relatively humane death
1080	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Arsenic	No	No	No	No	**Yes**	No
Cyanide	No	No	**Yes**	**Yes**	**Yes**	**Yes**
Pindone	No	No	No	**Yes**	**Yes**	No
Strychnine	No	No	No	No	No	No

From Table 3.1, it can be seen that 1080 poison best fits these criteria, and it was the obvious choice when poisons were being evaluated.

The APB and CALM makes extensive use of 1080 for pest control because of its unique toxicological and environmental properties. One of the great features of 1080 is that while it is very toxic to most introduced animals, many of WA's native animals have a relatively high tolerance to it. The reason for this is that 1080 occurs naturally in a group of WA's plants, and it is believed that through exposure to these plants many of our native animals have evolved a high tolerance to it. Introduced animals, however, have had no historical exposure to 1080 and have not developed this elevated tolerance. This special property has been used to target introduced pests with 1080 while minimising the risk of poisoning native animals (King 1990).

The other major advantage of 1080 is that it is biodegradable. In soil there are many species of bacteria and fungi which defluorinate 1080 and make it harmless. This is very fortunate because if microbial detoxification did not occur, the large quantities of 1080 dropped in leaves by 1080-producing plants would accumulate in the soil and would make the south-west of WA a very dangerous place in which to live (King 1990). An excellent discussion of 1080 in Western Australia is provided in Appendix 2 by Dr Dennis King in his paper "1080 and Australian Fauna".

The other major issue with using poisons is the method of application. The two obvious methods for poisoning goats are through their food or through their water. Other forms of poison application such as intravenous injection, gassing, or using an aerial dispersed skin contact poison, understandably were not considered.

To poison the food supplies of feral goats would be difficult. Either the rangeland vegetation upon which feral goats feed would have to be poisoned or a poison bait would need to be provided. To poison the rangeland vegetation by applying a poison gel over the leaves of the plants (Parkes 1983) would be logistically impractical, and would place pastoral stock and native herbivores at risk. To use an introduced poison bait, the feral goats would first have to be acclimatised to the bait by prior feeding. Designing a baiting system which does not also place other herbivores at risk would also be difficult and expensive. A much better solution is to poison the artificial water supplies upon which feral goats depend during dry periods.

Through extensive trial work, an effective method of poisoning feral goats using water troughs, and which does not place other species at risk, has been developed. The way in which this is done is described in detail in the following chapter.

3.4 ANIMAL WELFARE CONSIDERATIONS

The need to control feral goats raises issues of ethics and animal welfare.

Reducing the population of feral goats in rangelands could be done in three ways, either by moving them to another area in which they can live, by using some form of contraceptive control which over time diminishes their population, or by killing them either through direct means in conventional control or through indirect means such as biological control.

The first method of control, transferring feral goats to another area, is not a practical option and is undesirable as it simply shifts the environmental impact to another area.

The second method, using contraceptive control, while theoretically possible, would be extremely difficult and very expensive. In addition, it would take a long time to develop a contraceptive technique and many more years for it to become effective. For these reasons, contraceptive control has not been used. For some people, using contraceptive techniques is the only ethically acceptable form of control. However, to argue that if we cannot use contraceptive control we shouldn't control feral goats at all, is to neglect our environmental responsibilities.

The third way of reducing the feral goat population is by killing them. In having to kill feral goats, it should be done in the most humane way possible.

Poisoning is one way of killing feral goats. Unfortunately though, in our culture there is a great stigma attached to poisoning and it is such an emotive word that its use quickly clouds debate. However, it should be recognised that the use of poisons is an integral part of our society. Their use ranges from agricultural applications of pesticides and herbicides, to household insect sprays, rat baits and worming tablets for families and pets. Such a diversity of poisons and applications means that the ethical considerations of their use can only be assessed on a case by case basis.

So what is it like for a goat to die from 1080 poisoning? We can only gauge this from the behavioural observations made of feral goats dying of 1080 poisoning. Based on observations from the 1080 trial work (Norbury 1992), the first symptoms of 1080 poisoning become apparent some 2 to 4 hours after drinking the 1080 solution when the goats become lethargic and groggy. When mobs of poisoned goats were approached by trial officers, the goats began to run away, which is the usual response of feral goats. However, after running for a short period they became tired and had to sit down. During the latter stages of poisoning, goats lay down, appeared to be unaware of surrounding activity, and became unconscious. Death comes in this unconscious state from an apparent cardiac failure. The average time until death from drinking the poisoned water was 8 hours with a range from 3 to 12 hours.

A small minority of goats became distressed during the latter stages of poisoning. This was apparent from their vigorous bleating while seated. It is not known if distress would happen in the bush, as these goats may have been aware of the human activity around them during the trial, and as they were unable to run away they became distressed.

From this work we believe that 1080 poisoning causes a relatively humane death in feral goats and compares well with other forms of conventional control, i.e. being slaughtered in abattoirs or being shot in the field.

CHAPTER 4 1080 FERAL GOAT POISONING PROPOSAL

This chapter discusses how the APB proposes to use 1080 poison to control feral goats. The first section discusses 1080 poison, its history, how it works and how it is currently used in WA. The second section discusses the method used to poison feral goats, and the scope of a feral goat poisoning program.

4.1 1080 POISON

The poison sodium monofluoroacetate (1080) was first synthesised in Belgium in 1896, but its toxicity was not recognised until 1934 (Calver and King 1986). After this time, fluoroacetate was patented for use as a moth-proofing agent.

"It is not now used as an insecticide. Further studies were carried out in the 1940's to evaluate the potential of fluoroacetate and related compounds as chemical warfare agents. During those tests, it was found to be extremely toxic to rabbits. Further work showed that it was highly toxic to a wide range of mammals and it's particular value as a rodenticide was determined in the U.S.A. in 1944. The common name of 1080 was derived from the laboratory serial number given to it at that time. Compound 1080 was first used as a vertebrate pest control substance in the U.S.A. in the late 1940's and is still widely used there" (King 1990).

In Australia, 1080 was first used experimentally by the Tasmanian State Government for rabbit control in the early 1950's. In WA, trials using 1080 to control rabbits began in 1953. Since that time, it has replaced the poisons arsenic, phosphorus and strychnine for rabbit control and is now used extensively for the control of wild dogs, dingoes, foxes and feral pigs.

Pure 1080 is a white, tasteless, odourless powder. In Australia it is dyed red, blue or black as a safety precaution. The compound 1080 is very soluble in water but is relatively insoluble in most organic solvents, is non-volatile and is relatively stable, decomposing at a temperature of approximately 200°C. Commercial grade 1080 is about 94% pure and has a faint vinegar-like odour and a mild acid-salty taste.

4.1.1 HOW 1080 POISON WORKS

When fluoroacetate is ingested, it is absorbed by the gut and spread throughout the body by the circulatory system. Once in the body's cells, fluoroacetate is absorbed by mitochondria. Mitochondria are small sub-cellular bodies which act as little power houses for cells, converting food into energy. Mitochondria use a complex metabolic pathway to convert food into energy. One of the major components of this pathway is the Krebs citric acid cycle, or the Krebs cycle in short (Keeton and Gould 1986).

When fluoroacetate gets into mitochondria it is converted into fluorocitrate. Fluorocitrate is a powerful inhibitor of the enzymes aconitase and succinate dehydrogenase and prevents citrate metabolism in the Krebs cycle (Peters 1954, Peters 1972). This effectively blocks the Krebs cycle, preventing the release of energy necessary for normal cell functioning. Other energy-releasing mechanisms are also blocked by the resultant disruption of normal activity within cells. At this point, cardiac and central nervous system dysfunction occurs and death may result from heart and/or central nervous system failure. Herbivores generally die from cardiac failure, while carnivores die from central nervous system failure. Omnivores show mixed responses (McIlroy 1982; Calver and King 1986).

If a sub-lethal dose of fluoroacetate is taken, the poison is detoxified in the liver and kidneys and is excreted. Sub-lethal poisoning generally results in no permanent damage, though some species have subsequently shown temporarily reduced fertility (King 1990).

There is no effective antidote for 1080 poisoning, so great care must be taken with its use.

4.1.2 CURRENT USE OF 1080

In Western Australia, the APB and CALM make extensive use of 1080 to control pest animals. These animals include rabbits, wild dogs and dingoes, foxes, and feral pigs. The APB use 1080 mainly to control wild dogs and dingoes in the pastoral areas, and rabbits and foxes in agricultural areas. CALM uses 1080 in conservation reserves to control foxes, wild dogs, feral pigs and rabbits.

Because of 1080's extreme toxicity (0.7-5.0 mg/kg LD_{50} for humans) its use in WA is very tightly controlled. Under the Pesticides Regulations only the APB, or licensed agents, can manufacture or import the substance, and its distribution is restricted to trained APB and CALM officers. Low concentration preparations of 1080 are also supplied to farmers and pastoralists trained in the use of 1080.

The APB makes up several formulations of 1080 for use in it's pest control programs. These formulations include;

- 6.0 mg "1080 wild dog bait",
- 4.5 mg "1080 fox bait",
- 4.5 mg "1080 impregnated oats" for fox control,
- 6.0 mg "1080 impregnated oats" for wild dog control,
- 4.5 mg "One Shot 1080" impregnated oats for rabbit control,
- 225 g/l "1080 Concentrate Red" for injecting wild dog meat baits, and
- 200 g/l "1080 Concentrate Black" for treating rabbit oat baits.

These 1080 bait formulations are specially designed to use the minimum concentration of 1080 that will effectively kill the target pest, so as to minimise the risk to native animals. Single baits also contain such low levels of 1080 that they pose no risk to humans.

From July 1985 to April 1993 the APB has used 335 kg of pure 1080. The majority of this (280 kg) was used in the southern agricultural areas mainly for rabbit control with most of the remainder (54 kg) used in pastoral areas for wild dog and dingo control.

4.2 POISONING FERAL GOAT WATERING POINTS

With the growing concern about the increasing feral goat population, in 1991 the APB began to seriously examine the potential use of 1080 for controlling feral goats. By the end of the year trial work on the use of 1080 had begun. This work determined the effective lethal dose of 1080 for feral goats, and developed effective techniques of poisoning feral goat watering troughs while minimising the risk to non-target species. These trials were conducted by Dr Grant Norbury. His report on this work "The Use of 1080 to Control Feral Goats in Western Australia" is presented in Appendix 3.

In 1992 the EPA requested that the APB provide more information on the safety and effectiveness of 1080 for feral goat control. Early in 1993 the APB and CALM undertook further trials in the Upper Gascoyne, Leonora region, and on Peron Peninsula. These trials have enabled the APB to refine the poisoning technique and to develop operational procedures. The results of these trials are presented in Appendix 4, "Field Trials on the Efficacy of 1080 Poisoning for Feral Goat Control in Western Australia".

The operational procedures for using 1080 are detailed below in a profile of a poisoning operation.

4.2.1 POISONING OPERATION

In this section a brief explanation of how poisoning operations work is first outlined and then followed by a more detailed discussion. Please note that the environmental management aspects of these poisoning procedures are discussed in detail in the following chapter, Environmental Impacts.

On a pastoral station, an APB officer will install 1080 poisoning stations on a number of waters. These poisoning stations consist of special yards, an introduced poisoning trough and a transportable poison water tank.

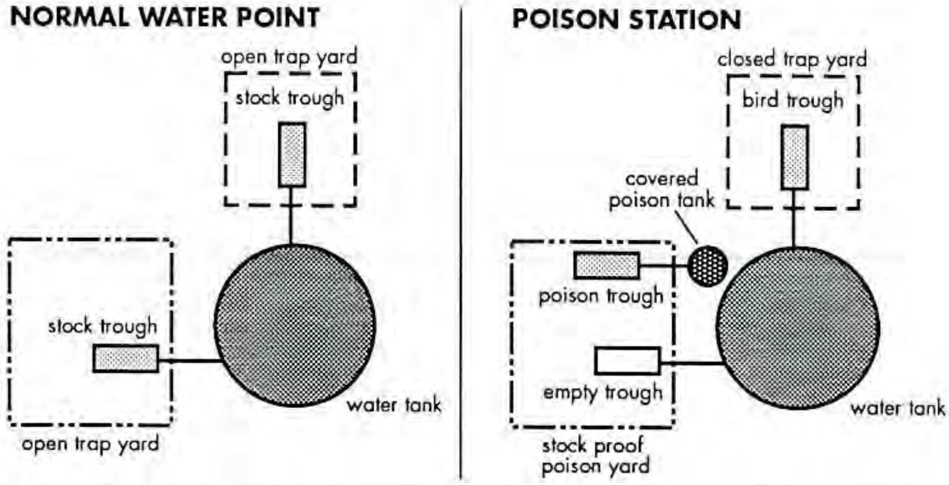

Figure 4.1 Installation of a poison station on a water point.

The introduced poison trough is placed in a sheep-proof trap yard. When poisoning is underway this yard is closed off from sheep by a special gate which feral goats can step through, but sheep can't. To provide safe drinking water for birds when poisoning is underway, one of the station's normal troughs is used as a bird trough. The bird trough is fenced off from feral goats, so the feral goats are forced to drink from the introduced poison trough. Because the poison trough is unfamiliar, birds will not drink from it. (See Appendix 4) If there is more than one trough at the station's water point the remaining troughs are turned off. Again, this is to force the feral goats to used the poisoned trough. Figure 4.1 illustrates the installation of a poison station on a water point.

Poisoning is undertaken during the morning drinking period of feral goats, from 7:00 am to 2:00 pm. Poisoning is not undertaken before 7:00 am because of the risk of kangaroos being poisoned. It is not extended later into the afternoon because of the stress it places on stock which cannot drink from the watering point during poisoning. A poisoning operation would generally run for 4 days.

Now for the more detailed description of a 1080 poisoning operation.

At the request of a control cell, an APB officer will discuss the possible use of 1080 poisoning on a station. If the numbers of goats are sufficiently high and they are centred around the station's water points, the APB and the control cell will fix a date for a poisoning operation.

A week prior to the poisoning, the target station and all of the surrounding stations will be gazetted in the Government Gazette to inform the public of the poisoning period. During this time and until the gazetting is cancelled a week after the completion of the poisoning, no feral goats are to be removed from these stations. Those who break this prohibition are liable for a $500 fine under Section 68 (3) of the Agriculture and Related Resources Protection Act (1976). An example of a 1080 feral goat poisoning notice is provided in Appendix 5.

A public notice will also be advertised in "The West Australian" newspaper and in a local newspaper one week prior to the poisoning, and prominent signs will be erected on the roads passing through the gazetted stations to notify the public of the poisoning activities.

There are four major activities the APB officer will undertake during a poisoning operation. These activities are; installing the poison stations, activating them for use, deactivating them, and removing them. While the installation and the removal of the poisoning stations is done at the beginning and at the end of the poisoning operation respectively, the activation/deactivation tasks are repeated every day during poisoning.

The poison station installation procedure

- unload and set-up the poison water tank and introduced poison trough,
- connect the hose between the poison water tank and introduced poison trough,
- install the sheep-proof gate on the feral goat poisoning yard, leaving the gate open,
- inspect the feral goat poisoning yard and the bird trough yard and modify them if necessary to ensure that they will perform correctly,
- inspect the overflow pipe of the property's water tank. If water is overflowing the property's tank, turn off the windmill, as feral goats may be able to use this as an alternative water supply when poisoning is underway,
- fill the poison water tank with water from the property's water tank using a petrol pump,
- measure the volume of water in the poison water tank using a calibrated measuring staff, and
- add the required volume of 1080 'Concentrate Black' (200g/l) solution to poison water feed tank to make the poison water concentration 7 milligrams of 1080 per litre of water (mg/l) $\pm$ 0.25 mg/l using a burette.

These installation procedures usually take less than a hour to perform. Note at this stage of the operation the poison station is not activated, as the poison trough is not turned on, all the yards are open and all of the property's water troughs are turned on.

The poison station activation procedure

- turn on the poison trough,
- close the sheep-proof gate on the poison yard,
- close the feral goat-proof yard around the bird trough, and
- turn off all any remaining troughs and sweep the water out of them.

The activation procedure take about 10 minutes to perform.

The poison station deactivation procedure

- turn off poison trough,
- drain the poisoned water out of the poison trough,
- spread the drained poisoned water over the ground using a rake,
- turn on other troughs, and
- open the poison yard and bird trough yard.

The deactivation procedure takes about 20 minutes to perform. Note that it is important for the poisoning officer to spread out the drained poisoned water as soon as possible, because he or she will need to remain present until all of the drained poisoned water has percolated down into the soil and there is no free standing poisoned water.

The poison station removal procedure

- detach the connector hose between the poison trough and the poison water tank at the trough end and use hose to spread out upon the ground the remaining poisoned water in the poisoned water tank,
- spread out any pools of poisoned water on the ground using a rake,
- remove the poison water tank and the introduced poison trough,
- remove the sheep-proof gate from the poison yard, and
- turn the windmill back on, if this was turned off to stop the properties water tank overflowing.

This procedure usually takes about an hour to perform. As with the deactivation procedure, the poisoning officer has to remain present until all poisoned water has percolated down into the soil and there is no free standing poisoned water. If feral goats have not used the poison station there may be up to 700 litres of poisoned water remaining. This volume of water generally takes about 40 minutes to infiltrate into the soil. It is important that the poisoning officer spreads this poisoned water out on the ground as soon as possible and then attends to other tasks, so he or she does not have to wait for an extra period for the poisoned water to infiltrate the soil.

Time Program for a Poisoning Operation

Monday:

8.00 am	- 12.00 pm	poisoning officer drives out to the pastoral station from base
12.00 am	- 1.00 pm	install 3rd poison station
1.00 pm	- 1.20 pm	drive to 2nd poison station
1.20 pm	- 2.20 pm	install 2nd poison station
2.20 pm	- 2.40 pm	drive to 1st poison station
2.40 pm	- 3.40 pm	install 1st poison station
3.40 pm		drive a short distance (1 km) from 1st poison station and camp

Tuesday:

6.50 am	- 7.00 am	activate 1st poison station
7.00 am	- 7.20 am	drive to 2nd poison station
7.20 am	- 7.30 am	activate 2nd poison station
7.30 am	- 7.50 am	drive to 3rd poison station
7.50 am	- 8.00 am	activate 3rd poison station
8.00 am	- 12.00 am	attend to other duties then drive to 1st poison station
12.00 am	- 12.20 am	deactivate 1st poison station
12.20 am	- 12.40 pm	drive to 2nd poison station
12.40 am	- 1.00 pm	deactivate 2nd poison station
1.00 pm	- 1.20 pm	drive to 3rd poison station
1.20 pm	- 1.40 pm	deactivate 3 rd poison station
1.40 pm	- 4.00 pm	return to poison stations which need poison tanks refilled
4.00 pm		drive back to camp

Wednesday & Thursday:
As for Tuesday

Friday:
As for Tuesday up to 1.40 pm when the 3rd poison station has been deactivated

1.40 pm	- 2.40 pm	remove 3rd poison station
2.40 pm	- 3.00 pm	drive to 2nd poison station
3.00 pm	- 4.00 pm	remove 2nd poison station
4.00 pm	- 4.20 pm	drive to 1st poison station
4.20 pm	- 5.20 pm	remove 1st poison station
5.20 pm	- 9.20 pm	return to base

The other important task listed above and which was not discussed earlier is that of refilling the poison water tank. This task is done in the afternoon once all the poison stations have been deactivated. In this process, the poisoning officer measures the volume of the water remaining in the poison water feed tank, pumps water into the poison tank, measures the volume of water in the poison tank again, and then doses the poison tank with 1080 so that its 1080 concentration is 7 mg/l ± 0.25 mg/l.

The activation and deactivation times for each poison station and the activation duration are listed below:

Poison Station No.	Activation Time	Deactivation Time	Activation Duration
1st	7:00 am	12:00 am	5 hours
2nd	7:30 am	12:40 am	5 hours 10 minutes
3rd	8:00 am	1:20 pm	5 hours 20 minutes

The differences in activation times and deactivation times of the different poison stations is due to the time required to travel between these poison stations. The differences in activation duration between poison stations is due to the longer period of time it takes to deactivate poison stations. Logistic constraints prevent a poisoning officer from operating more than three poison stations.

During a poisoning operation, poison stations are installed on adjacent watering points to use the control cell principle to reduce local populations of feral goats. After a 4 day poisoning operation trial data indicates that approximately 70% of the feral goat population using the water points would be destroyed. Extending the duration of the poisoning operations is usually not cost effective as the remnant feral goat population are very wary and difficult to poison. After a one week poisoning operation a poisoning officer may have destroyed between 500 and 1000 feral goats.

Afternoon poisoning operations

In special circumstances, there could be large numbers of feral goats using water points in the afternoon. In these situations, an afternoon poisoning operation would be required.

As with the morning poisoning operations, an afternoon poisoning operation would be limited to 5 hours and 30 minutes and poisoning stations are to be deactivated by sunset. All poison stations activated during the afternoon are monitored by a poisoning officer for the duration of the poisoning operation. In practical terms this means that a poisoning officer could only operate one poison station during the afternoon.

The reason afternoon activated poisoning stations are to be monitored is because of the potential risk of kangaroos being poisoned in the late afternoon. If any kangaroos approach the poisoning station during the afternoon, the poisoning officer will scare them away.

In operational terms the requirement for afternoon poisoning operations is likely to be very limited.

4.2.2 THE SCOPE OF A 1080 FERAL GOAT POISONING PROGRAM

The potential use of 1080 poisoning for feral goat control extends to all of the 272 pastoral stations which are currently involved in the FGEP covering an area of some 460,000 square kilometres. In practical terms however, the geographical scope of a 1080 poisoning program is likely to be more limited than this.

The major use of 1080 control would be for situations when other forms of control are not available or are unsuitable. These situations would include those when conventional control is too expensive, which could be due to long distances to markets, stations having financial difficulties or during a major decline in feral goat prices. In some areas, conventional control methods are unsuitable due to rugged terrain or very dense bush land. A case in point is the Zuytdorp cliffs of Shark Bay, where the feral goats have taken to hiding in caves while helicopter shooting is underway.

The use of 1080 control would be limited to hot dry periods when feral goats are forced to use the artificial waters on stations. This would generally limit poisoning operations to the summer months from November to March, some 20 weeks. However, during very dry years, the duration of poisoning operations could be extended a few months. In wet years, poisoning operations could be severely constrained.

As with all components of the FGEP, the best use for 1080 control would evolve over time as experience is gained in its use. The development of its use, of course, will be within the operational protocol laid down in this PER.

CHAPTER 5
ENVIRONMENTAL IMPACTS

This chapter examines the probable environmental impact that a 1080 feral goat poisoning program would have.

In environmental impact assessments, primary environmental impact is the direct effect on the environment of some action. A secondary environmental impact is caused through indirect means as a result of a change in the environment. An example of a primary impact in this proposal is that of the feral goats drinking poisoned water and being killed. The source of the environmental impact is the poisoned water and it is a single step process of the goats drinking this water which results in the environmental impact of their death. An example of a secondary environmental impact could be that the increased number of goat carcasses lying around may allow the blowfly population to breed up, which then causes an increased amount of blowfly strike in pastoral sheep. This secondary impact is a two step process with the poisoned water causing the increased number of goat carcasses, which then results in increased blowfly strike. By their nature, secondary environmental impacts are more complicated and difficult to predict than primary environmental impacts.

This chapter is broken down into these two major functional sections, the first dealing with the primary environmental impacts of 1080 poisoning, and the second with the resulting secondary environmental impacts.

The "primary impacts" section itself is divided into two sub-sections; the first examines the direct impact of 1080 poisoning on the target species, the goat, and the second discusses the possible impact of direct poisoning on the non-target species such as kangaroos, birds and pastoral stock.

The "secondary impacts" section deals with the three major groups of possible secondary impacts; secondary poisoning from goat carcasses containing 1080, the increased number of goat carcasses in the environment, and the fate of 1080 in the environment. Each of these major groups is given its own subsection.

The third and final section of this chapter discusses the health and safety hazards to the APB staff, station people and others who may be affected by a poisoning program.

5.1 PRIMARY IMPACTS

5.1.1 TARGET SPECIES

The aim of 1080 feral goat poisoning is to kill 100% of local feral goats while not endangering other species. To do this, the concentration of 1080 in the poisoned water should be as low as possible, while still being lethal to all feral goats. A trial to determine this concentration was conducted during the summer 1991/1992 (Norbury 1992). From this work it was determined that the optimum concentration of 1080 to use in drinking water to kill 100% of feral goats was 7 milligrams of 1080 per litre of water. The results of this trial are summarised below in Table 5.1.

Table 5.1 Percentage of feral goats killed at various concentrations of 1080 poisoned water (Norbury 1992)

1080 poisoned water concentration (mg/l)	Number of feral goats used	Mean maximum temperature (°C)	Percentage of feral goats killed	Estimated poison dose (mg/kg)
3	22	37	68 - 91	0.6
4	33	36	79 - 88	0.8
5	60	35	83 - 98	1
6	22	36	91 - 100	1.2
7-20	127	43	99 -100	1.4 - 4.0

From this trial it was estimated that the minimum lethal dose of 1080 which would kill 100% of feral goats was 1.4 mg/kg. The derivation of this estimate can be seen below in the calculation of the poison dose.

poison dose = amount of poisoned water consumed ÷ body weight x concentration of poison

1.4 (mg/kg) = 4.8 (l) ÷ 24 (kg) x 7 (mg/l)

In poisoning operations it is expected that there will be some feral goats which will not drink enough poisoned water to receive a lethal dose of 1080. These goats will develop some of the symptoms of fatally dosed goats, depending upon the dose they receive, but their bodies will detoxify the fluoroacetate before fluorocitrate reaches lethal concentrations. Within 48 hours all of the fluoroacetate should have been detoxified by the liver and kidneys, or excreted from the bodies of sub-lethally dosed animals (King 1990). From studies of sub-lethally dosed sheep, which are physiologically very similar to goats, and which have virtually the same sensitivity to 1080, it is expected that it will take some feral goats up to 5 days to fully recover from near-fatal poisoning experiences (McIlroy 1982).

Impact on feral goat populations

From trials conducted in 1993, it was estimated that on average 70% of the feral goats using water points were destroyed after four days of poisoning (Norbury 1993). Using the experience gained from these trials, and by simultaneously poisoning adjacent water points, the APB expects to achieve a kill rate of approximately 80% on water points after four days of poisoning.

The remnant populations of feral goats around water points after poisoning consisted of 'poison-shy' animals and new animals which had arrived at the water points. In the trials it was noted that the remnant population of 'poison-shy' goats often mostly consisted of billies and older nannies. This is fortunate, as these animals have relatively little impact on the population's ability to recover. "It appears that lactating nannies need to drink every day during the hot summer months. Consequently, the most productive part of the goat population is the most vulnerable to poisoning" (Norbury 1993).

5.1.2 NON-TARGET SPECIES

The non-target animals which are potentially susceptible to primary poisoning are pastoral stock, and introduced and native fauna.

Pastoral stock

Pastoral stock includes sheep *Ovis aries* and the cattle, *Bos taurus* and *B. indicus*. These animals would be killed by drinking 1080 poisoned water, as they are very sensitive to 1080, and have 1080 LD_{50}s similar to those of goats, 0.5 mg/kg and 0.3 mg/kg, respectively (McIlroy 1982). To prevent this from occurring, poison yards are designed to prevent pastoral stock gaining access to poison troughs.

Introduced animals

Introduced animals include, wild dogs *Canis familiaris familiaris*, foxes *Vulpes vulpes*, cats *Felis catus*, donkeys *Equus asinus* and horses *Equus caballus*. The 1080 LD_{50}s of these animals are: 0.11 mg/kg for dogs; 0.13 mg/kg for foxes; 0.4 mg/kg for cats; 0.3 mg/kg for donkeys; and 0.4 mg/kg for horses (McIlroy and Gifford 1992, McIlroy 1984). All of these animals are highly susceptible to 1080 poisoning at the concentration used to control feral goats.

However, as all of these animals have been introduced to WA's rangelands, and are pests, their destruction by 1080 poisoning would help to protect the conservation and agricultural resources of WA's rangelands. For these reasons, the APB would make no special attempt to protect these animals from 1080 poisoning operations.

In practice, it is likely that only the occasional fox or wild dog would be poisoned by drinking from poison stations. During the 29 days of poisoning trials only one fox was seen at a watering point. This animal drank a large quantity of poisoned water and was not seen subsequently.

Native animals

Of the native fauna in WA's rangelands it is only the kangaroos and birds that face any potential risk from drinking 1080 poisoned water.

Over the 29 days of poisoning trials some 3,026 observations were made of birds drinking at watering points between 7:00 am and 12:00 pm (Norbury 1993). The most common drinkers at waters during this morning period were the small zebra finches *Poephila guttata* (32%), followed by crested pigeons *Ocyphaps lophotes* (29%), galahs *Cacatua roseicapilla* (8%), crows *Corvus bennetti* (8%), Port Lincoln parrots *Barnardius zonarius* (6%), and the mulga parrots *Psephotus varius* (5%). Some 14 other species made up the remainder of the birds observed. These findings were similar to the results of a study of birds drinking from water points in the Murchison region (Davies 1972).

From the observations of the poisoning trials (Norbury 1992; Norbury 1993), the study of birds in the Murchison region (Davies 1972) and from local knowledge, there are about 40 species of birds that are likely to be exposed to 1080 feral goat poisoning operations. These 40 species of birds are listed in Table 5.3.

Of these 40 species, 11 have had 1080 sensitivity studies. An assessment of the poisoning risk to these birds was made by estimating the 1080 dose that they could receive and comparing this to the species' sensitivity to 1080, their LD_{50}. The classification of the birds' poisoning risk was done using categories of dose as a percentage of the species' LD_{50}. The risk assessment categories are listed below in Table 5.2.

Table 5.2 Poison risk assessment categories

Poisoning risk categories	Poisoning dose as a percentage of species' LD_{50}
very high	greater than 75%
high	75% to 40%
moderate	40% to 20%
low	20% to 10%
very low	10% to 5%
none	less than 5%

The estimated dose that these species would receive is calculated by multiplying the concentration of the poisoned water by the proportion of their body weight that they would be likely to drink during the hours of 7:00 am to 12:00 am. The proportions of body weight that they would drink were estimated to be: 0.5 for the small budgerigar, silvereye, and zebra finch; 0.25 for the medium sized common bronzewing pigeon, crested pigeon, galahs, magpie lark and Port Lincoln parrot; 0.2 for the large crow; 0.167 for the very large wedge-tailed eagle; and 0.1 for the huge emu (Nagy and Peterson 1988).

Working through one of these risk assessments; the zebra finch is a small bird and could possibly drink up to half its body weight in water during a morning. The dose of 1080 it could receive therefore, is 0.5 x 7 mg/l 1080 poisoned water = 3.5 mg/kg. The poisoning dose as a percentage of the zebra finch's LD_{50} is 3.5 mg/kg x 100 ÷ 3.1 mg/kg = 113%. This percentage LD_{50} places the zebra finch in the very high poisoning risk category. Please note that this system of poisoning risk assessment is used later for other groups of animals.

From Table 5.3, it can be seen that of the 11 species of birds with known LD_{50}s, 2 have a very high poisoning risk, 2 have a moderate poisoning risk, 4 have a low poisoning risk, 1 has a very low poisoning risk and 2 have no poisoning risk at all. However, for the remaining 29 species of birds we cannot accurately assess their poisoning risk, as we have no information on their sensitivity to 1080. We would expect, however, that many small birds would have a high risk of being poisoned, and many of the larger birds would face a moderate risk. Clearly, if 1080 feral goat operations allowed birds to drink the poisoned water, many birds would be killed and this would create an unacceptable environmental impact.

To prevent this from occurring, a poisoning technique was developed to prevent birds from drinking from the poisoned trough. The method uses an unfamiliar trough as the poisoning trough and one of the existing water point troughs as a bird trough. This technique proved to be 100% effective in deterring birds from drinking from poisoned troughs (Norbury 1993). An earlier technique of deterring birds from existing poison troughs used ridge capping on the edge of the trough to prevent them from obtaining a perch (Norbury 1992). In comparison, this earlier technique was only 93% effective. "In these cases, birds preferred to battle with the ridge capping on their regular troughs in their efforts for a drink, rather than drink from a foreign trough nearby" (Norbury 1993).

The only bird which may defeat this exclusion technique is the emu *Dromaius novaehollandiae*, which could simply walk into a poison yard, bow down and drink from a poisoned trough. Fortunately though, emu's tolerance to 1080 is extremely high, and their risk of poisoning is virtually non-existent.

Table 5.3 Rangeland birds and their poisoning risk
(dashes indicate that no information is available)

Bird species Common name	Scientific name	LD_{50} (mg/kg)	Dose (mg/kg)	Poisoning risk	Reference
Australian Pipit	*Anthus novaeseelandiae*	-	-	?	-
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	-	-	?	-
Boobook Owl	*Ninox novaeseelandiae*	-	-	?	-
Bourke's Parrot	*Neophema bourkii*	-	-	?	-
Brown Hawk	*Falco berigora*	-	-	?	-
Budgerigar	*Melopsittacus undulatus*	2.1	3.5	high	McIlroy 1984
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	-	-	?	-
Common Bronzewing Pigeon	*Phaps chalcoptera*	40	1.75	none	McIlroy 1984
Crested Bellbird	*Oreoica gutturalis*	-	-	?	-
Crested Pigeon	*Ocyphaps lophotes*	25	1.75	very low	Twigg & King 1989
Crimson Chat	*Ephthianura tricolor*	-	-	?	-
Crow	*Corvus bennetti*	13.4	1.4	low	McIlroy 1984
Emu	*Dromaius novaehollandiae*	102	0.7	none	Twigg et al 1988
Galah	*Cacatua roseicapilla*	5	1.75	moderate	Twigg & King 1989
Grey Butcherbird	*Cracticus torquatus*	-	-	?	-
Grey Currawong	*Strepera versicolor*	-	-	?	-
Hooded Robin	*Melanodryas cucullata*	-	-	?	-
Magpie Lark	*Grallina cyanoleuca*	8.8	1.75	low	McIlroy 1984
Mulga Parrot	*Psephotus varius*	-	-	?	-
Owlet-Nightjar	*Aegotheles cristatus*	-	-	?	-
Peaceful Dove	*Geopelia striata*	-	-	?	-
Pied Butcherbird	*Cracticus nigrogularis*	-	-	?	-
Port Lincoln Parrot	*Barnardius zonarius*	11.5	1.75	low	Twigg & King 1989
Red-capped Robin	*Petroica goodenovii*	-	-	?	-
Rock Parrot	*Neophema petrophila*	-	-	?	-
Rufous Whistler	*Pachycephala rufiventris*	-	-	?	-
Silvereye	*Zosterops lateralis*	9.3	3.5	moderate	McIlroy 1984
Singing Honeyeater	*Lichenostomus virescens*	-	-	?	-
Southern Stone Curlew	*Burhinus magnirostris*	-	-	?	-
Spiney-cheeked Honeyeater	*Acanthagenys rufogularis*	-	-	?	-
Spotted Bowerbird	*Chlamydera maculata*	-	-	?	-
Wedge-tailed eagle	*Aquila audax*	9.5	1.17	low	McIlroy 1984
Welcome Swallow	*Hirundo neoxena*	-	-	?	-
Western Magpie	*Gymnorhina tibicen*	-	-	?	-
White-browed Babbler	*Pomatostomus superciliosus*	-	-	?	-
White-fronted Honeyeater	*Phylidonyris albifrons*	-	-	?	-
White-plumed Honeyeater	*Lichenostomus penicillatus*	-	-	?	-
Willie Wagtail	*Rhipidura leucophrys*	-	-	?	-
Yellow-throated Miner	*Manorina flavigula*	-	-	?	-
Zebra Finch	*Poephila guttata*	3.1	3.5	very high	McIlroy 1984

The final major group of animals potentially at risk of drinking poisoned water are the kangaroos.

In the pastoral regions the most widespread species of kangaroos are the red kangaroo *Macropus robustus* and euros *M. rufus*, with some western grey kangaroos *M. fuliginosus* in the southern pastoral areas.

Determining the percentage body weight of water that these kangaroos may drink in a visit to a water point is difficult. Studies of the water balance of red kangaroos and euros during summer, determined that these animals turn over 4% of their body weight in water per day (Dawson *et al.* 1975). This 4% is replaced through water in the plants they eat and through drinking free water. After rainfall the water content of grasses can reach 90% of their weight, and in these conditions herbivores do not need to drink fresh water at all (Green 1989). As the water content of plants decline to 55 - 60%, herbivores need access to drinking water or they will decline in condition. A study on euros given only dry food showed that they require drinking water equivalent to 5% of their body weight each day (Ealey *et al.* 1965). From these studies it would be a safe or conservative estimate that rangeland kangaroos would drink no more than 5% of their body weight in water per day during summer.

Field studies of red kangaroos and euros have shown that they rarely drink daily, and on average would drink once every three days (Dawson *et al.* 1975, Ealey 1967). Therefore it is possible that these kangaroos could drink up to 15% of their body weight during a single visit to a water point. This would be a reasonable estimate, as Ealey *et al.* (1986) found that few euros drank every day in summer, and that their weekly drinking water intake averaged 12% of their body weight. A conservative estimate of 15% body weight is used below in Table 5.4 to determine the dose of 1080 kangaroos could receive, and the risk of poisoning they would face.

Table 5.4 Rangeland kangaroos and their poisoning risk

Kangaroos Common name	*Scientific name*	LD_{50} (mg/kg)	1080 dose (mg/kg)	Poisoning risk	Reference
Red Kangaroo	*M. rufus*	2 - 4	1.05	moderate-high	King 1990
Euro	*M. robustus*	2	1.05	high	King 1990
Western Grey	*M. fuliginosous*	11.3 - 34.5	1.05	none-very low	McIlroy 1982

From Table 5.4 in can be seen that red kangaroos and euros would have high risk of being fatally poisoned. To prevent this from occurring, poisoning operations are conducted outside normal kangaroo drinking times.

The late morning poisoning period takes advantage of kangaroos drinking behaviour. Kangaroos normally drink before sunrise and after sunset (G. Norbury pers. comm., Davies 1972, Dawson *et al.* 1975). As the introduced troughs will be poisoned only during the hours of 7:00 am to 2:00 pm, kangaroos will not be exposed to the poisoned water.

Factors which also work to prevent kangaroos being poisoned include their aversion to the unfamiliar poisoning troughs, and to the presence of feral goats and pastoral stock around waters (G. Norbury pers.comm., Dawson *et al.* 1975). As poisoning operations would only be conducted on water points with high feral goat numbers, it is even more unlikely that kangaroos would use these waters during the poisoning hours.

During the 29 days of poisoning trials only one kangaroo was observed at a poison station. This immature red kangaroo came into the water at 7:05 am and left without drinking some 20 minutes later, after it found all its usual drinking troughs were empty.

Even given these factors, it is still likely that a few redkangaroos and euros would be fatally poisoned in 1080 feral goat control operations. While this is unfortunate, this could not be assessed as having a significant environmental impact, as over the last five years some 931,000 red kangaroos and 20,000 euros were culled in WA's pastoral areas by kangaroo shooters.

As discussed earlier in Section 4.1, in special circumstances poisoning operations may be conducted in the afternoon. The poisoning duration of these operations, as with morning operations, would be no greater than five and a half hours, and would be completed by sunset.

These operations would pose a significant poisoning risk to kangaroos towards sunset. To prevent this from occurring all afternoon poisoning operations will be monitored by a poisoning officer. If any kangaroos approach a poisoning station during these operations the poisoning officer will scare the animals away.

The requirement for afternoon poisoning is likely to be very limited, and with poisoning officers monitoring these operations, there is no risk of kangaroos being poisoned.

5.2 SECONDARY IMPACTS

5.2.1 SECONDARY POISONING

With 1080 poisoning, there will still be a significant amount of 1080 remaining in the carcasses of the feral goats. Carrion eaters which consume these carcasses face the risk of being poisoned themselves by the residual poison. In WA's rangelands the predominant carrion eaters are crows, foxes, goannas, wild dogs and dingoes, wedge-tailed eagles and cats. There are also a multitude of invertebrate species, or bugs, that eat carrion, but they were not assessed for secondary poisoning.

Estimating the concentration of fluoroacetate and fluorocitrate remaining in the carcass is difficult. While the poisoned goat was still alive it would be continually detoxifying the fluoroacetate so there will only be a portion of the original fluoroacetate remaining. How much remains, however, cannot be accurately calculated.

From this point one could make a conservative estimate of the 1080 remaining in the carcass by assuming that no 1080 has been detoxified and the 1080 is spread evenly throughout the body. This would give a 1.4 mg/kg concentration of 1080 in the carcass. The fault of this estimate is in assuming that the 1080 is evenly spread throughout the body.

A study on secondary poisoning hazards was conducted by McIlroy and Gifford (1992). In this study five sheep were fed 333 mg/kg 1080 carrot bait. The poison dose the sheep were given was 1.0 mg/kg, which is close to the 1.4 mg/kg dose for feral goats. A biopsy was then performed on the carcasses determining the combined amount of fluoroacetate and fluorocitrate remaining in the kidneys, liver, heart, muscle and stomach and contents. The results of this biopsy are presented in Table 5.5.

Table 5.5 Mean concentration of 1080 in dried tissues and organs of 1.0 mg/kg dosed sheep; (mg/kg) ± s.e.
(McIlroy and Gifford 1992).

Kidneys	Liver	Heart	Muscle	Stomach & contents
6± 3	0	2 ± 2	0	11 ± 7

It is reasonable to discuss these results for estimating the concentration of 1080 in feral goat carcasses, as sheep and goats are physiologically and anatomically very similar.

From Table 5.5 it can be seen that the highest concentration of 1080 was in the stomach and its contents, followed by the kidneys and heart. No 1080 was measured in the liver or in muscle tissue. The high concentration of 1080 in the stomach and contents is due to the high 1080 concentration of the carrot bait (333 mg/kg). In feral goat carcasses, presumably the highest concentration would also be in the stomach and contents, but the concentration would be no greater than that of the poisoned water, 7 mg/kg. The kidneys presumably would also have a high concentration, somewhere in the order of 6 mg/kg (McIlroy and Gifford 1992).

Using these results it would be safe to assume that the highest concentration of 1080 in feral goat carcasses would be 7 mg/kg and this would be found in the stomach, intestinal tract and contents, and in the kidneys. This is the concentration we will use in assessing the secondary poisoning risks.

The next step in assessing the poisoning risks is to determine the percentage of their body weight that the carrion eaters could consume. The daily dry matter intake as a percentage of body weight for carrion-eaters is: 3.9% for wedge-tailed eagles; 13.4% for crows; 0.3% for sand goannas; 4.2% for dingoes and wild dogs; 5% for foxes; and 5.3% for cats (McIlroy and Gifford 1992). These animals, however, do not always eat daily. Therefore it is necessary to adjust these figures to estimate the largest feed of carcass that the carrion-eaters could consume in a single feeding session. For wedge-tailed eagles, dingoes, foxes and cats, the percentage daily intake was multiplied by a factor of 2, while for crows a multiplication factor of 1.5 was used. Sand goannas are a special case. These animals have very slow metabolisms, which is evident by their daily intake of only 0.3%, but they tend to have a "feast or famine" approach to life. In a single meal they may consume up to 25% of their body weight and then spend several weeks digesting it (King *et al.* 1989). So this maximum intake of 25% is used rather than their 0.3% daily intake.

The secondary poisoning risk to carrion eaters is assessed below in Table 5.6. It should be noted that this is a very conservative risk assessment as it assumes a very high concentration of 1080 in certain organs of the carcass, that there has been no degradation of 1080 in the carcass, and that the carrion-eaters confine themselves to consuming these high concentration portions of the carcasses.

Table 5.6 Risk of secondary poisoning to rangeland animals, assuming 7 mg/kg 1080 concentration in portions of feral goat carcasses

Animal Common name	Scientific name	Possible % of body weight eaten per day	LD_{50} (mg/kg)	Dose (mg/kg)	Poison risk	Reference
Wedge-tailed eagle	*Aquila audax*	8	9.5	0.56	very low	McIlroy *et al.* 1992
Crow	*Corvus bennetti*	24	13.4	1.68	low	McIlroy *et al.* 1992
Sand Goanna	*Varanus gouldii*	25	43.6	1.75	none	McIlroy *et al.* 1992
Dingo & wild dog	*Canis familiaris*	8	0.11	0.56	very high	McIlroy *et al.* 1992
Fox	*Vulpes vulpes*	10	0.13	0.7	very high	McIlroy *et al.* 1992
Cat	*Felis catus*	11	0.4	0.77	very high	McIlroy *et al.* 1992

From this risk assessment it can be seen that wedge-tailed eagles face a very low poisoning risk and crows face a low poisoning risk.

The sand goanna *V. gouldii* faces virtually no risk of being poisoned. Other species of carrion-eating reptiles in WA's rangelands include *V. panoptes* and *V. giganteus*. Unfortunately there is no 1080 sensitivity data for these species, but we would expect them to have a similar sensitivity to that of the sand goanna. Other Australian reptiles for which we have 1080 sensitivity data include, Rosenberg's goanna *V .rosenbergi* with an LD_{50} of 200-300 mg/kg in 1080-bearing plant areas and an LD_{50} of 50 mg/kg in 1080 free areas, the bobtailed lizard *Tiliqua rugosa* with an LD_{50} of 500-800 mg/kg in 1080 areas and an LD_{50} of 206 mg/kg in 1080 free areas, the bearded dragon *Pogona barbatus* with an approximate LD_{50} of 110 mg/kg, the lace monitor *V. varius* with an LD_{50} of approximately 100 mg/kg, and the blotched blue-tongued lizard *T. nigrolutea* with an LD_{50} of 336 mg/kg (King 1990, McIlroy and Gifford 1992). It is notable that none of these reptiles has a LD_{50} of less than 50 mg/kg.

Dingoes, wild dogs, foxes and cats face a very high risk of poisoning in this assessment. As discussed earlier in the Primary Environmental Impacts, these animals are considered to be pests in WA's pastoral regions and their destruction would be beneficial in conserving the natural and agricultural resources of the rangelands. For these reasons, the secondary poisoning of these animals is deemed not to have an adverse environmental impact.

The processes which remove 1080 from the carcasses include; leaching of 1080 out of the carcasses into the soil with the body's fluids, microbial defluorination and the removal of 1080 by maggots and other invertebrates consuming the carcasses (McIlroy *et al.* 1988, Wong *et* al. 1992a, Wong *et al.* 1991).

The rate of removal from leaching and biodegradation is not known, but would occur mostly during the first month of decay. After this time the carcasses become desiccated and the amount of 1080 leaching out, and microbial detoxification, would be greatly reduced.

A study of the effects blowfly maggots and rainfall have on the toxicity of 1080 fresh meat baits showed that maggots quickly removed 1080 from baits. During a summer trial where the baits were subjected to no rain by the 8th day, only 64.3% of the original 1080 remained in the baits and by the 32nd , only 33.3% of the 1080 remained. After a summer trial with rain, it was observed that by the 32nd , only 11.2% of the 1080 remained in the baits (McIlroy *et al.* 1988). While these fresh beef meat baits are considerably different to feral goat carcasses, we would expect a similar level of 1080 removal from decomposing feral goat carcasses.

The same genus of maggots as found in McIlroy's study, *Calliphora spp.*, have been found on feral goat carcasses in a carcass-maggot trial being conducted just north of Carnarvon. In addition, this trial also found *Chrysomya rufifiacies, Ch. varipes, H. rostrata* and *Mussca vetustissima* maggots in carcasses. Other arthropods found on carcasses included the beetles *Staphylinidae, Histeridae, Leiodidae, Siphidae, Trogidae, Phycosecidae, Dermestidae* and *Carabidae*, the wasps, *Pteromalidae, Figitidae* and *Chalcididae*, and the ant *Formicidae* (D. Cook pers. comm.). Large numbers of maggots have been found in all of the 24 feral goat carcasses examined so far in this trial.

The activity of invertebrates in carcasses would be gradually reduced as the carcasses are consumed and become desiccated. After a month or so it is probable that any 1080 remaining in the dried carcasses is likely to persist for a number of years (Hegdal *et al.* 1981). This may pose an ongoing poisoning threat to dingoes, wild dogs, foxes and cats.

In U.S. ground squirrel carcasses, 75% of the 1080 is reported to be detoxified (Marsh *et al.* 1987). Given this, and the 1080 removal rate in fresh meat baits, it would be reasonable to estimate that after 5 or 6 weeks of decay there would only be approximately 40% of the initial 1080 remaining in feral goat carcasses. The secondary poisoning risks to rangeland animals 5 to 6 weeks after a poisoning operation are assessed below, in Table 5.7. This assessment assumes that the highest concentration of 1080 in portions of the carcass is 2.8 mg/kg.

Table 5.7 Risk of secondary poisoning to rangeland animals, assuming 2.8 mg/kg 1080 concentration in portions of feral goat carcasses

Animal Common name	*Scientific name*	Possible % of body weight eaten per day	LD_{50} (mg/kg)	Dose (mg/kg)	Poison risk	Reference
Wedge-tailed eagle	*Aquila audax*	8	9.5	0.22	none	McIlroy *et al.* 1992
Crow	*Corvus bennetti*	24	13.4	0.67	very low	McIlroy *et al.* 1992
Sand Goanna	*Varanus gouldii*	25	43.6	0.7	none	McIlroy *et al.* 1992
Dingo & wild dog	*Canis familiaris*	8	0.11	0.22	very high	McIlroy *et al.* 1992
Fox	*Vulpes vulpes*	10	0.13	0.28	very high	McIlroy *et al.* 1992
Cat	*Felis catus*	11	0.4	0.308	very high	McIlroy *et al.* 1992

5.2.2 CARCASSES

A feral goat poisoning operation would result in many feral goat carcasses being spread around water points. The potential problems that these carcasses could cause are increased blowfly strike in sheep and botulism poisoning in cattle and possibly in sheep.

From ground searches during poisoning trials, feral goat carcasses were found from 100 metres to 6 kilometres from poisoning stations (Norbury 1992; Norbury 1993). The general distribution of feral goat carcasses around water points was not determined in these trials. A rough calculation of the density of feral goat carcasses around waters would be 200 to 400 carcasses spread over an area of a 6 km radius from the water point.

This would give an average carcass density of one carcass to every 28 - 56 hectares, or one carcass per 28,000 - 56,000 square metres.

Sheep blowfly strike

Since the beginning of the FGEP, some pastoralists have raised concerns over the possibility of the increasing number of feral goat carcasses in the field causing an increased amount of blowfly strike in sheep. Blowfly strike is a condition where certain species of blowfly lay their eggs on the bodies of sheep. From these eggs emerge maggots, or larvae, which then feed on the sheep causing blood poisoning, and often killing the sheep.

In Australia there are two species of blowfly that are responsible for fly strike, the Australian sheep blowfly *Lucilia cuprina*, and the hairy maggot blowfly *Chrysomya rufifiacies*. In the process of blowfly strike, *L. cuprina* initiates the strike by laying its eggs on a sheep. Once the *L. cuprina* maggots have emerged and have caused an infected area, *C. rufifiacies* lays its eggs on the sheep. When the hairy maggots emerge they consume the smaller smooth maggots of *L. cuprina*. The hairy maggots then burrow into the skin of the sheep and quickly cause blood poisoning and death. The hairy maggots are the real problem in sheep blowfly strike, but they need the *L. cuprina* blowfly to start a strike for them.

From studies of blowflys on sheep carcasses in eastern Australia it was found that *L. cuprina* does not breed on carcasses (Anderson *et al.* 1988). However, it was not known that this was the case in WA's pastoral areas. To determine if the FGEP could cause increased sheep strike, a year long study was initiated on Boolathana Station in September 1992. This study is examining the blowfly population and the emergence of blowflys on sheep and feral goat carcasses every month. Results so far have shown that no *L. cuprina* have been able to emerge from feral goat and sheep carcasses. The main reason for this appears to be the predation of the smooth *L. cuprina* maggot by the hairy *C. rufifiacies* maggot.

From this trial work, which has now covered a summer season, we do not believe that the increased number of feral goat carcasses in the field as a result of 1080 poisoning, would cause increased blowfly strike in sheep over summer. It is important to note that 1080 feral goat control would only be conducted over the summer months or during other dry, hot periods when feral goats are forced to use water points.

Botulism poisoning

The second potential threat of feral goat carcasses to the pastoral industry is in the form of botulism. Cattle, and sheep to a lesser extent, often chew the bones and carcasses of animals. It is thought that this behaviour many be due to phosphorous or other nutritional deficiencies (Buckman 1983). In eating these carcasses, cattle and sheep may consume the botulism toxin, which causes muscular paralysis and ultimately death. Botulism occurs throughout the rangelands, but usually only becomes a major problem during drought, when little feed is available.

Botulism poisoning, as a result of 1080 feral goat operations, poses a real threat to pastoral cattle and could cause stock losses. Botulism poisoning also poses some threat to pastoral sheep, but probably only under conditions of severe drought where the sheep are suffering from nutritional deficiencies (Morrissey 1972).

To prevent cattle losses from botulism poisoning, pastoralists would be well advised to inoculate their cattle with a bivalent Botulism C + D vaccine. It would probably not be worth vaccinating sheep because of their reduced risk and the comparatively high cost of vaccination.

5.2.3 FATE OF 1080 IN THE ENVIRONMENT

The final section of the secondary environmental impacts is the fate of the 1080 poison in the environment. In feral goat poisoning operations 1080 would be spread through the environment by the carcasses of poisoned goats and would be concentrated around water points through the dumping of surplus 1080 poisoned water.

In determining the amount of 1080 spread by poisoned feral goat carcasses, a single poison station could poison 200 feral goats each day for four days. This would constitute 4000 litres of 7 mg/l 1080 poisoned water or 28 grams of 1080. Assuming that no detoxification of 1080 occurred before death and no biodegradation in the carcasses, with poisoned feral goats ranging up to 6 kilometres from a water point, this 28 grams of 1080 poison would be spread over an area some 11,000 hectares, or would give a average poison spread of 2 mg/ha or 0.2 $\mu g/m^2$. The distribution of 1080 in the rangeland surrounding water points would of course not be uniform, but the very small amount of poison spread over such a large area would not constitute an environmental hazard. In addition to this, after a month or so much of the 1080 in the carcasses will have leached into the soil, or will have been broken down by maggot and microbial activity.

Much higher concentrations of 1080 would be found in the soil around water points from the dumping of surplus poisoned water. Given a "worst case" scenario where no feral goats where poisoned on the last day of poisoning operations and 1000 litres of poisoned water was dumped, plus the dumping of poison trough water over the previous three days, some 75 litres, a total of 1075 litres of poisoned water could be dumped at a water point. At a concentration of 7 mg/l this equates to 7.525 grams of 1080. The area over which this poison is spread would vary, but would generally be around 20 square metres. The spread of the poison therefore would be 0.3 g/m^2. The concentration of the poison in the soil would depend upon the depth of infiltration of the poisoned water. The depth of infiltration would vary greatly with the different soil types around water points. There is often a fairly impervious hard pan layer at a depth of 30-50 cm around water points, due to soil compaction by stock and natural silcrete. Assuming then that 30 cm is the depth to which the 1080 poisoned water could infiltrate, the concentration of the poison would be 12 ng/cm^3, or 12 billionths of a gram of 1080 per cubic centimetre of soil. At this concentration, 1080 would pose no threat to most forms of life. The distribution of 1080 throughout the soil will not be uniform, and much higher concentrations of 1080 may result, but as the poison is not available to any vertebrate species it does not pose an environmental hazard.

Over time it is expected that 1080 in the soil will break down. The speed at which 1080 will break down will depend upon the bacteria and fungi present in the soil, and upon the soil temperature and moisture content. Studies have shown that WA soil microflora in WA were able to defluorinate over 50% and up to 87% of 1080 within 5 to 9 days in soil with a moisture content of about 10% (Wong *et al.* 1992b). There have been no studies of 1080 breakdown in the soils of the semi-arid and arid rangelands, but as 1080 defluorinating microflora are ubiquitous, it is expected that 1080 would be defluorinated in rangeland soils while sufficient soil moisture is present (D. King pers. comm.).

The defluorination of 1080 in the soil under feral goat carcasses would be expected to be much faster than that in the soil around water points, as this soil would be enhanced by nutrients leaching out of the carcass above, and the soil would remain moist for many weeks as the carcass above provide insulation from solar radiation.

Surplus poisoned water dumped in 1080 feral goat control operations poses no threat of poisoning pools, streams or rivers, as 1080 operations would only be conducted in areas where there is no free standing water for feral goats to use.

It is possible that a water could be poisoned twice a year, but it would be very unlikely.

5.3 HEALTH AND SAFETY

There are three potential health risks to people associated with 1080 feral goat poisoning operations. These risks are:

1. APB poisoning officers accidentally swallowing 1080 'Concentrate Black' solution.
2. People uninformed of the health risks drinking poisoned water from poison troughs.
3. People uninformed of the health risks consuming poisoned feral goats.

An accurate LD_{50} for humans has, understandably, not been determined, and estimates range from 0.7 to 5.0 mg/kg (Backholder 1980). However most literature takes a conservative approach and estimates the LD_{50} to be between 1.0 and 2.0 mg/kg. An LD_{50} of between 1.0 to 2.0 mg/kg is used in the discussion below.

5.3.1 HAZARDS TO APB POISONING OFFICERS

The only significant occupational hazard for APB poisoning officers is handling the 200 g/l 1080 'Concentrate Black' solution. While there is virtually no poisoning risk from spilling the concentrated poison on skin, swallowing the poison would be extremely dangerous.

Using an LD_{50} of 1.0 mg/kg, a 70 kg poisoning officer would only need to swallow 0.35 ml, or seven drops, of 1080 'Concentrate Black' to have a 50% chance of being fatally poisoned. Using an LD_{50} of 2.0 mg/kg an officer would need to swallow twice the amount to have a 50% chance of being fatally poisoned.

To prevent accidental poisoning from occurring, poisoning officers are trained to handle the 1080 'Concentrate Black' solution, and are aware of the hazards it poses. High concentration solutions of 1080 are handled daily by APB staff preparing poison baits, and in the past 40 years of use there have been no incidents of accidental poisoning.

5.3.2 HAZARDS TO PEOPLE DRINKING POISONED WATER

The risk here is of people, who are not informed of the poisoning operations drinking poisoned water from poisoning troughs. The probability of this occurring is extremely small. The reasons for this are:

1. The location and duration of poisoning operations would be advertised in "The West Australian" newspaper, a local newspaper, and in the Government Gazette one week before poisoning operations.
2. Prominent warning signs would be placed on all public roads leading into gazetted stations.
3. Poisoning stations would be clearly labelled with warning signs on the 1080 poison water tanks and on 1080 poisoning troughs. These signs incorporate the universally acknowledged 'skull and crossbones' symbol to inform illiterate people of the poisoning danger.
4. All the staff and people on gazetted pastoral stations would be briefed on the poisoning operations and their associated hazards.
5. Pastoral properties are remote from population centres, and the watering points upon which poison stations are installed are serviced by private roads not used by the public.
6. Poisoning troughs would be activated for no longer than five and a half hours per day.

If someone were to drink from a poisoned trough, they would have to make a very concerted effort to drink enough poisoned water to receive an LD_{50}, i.e. a dose that would have a 50% chance of killing them. Using the 1.0 mg/kg LD_{50} a person would need to drink a seventh of their body weight in poisoned water to receive an LD_{50}. For a 70 kilogram person, this works out to be 10 litres of poisoned water. Using the 2.0 mg/kg LD_{50}, a person would need to drink nearly a third of their body weight in poisoned water. For a 70 kilogram person this is 20 litres of poisoned water.

While it is technically possible to drink a tenth of your body weight per day, it is extremely difficult. It would require considerable physical activity to generate sufficient water loss from the body to be able to consume this proportion of body weight in water. Table 5.8 presents estimates of the poisoning risk to people drinking various volumes of poisoned water.

Table 5.8 Poisoning risks for people drinking poisoned water; this assessment is based on a 70 kilogram person and the 1080 concentration of the poisoned water being 7.0 mg/l

Volume of poisoned water consumed	Dose (mg/kg)	1.0 mg/kg LD_{50} Percentage of LD_{50}	1.0 mg/kg LD_{50} Poisoning risk	2.0 mg/kg LD_{50} Percentage of LD_{50}	2.0 mg/kg LD_{50} Poisoning risk
1 litre	0.1	10%	low	5%	very low
2 litres	0.2	20%	moderate	10%	low
4 litres	0.4	40%	high	20%	moderate
6 litres	0.6	60%	high	30%	moderate
8 litres	0.8	80%	very high	40%	high
10 litres	1	100%	very high	50%	high

5.3.3 HAZARDS TO PEOPLE CONSUMING POISONED FERAL GOATS

The risk of poisoning to people who consumed poisoned feral goat carcasses is even lower than that of drinking poisoned water. As with the hazard posed by poisoned troughs, the hazard posed by poisoned feral goats is ameliorated by:

1. The location and duration of poisoning operations would advertised in "The West Australian" newspaper, a local newspaper, and in the Government Gazette one week before poisoning operations.
2. Prominent warning signs would be placed on all public roads leading into gazetted stations.
3. All the staff and other people on gazetted pastoral stations would be briefed on the poisoning operations and their associated hazards.
4. Pastoral properties are remote from population centres.
6. Poisoned feral goats die within 12 hours of poisoning, so there is only a limited opportunity for a person to take a live poisoned feral goat.
7. Sub-lethally poisoned feral goats should have completely detoxified the 1080 poison within 48 hours, and will not pose an ongoing secondary poisoning risk.

As poisoned feral goats are able to walk up to six kilometres from a poisoning station before they die, it is possible that they could walk onto adjacent pastoral stations. Because of this hazard, pastoral properties adjacent to the target pastoral station are gazetted for the duration of the poisoning operations and for the following week.

In considering the situation where someone did pick up a poisoned feral goat, it would be extremely difficult to ingest an LD_{50} dose.

Most people who eat goat, eat the meat of the carcass. Autopsies have shown that sheep dosed with 1.0 mg/kg 1080, see Table 5.5 (McIlroy and Gifford 1992), have very low concentrations of 1080 in muscle tissues and therefore would not pose any poisoning risk. Portions of the carcass which could pose problems include the stomach, intestines and the kidneys. To face a poisoning risk, people would have to confine themselves to eating these portions of the carcass. They would also have to eat this offal raw, as 1080 decomposes at 200°C. Assuming that the 1080 concentration of these portions of offal was 7.0 mg/kg, a person would need to consume a seventh of their body weight in offal in a day to receive an LD_{50}, using the 1.0 mg/kg LD_{50}. Using the 2.0 mg/kg LD_{50}, a person would need to consume nearly one third of their body weight in offal in a day to receive an LD_{50}. For a 70 kilogram person this would be 20 kilograms of raw offal.

In addition to this, the weight of the intestinal tract and the kidneys in the average feral goat is 4.1 kilograms. So to obtain enough of these high concentration organs a person would have to use 2 to 3 poisoned feral goats, and prepare a combined meal of these organs.

The secondary poisoning risk assessment table is identical to the risk assessment table for poisoned water risks, except that the litres of water drunk is replaced by kilograms of high concentration of offal consumed. These risks are presented in Table 5.9.

Table 5.9 Poisoning risks for people eating high concentration portions of poisoned feral goat carcasses raw; this assessment is based on a 70 kilogram person and assumes that the 1080 concentration of the intestinal tract and kidneys is 7 mg/kg.

Weight of poisoned offal consumed	Dose (mg/kg)	1.0 mg/kg LD_{50}		2.0 mg/kg LD_{50}	
		Percentage of LD_{50}	Poisoning risk	Percentage of LD_{50}	Poisoning risk
1 kg	0.1	10%	low	5%	very low
2 kg	0.2	20%	moderate	10%	low
4 kg	0.4	40%	high	20%	moderate
6 kg	0.6	60%	high	30%	moderate
8 kg	0.8	80%	very high	40%	high
10 kg	1	100%	very high	50%	high

CHAPTER 6. SUMMARY AND MANAGEMENT COMMITMENTS

This chapter is a summary of this public environmental review. The first section discusses the environmental impacts that a 1080 feral goat control program would have, and the second section lists the environmental management commitments that the Agriculture Protection Board makes in using 1080 to control feral goats.

6.1 ENVIRONMENTAL IMPACT

Feral goat control with 1080 would have a positive environmental impact on the goat-infested rangelands of Western Australia. The control of feral goats would reduce the grazing pressure on rangeland vegetation and would reduce soil erosion.

This proposal will not have any significant adverse environmental impacts.

A small number of red kangaroos and euro kangaroos would probably be poisoned by 1080 feral goat control operations. However, this small number of fatalities cannot be assessed as having a significant environmental impact, as annual quotas for these species in WA are 350,000 and 10,000 animals respectively.

No other native animals face a significant risk of being fatally poisoned by 1080 feral goat control operations.

A small number of dingoes, wild dogs, foxes, and possibly cats, donkeys and horses, would be fatally poisoned by drinking poisoned water in control operations. In addition, a small number of dingoes, wild dogs, foxes and cats, would be fatally poisoned by consuming poisoned feral goat carcasses. These poisonings would not be considered to be an adverse environmental impact, as these animals are considered to be pests in WA, and their destruction would be of benefit in preserving the conservation and production attributes of the rangelands.

The method of using 1080 to control feral goats presented in this PER would pose no significant health risks to the APB staff conducting these operations, or to the general public.

6.2 MANAGEMENT COMMITMENTS

Using 1080 to poison feral goats is a potentially hazardous operation to people, native animals and pastoral stock. It is only through strict adherence to the proposed operational protocols that these hazards will be ameliorated.

PREVENTION OF PUBLIC HEALTH HAZARDS

Protocol 1. Pastoral properties on which 1080 feral goat control poisoning operations are carried out, and adjacent pastoral properties, are to be gazetted inthe Government Gazette as properties from which goats may not be taken for the duration of the poisoning operations and for one week after the completion of the poisoning operations.

Protocol 2. One week before poisoning operations commence public notices are to be printed in "The West Australian" newspaper and in a newspaper local to the area of the poisoning operations. These public notices are to advertise the prohibition of removing, or consuming, feral goats from the gazetted pastoral properties for the duration of the poisoning operations, and for one week thereafter. These public notices are also to explain the hazards of contravening the prohibition.

Protocol 3. Prominent warning signs are to be placed on all public roads leading into gazetted pastoral properties at least one day before commencement of poisoning operations. These signs are to advertise the prohibition of removing, or consuming, feral goats from the gazetted pastoral properties and are to also explain hazards of contravening the prohibition.

Protocol 4. The transportable poison water tanks and poison troughs used for 1080 feral goat control are to be clearly labelled stating that they contain the 1080 poisoned water and explain the health hazards of consuming 1080 poisoned water. This label will include the "skull and crossbones" symbol to inform illiterate people of the poison hazard.

PROTECTION OF NATIVE WILDLIFE

Protocol 5. The concentration of sodium monofluoroacetate used in the 1080 feral goat control is to be 7 milligrams per litre of water, with variance not greater than 0.25 milligrams per litre.

Protocol 6. Activation period of 1080 feral goat control poison stations is to be no greater than 5 hours and 30 minutes per day.

Protocol 7. Activation of 1080 feral goat control poison stations for morning poisoning operations is to be limited to the hours of 7:00 a.m. to 2:00 p.m.

Protocol 8. An introduced (unfamiliar) trough only is to be used as the feral goat poisoning trough at poison stations.

Protocol 9. A non-poisoned water trough is to be available for birds to drink from while poisoning stations are activated.

Protocol 10. A permanent trough only is to be used as the bird watering trough at poison stations.

Protocol 11. Agriculture Protection Board poisoning officers are to remain present at deactivated poison stations until all poisoned water emptied out of poisoning troughs and poison water tanks has completely infiltrated into the soil and no free standing poisoned water is present.

Protocol 12. 1080 feral goat control poison stations activated for afternoon poisoning operations are to be deactivated no later than sunset.

Protocol 13. All 1080 feral goat control poison stations activated for afternoon poisoning operations are to be monitored by an APB poisoning officer.

Protocol 14. Any native fauna being at risk of being poisoned at a poison station, which is activated during an afternoon poisoning operation are to be scared away by the APB poisoning officer monitoring the poison station so they are not poisoned.

ADHERENCE AND ACCOUNTABILITY OF POISONING OPERATIONS

Protocol 15. 1080 feral goat control operations are to be conducted only by certified Agriculture Protection Board poisoning officers. 1080 Feral Goat Control certification is to be gained only by Agriculture Protection Board officers who have successfully completed the 1080 Feral Goat Control training course.

Protocol 16. Agriculture Protection Board poisoning officers are to maintain a log of all 1080 feral goat control operations. This log will record the location, date and activation hours of all poisoning stations. The log will also record the volume of 1080 poison and water used to fill the poison water tanks and will record the volume of poisoned water remaining in the poisoned water tanks at the time of poison station deactivation.

REFERENCES

This section describes how to use the Harvard referencing system and provides a full Harvard listing of works referenced in this document.

The Harvard referencing system was developed in Harvard University in the U.S.A. The Harvard system is the international standard for referencing of scientific papers and reports. The key components of this system are the names of the authors and the date on which the paper was published. With a full Harvard reference, any scientific paper published in an internationally recognised journal should be able to be procured.

Twigg, L. E. and King, D. R. (1989). Tolerance to Sodium Fluoroacetate in Some Australian Birds *Australian Wildlife Research*, **16**, pp.46-62.

Take this example referenced in the document as (Twigg and King 1989). In this paper the authors were Twigg and King. The paper is called "Tolerance to Sodium Fluoroacetate in Some Australian Birds" and this appears in the journal *Australian Wildlife Research*. Next we have the volume of the journal that the paper appears in, in this case it's volume **16**, and the paper covers pages 46 to 62. Papers with more than two authors are usually referenced for the first author *et al.*, for example (Dawson *et al.* 1975).

With these details you would go down to your local university library, as you won't find these journals in your local shire library, and ask a librarian for help in finding the paper.

References of personal communications, or verbal discussions, between the author of this document and authorities on certain subjects are made by quoting the name of the authority followed by an abbreviation of personal communications, e.g. (G. Norbury pers. comm.).

For your convenience the most important references in this document have been included in the appendices.

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GLOSSARY

1080	common name for sodium monofluoroacetate
AAVCC	Australian Agricultural and Veterinary Chemicals Council
ANPWS	Australian National Parks and Wildlife Service
ANU	Australian National University
APB	Agriculture Protection Board
burette	a volumetric measuring tube used to accurately measure out liquids
CALM	The Western Australian Department of Conservation and Land Management
CER	Consultative Environmental Review
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWA	Western Australian Department of Agriculture
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
ERMP	Environmental Review and Management Plan
FGEP	Feral Goat Eradication Program
invertebrates	animals without a backbone, e.g. insects or worms, as against vertebrates which have a backbone, e.g. mammals, birds or fish.
Krebs cycle	the citric acid cycle used by cells in aerobic respiration
LCD	Land Conservation District, statutory bodies set up under the Soil and Land Conservation Act of 1945 to promote the development of soil conservation and sustainable agricultural practices.
LCDC	Land Conservation District Committee
LD_{50}	median Lethal Dose for 50% of a test population of a species
mitochondria	sub-cellular organelles used as the sites for aerobic respiration
PER	Public Environmental Review
trapping	a term used for capturing goats, and sheep and cattle for that matter, around waters in special yards. The goats enter these yards through one-way gates when they go in to water at troughs and are then caught in these yards.
WA	Western Australia
water point	a term used for pastoral mills, bores and tanks which are used to supply water to stock

APPENDIX 1

EPA Guidelines

Public Environmental Review

Assessment no. 752

GUIDELINES FOR THE PUBLIC ENVIRONMENTAL REVIEW (PER) - TRIAL USE OF 1080 TO CONTROL FERAL GOATS IN WESTERN AUSTRALIA

In Western Australia, the environmental assessment process is about protecting the environment. The fundamental requirement is for the proponent to describe the proposal in some detail, to discuss the environmental impacts and potential environmental impacts of the proposal, and then to describe how those environmental impacts are going to be avoided, ameliorated or managed so that the environment is protected.

Throughout the process, it is the aim of the Environmental Protection Authority (EPA) to advise and assist the proponent to improve or modify the proposal in such a way that the environment is protected. However, it is the responsibility of the proponent to design and implement proposals which protect the environment, and to present the design proposals for review.

These guidelines have been prepared to assist the proponent in identifying issues which should be addressed within the Public Environmental Review (PER) for the Trial use of 1080 to control feral goats in Western Australia. They are not intended to be exhaustive and the proponent may consider that other issues should be included in the document.

The PER should facilitate a review of the key environmental issues. The purpose of the PER should be explained, and the contents should be concise and accurate as well as being readily understood. Specialist information and technical description should be included only where it assists the understanding of the proposal. Where specific information has been requested by a Government Department or the Local Authority this should be included in the document.

It is not intended that the document be unduly lengthy. Rather it is intended that all relevant material should be succinctly presented in order that the key environmental issues may be assessed.

The principal function of the PER is to place this project in the context of the regional environment and of any expected cumulative impacts. It seeks to explain why this project is being proposed in the way that it is, at this place and at this time. It should also set out the environmental impacts the project will have, and what management steps the proponent intends to use to avoid, ameliorate or mitigate any negative environmental impacts.

A copy of these guidelines should appear as an appendix in the PER.

PROJECT DESCRIPTION

This should include a description of the proposal itself, including specifically what is proposed, how it is to be carried out, the timing of the project, and what measures will be taken to ameliorate possible negative effects. It should specify criteria for deciding where and under what circumstances the method of control would be implemented. Provisions for training and supervision of implementation should be outlined. There should be some indication of the likely overall scale of implementation (given the above criteria) in the context of the problem and the other mechanisms for control.

A discussion of the efficacy of 1080 poisoning, and how the use of 1080 in water would complement or replace other control measures should be included, as well as the practical logistics for its use. A discussion of alternatives considered, and how this proposal fits into the overall context of feral goat control should be also included. Some discussions of the expected benefits to conservation of feral goat control could be a part of this discussion.

ENVIRONMENTAL IMPACT AND MANAGEMENT

This section should discuss predicted environmental impacts and proposed measures to overcome or minimise these problems. Any expected 'positive' impacts could be included here.

The specific environmental concerns with the proposed use of 1080 to control feral goats include:

- the fate of 1080 in carcasses, soil, water
- risks, both primary and secondary, to non-target species, whether domestic or native
- risks to operators and other humans
- what are the occupational health risks?
- what are the public health risks?
- animal welfare

Discussion here should include information on dangers and proposed safeguards with regard to the use of 1080 in water, in the circumstances under which it would be used. What risks are there of accidental poisoning of non-target species, both from direct poisoning by drinking water intentionally containing 1080, or by secondary poisoning through eating carcasses of animals poisoned with 1080, or through inadequate or inappropriate disposal of poisoned water? What measures will be taken to see that does not happen? What occupational health and public safety measures, signage, and protocols for use will be implemented to ensure that animal deaths are humane, and what measures will be undertaken to prevent suffering if the 1080 results in partial but not lethal poisoning?

COMMITTMENTS

Specific commitments should be given to all components of the management programme. Where appropriate, the commitments should include

a) who is responsible for the commitment and who will do the work,

b) what is the nature of the work,

c) when and where the work will be carried out an

d) to whose satisfaction will the work be carried out.

A summary of commitments in numbered form should be given. A set of well written concise commitments covering the key issues of the proposal and its effects will help to expedite assessment of the proposal.

APPENDIX 2

1080 AND AUSTRALIAN FAUNA

by
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INTRODUCTION

In 1953 the poison 1080 (sodium monofluoroacetate) was first used in W.A. for the control of rabbits. It has since replaced poisons like arsenic, phosphorus and strychnine for that purpose, and has also been used in W.A. for the control of other species such as dingoes, foxes, agile wallabies and pigs.

This poison, one of the most toxic substances known, was first synthesized in Europe in the 1890's. Its toxicity to insects was recognized in the 1920's and it was patented for use as a moth-proofing agent. It is not now used as an insecticide. Further studies were carried out in the 1940's to evaluate the potential of fluoroacetate and related compounds as chemical warfare agents. During those tests, it was found to be extremely toxic to rabbits. Further work showed that it was highly toxic to a wide range of mammals and it's particular value as a rodenticide was determined in the U.S.A. in 1944. The common name of 1080 was derived from the laboratory serial number given to it at that time. Compound 1080 was first used as a vertebrate pest control substance in the U.S.A. in the late 1940's and is still widely used there.

The commercial-grade 1080 which is used by the A.P.B. is a tasteless and odourless powder which is readily soluble in water but relatively insoluble in most organic solvents, fats and oils. It has a high level of chemical stability, but decomposes at approximately 200°C .

Mammals are generally more sensitive to 1080 than are other groups of animals. It is highly toxic to most insects, birds and mammals. It is particularly toxic to canids (dogs, foxes, coyotes, etc) and felids (cats). It is an effective poison for rodents. Domestic stock and humans are also sensitive to 1080. Native wildlife in most parts of the world are also readily poisoned by it, either by eating the bait or by feeding on the carcasses of poisoned animals. The use of the poison in vertebrate pest control programs is thus often opposed and it's use is highly restricted in many countries.

MODE OF ACTION AND SYMPTOMS

Solutions of 1080 are absorbed through the gastrointestinal tract, open wounds, mucous membranes and the pulmonary epithelium but not through intact skin.

In the body, fluoroacetate is converted into fluorocitrate, which blocks the Krebs Cycle which is the major pathway for releasing energy from food. Other energy-releasing mechanisms are also blocked by the resultant disruption of normal activity within the cells. The energy supply to the cells is reduced. Cardiac and central nervous system dysfunction occurs and death may result from heart and/or nervous system failure.

The actual cause of death from fluoroacetate poisoning is not fully understood. Ionic imbalances are created in the body which may cause cardiac or central nervous system irregularities and disruption of the movement of some compounds between parts of the cells.

Herbivores generally develop cardiac symptoms, carnivores mainly show central nervous system disorders and omnivores show mixed responses.

There is a latent period between the time fluoroacetate is ingested and the time when the first symptoms of poisoning occur. The length of this period varies, depending on the size and the rate of metabolism of the animal, but is generally in the range of 30 minutes to 3 hours in mammals. This delay presumably results from the time taken for the 1080 to be absorbed and penetrate the cells, to be converted into fluorocitrate and for it to disrupt the processes of the cells. Death generally occurs within 24 hours, but may occur after that time. Sublethal doses are detoxified in the liver and kidneys or excreted, so the poison is not accumulated in the body.

Many species show signs of increased excitability when poisoned. They may run wildly, howl and convulse. Others may simply die while still feeding on bait material and not show any symptoms of distress.

There is no effective antidote for 1080. Some treatments have been suggested but they appear to mainly treat the symptoms rather than the causes and have limited value. Great care must therefore be used when handling this poison.

Sublethal levels of fluoroacetate can cause damage to the testes, reduced sperm production or lower levels of reproductive hormones which can decrease the fecundity of the animals. This could result in species which are not fatally poisoned being placed at risk through lower than normal reproductive rates. This could be of particular importance in those non-target species such as small dasyurids like the Red-tailed Phascogale (*Phascogale calura*) and the Dibbler (*Parantechinus apicalis*) where all the males die at the end of each breeding season. Entire populations of these species could disappear if the baiting caused males to become sterile during or before the breeding season. In animals which ingest sub-lethal levels of 1080, this can also result in temporary sterility of males. A higher level of tolerance to the poison in that species can evolve than is necessary to avoid being poisoned fatally by simply eating the poison. This has apparently occurred in the Bobtail lizard (*Tiliqua rugosa*). (See following).

NATURAL OCCURRENCE

Many years after 1080 was first synthesized, its toxic principle was found to occur naturally. In 1944 fluoroacetic acid was identified as the toxin contained in an African genus of plants (*Dicapetalum*). The first species from which it was isolated was a plant in South Africa (*Dicapetalum cymosum*, commonly known as "Gifblaar ") which had for many years been known to be poisonous to livestock. The particular poison involved was however unknown until that time. Subsequently, in 1963 and 1964, it was found to be the toxin in Gidyea, an acacia (*Acacia georginae*) which occurs in the Georgina River basin, on the Northern Territory - Queensland border. It was also detected in several species of the genus *Gastrolobium* (which is found in northern and southwestern Australia) and also in the genus *Oxylobium* in the southwest of Western Australia. Levels of 1080 in the dried leaves differ markedly between species, ranging from 50 mg/kg to 2650 mg/kg.

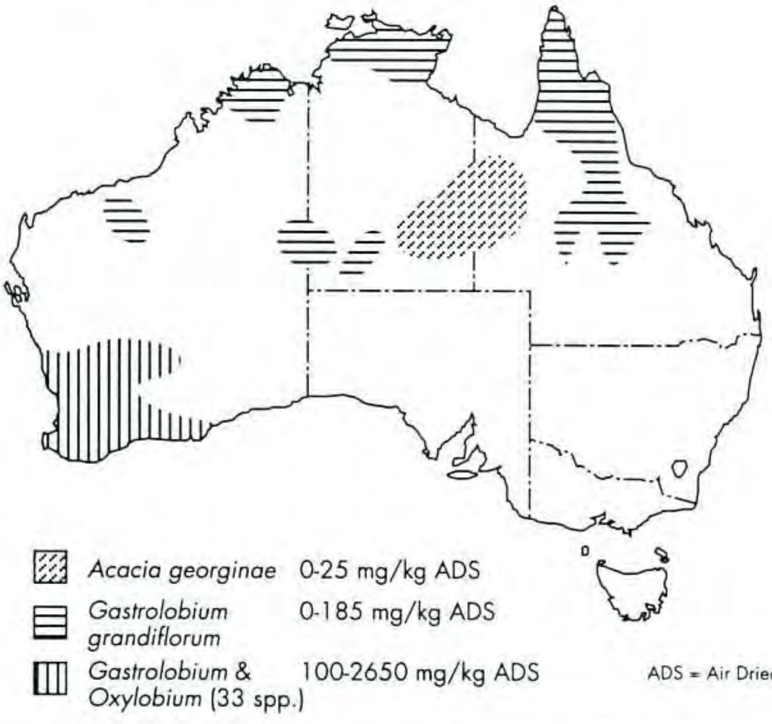
The poisonous nature of *Gastrolobium* species to livestock was known as early as 1839. The government of the colony of Swan River attempted to conceal that fact for some time lest intending settlers be discouraged from immigrating to the colony because of the threat posed to their livestock by poisonous plants. Economically significant losses of livestock have occurred in Australia as a result of feeding on these plants. The widespread distribution of these toxic plants in some areas of Australia has prevented some areas from being fully used for primary production. It has also resulted in many areas in the southwest of W.A. retaining their value as nature reserves because care is taken to exclude livestock from them.

Fluoroacetate also occurs in the South American genus *Palicourea*..

The toxic levels of different parts of the plants vary considerably. The production of fluoroacetic acid, which is presumably produced for the purpose of deterring animals from feeding on the plants, requires the investment of energy and material by the plants. Therefore, it is most efficient if the toxin is concentrated in the most important parts of the plants, such as the seeds, flowers and young leaves rather than being spread thinly through the tissues of the plant, including those less likely to be eaten by an animal.

DEGRADATION OF 1080 IN SOILS

Figure 1. DISTRIBUTION OF PLANTS CONTAINING FLUOROACETATE IN AUSTRALIA



Several species of bacteria, fungi or algae have been found to degrade 1080 in moist soils in New Zealand, Japan and England, where the toxin does not occur naturally. Microorganisms from these groups also defluorinate and thus detoxify 1080 in soils in Western Australia. If microbial detoxification of 1080 did not occur in Australia, large quantities of 1080 contained in shed leaves of the toxic plants would have passed into the soil and remained there, making the southwest of W.A. a very hazardous place.

The distribution of fluoroacetate-bearing vegetation in Australia is shown in Fig. 1. Most of the toxic species and those with the highest concentrations of fluoroacetate in their tissues are found in the southwest of W.A. where 33 species have been found to contain the toxin. Toxic plants containing 1080 occur over much of the southwest of W.A. and occur in a variety of vegetation and soil types. They are not found in the deep sandy soils of the coastal plain. Their abundance in a region is quite variable but in some areas a single species can form very dense stands of plants.

Toxic species of *Gastrolobium* and *Oxylobium* do not occur in the southeast of Australia (Fig.1). The native fauna there have consequently not evolved an elevated tolerance to 1080 as have those in the southwest. The level of tolerance to 1080 can therefore differ greatly between populations within the same species. The brushtailed possum clearly demonstrates this difference.

EVOLUTION OF TOLERANCE IN NATIVE FAUNA

It had been suspected for years that some native animals in W.A. were tolerant to these poisonous plants but no firm evidence of this was obtained until the 1970's. It was then discovered that the brushtailed possum from areas in the Darling Ranges had much higher levels of tolerance to 1080 than did possums from the eastern states of Australia or those which had been introduced into New Zealand from the eastern seaboard. High levels of tolerance have since been found to occur in many species of native animals in Western Australia. These include animals from many independent evolutionary lineages, ranging from insects through reptiles, birds and both the marsupial and the placental mammals. The elevated levels of tolerance must therefore have evolved independently on several occasions, presumably through coevolutionary associations with the toxic plants. As the poison levels of the plants increased, the least tolerant individuals of a species which fed upon them would have been fatally poisoned whereas the most tolerant would have survived and subsequently bred. Their offspring would have inherited the ability to tolerate the toxin and thus the level of tolerance of that species would have increased. The tolerances of some native Australian species, on a body weight basis, are over 1000 times those of introduced dogs or foxes. Those species with the highest tolerances have had long evolutionary associations with the toxic plants and have relied heavily on those types of plants for their food. Evolution of increased levels of tolerance to 1080 has not occurred in introduced species, apparently because of the disparity between the high 1080 levels in the plants and the low levels of tolerance of the introduced animal species. They have simply arrived too late in the game. If they eat even small quantities of the plants they will die and consequently those species are highly unlikely to ever acquire substantial levels of tolerance to 1080. The techniques used for poisoning the animals whose numbers are being controlled with 1080 ensure that an animal feeding on the poisoned bait is almost certain to eat enough to cause it to die. This ensures that increased levels of tolerance to the poison will not develop in pest species in that way.

Rabbits from areas of Western Australia where poison plants are abundant (Chidlow) and where the toxic plants occur and 1080 baiting has been done regularly for over 30 years (Mt Barker) do not have higher levels of tolerance than do those from eastern Australia. They are also similar to those of rabbits from an area in W.A. where rabbit poisoning with 1080 has not been done and where plants containing 1080 do not occur (Quobba Station). They have not acquired higher levels of tolerance of 1080 either by being baited or from coming into contact with plants containing the toxin.

The biochemical mechanism by which animals have developed elevated levels of tolerance to 1080 is not definitely known but it is thought to involve changes to the transport system in the mitochondrial membranes of cells. The enzyme glutathione, which is involved in the detoxification of many poisons, detoxifies fluoroacetate by defluorinating it and also has some protective effect on the liver. Animals with depleted liver glutathione levels have increased levels of susceptibility to toxins. Sublethal levels of 1080 reduce the level of glutathione in the liver, which may remain at a reduced level for several days or weeks. The detoxification capabilities of sensitive animals from the eastern states are as good as those of the same species from Western Australia, but are not sufficient to protect them from high doses of 1080. The unfortunate easterners are still frantically detoxifying the 1080 when it kills them. The tissues of their western counterparts are somehow protected through unknown mechanisms for long enough to enable them to completely detoxify the 1080 which they have ingested.

In addition, western populations of native animals have higher levels of tolerance to 1080 than eastern populations and thus are able to survive the same dose which will quickly kill the animals from the southeast.

Herbivores are generally more tolerant to the poison than are carnivores. *Gastrolobium* and *Oxylobium* species are shrubs and those herbivorous species with the highest levels of tolerance are the browsers which feed upon them. Those species of herbivorous animals with lower levels of tolerance are primarily grazers. These may have browsed a few bushes or accidentally eaten leaves from the toxic plants which have become mixed into their normal food material of grasses and forbs. Native carnivores in the southwest also have increased tolerances to 1080 compared to those from elsewhere which have presumably become elevated through secondary ingestion of the poison present in their prey.

In retrospect, it should have been apparent that a high level of tolerance to fluoroacetate was present in at least some animals native to Western Australia. The levels of toxin contained in some of the toxic species of *Gastrolobium* and *Oxylobium* are otherwise unreasonably high. The plants must devote material and energy to produce the toxins and it is not efficient to incur extra costs by producing higher levels than necessary to prevent or reduce grazing.

Despite the fact that birds and reptiles are generally more tolerant of 1080 than are mammals, increased tolerance in southwestern populations of both has been found. Bronzewing pigeons from the southwest are approximately half again as tolerant as those from South Australia while Rosenberg's monitor, a goanna from the south coast of W.A., is approximately 6 times more tolerant than the same species from Kangaroo Island, S.A..

Following the discovery of the high levels of tolerance of some native Australian mammals, it was predicted that some species of African and South American animals would also be shown to have elevated levels of tolerance. This has recently been confirmed in a number of native mammals in southern Africa. Thus coevolution between the fluoroacetate-bearing plants and the native fauna has happened on at least two continents. There are also indications from published work that some South American mammals also have elevated tolerances to 1080.

Grey kangaroos in the southwest of W.A. eat substantial amounts of the leaves of *Gastrolobium* and *Oxylobium*. They eat more of those which contain low levels of fluoroacetate than they do of those with high levels of the toxin.

DETERMINATION OF LEVELS OF TOLERANCE TO 1080

The term LD50 will be used frequently here. It refers to the estimated dose of poison at which 50% of a group of animals will be killed. The value is usually determined by giving small groups of animals different doses of the poison and determining the level at which they die. These tests are usually conducted on animals kept under laboratory conditions. There are a number of environmental factors which can influence the LD50. These values are not as precise as they appear to be - the results obtained in different laboratories can differ slightly from one another because of the experimental conditions and techniques which apply. A high LD50 value, however, means that the animal has a high level of tolerance to the toxin.

Methods other than LD50 determinations are used to indicate the sensitivity of a species of animal to a toxin. Among these are values for the ALD (approximate lethal dose) which is also known as the MLD (minimum lethal dose). These values are obtained using the same experimental procedures used in obtaining the LD50 but they indicate the dose at which individuals of that species begin to die. When 10% or more of the animals in a dose group die, the ALD (or MLD) has been reached and dosing ceases. Therefore far fewer individuals need to be used in testing the toxicity of a substance than are needed for an LD50 trial and the trials are also less expensive to conduct. Although ALD values are obviously lower than LD50 values, there is a strong correlation between the scale of tolerances determined by these methods.

Another method used to determine the level of tolerance of species or populations to 1080 relies on measuring the increase in the level of citrate in the plasma which results from fluoroacetate poisoning. Within a species the level of plasma citrate reached following dosing is related to the size of the dose. The smallest rises in citrate levels at a given dose occur in the animals which are least susceptible to 1080. Differences in size and type of animal influence their rates of metabolism and prevent this technique being used to compare results obtained from species which are not closely related to one another.

Citrate levels are determined from blood samples collected from a small number of animals, which are then injected with 1080. Further blood samples are collected at intervals over the next 24 to 48 hours and changes in plasma citrate levels are determined. The increases above the initial level can then be compared with those of other species or populations. If data on mortality levels for one species are available, estimates of LD50 values can then be made for other closely related species. This minimises the number of animals used during trials and also the number of animals which die during trials. Such an approach (which produces approximate LD50s) is ethically more acceptable than conducting LD50 trials (during which 50% or more of the animals may die) on large samples of animals . It is also important when conducting trials on rare or endangered species of animals.

Fluoroacetate poisoning disrupts the energy supply to the cells resulting in a decrease in body temperature of poisoned animals. This can be a useful indication of whether or not a particular level of 1080 is having an adverse effect on animals whose tolerance is being assessed.

VARIATION IN TOLERANCE BETWEEN POPULATIONS

Different populations of some species of native animals have different levels of tolerance to 1080. This may occur because the different populations had different levels of exposure to plants containing 1080 during their evolutionary history. Incorrect taxonomy of the animals - that is, two or more species being incorrectly classified as constituting one species - sometimes explains apparent differences in tolerance within a species. This has been found during the work on the 1080 sensitivity of West Australian species. The tolerances of animals which were supposedally Sandy Inland Mice (*Pseudomys hermannsburgensis*) from the same population differed substantially, and several of the animals were subsequently found to belong to another species, Bolam's Inland Mouse (*Pseudomys bolami*).

The most common reason for differences in tolerances between populations, however, is different evolutionary exposure to the toxic plants. Possums from near Canberra were found to have an LD50 of 0. 68 mg /kg whereas possums from Western Australia have LD50's of over 100 mg/kg. The differences in the levels of tolerance of other species of animals which occur in both areas are less extreme than those for possums but populations from the southwest are generally more tolerant than those from the southeast. Different levels of tolerance are found between eastern and western populations of Tammar Wallabies (*Macropus eugenii*) but not for W.G.K. (*M. f.*). The tolerances of Tammars from South Australia (LD50 = 0. 3 mg/kg) and those from near Manjimup, Western Australia (LD50 = approximately 5 mg /kg) differ substantially, while that of Tammars from Garden Island is intermediate between them. The tolerance of Western Grey Kangaroos at the eastern edge of their distribution in New South Wales is the same as that for Grey Kangaroos from Western Australia (LD50 = approximately 20 mg/kg). The apparent explanation for these differences is that there are no toxic species of *Gastrolobium* or *Oxylobium* in New South Wales or South Australia and that Tammar Wallabies originated in southeastern Australia, whereas Western Grey Kangaroos originated in southwestern Australia. Both species subsequently spread into other areas, with Tammars moving westwards and acquiring higher levels of tolerance to the toxin when they encountered it in their newly encountered food plants. The tolerance of Garden Island Tammars is lower than that of Tammars from Manjimup. There are none of the toxic plants on Garden Island, which has been isolated from the mainland for at least 8000 years, whereas they are abundant in the Manjimup area. Evolution of higher levels of tolerance by Tammars from Manjimup continued while that of the Garden Island population did not. Western Grey Kangaroos, which evolved as a separate species in the southwest, apparently acquired a high level of tolerance during a period of separation from contact with an ancestral stock which also gave rise to the closely-related Eastern Grey Kangaroos, which are much more sensitive to 1080 (Table 1 in Appendix) than are Western Grey Kangaroos. The Western Grey Kangaroos then spread eastwards at some later time and retained their high level of tolerance in spite of the absence of 1080-bearing plants in the southeast of Australia.

The levels of tolerance to 1080 in different populations of several species from the southwest vary somewhat depending on the degree of their exposure to the toxin during the course of their evolution. The levels of tolerance to 1080 in Quokka (*Setonix brachyurus*) populations within Western Australia differ. Those from mainland sites near

Dwellingup and Pemberton and from Bald Island, which is off the coast near Albany and which has fluoroacetate bearing plants growing on it, have high levels of tolerance with LD50's of approximately 40 mg/kg. Some quokkas from Rottnest Island have similar high levels of tolerance while others are much more sensitive to the toxin. This variation in responses to 1080 is probably caused by interbreeding in the past by members of a highly tolerant and a sensitive population. As the toxic plants do not occur on deep sandy soils, such as those on the coastal plain of the southwest, but are abundant on the heavier soils of the Jarrah forests, animals which live in the forest are thus in contact with the toxin and evolve a tolerance to it while those on the sandplain do not. If tolerant animals move into an area where there are no toxic plants they retain their elevated tolerance to 1080, but no longer need it to survive. However, if animals with very low tolerance move from the sandplains into areas where the toxic plants occur and feed on highly toxic plants, they will die.

The Bush Rat (*Rattus fuscipes*) is an example of an animal showing both of these conditions. Populations from eastern Australia are sensitive to 1080 (LD50 of approximately 1 mg/kg in New South Wales and South Australia) and those from Western Australia are highly variable, with LD50's ranging from approximately 1 to 80 mg/kg. Rats from the most southerly and easterly of the islands in the Recherche Archipelago have the very low levels of tolerance similar to those of the South Australian rats. No toxic species of *Gastrolobium* or *Oxylobium* occur on those islands. Bush Rats from mainland localities near Albany and Manjimup have LD50's of approximately 30 mg/kg. They live in areas with heavy soils and have some contact with toxic plants and presumably feed on them. Those from islands near Albany which lack toxic plants also have high levels of tolerance. Bush rats from Greenhead, which live on deep sandy soils where there are are no fluoroacetate - bearing plants have a lower level of tolerance (LD50 about 25 mg/kg) than those from the mainland near Albany. There are some members of the Greenhead population which have low levels of tolerance and some which are highly tolerant. Bush rats with the highest known levels of tolerance (80 mg/kg) are from Mondrain Island where the highly toxic species *Gastrolobium bilobum* occurs. The densities of rodents on islands are often very high as they have nowhere to disperse to when their numbers increase. They may thus experience food shortages more often than do those on the mainland and be forced to feed more frequently on unpalatable or toxic plants, thus increasing the selection pressure placed upon them. They consequently may develop higher levels of tolerance to toxins. Genetic isolation from other, non-resistant, populations then ensures that the levels of tolerance are maintained. Further increases in tolerance are also likey, leading to the ability to actually use the toxic plants/seeds as a food source.

Explanations for differences in the tolerance to 1080 of populations of other native Western Australian species such as the rodents *Pseudomys hermannsburgensis*, *Zyzomys argurus*, *Notomys mitchelli* and the dasyurid marsupial *Sminthopsis ooldea* also relate to the extent of their current and previous exposure to these toxic plants.

The Bobtail lizards (*Tiliqua rugosa*) in some areas in the southwest of Western Australia have evolved very high levels of tolerance to 1080. They exceed the levels which would be necessary to prevent a lizard whose entire daily food intake was from the most toxic species of *Gastrolobium* or *Oxylobium* it could encounter from being fatally poisoned. When male Bobtail lizards were dosed with amounts of 1080 well below that which would kill them, the amounts of reproductive hormones they produced were much lower than normal and they would probably have been incapable for 1 to 2 weeks of breeding successfully. The evolution of the high levels of tolerance to 1080 in those populations was probably a means of avoiding a possible reduction in fertility, rather than being directly killed. Male rats given sublethal levels of 1080 become temporarily sterile and 1080 may thus have detrimental effects on other animals which do not take in enough of it to actually kill them. The extent to which animals are tolerant of the poison can be influenced by limitations on their reproductive capacity, but the significance of this to non-target species during pest control programs is unknown.

ISLAND POPULATIONS AND THE RETENTION OF TOLERANCE

Once a tolerance to the poison evolves in a species it does not appear to decline when animals are separated from exposure to the plants which are the reason for the evolution of that tolerance. Many populations of native animals which are not currently in contact with toxic plants still retain high levels of tolerance to 1080. This is of particular importance as many of Australia's rare and endangered species of mammals now occur only on island reserves off the coast of Western Australia which have been separated from the mainland within the last 8000 to 15000 years. During that period sea levels have risen greatly and most of the islands now off the coast became isolated. They now have major conservation implications. Few of the islands have *Gastrolobium* or *Oxylobium* growing upon them as their soils are generally inappropriate. Mondrain Island in the Recherche Archipelago and Bald Island near Albany are important exceptions to this. Mammals which now occur on Barrow, Bernier, Dorre, West Wallabi, Rottnest, Garden, Mistaken and several islands in the Recherche Archipelago in W.A. and Kangaroo Island in South Australia retain high levels of tolerance to 1080 although no fluoroacetate-bearing plants occur on those islands. Some mainland populations which occur in areas where toxic species of *Gastrolobium* or *Oxylobium* are not found also retain high levels of tolerance, presumably for the same reasons. The levels of tolerance of populations not currently in contact with toxic plants can thus not always be predicted correctly on the basis of their current distribution and degree of contact with poison plants.

IMPACT OF POISONING PROGRAMS ON NON - TARGET SPECIES

The effect of poisoning programs on non-target species is very difficult to determine directly. Most species of birds are highly mobile and may travel long distances in search of food, water, or other needs, and thus the number present in an area can vary considerably from day to day, often in an unpredictable manner. Most species of native mammals are nocturnal and many are very small, sparsely distributed, secretive and difficult to trap. It is therefore difficult to determine whether populations have declined following baiting, and if they have, whether it is because of the baiting or because of natural fluctuations of their numbers. Attempts have been made, however, to investigate the effect of baiting programs on non - target species. In New South Wales, prior to and after two trail baiting programs for the control of wild dogs, bird populations were counted daily along transects. Small mammals were trapped in cage traps, marked and released. Population assessments were done in the area to be baited and in a nearby area which was similar but not to be baited. Changes in numbers in the two areas after baiting were compared to give an indication of whether they might be due to the baiting. Populations of neither birds nor small mammals seemed to have been significantly affected by the poisoning programs.

Because of the uncertainty involved in interpreting these sorts of results, most studies of the possible hazards posed to non - target species by baiting have been done on captive animals in the laboratory. Studies of the tolerances of many species have now been conducted by C.S.I.R.O. in southeastern Australia and by the Research Section of the A.P.B. in Western Australia. These trials include a study on small mammals from the pastoral areas of W. A. The sensitivity of the animals to 1080 (Table 1, Appendix) and their daily food consumption rates in the laboratory were determined. The extent to which they will eat the bait material (when other food is available or when it was the only food provided) was also determined for 6 species of rodents and 9 species of dasyurid marsupials. Combining the results on what and how much they will eat and how sensitive they are to 1080 gives an indication of how susceptible they would be to poison baiting with 1080. The results indicated that 4 of these species would theoretically be at risk of poisoning from feeding on meat baits used for dingo control. Of these, the Northern Quoll (*Dasyurus hallucatus*), also known as the Northern Native Cat, was the most likely to be poisoned because of its large size (it would be able to eat more bait than the smaller species, and thus ingest more 1080) and its voracious appetite. A radiotracking study of this species was thus carried out in the field to determine the actual risk they faced under normal conditions. Quolls were trapped, fitted with collars containing radio - transmitters and released. They were then located daily, when possible, for periods of up to two weeks to determine the location and size of the areas in which they lived. Aerial baiting with 1080 meat baits was then done by A.P.B. field staff. The movements and survival rate of the collared animals was then monitored for a further two weeks after the baiting. It was expected, on the basis of the results from the laboratory study, that some of the Quolls would be killed by eating the baits. However, all 10 animals which were wearing collars at the time of baiting were still alive at the end of the monitoring period. As the Quoll was the species considered to be most at risk, this strongly suggests that the aerial baiting programs in the pastoral regions have little or no effect on them or on other less susceptible non-target species.

BAIT DESIGN

The disparity in tolerance of 1080 between native and introduced species in Western Australia can be used to advantage in designing baiting strategies which present little or no threat to non - target species. Baits can be produced which are large enough and contain a low enough concentration of 1080 so that the small native species cannot eat enough of them to take in a fatal dose of the poison, yet are small enough to enable the pest species, such as dingoes or foxes, to easily eat the whole bait. Other aspects of bait design and presentation can be used to further reduce the risk posed to native species during baiting programs. These include the type of bait material chosen and its acceptability to target and non-target species, bait placement, the timing of baiting, and quality control in bait preparation. Appropriate size of baits is important in ensuring that the maximum level of target specificity is attained. Adequate drying of the baits will prevent loss of 1080 from them and will minimize the extent to which ants and other insects can damage them. It will also further improve target specificity of the baits as it is very difficult for the small native mammals to eat significant amounts of dry meat baits.

1080 AND CONSERVATION

Most 1080 use in Australia is for the purpose of protecting primary industry by controlling pest species. The disparity in 1080 tolerances between native and introduced species in W.A. is important in that it makes target specificity in control programs easier to achieve than usual. The disparity is also important in the management and conservation of native species. Pest species such as rabbits and foxes also damage native flora and fauna in reserves and national parks. Baiting programs using 1080 are employed by conservation authorities as the major means of controlling these pests. A low level of risk is posed to native fauna by well designed 1080 baiting programs which consider bait size and food intake of non-target animals. For areas which contain rare and endangered fauna special attention to the methods of bait preparation or distribution may be warranted to reduce even further the threat posed to those species by using 1080 baits.

SUMMARY

Compound 1080 is highly toxic to most vertebrates. It is used in many countries to control a number of vertebrate pest species. Its use in Australia began in the early 1950's and large amounts of it are now used to poison rabbits, dingoes, foxes and some other species of pests.

In 1944, 1080 was found to occur in plants in South Africa which were known to be poisonous to livestock. It was not known until 10 years after it was first used in Australia that it also occurred naturally in native plants which occur over a large area of this country. Most of the more than 30 species which contain 1080, including the most toxic species, are only found in the southwest of Western Australia.

Most species of native animals in the southwest have evolved a high level of tolerance to 1080 through feeding on the plants which contain the poison. Some have developed increased tolerance directly by eating the plants while others have developed it indirectly by eating other animals which have eaten those plants. Levels of tolerance to 1080 reflect the extent of exposure to the plants which a species or population of animals has had during its evolutionary history.

The high levels of tolerance to 1080 which native animals have makes it much easier to achieve target-specificity in pest control programs which use 1080 in Western Australia than is the case in most other countries. The main reason for this is the disparity in levels of tolerance between native species of animals and the major pest species. Most vertebrate pest species in Australia have been introduced from other countries where 1080 does not occur naturally. It is probably unique to find that the main poison used as a pest control agent is found in high concentrations in plants which are abundant in that country.

The target-specificity of a control program can be increased by designing baits of an appropriate size to further capitalize on that disparity. Most Australian native carnivores are smaller than the pest animals. Meat baits can be made large enough so most small native animals cannot eat enough of them to ingest a lethal dose of 1080 whereas they can be entirely eaten by the introduced pest species. One bait contains more than enough 1080 to kill the pest. The frequency of encounters by non-target species with meat baits can also be be reduced by appropriate choice of bait material, timing of control programs and placement of baits. These factors should also be considered where feasible, but special requirements for bait placement may involve extra effort and cost. Grain bait should contain only enough 1080 to ensure that the pest species will be killed if it eats the bait. Placing too much 1080 in bait will pose unnecessary risks to native and domestic non-target species and can actually result in less effective control of the pest species.

The occurrence of the high levels of tolerance to 1080 in Western Australian animals is a very fortunate coincidence and care must be taken to maximise the benefits from the situation. Proper use of the poison will go a long way towards achieving that goal. Recommended dose levels should be strictly adhered to and quality control of bait material and size should be diligent. Much research effort, time and money has gone into determining what is required to satisfactorily control pest species. Procedures should only be varied if new ideas or information have been adequately examined and the results

SUMMARY

indicate a need for revising the methods, materials or quantities of bait material or poisons which are used.

Care must be taken when using 1080 to minimise the risks posed to the operator and to others , and to domestic or native non-target species of animals . If it is not used properly, 1080 is a very dangerous substance. There is no antidote for it and it is fatal to ingest a large dose of 1080. When it is used properly, it is a very effective poison and presents no risk to the user. It also presents a mimimal risk to non-target species, and does not accumulate in the environment , as it is detoxified in the bodies of tolerant animals and is degraded in the soil. There are thus no rational grounds for restricting its use further as long as there is compliance by users with the guidelines for its use.

The use of 1080 is important in Western Australia for both primary production and conservation of the environment. Control of pest species is of benefit to domestic livestock, native flora and fauna. Because of its effectiveness in killing pest species and the high levels of tolerance of the native fauna to it, 1080 is a very useful and safe poison for the control of the main vertebrate pest species in Western Australia.

APPENDIX

TABLE 1 TOLERANCES OF AUSTRALIAN FAUNA - DETERMINED BY LABORATORY TESTING

Southwest and Wheatbelt	LD50 mg kg^{-1}	Approx LD50	ALD	Group
REPTILES				
Bobtailed Lizard (*Tiliqua rugosa*)		500 - 800		E
Sand Goanna (*Varanus gouldii*)		50		H
Rosenberg's Goanna (*Varanus rosenbergi*)		200-300		E
BIRDS				
Emu (*Dromaius novaehollandiae*)	102			E
Black Duck (*Anas superciliosa*)		15 - 20		M
Wood Duck (*Chenonetta jubata*)		12. 5		M
Common Bronzewing (*Phaps chalcoptera*)		40		E
Crested Pigeon (*Ocyphaps lophotes*)		25		H
White-tailed Black cockatoo (*Calyptorhyncus baudinii*)		2		V
Galah (*Cacatua roseicapilla*)		5 -6		S
Regent Parrot (*Polytelis anthopeplus*)		12. 5		M
Port Lincoln Parrot (*Barnardius zonarius*)		11. 5		M
Western Rosella (*Platycercus icterotis*)		75		E
Red-capped Parrot (*Purpureicephalus spurius*)		25		H

** Indicates that more than 1 population has been tested and that values for them differed.*

Group refers to the general level of tolerance of the species as follows :

V = very sensitive - LD50 up to 2 mg /kg
S = sensitive - LD50 2-5 mg /kg
M = moderately tolerant - LD50 between 5-20 mg /kg
H = highly tolerant - LD50 between 20-100 mg/ kg
E = extremely tolerant - LD50 greater than 100 mg /kg

APPENDIX

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
MAMMALS				
Southern Brown Bandicoot (*Isoodon obesulus*)		20		H
Common Ringtail Possum (*Pseudocheirus peregrinus*)		2		V
Common Brush-tailed Possum (*Trichosurus vulpecula*)		125		E
Western Pygmy Possum (*Cercartetus concinnus*)		10		M
Red-tailed Phascogale (*Phascogale calura*)		17. 5		M
Yellow-footed Antechinus (*Antechinus flavipes*)		12. 5		M
Fat-tailed Dunnart (*Sminthopsis crassicaudata*)			3	S
Grey-bellied Dunnart (*Sminthopsis griseoventer*)			4. 5	S
White-tailed Dunnart (*Sminthopsis granulipes*)			8. 5	M
Dibbler (*Parantechinus apicalis*)		10		M
Chuditch (*Dasyurus geoffroii*)		7. 5		M
Quokka (*Setonix brachyurus*)		10, 40 *		H
Brush-tailed Bettong (*Bettongia penicillata*)		100		E
Tammar Wallaby (*Macropus eugenii*)		2, 5		S
Western Brush Wallaby (*Macropus irma*)		5-10		M
Western Grey Kangaroo (*Macropus fuliginosus*)		20		M
Ash-Grey Mouse (*Pseudomys albocinereus*)	Highly variable - see text			
Western Mouse (*Pseudomys occidentalis*)			25	H
Heath Rat (*Pseudomys shortridgei*)			25	H
Bush Rat (*Rattus fuscipes*)	Highly variable - see text			

APPENDIX

Pastoral Areas	LD50 mg kg⁻¹	Approx LD50	ALD	Group
BIRDS				
Wedge-tailed eagle (*Aquila audax*)	9. 5			M
Little Crow (*Corvus bennetti*)	13. 4			M
MAMMALS				
Northern Brush-tailed Possum (*Trichosurus arnhemensis*)		0. 5		V
Golden Bandicoot (*Isoodon auratus*)	8. 9			M
Western Barred Bandicoot (*Perameles bougainville*)		10		M
Bilby (*Macrotis lagotis*)		15		M
Wongai ningaui (*Ningaui ridei*)			3	S
Pilbara Ningaui (*NIngaui timealeyi*)			12	M
Yvonne's Ningaui (*Ningaui yvonnae*)			3	S
Common Planigale (*Planigale maculata*)			4	S
Ooldea Dunnart (*Sminthopsis ooldea*)			1, 5 *	S
Hairy-footed Dunnart (*Sminthopsis hirtipes*)			7	M
White-tailed Dunnart (*Sminthopsis granulipes*)			8. 5	M
Fat - tailed Dunnart (*Sminthopsis crassicaudata*)			3	S
Little Long-tailed Dunnart (*Sminthopsis dolichura*)			8	M
Spectacled Hare Wallaby (*Lagorchestes conspicillatus*)		5		M
Banded Hare Wallaby (*Lagostrophus fasciatus*)		100-125		E
Brush-tailed Rock Wallaby (*Petrogale penicillata*)		1. 0+		?

APPENDIX

	LD50 mg kg-1	Approx LD50	ALD	Group
Rothschild's Rock Wallaby (*Petrogale rothschildi*)		2. 0+		S
Agile Wallaby (*Macropus agilis*)	0. 2			V
Common Wallaroo, Euro (*Macropus robustus*)		2		S
Red Kangaroo (*Macropus rufus*)		2 - 4		S
Sandy Inland Mouse (*Pseudomys hermannsburgensis*)			2, 5, 14	V-M
Bolam's Inland Mouse (*Pseudomys bolami*)		1		V
Shark Bay Mouse (*Pseudomys praeconis*)		4 - 5		S
Lakeland Downs Mouse (*Leggadina lakedownensis*)			4	S
Mitchell's Hopping Mouse (*Notomys mitchelli*)		10, 20 *		M
Common Rock-Rat (*Zyzomys argurus*)	3, 5 *			S
Tunney's Rat (*Rattus tunneyi*)			3	S
Long-haired Rat (*Rattus villosissimus*)	1. 4			V

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
Eastern and Central Australia				
AMPHIBIA				
Spotted Grass Frog (*Lymnodynastes tasmaniensis*)		60		H
REPTILES				
Bearded Dragon (*Pogona barbatus*)		110		E
Sand Goanna (*Varanus gouldii*)	43. 6			H
Lace Monitor (*Varanus varius*)		100		E
Blotched BlueTongue (*Tiliqua nigrolutea*)	336			E
Bobtail Lizard (*Tiliqua rugosa*)	206			E
BIRDS				
Black Duck (*Anas superciliosa*)	18. 9			M
Maned Duck (*Chenonetta jubata*)	12. 6			M
Black Kite (*Milvus migrans*)	18. 5			M
Bar-shouldered Dove (*Geopelia humeralis*)	16. 3			M
Diamond Dove (*Geopelia cuneata*)	35. 5			H
Galah (*Cacatua roseicapilla*)	6			M
Sulphur-crested Cockatoo (*Cacatua galerita*)	3. 5			S
Budgerigar (*Melopsittacus undulatus*)		2		S
Crimson Rosella (*Platycercus elegans*)		0. 9		V
Eastern Rosella (*Platycercus eximius*)		3. 5		S
Port Lincoln Parrot (*Barnardius zonarius*)		9		M

APPENDIX

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
Red-rumped Parrot (*Psephotus haematonotus*)		5		M
Fan-tailed Cuckoo (*Cuculus pyrrhophanus*)		6		M
Laughing Kookaburra (*Dacelo novaeguineae*)		6		M
White's Thrush (*Zoothera dauma*)		12		M
Eastern Yellow Robin (*Eopsaltria australis*)		11. 7		M
Grey Shrike-thrush (*Colluricincla harmonica*)		12		M
Golden Whistler (*Pachycephala pectoralis*)		18		M
Superb Fairy Wren (*Malurus cyaneus)*		3. 4		S
White-browed Scrubwren (*Sericornis frontalis*)		4. 5		S
Little Wattlebird (*Anthochaera chrysoptera*)		7. 8		M
New Holland Honeyeater (*Phylidonyris novaehollandiae*)		8		M
Yellow-faced Honeyeater (*Lichenostomus chrysops*		8		M
Yellow-tufted Honeyeater (*Lichenostomus melanops*)		7. 5		M
Silvereye (*Zosterops lateralis*)		9. 3		M
Red-browed Firetail (*Emblema temporalis*)	0. 6			V
Zebra Finch (*Poephila guttata*)		3		S
White-winged Chough (*Corcorax melanorhamphos*)		1. 8		V
Australian Magpie-lark (*Grallina cyanoleuca*)	8. 8			M
Australian Magpie (*Gymnorhina tibicen*)	9. 9			M
Pied Currawong (*Strepera graculina*)	13. 1			M

APPENDIX

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
Australian Raven (*Corvus coronoides*)		5		M
Little Raven (*Corvus mellori*)	3. 1			S
Mammals				
Brown Antechinus (*Antechinus stuartii*)	1. 9			V
Dusky Antechinus (*Antechinus swainsonii*)	3. 2			S
Fat-tailed Dunnart (*Sminthopsis crassicaudata*)	2. 1			S
Stripe-faced Dunnart (*Sminthopsis macroura*)	1			V
Kowari (*Dasyuroides byrnei*)		2. 9		S
Eastern Quoll (*Dasyurus viverrinus*)	3. 7			S
Tiger Quoll (*Dasyurus maculatus*)	1. 9			V
Tasmanian Devil (*Sarcophilus harrisii*)	4. 2			S
Long-nosed Bandicoot (*Perameles nasuta*)	7. 7			M
Southern Brown Bandicoot (*Isoodon obesulus*)		7		M
Eastern Barred Bandicoot (*Perameles gunni*)		5. 4		M
Common Brush-tailed Possum (*Trichosurus vulpecula*)	0. 8			V
Common Wombat (*Vombatus ursinus*)	0. 2			V
Southern Hairy-nosed Wombat (*Lasiorhinus latifrons*)	0. 2			V
Tasmanian Bettong (*Bettongia gaimardi*)		1		V
Long-nosed Potoroo (*Potorous tridactylus*)		0.2		V
Red-bellied Pademelon (*Thylogale billardieri*)	0. 1			V

APPENDIX

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
Tammar Wallaby (*Macropus eugenii*)	0. 3			V
Bennett's Wallaby (*Macropus rufogriseus*)		0. 2		V
Western Grey Kangaroo (*Macropus fuliginosus*)		20		H
Eastern Grey Kangaroo (*Macropus giganteus*)		0.3		V
Spinifex Hopping Mouse (*Notomys alexis*)	32. 7			H
Mitchell's Hopping Mouse (*Notomys mitchelli*)	19. 4			M
Plains Mouse (*Pseudomys australis*)	1. 2			V
Sandy Inland Mouse (*Pseudomys hermannsburgensis*)	39. 3			H
Long-tailed mouse (*Pseudomys higginsi*)	9. 0			M
Water Rat (*Hydromys chryogaster*)		3		S
Bush Rat (*Rattus fuscipes*)	1. 1			V
Swamp Rat (*Rattus lutreolus*)	1. 7			V
Canefield Rat (*Rattus sordidus*)	1. 3			V

APPENDIX

	LD50 mg kg^{-1}	Approx LD50	ALD	Group
Introduced Pests				
BIRDS				
Laughing Dove (*Streptopelia senegalensis*)	5. 9			M
Barbary Dove (*Streptopelia roseogrisea*)		7. 5		M
Pigeon (*Columba livia*)	4.0			S
Blackbird (*Turdus merula*)		9. 5		M
House sparrow (*Passer domesticus*)	2. 8			S
Starling (*Sturnus vulgaris*)		4. 8		S
MAMMALS				
House mouse (*Mus musculus*)	8. 3			M
Black Rat (*Rattus rattus*)	0. 8			V
Rabbit (*Oryctolagus cuniculus*)	0. 4			V
Pig (*Sus scrofa*)	4. 1			S
Goat (*Capra hircus*)		0.5		V
Cat (*Felis catus*)	0. 4			V
Fox (*Vulpes vulpes*)		0. 13		V
Dingo (*Canis familiaris dingo*)	0. 11			V

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APPENDIX 3

THE USE OF 1080 TO CONTROL FERAL GOATS IN WESTERN AUSTRALIA

by
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February 1992

THE USE OF 1080 TO CONTROL FERAL GOATS IN WESTERN AUSTRALIA

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EXECUTIVE SUMMARY

This report examines the feasibility of using compound 1080 in water to poison feral goats in the pastoral areas of Western Australia. It also assesses the risk of poisoning non-target species.

The minimum concentration of 1080 required to kill 100% of goats was estimated from yard trials to be 7 mg of 1080 per litre of water. This equates to a dose of 1.4 mg per kilogram of body weight. There appeared to be minimal suffering from poisoning.

If precautions are not taken to prevent non-target species from drinking, Zebra Finches, Budgerigars and some Galahs will be at risk of poisoning. Other bird species are resistant to 1080 at the poisoning rates required to kill goats. When inverted sheet metal guttering was applied to the edges of poisoned troughs, birds could not perch safely when attempting to drink. Provided an alternative watering trough was available, birds rarely drank from the poisoned troughs. Some kangaroos will also be at risk from poisoning unless poison is removed at the recommended time of 1200 hr.

It is technically feasible to selectively poison feral goats with 1080 provided the appropriate safeguards are adopted to protect non-target species. Six guidelines are recommended for goat poisoning campaigns.

INTRODUCTION

This report examines the feasibility of using compound 1080 (sodium monofluoroacetate) in water to poison feral goats in the pastoral areas of Western Australia.

The dose of 1080 that kills 50% of goats has been estimated to be 0.3-0.7 mg per kilogram of body weight (U.S. Public Health Service 1949). These estimates, however, are rudimentary and based on little data. For the purposes of controlling feral goat populations in Western Australia's rangelands, further study is required to establish the minimum concentration of 1080 in water that will kill 100% of goats, and to assess the risk of poisoning non-target species.

METHODS

Poison Concentration

Two sites were chosen for study on Doorawarrah Station, 100 km east of Carnarvon. Site A consisted of three watering troughs at the boundary of three paddocks. Site B consisted of two watering troughs at the boundary of two paddocks. Each trough was surrounded by 30 m of weldmesh. Goats entered the yards through one-way spear gates (Plate 1). Two traps were set at both sites and varying concentrations of '1080 Concentrate Black' (see below) were applied to the troughs between 0800 and 1200 hr over a ten day period during December 1991 and February 1992.

An average of eight goats were caught in the yards during each trapping and then blocked off to prevent further access. Shade was provided and goats were checked throughout the day. The drinking behaviour of birds was observed whenever possible.

1080 concentrations varied from 3-20 mg per litre of water or 75-500 ml of '1080 Concentrate Black' per 1000 lt of water. By noting the level of water remaining in the trough after a known number of goats had drunk, it was estimated that an average sized goat of 24 kg (K. Russell, personal communication) consumed about 4.8 lt of water during each drink when temperatures were about $40^{o}C$ (Fig.2). This supports Dawson *et al.*'s (1975) and Henzell & McCloud's (1984) estimates that goats drink about 20% of their body weight during each drink. Therefore, the above concentrations of poison equate to doses ranging from 0.6-4.0 mg of 1080 per kilogram of body weight.

Dead goats were removed from the yards at 0700 hr the following morning and the troughs were re-poisoned. Live goats were shot if they appeared to be suffering from poison or close to death. Healthy goats were shot to avoid repeated poisoning.

There was insufficient time to monitor the eventual outcome of sub-lethally dosed goats and so it was not always possible to accurately score the death rate. Therefore, a minimum death rate was estimated from the number of dead goats plus those that died when disturbed. Maximum rates also included goats that showed some adverse reaction to the poison.

Sheep were allowed to drink in the early morning before goats arrived at the waters and poisoning began. Access thereafter was prevented with plain-wire fencing placed in front of the one-way gates.

Safeguards for Non-target Species

The third trough at site A was not poisoned and provided alternative water for birds. The yard remained closed during poisoning to prevent goats from drinking. There was no alternative trough at site B, but two halves of a 200 lt drum were provided, filled with water and fitted with perches. Two-metre lengths of inverted sheet-metal guttering, manufactured specifically for this trial, were applied to the edges of the poisoned troughs to prevent birds from perching safely as they attempted to drink (Plate 2, Fig.1). The ends of the troughs were covered.

Flagging tape, suspended at 30 cm intervals along a string spanning the length of the trough and about 50 cm above the water, was also tested for its effect in deterring birds.

RESULTS AND DISCUSSION

Poison Concentration

The proportion of goats that died from doses of 1080 ranging from 0.6-1.0 mg/kg varied from a minimum of 68% to a maximum of 98% (Table 1). The percentage kill at 1.2 mg/kg ranged from 91% to 100%. Mean maximum temperatures at these doses ranged from 35^{o}C to 37^{o}C. Doses of 1.4-4.0 mg/kg caused death rates ranging from 99% to 100%. However, these higher doses coincided with maximum temperatures averaging 43^{o}C, when goats were drinking more (see Fig.2). The time taken for goats to die varied from 3-12 hours and averaged 8 hours.

The minimum dose of 1080 required to kill 100% of goats appeared to be about 1.4 mg/kg. This equates to 7 mg/lt or 175 ml of '1080 Concentrate Black' per 1000 lt of water. It is possible that enclosing goats in yards and inspecting them occasionally caused them some distress. Stress can enhance the potency of 1080 and so the death rates described here may be overestimated. Although doses of 1.2 mg/kg are likely to achieve significant reductions in goat populations, the higher rate of 1.4 mg/kg is recommended to ensure 100% kill of free-ranging goats.

Five attempts were made to count a discrete number of goats that were allowed to enter a yard, drink the poison and leave the yard at their leisure. Ground searches were conducted the following day over a one kilometre radius from the yard and the number of dead goats recorded. It was only possible to count a discrete number of goats entering a yard on one occasion, at a dose of 1.0 mg/kg. All of the nine goats that drank the poison were found dead at distances between 100m and 500m from the poisoning station.

The salinity content of the water used in this trial was quite low (about 2000 ppm). The rate of water consumption will rise with increasing salinity and with more saline vegetation. These factors should enhance the death rate.

There appeared to be minimal suffering from 1080 poisoning. If undisturbed, most goats died in a resting position. Sub-lethally dosed animals mostly rested and appeared to be largely unaware of surrounding activity. Prolonged human activity in the vicinity of sub-lethally dosed animals often promoted their death.

Non-target Species

Given the susceptibility of birds to 1080 (see King 1990) and their rates of water consumption (Nagy & Peterson 1988), it is estimated that of the commonly occurring birds in pastoral areas, 100% of Zebra Finches and 100% of Budgerigars will die if allowed to drink 1080 at the concentration required to kill 100% of goats. An approximate death rate for Galahs is estimated to be 30%. These death rates are maximum estimates because they are based on the upper limits of water intake. Larger birds should be tolerant to goat poison.

Birds were successfully deterred from drinking at poisoned troughs when inverted sheet metal guttering was applied to the edges of the troughs and the trough ends covered. This prevented birds from drinking because they were unable to perch securely and reach the water. It was important that the water level in the troughs was maintained at a level above the lower edge of the sheet metal so that birds were unable to perch on the sloping inner surface of the trough. This level also ensured that birds were unable to land in the water and sit partially immersed on the floor of the trough. The water level should also be about 10 cm below the apex of the guttering so that birds are unable to reach the water when perched on the apex. The same can be achieved with higher guttering but this can restrict young goats from drinking.

These desperate attempts at drinking by birds were mostly observed when no alternative watering trough was available. Provided the above steps were taken, birds were rarely observed attempting to drink from the poisoned troughs.

Flagging tape did not always deter birds from drinking from poisoned troughs and so cannot be recommended.

About 40% of Red Kangaroos and Euros are estimated to die if allowed to drink goat poison (see King 1990). Again, this is only an approximation.

The anticipated death rates of non-target species are only marginally higher than those anticipated from the next lowest dose of 1.2 mg/kg. At this dose, all Zebra Finches and Budgerigars are still at risk from poisoning, while the death rates for Galahs is reduced to about 25% and that of kangaroos to about 35%.

Sheep and cattle have similar sensitivity to 1080 as goats (McIlroy 1982). If precautions are not taken to water stock outside poisoning hours or to restrain them with plain wire fencing, sheep and cattle will be at risk of poisoning.

There is minimal risk of secondary poisoning from the carcasses of poisoned goats. The native animals that are likely to feed from the carcasses are Sand Goannas, Wedge-tailed Eagles and Crows. These animals are resistant to 1080 concentrations required to kill goats. Furthermore, the concentration of poison in the muscles of the goats would be lower than in the gut; some of the 1080 would be excreted; and some would be detoxified.

There is minimal risk to humans from 1080 poisoning at the concentration required to kill goats (see Timm 1982). It is estimated that a 70 kg person would have to drink about 30 lt to be certain of death.

RECOMMENDED USE OF 1080 FOR POISONING GOATS

This study shows that it is technically feasible to poison feral goats with 1080 in water. Poisoning may therefore have a role in controlling feral goat populations in Western Australia.

There is considerable public concern about the environmental impact of poisoning as a means of pest control. Goat poisoning campaigns are likely to come under particular attention. To ensure the long-term success of a poisoning campaign, every effort must be made to minimize the risk to non-target species. The following six guidelines are recommended.

1. Poison concentration

No more than 7 mg of 1080 per litre of water, or 175 ml of '1080 Concentrate Black' per 1000 lt, should be offered to goats. Higher concentrations will further increase the risk of poisoning non-target species.

2. Bird deterrents

Inverted sheet metal guttering of the approximate dimensions shown in Fig.1 should be fitted along the edges of poisoned troughs to deter birds from perching safely and drinking. If the apex of the guttering is any closer to the water than about 10 cm, some of the larger birds, such as Galahs, will drink. Further deterrence may be possible by smearing grease along the apex of the guttering. The ends of the trough should be covered to prevent drinking.

It may be preferable to offer poison in a trough that is already fitted with bird deterring features and is portable between poisoning stations. Some watering troughs may be suitable on their own in deterring birds. For example, there is anecdotal evidence that metal troughs and 'cup and saucer' troughs are not frequented by birds. The efficacy of these troughs should be checked by Agriculture Protection Board Officers before they are used to hold poison. A disadvantage of mobile troughs is that several days may be required to accustom goats to the foreign trough. This will delay the use of the trough elsewhere.

3. Water level

Large storage tanks (preferably 1000 lt capacity and moveable between poisoning stations) are required to maintain the level of poison in troughs so that birds are deterred from perching inside the troughs and in shallow water. Large tanks are necessary, in any case, to maximize the number of goats poisoned. A standard 150 lt trough will only poison about 30 goats. The water level should not be too high so that it is within easy reach of birds perched on the apex of the guttering.

4. Alternative water

An alternative watering point at each poisoning station is essential to minimize the risk of poisoning birds. If a new alternative water supply must be added, birds should be allowed sufficient time to become accustomed to the new supply before poisoning is attempted.

5. Poisoning times

Most goats drink between 0800 and 1200 hr during summer. Poisoning should be restricted to these hours to reduce the risk of poisoning non-target species, in particular, kangaroos. It may be possible to water most stock before 0800 hr.

Poisoning should only be attempted when conditions are sufficiently hot and dry to ensure that all goats are drinking.

6. Agriculture Protection Board supervision.

If the above guidelines are not followed and non-target species are poisoned during a goat poisoning campaign, the legitimate use of 1080 for further goat control, and indeed already established poisoning campaigns for other pest species, may be jeopardized.

Agriculture Protection Board Officers should supervize goat poisoning campaigns to ensure there is compliance with the above guidelines. When satisfied, APB Officers could dispense a specially diluted bottle of 1080 concentrate to a storage tank of known volume, and then move onto the next poisoning station.

It is unlikely that APB Officers will have the time to man each water for the duration of poisoning. Therefore, it will not always be possible to ensure that pastoralists are removing the poison at 1200 hr. It is recommended that pastoralists be made to read and sign an indemnity form for each allocation of poison. This form should argue in the strongest terms that indiscriminate use of poison is likely to jeopardize future poisoning campaigns of any kind. It should clearly warn that if poison is not removed by 1200 hr, future allocations of poison will be withheld.

The logistical constraints of supervizing individually organized attempts at poisoning would be reduced by organizing local groups of properties to poison simultaneously. This would further enhance the impact of poisoning on local goat populations.

ACKNOWLEDGEMENTS

Special thanks to Dale Norbury of the Department of Agriculture and John Russell-Pell and Terry Donnelly of the Agriculture Protection Board for their assistance in the field and lively discussions on goat control. Geoff Eliot, Mike Dowd, Rick Sullivan, Richard Allen and Ian Watson also assisted in the field. Dr. Dennis King provided helpful advice on 1080. Brian Moore allowed access to Doorawarrah Station for the trial. The study was approved by the Animal Experimentation Ethics Committee (Reg. No. 04-91-53).

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Plate 1 Goats entered the trap-yards through one-way spear gates.

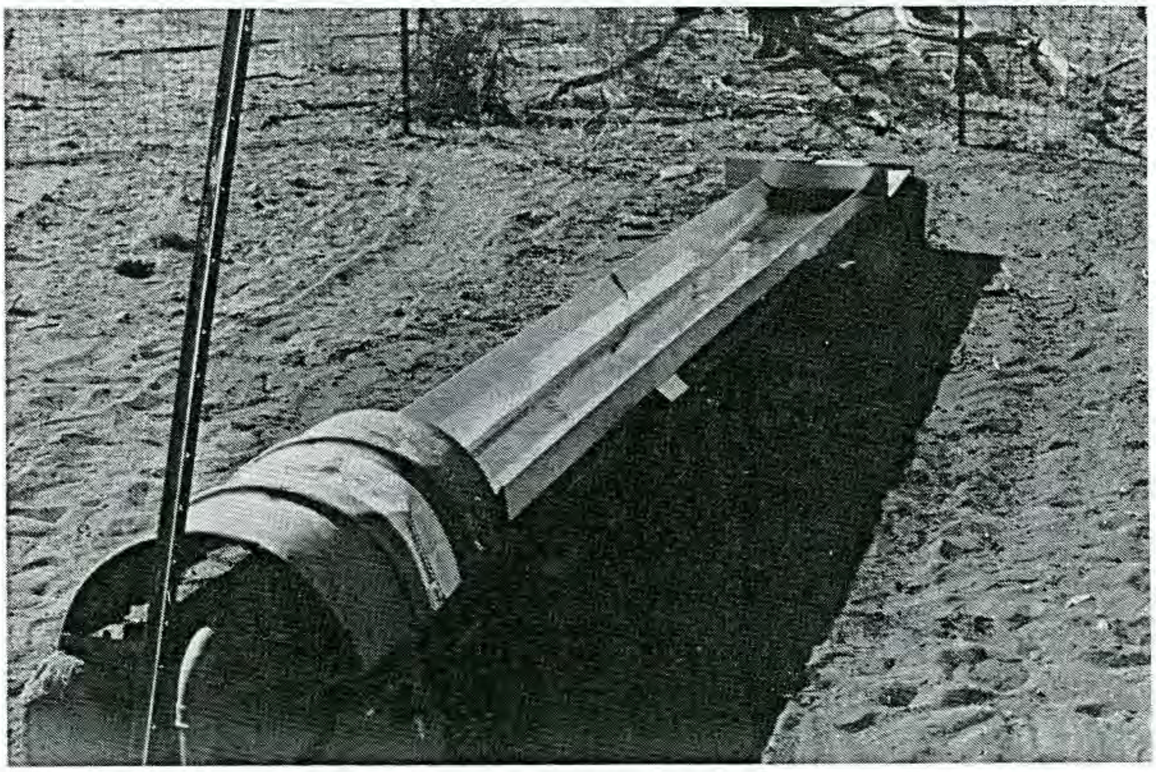

Plate 2 Inverted sheet metal guttering was fitted along the edges of poisoned troughs to deter birds from perching safely and drinking. The ends of the troughs were covered.

Table 1 The mean percentage of goats killed at varying doses of 1080. Minimum estimates were based on the number of dead goats plus those that died when disturbed. Maximum estimates also included goats that showed some adverse reaction to the poison.

Dose (mg/kg)	Mean maximum temperature	No. goats trapped	% goats killed
0.6	37°C	22	68% - 91%
0.8	36°C	33	79% - 88%
1.0	35°C	60	83% - 98%
1.2	36°C	22	91% - 100%
1.4 - 4.0	43°C	127	99% - 100%

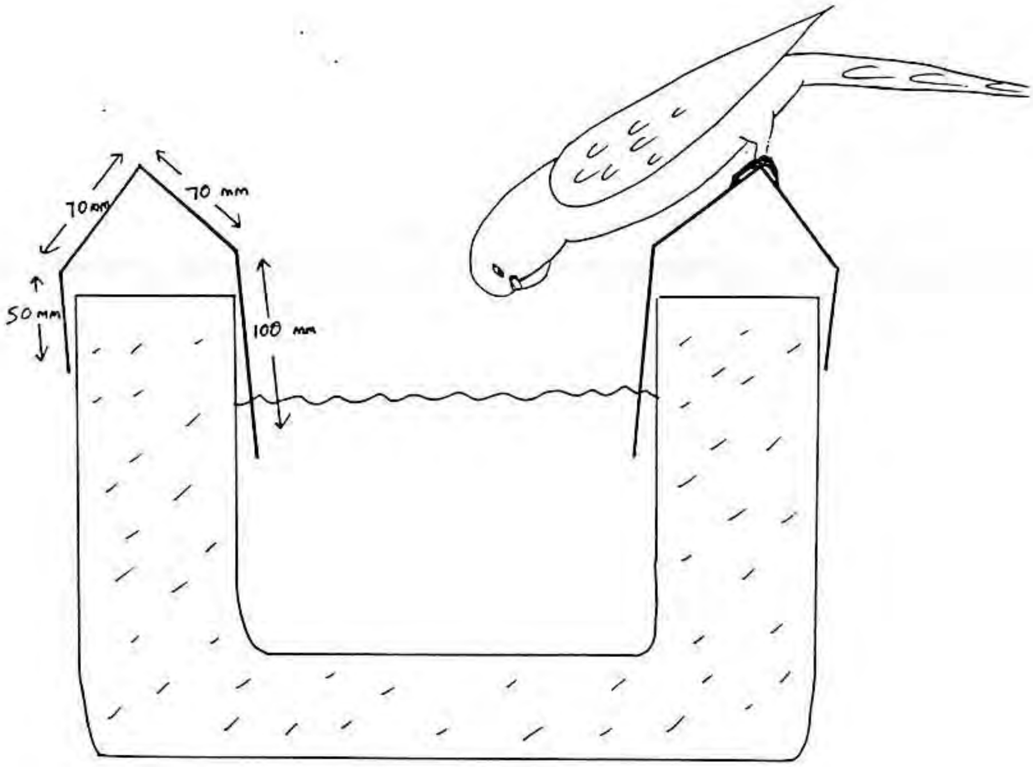

Fig. 1 Schematic representation of a cross section of the inverted guttering fitted to the edges of poisoned troughs. If the water level was below the bottom edge of the guttering, birds could perch on the inside of the trough. If the water level was too high, birds could reach the water from the apex. The latter could also be avoided by increasing the height of the guttering above the trough but this sometimes restricted access by young goats.

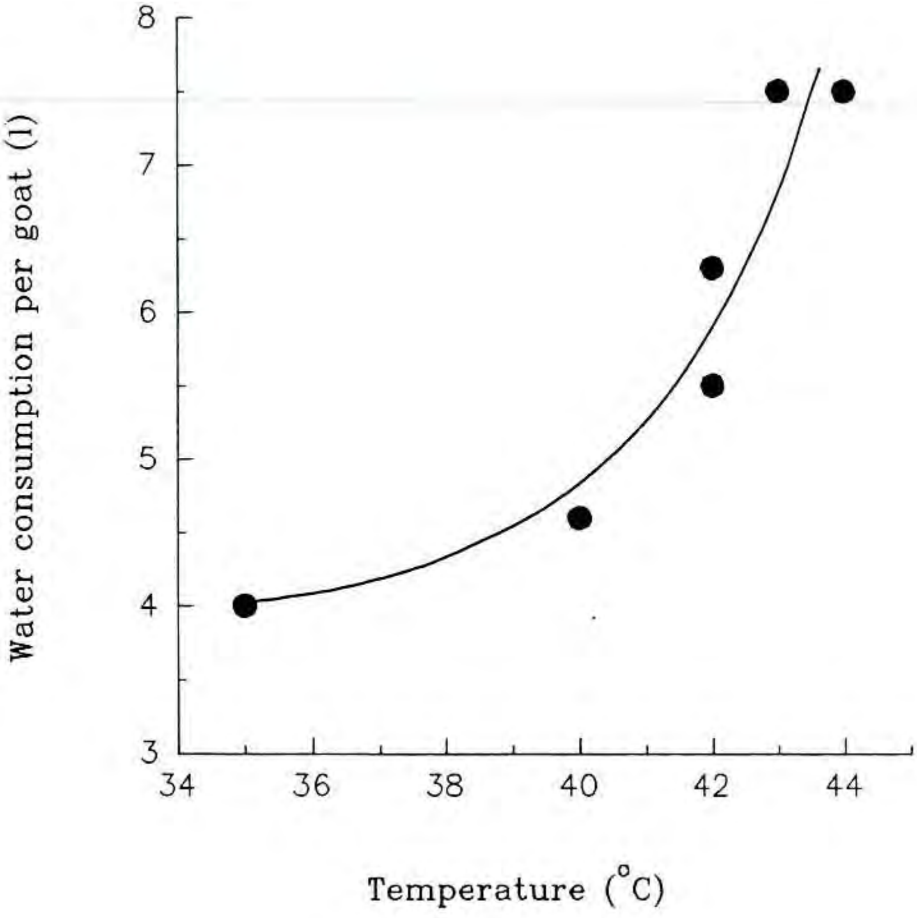

Fig. 2 The relationship between maximum temperature and water consumption by goats.

APPENDIX 4

FIELD TRIALS ON THE EFFICACY OF 1080 POISONING FOR FERAL GOAT CONTROL IN WESTERN AUSTRALIA

by

Grant Norbury

Research Officer

Agriculture Protection Board

of Western Australia

April 1993

SUMMARY

1. A 70% reduction in the number of feral goats frequenting poisoned watering troughs was achieved over a 4-7 day period using a concentration of 7 mg of 1080 per litre of water between the hours of 6:30 am and 12:30 pm.
2. Many of the remnant goats were billies and older nannies, animals that have the least potential to achieve a rapid population recovery.
3. Poison delivered to goats from dull-coloured introduced troughs was less repellent to goats than existing troughs that were modified with bird-deterring ridge capping.
4. Goats were willing to drink from poisoned troughs placed adjacent to the goats' favourite drinking trough.
5. Poisoned goats dispersed up to 6 km from a poisoning station, thereby avoiding congestion of carcasses.
6. Goats succumbed to poison with little apparent suffering.
7. Introduced poison troughs were 100% effective in deterring birds, provided their regular drinking trough was available.

INTRODUCTION

These trials were conducted to examine the practicalities and efficacy of using compound '1080' (sodium monofluoroacetate) in water to reduce feral goat populations frequenting targeted watering points in the pastoral areas of Western Australia. The risk of poisoning non-target species was also examined.

METHODS

A total of six watering points that were frequented by relatively large numbers of goats were chosen for study in the Gascoyne (3 points), Goldfields (1 point) and Shark Bay regions (2 points).

Poison was offered to goats at a concentration of 7 mg of 1080 per litre of water. Norbury (1992) found this concentration sufficient to kill 99-100% of yarded feral goats. At some sites, poison was offered in an existing watering trough that was modified to deter birds from drinking (see later). An adjacent trough was introduced as an alternative water source for birds and meshed off from goats. At other sites, poison was offered in an introduced trough that, by virtue of its foreign nature, had inherent bird deterring characteristics. At these sites, birds were able to drink from an adjacent existing trough that was meshed off from goats. Over 3,000 observations were made opportunistically of birds drinking at the study sites.

Poison troughs were connected to mobile tanks that stored the poisoned solution. Sheep are susceptible to the 1080 solution required to kill 100% of goats. Therefore, it was necessary to mesh off the poisoned troughs from sheep and provide a narrow plain wire gate that allowed goats to pass through but obstructed sheep from entering the yard. The number of goats passing through the plain wire was recorded. Poison was removed at 12:30 pm and the plain wire removed to allow sheep to drink. The volume of poison remaining in the tank was measured to determine the average volume of poison consumed per goat.

The effect of poison in reducing goat population size was indexed by recording the decline in the number of goats frequenting targeted watering points. The initial population was calculated by averaging the daily number of goats seen before poisoning began, and the numbers seen during the first two days of poisoning. The frequency at which goats drink is uncertain, but probably occurs every 1-3 days during warmer months (Dawson *et al.* 1975). This will depend on age, sex, breeding status, temperature, food quality and water quality. Therefore, the number drinking during the first two days of poisoning was considered a suitable contribution to an estimate of the local population size that existed before the effects of poisoning took place. The number of goats on the last day of poisoning was taken as a crude estimate of the number remaining after poisoning. Lack of time and resources precluded monitoring the watering points for several days after the poisoning period. The percentage population decline was calculated using the initial and final numbers of goats. It should be pointed out that these reduction rates do not necessarily indicate percentage kill, because they will be confounded to some extent by immigration and emigration of goats into and out of the study sites.

The trials took place between February 15 and March 3 1993, from 6:30 am to 12:30 pm. Some variations in methodology between study sites was necessary to accommodate the different situations at each site.

STUDY SITES

Site A - Allen's Well, Minara station, Goldfields region.

The poison trough was an existing trough that was modified with ridge capping applied to the edges of the trough so that birds were unable to reach the poison (see Plate 2 in Appendix A2). An alternative trough was introduced for birds and meshed off from goats. A pre-poisoning period of five days was allowed to survey the number of goats frequenting the watering point, and to examine the effect of the poison trough in deterring birds. The equipment was removed for three days, then re-introduced on day 9 and poisoned for the following four days.

Site B - Latham's Tank, Doorawarrah station, Gascoyne region.

The poison trough was an existing trough that was modified with ridge capping to deter birds. An alternative trough was introduced for birds and meshed off from goats. The pre-poisoning period lasted for three days, followed by a four-day break, and four days of poisoning.

Site C - Yarrabiddy Tank, Doorawarrah station, Gascoyne region.

The poison trough was an introduced trough. An existing trough was meshed off from goats and provided water for birds. The pre-poisoning period lasted for three days, followed by a four-day break, and four days of poisoning.

Site D - South Walbinalya Bore, Doorawarrah station, Gascoyne region.

The poison trough was an introduced trough. An existing trough was meshed off from goats and provided water for birds. There was no pre-poisoning period and poisoning lasted for seven days.

Site E - Eagle Bluff Bore, Peron Peninsula, Shark Bay region.

The poison trough was introduced onto a bore that had previously not been operating. No alternative trough was available for birds. There was a pre-poisoning period of three weeks in order to attract goats to the watering point. Poisoning occurred over five days.

Site F - Peron Homestead Bore, Peron Peninsula, Shark Bay region.

The poison trough was introduced onto a site that had a small pool that filled from an artesian bore overflow. The pool was meshed off from goats and provided alternative water for birds. For simplicity, the birds drinking from the pool were classified as those drinking from an existing bird trough (see Table 2). The poison trough was introduced three weeks before poisoning in order to accustom the goats to the trough. Poisoning occurred over five days.

RESULTS AND DISCUSSION

Goat Poisoning

The percentage reduction in goat numbers frequenting poisoned watering troughs during a poisoning period of 4-7 days varied from 20% to 96% (Table 1). By pooling the data from the six study sites, an average reduction of 70% of the original population was estimated.

Table 1 The percentage reduction in the number of goats frequenting poisoned watering troughs during a 4-7 day poisoning period at six sites in Western Australia. 100(X-Y)/X where X=daily average number of goats before poisoning (where appropriate) and during the first two days of poisoning; and Y=the number of goats present on the last day of poisoning.

Site	Poison trough	% Reduction in site's feral goat population	Average volume drunk per goat	Mean max. temperature	Water salinity
A	Modified existing	100(83-3)/83 = 96%	3.8 litres	34°C	935 ppm
B	Modified existing	100(59-17)/59 = 71%	3.3 litres	40°C	1865 ppm
C	Introduced	100(71-33)/71 = 54%	3.7 litres	40°C	1474 ppm
D	Introduced	100(113-21)/113 = 81%	4.9 litres	35°C	5825 ppm
E	Introduced	100(59-22)/59 = 63%	8.1 litres	27°C	3540 ppm
F	Introduced	100(40-32)/40 = 20%	4.9 litres	27°C	4728 ppm
	AVERAGE	100(425-128)/425 = 70%	4.8 litres	34°C	3061 ppm

There was no apparent correlation between goat reductions and the volume of poison consumed per goat. There was, however, a negative correlation between consumption per goat and the mean maximum air temperature; and a weaker, positive correlation between consumption per goat and water salinity (Table 1). Why goats appeared to drink less with increasing temperature is puzzling and is the opposite to that found by Norbury (1992). However, no account is taken of regional differences in drinking frequency. For example, the goats at Sites A, B and C may have drunk every day and therefore required less water per drink, compared to goats at the other sites that may have drunk every two days and therefore required more water per drink. These trends are also difficult to interpret because of variations in vegetation structure, and hence goat diets, between study sites.

Occasional ground searches found goat carcasses anywhere up to 6 km from the poisoned troughs. This high dispersion of poisoned goats means that congestion of carcasses around watering points will not be a problem for station managers.

Norbury (1992) observed no obvious signs of yarded goats suffering from the effects of 1080 poisoning. The same result was apparent for goats that had dispersed and died away from the watering points. Evidence of physical struggling was rarely present.

Factors Influencing Goat Drinking Behaviour

While a minority of goats drank during the late afternoon, the vast majority drank before midday. Ninety-five percent of the morning drinkers drank between 6:30 am and 11:30 am (Fig. 1).

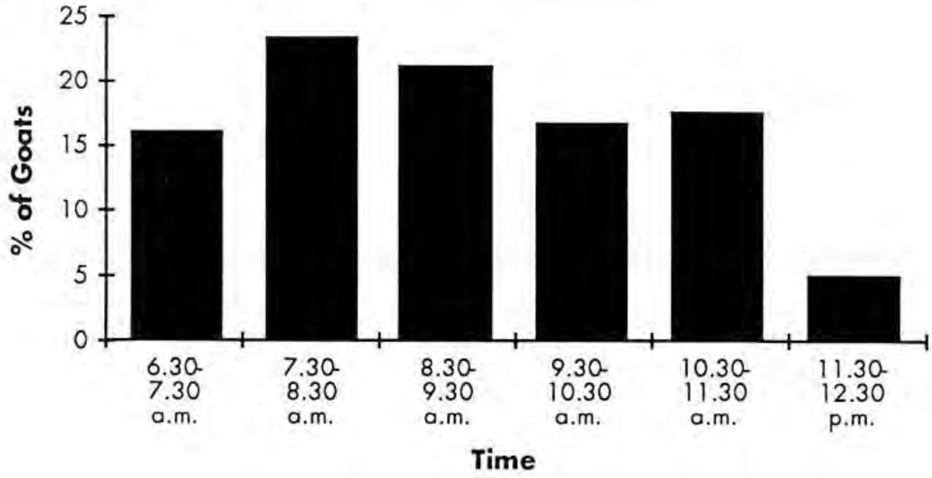

Figure 1 **The percentage of goats seen arriving at the targeted watering points during one hour intervals between 6:30 am and 12:30 pm (N=1948 goats).**

When goats approached a poisoned trough for the first time, they baulked at the modifications in place and were reluctant to enter the yards for the first 10 minutes or so, or for a whole day, in the case of very cautious individuals. Goats that found their regular watering trough closed off took a long time to adjust to entering a poisoning yard that appeared to be an unpreferred choice. There was insufficient data to numerically differentiate between the time taken for goats to habituate to introduced poison troughs versus modified, existing poison troughs. However, it appeared from our observations that introduced troughs, placed immediately adjacent to the goats' favourite trough, took less getting used to compared with existing troughs that were modified with ridge capping. For example, if goats knocked the sheet metal capping, it startled them and induced extra caution. Moreover, displaced capping occasionally allowed birds to drink. The time taken for goats to habituate to poisoning equipment was reduced if dull colours were used and daily maximum air temperatures were high.

When large numbers of goats were milling around the poisoned troughs, it was difficult to determine the number of goats that had actually consumed the poison. It was estimated that 65-70% of the goats frequenting a watering point had consumed the poison. This figure concurs with the overall population reduction rate of 70%.

Goat numbers were never reduced to zero following a 4-7 day poisoning period. Remnant goats consisted of those that were shy of the poisoning equipment, and new individuals that had not previously been observed. It was sometimes noted that the majority of the remnant population comprised billies and older nannies. This has important implications for goat control because these animals have relatively little impact on the population's ability to recover. It appears that smaller, lactating nannies need to drink every day during the hot summer months. Consequently, the most productive part of the goat population is the most vulnerable to poisoning.

Poison Concentration in Carcasses

The average volume of poison solution consumed per goat was 4.5 litre (N=1778 goats). This is about 19% of the body weight of an average sized 24 kg goat (K. Russell pers. comm.). The concentration of poison offered to goats was 7 mg/l. This means that an average goat received a dose of about 1.3 mg of 1080 per kg of body weight. Norbury (1992) found this dose sufficient to kill nearly 100% of goats.

There is minimal risk of secondary poisoning from the carcasses of poisoned goats. The native animals that are likely to feed from the carcasses are sand goannas, wedge-tailed eagles and crows. These animals are resistant to 1080 concentrations required to kill goats. Furthermore, the concentration of poison in the muscles of the goats would be lower than in the gut; some of the 1080 would be excreted; and some would be detoxified.

Non-target Species

Only two crows were able to drink from an introduced poison trough. This occurred only at site E, where no alternative water was available for birds. This was in stark contrast to a total of 2,633 birds observed drinking from adjacent existing bird troughs during the same observation period (Table 2).

Twenty-nine birds were seen drinking from the modified, existing poison troughs. These comprised 15 galahs, six zebra finches, three crows, three yellow-throated miners, one mulga parrot and one spotted bowerbird. These birds were able to drink either because the ridge capping had been displaced by goats or because the birds were drinking water on the wing, as was the case for zebra Finches and yellow-throated miners. A total of 362 birds were seen drinking from adjacent introduced bird troughs during the same observation period (Table 2).

The introduced poison trough, with an existing trough for birds nearby, was 100% effective in deterring birds from the poison trough. Provided the birds' regular drinking trough was available, and a foreign poisoning trough was in place for only the duration of poisoning, birds were never interested in attempting to drink from the foreign trough. This was evidenced by the fact that some birds were successful in drinking from the existing troughs that were modified to deter birds. In these cases, birds preferred to battle with the ridge capping on their regular troughs in their efforts for a drink, rather than drink from a foreign trough nearby. In fact at site B, it appeared as though many birds had dispersed from the watering point, despite the presence of an introduced bird trough. Some birds eventually drank from the introduced bird trough at site A after it was painted 'mission brown' (previously aqua). Reducing the brightness of troughs in this manner also reduced the caution shown by goats.

Table 2. The species and numbers of birds observed drinking from introduced poisoned troughs; from existing bird troughs that were meshed off from goats (these types of troughs were both at sites C, D, E and F); from existing poison troughs that were modified to deter birds; and from troughs that were introduced for birds as alternative water (these types of troughs were both at sites A and B). * = no alternative trough for birds.

Common Name	Scientific name	Intro. poison trough	Existing bird trough	Modified existing poison trough	Intro. bird trough
Australian Pipit	*Anthus novaeseelandiae*	0	12	0	0
Black-faced Cuckoo-shrike	*Coracina novaehollandie*	0	3	0	0
Bourke's Parrot	*Noephema bourkii*	0	23	0	1
Common Bronzewing Pigeon	*Phaps chalcoptera*	0	54	0	1
Crested Pidgeon	*Ocyphaps lophotes*	0	825	0	54
Crow	*Corvus bennetti*	2*	223	3	2
Galah	*Cacatua roseicapilla*	0	163	15	69
Grey Currawong	*Stepera versicolor*	0	3	0	1
Magpie Lark	*Grallina cyanoleuca*	0	3	0	1
Mulga Parrot	*Psephotus varius*	0	132	1	10
Peaceful Dove	*Geopelia striata*	0	92	0	0
Port Lincoln Parrot	*Barnardius zonarius*	0	147	0	29
Silvereye	*Zosterops lateralis*	0	1	0	0
Singing Honeyeater	*Lichenostomus virescens*	0	8	0	0
Spiney-cheeked Honeyeater	*Acanthagenys rufogularis*	0	5	0	9
Spotted Bowerbird	*Chalmydera maculata*	0	41	1	48
Welcome Swallow	*Hirundo neoxena*	0	12	0	0
Willie Wagtail	*Rhipidura leucophrys*	0	6	0	3
Yellow-Throated Miner	*Manorina flavigula*	0	1	3	52
Zebra Finch	*Poephila guttata*	0	879	6	82
TOTAL		2*	2633	29	362

King (1990) lists the sensitivity of some bird species to 1080. Although the list is not extensive, only two of the 20 species observed drinking during this study would be at some risk from the 1080 solution required to kill goats. These were zebra finches and galahs. Although not observed in this study, emus may attempt to drink during poisoning hours. Even if they were able to negotiate the plain wire fence that obstructs access to the poisoned trough, they would show no adverse effects because they are highly tolerant to 1080 (see King 1990).

Some red kangaroos and euros will be at risk from poisoning if they drink the 1080 solution at the concentration required to kill 100% of goats (Norbury 1992). However, because kangaroos and euros are dusk and night-time drinkers, poisoning between 6:30 am and 12:30 pm should pose no risk to kangaroos.

The goat mesh used to exclude sheep from the poisoned troughs is insufficient to deter cattle. Therefore, where cattle are present, portable cattle yards will need to be erected around poisoned troughs.

Foxes were sometimes seen drinking the poison during the early hours of the morning. Foxes are highly susceptible to 1080 and are currently subject to pest control programs.

ACKNOWLEDGEMENTS

These trials were conducted by Colin Holt, Geoff Thomas, Terry Donnelly, John Russell-Pell, Simon Kniveton, Geoff Cahill, Danny Carlisle, John Websdale, Rex Walker, Ron Shepherd, Mark True, Arthur Pepper and Malcolm Edgar. Thanks also to Dr. Dennis King for his advice. Brian Moore and Murray Thomas kindly allowed access to Doorawarrah and Minara stations, respectively.

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King, D.R. (1990). 1080 and Australian fauna. Agriculture Protection Board of Western Australia Technical Series No. 8. (This reference is provided in Appendix 2.)

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APPENDIX 5

EXAMPLE OF A 1080 FERAL GOAT POISONING NOTICE

AGRICULTURE AND RELATED RESOURCES PROTECTION ACT 1976

POISONING OF FERAL GOATS IN PARTICULAR AREAS

Notice under Section 68 (3)

Agriculture Protection Board to use Poison

1. The Agriculture Protection Board proposes to use Sodium Fluoroacetate (1080) in the area specified in the Schedule.

Taking of feral goats is absolutely prohibited for a period of time

2. The taking of feral goats is prohibited in the area specified in the Schedule from December 6 1994 to December 17 1994 at which time this notice is deemed cancelled.

Offence to take feral goats - penalty $500

3. Any person who takes feral goats in the area specified in the Schedule commits an offence under Section 68 (3) of the Act, the penalty for which is $500.

WARNING

FERAL GOATS TAKEN FROM THE AREA SPECIFIED IN THE SCHEDULE DURING THE TIME THIS NOTICE IS IN FORCE ARE LIKELY TO ENDANGER OR BE DETRIMENTAL TO HUMAN HEALTH OR LIFE IF HANDLED OR CONSUMED.

Schedule

Brickhouse Station	(Lease Number	3114/593)
Corralya Station	(Lease Number	3114/577)
Doorawarrah Station	(Lease Number	3114/724)
Ella Valla Station	(Lease Number	3114/733)
Jimba Jimba Station	(Lease Number	3114/850)
Mardathuna Station	(Lease Number	3114/1206)
Meeragoolia Station	(Lease Number	3114/402)
Mooka Station	(Lease Number	3114/1199)
Yalbalgo Station	(Lease Number	3114/964)

M.D. CARROLL, Chairman, Agriculture Protection Board.