# ESP PROJECT NUMBER 38

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# YEAR END REPORT (JUNE 1992) TO THE AUSTRALIAN NATIONAL PARKS AND WILDLIFE SERVICE

## Project Title: Control and Ecology of the Red Fox *Vulpes vulpes* in Western Australia

**Nominated Officer**
**Chief Investigator: Dr. Jack Kinnear**
**Consultants: Dr. David Algar**
**Ms. Nicola Marlow**

**Western Australian**
**Department of Conservation and Land Management, Wildlife Research Centre, P.O. Box 51, Wanneroo, 6065.**

**Ph. (09) 405-5137 ♦ Fax (09) 306-1641**

# TABLE OF CONTENTS

## EXECUTIVE SUMMARY

### Preamble

The purpose of this is section of the report to provide a overview of the research on the fox as carried out by CALM. We believe that this will be helpful in the light of an important development regarding fox control namely, the award of a Cooperative Research Centre (CRC) dedicated to controlling vertebrate pests through the biological control of fertility.

The creation of the CRC was a significant event for it signified that the fox is now officially recognised as a major threat to the nation's wildlife. In effect the award sanctioned the need for biocontrol. This was a decision that was most welcomed in CALM because from the beginning, we have structured and designed our research towards achieving this goal.

The following summary will highlight this aspect. Details relating to the specific scope items follow this section.

### Research Objectives

ANPWS funding of CALM's research program on fox ecology and control has been directed along the following inter-related lines of research.

- **Predator Control** of which there are two lines of investigation in progress:

    1. Control by baiting with 1080.
    2. Control of fertility by biological means.

- **Predation Ecology** with emphasis on identifying those species of native wildlife at risk to introduced predators, primarily the fox.

All of these lines of investigation are integrated to varying degrees.

**Control Through 1080**

Control of the fox using 1080 baits is a well established method. What has not established is the level of control that is cost-effective especially for wide-area control. Such information is essential if large areas such as National Parks are to be baited.

Four variables govern the economics of fox control; they are: baiting frequency; number of baits laid; bait uptake by foxes, and the re-invasion rate of foxes into baited areas.

Field experiments have been performed to quantify these variables. In an experiment designed to determine the timing and extent of recolonisation, foxes were eradicated (Watheroo National Park) and at appropriate intervals, the park was baited with non-toxic tetracycline labelled baits. These baits induce a 'label' in the teeth of foxes each time they ingest them. By repeatedly laying these baits at appropriate time intervals throughout the year, it is possible to determine when an individual entered an area by counting the number of labels present in its teeth. This is done without disrupting the natural immigration pattern. An estimate of relative fox density is also obtained when the foxes are finally sampled using cyanide transects.

The timing of recolonisation of Watheroo National park has not yet been determined because the analysis of the biomarker in the teeth is not yet complete. It is clear, however, that the minimum baiting regime is twice per year, but whether or not this intensity affords adequate predator control is not known; this question is being addressed elsewhere (see below).

In an another field experiment, tetracycline baits provided a means to measure bait uptake (proportion of foxes ingesting at least one bait) as a function of number of baits laid. Replicate trials were conducted in which baits were laid at two levels (5 and 10 bait/$km^2$). Cyanide baits were then used to sample the fox population and to determine the proportion of the population that had ingested the tetracycline baits at each baiting rate.

**Applying a Baiting Protocol: FRNP**

The preliminary results from these experiments have been put to test in Fitzgerald River National Park (FRNP). Baiting has been restricted to two occasions per year at an5 application rate of 6 baits per $km^2$. The FRNP experiment is significant because it will test a baiting strategy for large reserves carrying endangered fauna. It was designed to extend our knowledge about the range of species affected by exotic predators. The FRNP, with its rich array of species (22 mammals), affords an opportunity to extend our knowledge about this aspect and thus, it is a very efficient experiment in this regard.

**Biocontrol Through Baiting**

The experiments described above, although designed to establish cost-effective baiting procedures have immediate application to a current CRC biocontrol research program. Dr. Mark Bradley proposes to deliver via baits, a fox sperm antigen that would induce antibodies to sperm thus blocking fertilisation. Given the successful development of this proposal, we would be able, by combining our knowledge of baiting regimes with that of cyanide baiting, to recommend and carry out the following: the number of sterilising baits required; the rate of lay; the optimum timing of baiting; the density of foxes exposed to the baits, the proportion of foxes taking baits; and the proportion of the fox population sterilised by the baits.

In a similar manner, using immunocontraceptive baits we would be able to determine the proportion of the population that **needs** to be sterilised to substantially reduce the fox population. Finally, we would be able to answer this very important question: What percentage of the fox population **must one make sterile** in order to relieve the predation pressure on the fauna at risk. At this stage, we cannot predict to what level we need to reduce the fox population (through infertility) to afford protection to prey species.

At present we are able to test the CRC concept of fertility control using the tools and methods that we have developed to date. In other words, we will be able to determine whether the concept is feasible. Moreover, when the Bradley proposal is ready for field testing in 3-4

years time, we will undoubtedly be in a position to do it even more efficiently.

### Epidemiology: Additional CRC Related Research

CALM's research has been guided by the epidemiological models described by Anderson (1991). We have endeavoured to develop the necessary tools and methods to quantify the parameters that will enable a modeller to solve the relevant differential equations that describe the epidemiology of a biocontrol agent. When a viral vector is selected, various epidemiological parameters that relate to its spread need to be quantified. We need to know more about fox social organisation, contact rate, and about some characteristics of the fox as a viral host. If a sexually transmitted virus is adopted, an understanding of the mating system must also be known.

### Contact Rate: two approaches

Contact rate is a very difficult parameter to quantify and it is usually the one epidemiological factor that is least understood. Two approaches are being used to investigate it: the first uses DNA profiling (fingerprinting) and the second employs a new form of telemetry which aims to measure contact rate directly.

### DNA Profiles

The DNA profiling technique is currently being developed. To apply it, a fox population must be adequately sampled and this involves the use of cyanide. However, killing foxes with our cyanide technique results in the degradation of DNA and standard probes cannot be used on degraded DNA. To overcome this limitation, a micro-satellite probe is being developed which can be used on even highly degraded DNA.

DNA profiling will be used to provide information about minimum sexual contact rate, the mating systems of foxes, and the parentage of litters. All of these studies will yield information relevant to the epidemiology of the viral vector.

### Screening for Fox Viruses

CALM researchers have been involved in collecting sera for viral screening of foxes in an attempt to find a suitable vector for genetic

engineering. Other biological samples such as reproductive hormones, ovaries and testes have also been collected for processing by CRC scientists in Canberra.

**Research on 1080**

Fertility control of foxes holds considerable promise, but it is estimated that apart from the time required for the research and development, the approval process may take even longer. Moreover it remains to be shown that fertility control alone will be sufficent to control foxes; a mortality agent may still have to be employed under some circumstances. This means that the need for 1080 to control predators will still be with us for a considerable time to come. Indeed, fox control using 1080 baits is a major component of ANPWS funded recovery plans for many endangered mammal species.

Public concern about the use of 1080 is often expressed through the media and it is usually ill-informed. In some countries the use of 1080 is banned. It is important therefore, that conservation agencies demonstrate convincingly that 1080 is being used responsibly and with understanding.

Our understanding is limited because 1080 is difficult to analyse in complex organic materials and particularly in the case of meat baits. A new bioassay has been developed which holds considerable promise. At this stage, it is suitable for all materials except for meat, but this should be resolved in the near future. Once these problems are overcome, we will be able to deliver to conservation agencies a very useful 1080 assay.

To conclude this summary, the most significant event during the year was the formation of the CRC. It is pleasing to be able to state that CALM's fox projects as funded by ANPWS have already addressed areas of research highly relevant to the aims of the CRC.

## SCOPE ITEMS

### 1. Recolonisation Of Watheroo National Park By Foxes

The study of fox re-invasion into Watheroo National Park, situated approximately 200km north-east of Perth, was conducted as part of a broader investigation examining various aspects of fox dispersal. In October 1990 all tracks and firebreaks within the 100km$^2$ study area were initially baited with cyanide capsules to determine a CPUE index for a previous study (Algar and Kinnear 1991); a follow-up 1080 baiting was then conducted. 1080 meat baits (4.5mg 1080/bait; 10 baits/km$^2$) were laid along all tracks from a vehicle to remove any remaining resident foxes from the area. Using this baiting regime it is reasonable to assume (*op. cit.*) that the foxes collected at a later date were animals that had migrated into the area following the baiting exercises.

Non-toxic, tetracycline labelled meat baits were used to determine the timing and extent of migration into the study area. Tetracycline is incorporated into tooth dentine after a labelled bait is eaten, and appears as a yellow fluorescent ring under UV light. The methodology for the use of tetracycline labels is discussed in detail by Johnson *et al.* (1989). Tetracycline labels are located within the Von Ebner lines in chronological order; and so it is possible to assign foxes to a particular re-invasion period if labelled baits are laid at specific time intervals. The major benefit of using a tetracycline label lies in the ability to examine migration into an area without disturbing or destroying the population.

Previous research (Algar and Kinnear 1991) indicated that dispersal is primarily undertaken by juveniles. From late January onwards, juvenile foxes appear to be sufficiently mobile and independent to disperse from their natal ranges. These animals would need to have successfully settled and established their home ranges prior to the onset of breeding (June/July). Re-invasion into the control area was therefore examined during three time intervals, shown below. Tetracycline baits were laid at the beginning of February and April. Foxes colonising the area and consuming these baits could then be

assigned to a particular recruitment period based on the number and location of fluorescent rings in the dentine (Table 1).

Table 1. Use of a Biomarker (Tetracycline) to determine the time of recolonisation by foxes into a control area.

| Period | Labelling Period | Max. Number of Bio-labels |
|---|---|---|
| 1 | Jan.- Feb. | 2 |
| 2 | Feb.- April | 1 |
| 3 | Apr.- June | 0 |

A capsule containing 150mg of tetracycline-HCl was inserted into each meat bait. Baits were cut from kangaroo meat (120g wet-weight) and then dried to 40 percent of their original weight. The labelled baits were placed at 100m intervals along all tracks and firebreaks within the study area. This level of baiting intensity was used to try to ensure that all foxes within the area would consume a labelled bait. The baits were left in place for four days and any baits not consumed were retrieved to avoid confusing the recruitment period.

Foxes were collected, using cyanide baiting, at the beginning of June 1991. Cyanide capsules were placed at 200m intervals along the network of tracks within the study site. This allowed population density, recruitment period and age classes to be assessed. The methodology and sampling of fox populations using the cyanide technique is described in Kinnear and Algar (1991) and in Algar and Kinnear (1992).

A total of 32 foxes and 4 cats were collected over the three day period. The number of foxes collected, and the CPUE indices for each of six transects are given in Table 2.

Table 2. Number of foxes killed and CPUE indices for individual transects

| Transect No. | Foxes Killed | CPUE Index |
|---|---|---|
| 1 | 2 | 0.8 |
| 2 | 11 | 7.2 |
| 3 | 2 | 1.3 |
| 4 | 9 | 6.4 |
| 5 | 7 | 4.0 |
| 6 | 1 | 0.6 |

The data indicate an apparent non-uniform distribution of foxes within the study area as shown by the high variability between individual transect CPUE indices. The implications and importance of heterogeneous fox densities to control strategies are discussed in Section 2.2.

The sex ratio of foxes collected did not differ significantly from 1:1 (16 males to 16 females). The number of foxes killed on the two different lures also did not differ significantly (17 on liver-blood paste to 15 on condensed milk). All cats were killed on the liver-blood paste lure.

Analysis of the population age structure and tetracycline labelling has yet to be completed. Difficulties were experienced when sectioning teeth with a borrowed single blade isomet saw and so a double bladed model was purchased. We have only recently gained delivery of this equipment and the fluorescent barrier filters required to detect the tetracycline labels. We are now in the process of completing the laboratory work. Results of these analyses will be presented in the next report.

## 2. Wide-Area Baiting Intensity Trials

### 2.1 Determining The Effectiveness Of Different Levels Of 1080 Baiting

The main method of fox control, both in nature conservation and agricultural areas in WA, is baiting using meat baits containing 1080 (sodium monofluoroacetate). The recommended baits for fox

control in WA are cut from kangaroo meat (120g wet-weight), injected with 4.5mg of 1080, and then dried to 40% of their original weight. The baits are manufactured by the Agriculture Protection Board.

The aim of this initial study was to establish a benchmark for measuring the effectiveness of 1080 baiting for fox control. It is naturally desirable to conduct baiting programmes that are economic and effective rather than using an excessive number of baits that would be costly and pose additional risks to non-target species.

A previous study at Watheroo National Park indicated that a baiting regime of 6 baits/km$^2$ reduced fox population levels by approximately 90 percent (Algar and Kinnear, 1992). This study examines the effectiveness of two levels of baiting intensity (i.e. number of baits laid per km$^2$) on fox populations in three different geographic regions, described below. Baiting intensities of 5 and 10 baits/km$^2$ were chosen as the reference points for any future baiting experiments. Thus, ultimately it will be possible to prescribe an optimal baiting intensity for effective fox control at different fox densities, taking into account regional differences.

The three geographic areas were:

Study Area 1
Nepowie situated in the Central Wheatbelt, approximately 250km south east of Perth. The site consists of small nature and game reserves interspersed between agricultural land.

Study Area 2
Pinjarrega Nature Reserve/Big Soak Plains situated in the Northern Sand Plain region, approximately 250km north of Perth. The site comprises Nature Reserves and Vacant Crown Land, typical of this region.

Study Area 3
Scott River, situated on the south coast, approximately 350km south of Perth. The site consists of State Forest and vacant Crown Land.

Evaluation of the effectiveness of different baiting intensities is based on the percentage of that population killed at each baiting intensity. The availability of baits to any individual fox will depend on the number of baits laid and the number of foxes in that area. Population density cannot be assumed to be the same in all areas and therefore must be measured in each site.

Cyanide bait stations along standard transects, (see Kinnear and Algar 1991), were used to generate an index of fox density. There is a functional relationship between CPUE and relative changes in fox density (Algar and Kinnear 1992). Therefore, it is possible to use this index to ascertain whether fox densities in different areas are comparable. The index has not yet been calibrated for absolute fox density for a given area and therefore it is not possible to provide actual density values for the study sites.

Use of the biomarker tetracycline (see Sections 1.1 and 1.2) provides a simple technique for measuring the effectiveness of baiting regimes. Tetracycline produces a fluorescent mark in animals that have taken a bait.

Two sites, one for each baiting intensity, within each study area were aerially baited along flight transects 1km apart. The two sites were separated by a buffer of at least 5km to avoid any confounding of treatment. A minimum period of at least 10 days was allowed for the baits to be consumed prior to implementing cyanide baiting. Cyanide baiting was then conducted within each site to sample the fox population and to determine the percentage of the population labelled. Additional samples were collected in some sites by shooting at night with the aid of a spotlight. The effectiveness of each baiting intensity is then judged by the proportion of the population labelled.

Cyanide baiting campaigns, at the three sites, were completed during December 1991. The number of foxes collected at each site is given in Table 3.

Table 3. Number of foxes collected; (·)numbers shot.

| Study Area | Foxes Collected |
|---|---|
| Area 1 | 43 (4) |
| Area 2 | 119 (0) |
| Area 3 | 98 (22) |

Comparisons of the CPUE index (mean ± standard error) for the two sites within each study are given in Table 4.

Table 4. CPUE statistics for sites within areas.

| Study Area | CPUE Site 1 | CPUE Site 2 |
|---|---|---|
| Area 1 | 3.96 ± 1.42 | 3.49 ± 0.80 |
| Area 2 | 11.92 ± 6.94 | 6.33 ± 0.46 |
| Area 3 | 13.34 ± 6.67 | 9.89 ± 4.65 |

These data indicate that relative fox densities within the two sites for each study are not significantly different. However, it must be noted that, as with data in Table 2, fox numbers collected along individual transects within sites vary considerably as indicated by the high standard error. As such, fox density is unlikely to be uniform across an area but rather to vary according to resource variations.

The population structure of the sampled foxes, for each study area, is presented in Table 5 (see Sections 2.3 and 2.4).

Examination of tetracycline labelled animals has been hampered by the late delivery of an isomet saw, as described in the previous scope item. We are now at the stage of sectioning the teeth and completing the laboratory work. Results of the analyses will be forwarded in the next report.

### 2.2 Calibration Of The CPUE Index

The cyanide baiting technique, discussed earlier in this report, provides a rapid and efficient method for sampling a fox population. Moreover, the method is potentially useful for estimating fox density. Quantification of fox density is essential for:

- determining the intensity of baiting regimes
- evaluating the effectiveness of control whether it be conventional 1080 baiting or biological control,
- modelling fox population dynamics,
- modelling predator-prey dynamics.

As discussed in the previous report, it was originally hoped to conduct preliminary calibrations of the CPUE index during the wide-area baiting intensity trials. After considerable trapping effort, radio collar failures unfortunately precluded any detailed assessment. Continual manufacturing faults observed in radio transmitters from various suppliers have prompted our recent development of a new improved design. The prototype has been bench tested during the last six months and it shows considerable promise.

An integrated approach is proposed for the examination of CPUE indices and fox density, and is presented in the Scope items for 1992-93. The new technology, which enables recording of contact events, will permit investigation of the apparent variability of fox density levels within areas. It will therefore be possible to assess whether the observed variability between transects is real or an artefact of our sampling procedures. The presence of heterogeneous fox densities, within relatively small areas, have important consequences to an understanding of predation pressure and to the interpretation of the effectiveness of control strategies.

**2.3 and 2.4. Social And Age Structure Of Fox Populations: Viral Screening**

The cyanide transects used in the wide-area baiting intensity trials (see Section 2.1) have provided samples for the examination of various aspects of fox biology relevant to biological control strategies in widely different geographic regions. Aspects to be investigated include:

- age structure
- social structure
- viral reservoirs as possible sources of biocontrol vectors.

Details of age structure, in terms of annual cohorts, will be available when the tooth sectioning work is completed. Nevertheless, it is possible to divide the animals collected into the categories of adult or juvenile. The population age structure on this basis, for the three study areas, is presented in Table 5.

Table 5. Population age structure.

| Study Area | Adult | | Juvenile | | Total |
|---|---|---|---|---|---|
| | Male | Female | Male | Female | |
| Area 1 | 14 | 29 | 0 | 0 | 43 |
| Area 2 | 20 | 24 | 39 | 36 | 119 |
| Area 3 | 27 | 23 | 25 | 23 | 98 |

No juvenile animals were collected from Study Area 1. This was the first of the areas to be baited with cyanide and at this time the data indicate that cubs were most likely restricted to the den area. Of the vixens collected only three had cubs still *in utero*.

Male to female ratios for foxes collected in Study Areas 2 and 3 do not differ significantly from 1 : 1. The significant 1 : 2 ratio observed in Study Area 1 is not consistent with the 1 : 1 ratio obtained from trapping data for the region. When the data were examined on a site basis within the area, we found that a number of collared male foxes were not retrieved in the eastern site. The reason for this was not clear; however, local reports indicated that fox shooting had been undertaken on several farms, during lambing, immediately prior to the cyanide poisoning campaign. Shooting may have been biased towards males at this time because vixens would have been whelping and nursing cubs, and would thus be less likely to be shot as they remained close to their den sites.

Placental scars were used to determine the number of breeding females and their fecundity for each area (see Table 6). The technique used to identify placental scars is discussed by Englund

(1970). The litter size may be slightly overestimated as it has been found that some scars may represent abortions/resorptions or be persisting from earlier pregnancies (Lindstrom, 1981).

Table 6. Percentage of breeding females within populations and their litter size.

| Study Area | Breed Females | Placental Scars |
|---|---|---|
| | Percent | Mean ± s.e. |
| Area 1 | 82.8 | 3.6 ± 0.2 |
| Area 2 | 87.5 | 3.7 ± 0.2 |
| Area 3 | 73.9 | 3.7 ± 0.2 |

The relatively high percentage of breeding females within each of the populations and the apparent 1 : 1 male to female ratios suggest the social structures consists of mated pairs. However, interpretation of social organisation from a sub-sampled population rather than a total kill should be treated with caution. To be able to accurately define social structure it is necessary to examine survivorship of cubs and their parentage as well as male/female ratios. This was not possible for the above study areas but these matters have been addressed and are presented in Scope Items 1992-93.

To be able to determine parentage of cubs in future work, spleen samples were removed from all foxes collected and supplied to Ms. N. Marlow so that the DNA profiling technique could be refined (see Section 9.1). Sera samples were also collected to screen for viral antibodies. This material was supplied to Dr. S. Crerar, CSIRO. Wildlife and Ecology, Canberra.

## 3. Dispersal Of Foxes

A knowledge of various aspects of fox dispersal is a key factor in optimising control strategies. Patterns of fox dispersal will determine the timing and frequency of baiting programmes and the extent of buffer zones required to minimise immigration into protected/cleared areas. Dispersal data will also define, in part, the transmissibility and rate of spread of biological control agents and will be essential for modelling fox population dynamics.

Field work for this study commenced at the beginning of December. Individuals from 10 dens were captured and radio-collared. As outlined in the covering letter, commitments to the development of CRC proposals and schedules prevented further detailed work being undertaken. However, we were able to establish and refine the techniques necessary for this study to be conducted. Collaring individual cubs enabled the identification of active dens for excavation. It was then possible to excavate these den sites to collect all members of the litter.

The integrated research approaches, outlined in Scope Items for 1992-93, and the advances in our radio-tracking technology, will provide us with the unique ability to gain valuable information on the various aspects of dispersal relevant to control strategies, as listed below:-

- natural mortality of residents and juveniles
- litter size
- the timing, direction and distances covered by dispersing foxes,
- age structure of the dispersing population
- factors governing dispersal distances, including mortality.

## 4. Migration Of Foxes Into An Area Not Subjected To Control

A site has been selected in the northern area of Kalbarri National Park to examine the extent of recruitment into a non-disturbed (no fox control) area. Tetracycline baits were laid at the beginning of January to label the resident adult fox population and juveniles born in the area. Baits were laid, at 100m intervals, along a 85km network of tracks. The baits were left in place for four days and then any that had not been consumed were retrieved to avoid confounding of the treatment effect. Examination of the bait stations after four days indicated that all but five of the 950 baits had been consumed by foxes. The remaining five baits had been taken by pigs.

Cyanide baiting will be used to sample the population in August 1992. This timing was chosen because dispersal movement will have been completed and the next generation of cubs will be *in utero*. This study is designed to provide information on the following:

- the extent of dispersal into an area containing a resident population (dilution of marked animals)
- the extent of juvenile dispersal out of a stable population
- social structure: (sex ratio, percentage of females breeding and parentage [DNA profiles])
- fecundity

The study will also enable collection of material, from a large number of individuals, essential to biological control programmes. Blood will be collected for antibody assays to enable viral screening. Ovaries and testes will also be collected as part of the CSIRO study to identify specific proteins from eggs and sperm.

Progress in this study will be outlined in subsequent reports.

### 5. Gibson Desert Broad-Acre Baiting Program

The status of the fox in the Gibson desert has been investigated now for the past 3 years. Evidence to date suggest that fox numbers vary greatly and is related to rainfall events. Past investigations were concerned with the assessment of fox densities with the view to designing a baiting programme. This was in preparation for the reintroduction of two rare and endangered marsupial species (Boodie, *Bettongia lesureur* and the Golden Bandicoot, *Isoodon auratus*). The predatory nature of foxes and the lack of proper control was identified as the major factor in the failure of similar reintroduction studies in other states. This study incorporates fox control as a fundamental step in ensuring their prolonged survival. This reports on the baiting strategy employed and outlines further work to be done in May. The investigation aimed to:

1. Aerial bait a 40km × 40km zone around the release site for Boodie and Golden Bandicoots. The strategy employed was to intensely bait watercourses and roads, which were identified as the main arteries for reinvasion of foxes into the study area. A secondary or lower level of baiting intensity was to be given to the remainder of

the 40 × 40 grid, particularly on "harsh" country. Harsh country was defined as rocky ridges with sparse vegetation found from experience not to be suitable as a fox habitat. The release site, which is the central core of the aerial baiting and approximately 5km × 5km was excluded from aerial baiting.

2. Install bait stations and hand baiting of the release site. The 5km × 5km zone excluded from aerial baiting was to be pegged at 200m intervals to form numbered bait stations around the perimeter and proved a "sink" around the study tracks constructed to make the perimeter. All intervening tracks within the release site are to be pegged and baited to form additional protection.

3. Dragging of roads around the release site. All roads and tracks around the release site are to be dragged to remove all grass and vegetation and leave surface soft and powdery so that fox tracks become visible and easily detected. While on site, roads and tracks are to be inspected for fox tracks and freshened up each day before dragging with a lights metal bar or sheet of mesh to erase previous tracks. Daily plots of fox tracks are to be made to note movement and locate the most highly used areas. Further information on terrain preference can be obtained.

4. Test of aerial baiting effectiveness. Following a suitable period (1-2 months) 2 cyanide transects, each 30 km in length and capsules at 400m intervals are to be installed. The usual procedures of tying down capsules and treating with "lure" are to be employed. Samples of fox gut, snout and spleen will be collected from any kills. This work will be left till the next scheduled field trip planned for early May.

5. As an extra precaution the hand baiting of bait stations with "fresh" meat baits around the fenced enclosures is to be carried out prior to the release of Boodies and Bandicoots into the enclosures. This will be carried out in May, 1 week before the animals arrive and continue until the fence is removed and animals allowed to disperse.

After an aborted first attempt, aerial baiting was carried out on 19th March 1992 by Agriculture Protection staff. The strategy set was

achieved with priority given to drainage line ("soft" more productive type country) and roads, followed by a griding of the 40km × 40km baiting zone at a lesser intensity. Altogether, 7800 dried meat baits were dropped (see attached APB report on aerial baiting). Care was taken to exclude the central core which was hand baited ("sink" area). Aerial baiting was planned to take place on the 4th to 7th March using CALM staff and an Islander aircraft currently on lease to CALM. This was aborted due to the passage of cyclone Ian thought the area at that time. A reorganisation of the aerial baiting plan ensued with APB officers engaged to complete this work. This resulted from other commitments for the Islander and CALM staff and because APB officers based at Kalgoorlie were embarking on an aerial baiting programme of their own and would be close to the study area anyway. This was a fortunate turn of events and allowed us to complete the aerial baiting programme within the allocated budget.

A perimeter was established around the study site totalling 31.5km. This perimeter was pegged with metal fence droppers at 200m intervals and numbered. Each of these pegged bait stations was baited with a dried meat bait. All interior and intervening tracks were also pegged and baited; approximately 300 bait stations were established.

On advice from APB officers and experience gained, these bait stations will be rebaited in May with 5-6 baits at each station. Baits will be laid in two separate piles 5-10m apart near the bait station and in a shaded area near a shrub or tree to extend bait quality. The reason is to cater for animals travelling in pairs, thus ensuring both animals are exposed to the baits.

All tracks around and within the study site were graded with a drag and worked to provide a clear powdery surface. These were inspected daily while encamped and tracks of two pairs of dogs, 2 foxes and 2 cats were detected.

In future visits to the study area all tracks will be dragged with a light metal bar or sheet of mesh to erase old animal tracks and freshen the road surface. Bait station peg numbers will be used to

plot locations of any new tracks. Over time, plots of fox tracks may provide an insight into the type of country preferred by foxes and strengthen data already collected. Future baiting strategies would then concentrate on these areas.

The effectiveness of the aerial baiting was to be tested during May 1992 with 2 × 30km cyanide transects. Unfortunately, access was not possible due to heavy and extensive rain throughout the desert region.

## 6. Research on 1080

Little is known about the fate of 1080 in baits following manufacture and application in the field. Does it leach out after rain? Is 1080 degraded by microbes commonly found in the workplace? For how long is a bait potent? What is the minimum lethal dose for a fox when dosed using a standard bait? Is 1080 environmentally persistent?

None of the above questions could be answered when we began our research. We now understand why so little was known—1080 is an analytically intractable substance especially when it is associated with meat.

### 6.1 A Bioassay for 1080

Prevailing methods for 1080 analyses are laborious, require sophisticated equipment and skilled operators. In searching for a less demanding method, Dr. Dee Wong of Curtin University asked this question: since 1080 can poison mammal cells, then maybe it can poison bacteria too, or if not, maybe it could at least inhibit bacterial growth? Initially using lab cultures, none of the bacteria were inhibited so she left the lab and extended her tests to wild bacteria. Eventually she found two species that stopped growing in the presence of trace amounts of 1080; one was isolated from a metropolitan lake.

Using this bacterium, Dr. Wong has developed a bioassay for 1080. The beauty of the technique is that it is relatively simple as it avoids the need for sample cleanup and purification. It requires of course, microbiological expertise and facilities, but for analysing 1080 in

complex organic materials it is most promising. However, in the case of meat, the technique still requires more research.

### 6.2. What We now know about 1080

While the bioassay for 1080 needs more research in the case of meat baits (see below), much has been learned. The following summarises what we have learned, and what we plan to do with the assay.

We have shown that:

1. 1080 is not a environmentally persistent pesticide in WA soils.

2. 1080 is degraded by both fungi and bacteria which are ubiquitous in soils.

3. One of the fungal species, a potent 1080 degrader, is a common contaminant of oat grains used to produce 'One Shot' 1080 poison oats for rabbit control. The manufacturer was alerted to this fact and has taken appropriate steps.

4. It has been demonstrated that the microbes commonly found in the workplace, and on bait materials, are capable of degrading 1080.

5. It has been shown that these microbes, if precautions are not taken, will severely contaminate baits and cause 1080 degradation during the drying process.

6. In recognition of the above, there is an ongoing need for quality control in the bait manufacturing process. The bioassay, given that the problems associated with the analysis of 1080 in meat baits are resolved, would be the method of choice.

## 7. Future Research on 1080

The Curtin University bioassay for 1080 is a useful and practical technique for analysing an otherwise intractable substance in organic materials, but more work is necessary with regard to meat baits. We need to persist with assay for meat as there is nothing else that is suitable for routine quality control. In all other aspects, the bioassay represents a significant achievement.

At this stage, the assay needs some more work as recoveries from meat baits are not yet consistent enough. Given that this problem can be overcome, the assay will enable the following to be done:

1. Bait potency studies: we have no knowledge about how long a bait remains potent in the field; it would be useful to know this as this will determine the frequency of baiting.

2. The assay could be used to develop a long-lasting bait for use in remote areas such as the desert regions.

3. The assay would enable the development of baits with a limited toxic life span. Baits could be designed to detoxify after a desired period by innoculating the bait during preparation with 1080 degrading microbes. Such baits would be used to minimise the risk to vulnerable non-target species such as farm dogs.

4. Forensic analyses: analysing 1080 in complex organic substances is fraught with problems when using standard chemical analyses. The bioassay overcomes these problems and it could be used to confirm whether or not a victim ingested 1080. We refer to the following circumstances: dog poisonings and poisoning of fauna, alleged or otherwise.

Perhaps the most important benefit of these studies is this: it is now possible for any agency using 1080 to demonstrate that one can use a very toxic substance responsibly and with understanding.

Two papers have been published, two more are in press, and a fifth paper is in preparation.

## 8. The Fitzgerald River National Park Study

Fitzgerald River National Park (FRNP; 320,615 ha) lies on the central south coast of Western Australia, 420 km south-east of Perth between Bremer Bay and Hopetoun. The park is notable for its vertebrate fauna; it has 22 species of mammals (7 declared rare) and 184 species of bird (3 declared rare). The latter are ground-dwelling and presumably they could be at risk from introduced predators.

The FRNP was selected as a study site for the following reasons:

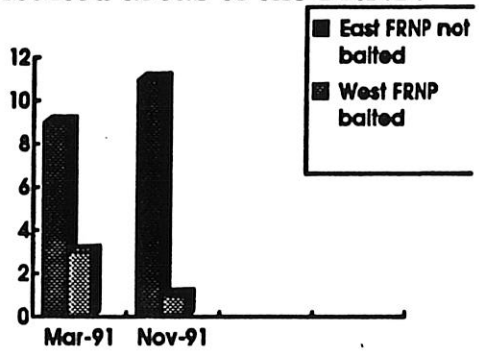
1. With its suite of mammals and birds, the FRNP provides a study site that enables one to determine the population responses of a range of mammal and bird species to predator control. Thus, the experiment is a very efficient one, as it will yield a great deal of information about new prey species at risk to introduced predators.

2. The site provided an opportunity to test the level of baiting required to allow species to increase. Previous studies at Watheroo National Park (no extant prey species) suggested that two baitings per year (Sept, Mar; 6 baits/km$^2$) should afford sufficient protection.

The park mammal populations were censused as was the ground parrot populations (Alan Burbidge, pers comm). The park was partitioned into 2 parts (E/W) with the western side made subject to predator control. Aerial baiting commenced on 27/2/91. Three baitings have been carried out to date.

The effectiveness of the baitings were assessed by measuring the CPUE for foxes on the W and E partitions. The results are shown in Fig 1.

Fig. 1. Number of foxes sampled by cyanide transects in baited and unbaited areas of the FRNP.




The results show that, following the 1080 baitings on W. FRNP, fox densities are much reduced as determined from cyanide transects

The experiment will be maintained for 5 years. It is planned to conduct the first mammal census in late 1992.

## 9. Contact Rate Studies

### 9.1 DNA Profiling

The contact rate between individual foxes must be quantified if the transmissibility and hence the successful spread of a biological control agent is to be determined. Current research has concentrated on estimating the sexual contact rate between foxes because it was believed that a sexually transmitted Herpes virus, due to its large size and presumed prevalence, was the most likely candidate virus type for the biological control agent. The minimum sexual contact rate that occurred within a population was investigated using DNA profiles. These profiles identify the relationships between individuals and from this the number of matings that occurred can be quantified.

Samples of DNA were collected from various sites in Western Australia so that the differing rates of transmission in different habitats and at different fox densities could be assessed. Twenty eight samples were obtained from Yanchep National Park; 33 from Nambung National Park; 48 from Big Soak Plain; 50 from Narrogin; 52 from Pinjarrega and 100 from Scott River.

The individuals sampled at Nambung National Park included fifteen vixens that were either pregnant or had recently given birth. DNA samples were obtained from each vixen and from the embryos or placental material. These samples can be used to determine if single litters of cubs can have more than one sire and thus whether a vixen has mated successfully with more than one male. Multiple sires of a single litter of pups have been reported for domestic dogs but whether this occurs in foxes has not yet been ascertained. A knowledge of this phenomenon is important in determining the spread of the biological control agent. The in utero sampling was undertaken because it ensures that all individuals within a litter are sampled and this may not be the case when collecting cubs. Also, it is much easier to determine the identity of the sire of a litter of cubs if the relationship between the vixen and embryos is known with certainty, especially if individuals within a population are closely related.

#### 9.2 Development Of A Micro-Satellite Probe

The DNA profiling is being undertaken at Curtin University. Standard Jefferies probes were used initially to produce profiles for each sample. Limitations to this technique were encountered because most of the foxes sampled had been killed with cyanide and it was discovered that cyanide degrades DNA. An experiment was undertaken to determine how quickly this degradation occurred and this involved killing a sample of foxes with cyanide and taking serial DNA samples. The results indicated that after six hours the DNA was degraded to such a level so as to make the use of standard probes impossible. Because foxes killed by cyanide in the field cannot be retrieved in less than six hours it was concluded that a new probe was needed. The development of a new fox-specific micro-satellite probe has thus been initiated. This probe will enable samples of even highly degraded DNA to be analysed and it will also decrease the cost of analysis of each sample from $50.00 to $6.00. The probe will take 6 months to develop and then the analysis of the samples already collected will be undertaken.

### 9.3 Provision Of Samples For Virus Antibody Screening

Recent discussions with virologists from CSIRO in Canberra have revealed that *Herpes* viruses are actually less likely to occur in canid populations than previously assumed. Other types of viruses are thus currently being investigated for their prevalence and suitability as candidates for genetic engineering. In collaboration with CSIRO, the serum from all of the samples collected has been sent to Canberra to be analysed for the presence of viral antibodies. To date, approximately 40% of the samples have been seropositive for canid adenoviruses. Because adenoviruses are spread through aerosol spray, a knowledge of the direct contact between foxes is necessary in the prediction of the spread of this type of virus. Similarly if pox viruses are used then a knowledge of contact rate would be important because pox viruses are spread by arthropod vectors such as mange mites. More sera samples are required from different areas and from different seasons to determine the prevalence of these and other types of virus.

## 10. Assessment Of Predation Pressure

To determine the possible effectiveness of a biological control programme, it is necessary to determine the predation pressure that prey species can sustain, and the consequent level to which fox populations must be reduced.

A baseline estimate of fox predation upon prey species can be obtained by investigating fox density within a baited reserve where healthy populations of prey species occur. Tutanning Nature Reserve was selected as a study site because it has healthy populations of *Bettongia penicillata, Macropus irma, M. eugenii* and *Trichosurus vulpecula*. An estimation of fox densities in this reserve could be made by baiting the area with cyanide just before each of the regular monthly 1080 baitings. The number of foxes that had been resident within the Reserve during the previous month could thus be quantified. To ensure that no non-target species were affected by the cyanide, a 'mock cyanide' baitng was undertaken. Sand was substituted for cyanide within the capsules. The results of this experiment were inconclusive because significant numbers of baits were damaged by non-target prey species but it was not possible to determine whether the baits had actually been ingested. Because

cyanide baiting cannot be conducted in areas where non-target species may be at risk, this experiment was postponed until a new bait delivery system can be devised or until a new site can be investigated

## 11. Liaison

J. Kinnear took long-service leave from September to December, 1991. He attended the 4th European Conference on Wildlife Telemetry in Aberdeen in September. The Conference was very well organised and the calibre of the papers high. Telemetry manufacturers were well represented and the opportunity was taken to discuss the feasibility of contact telemetry with representatives of many firms. The idea was new to most, and none had any ready-made solutions though they were intrigued and challenged by the proposal. Some have since made contact regarding designs.

In October, I attended a conference on rabies held in Nancy, in Northern France. The keynote address on the epidemiology of rabies by Prof. Roy Anderson was the highlight of the conference. The conference was not well organised and the translation facilities were limited.

Of interest was the research on rabies control by vaccination of foxes, a technique that is comparable to the Bradley experiment planned in 3-4 years. The Europeans have problems in evaluating the success of their vaccination program because they cannot sample the fox population adequately. What they need is CALM's cyanide technique.

In April, J. Kinnear received an invitation to attend a Predation Workshop held near Christchurch, New Zealand. He presented a talk on the impact of exotic predators on marsupials in WA. Judging from the following discussion it was evident that it was received with considerable interest. NZ abounds in introduced predators and they are apparently impacting severely on the bird fauna. With so many predators potentially involved, the predation ecology is extraordinarily complex.

A morning session was devoted to feral cats and methods of eradication. New Zealand scientists have demonstrated that cats can be eradicated from islands under very difficult circumstances. Most importantly, they have shown that it can be done if the commitment is there.

Kinnear also spent a very productive day with Dr. C. Eason (a toxicologist) in Christchurch. He and his associates have devised a very sensitive but complex method for analysing 1080. It is not suitable for routine analyses of 1080 in baits, but it is capable of detecting 1080 at the picogram level.

Eason is also involved in bait design for feral cats. This work is very promising.

In May, Kinnear inspected yellow-footed rock-wallaby sites near Broken Hill at the invitation of Dr. N. Sheppard, of the NSW NP&WS. He later was joined by P. Alexander from Adelaide and sites were inspected in SA. A report was written

N. Marlow attended the Conservation Biology Conference in Brisbane in September 1991. She also attended the Australasian Wildlife Management Society Conference in Dubbo in November 1991; she is a committee member of this organisation.

### 11.1 CRC Liaison

Dr. Hugh Tyndale-Biscoe visited WA in February on matters relating to the CRC. A workshop was convened and this was followed by an overnight field trip to Dryandra State Forest to observe wildlife now numerous because of fox control.

In March, Dr. Scott Crerar (CRC virologist; CSIRO Canberra) visited WA to collect material from foxes for viral screening. Useful discussions were held.

In June, Dr. L. Hinds, (CRC Reproductive Endocrinologist; CSIRO, Canberra) visited WA. Useful discussions were held.

J. Kinnear, D. Algar, N. Marlow attended the inaugural CRC Workshop held near Bateman's Bay. Everyone agreed that it was a very profitable exercise in numerous ways.

Clive Marks and Dave Pridell's Technical Officer visited CALM's Wildlife Research Centre for training in the preparation and use of cyanide baits. Additional requests for training have been arranged with staff from other conservation organisations in E. Australia.

Mr Peter Thomson, of the WA. Agriculture Protection Board, and his two technical associates have been collaborating with CALM officers. Mr Thomson is a participant in the Cooperative Research Centre. Monthly meetings are held to discuss and coordinate fox research. Resources have been pooled and joint studies have been organised.

CALM Predator Research and Management Unit: In recognition of the importance of predator research and control, CALM has established a special research unit dedicated to the task of carrying out research on the control and management of introduced predators. The unit will be directed by Dr. J.E. Kinnear. Mr. Paul de Tores has been appointed Executive Officer. He will act primarily in a coordinating role seeking to integrate CALM regions and districts into the research process.

## 12. References

Algar, D. and Kinnear, J.E. (1991). Fox density and dispersal into baited areas. *Proceedings of the 9th Vertebrate Pest Conference*, pp 177-80.

Algar, D. and Kinnear, J.E. (1992). Cyanide baiting to sample fox populations and measure changes in relative abundance. In : *Wildlife Rabies Contingency Planning in Australia.* (eds. O'Brien, P.H. and Berry, G.N.). Bureau of Rural Resources Proceedings No. 11. Australian Government Publishing Service, Canberra, pp 135-38.

Andersen, R.M. (1991). Populations and infectious diseases: ecology or epidemiology? *J. Animal Ecol.* **60**: 1-50.

Englund, J. (1970). Some aspects of reproduction and mortality rates in Swedish foxes (*Vulpes vulpes*) 1961-63 and 1966-69. *Swedish Wildl.*, 8: 1-82.

Johnson, D.H.; Joachim, D.G.; Bachmann, P.; Kardong, K.V.; Stewart, R.E.A.; Dix, L.M.; Strickland, M.A. and Watt, I.D. (1989). Aging furbearers using tooth structure and biomarkers. In: *Wild Furbearer Management and Conservation in North America*. (eds. Novak, M.;Baker, J.A.; Obbard, M.E. and Malloch B.) Ontario Ministry of Natural Resources. pp 228-43.

Kinnear, J.E. and Algar, D. (1991). A Manual on Fox Control. *Project 106*; World Wide Fund for Nature (Australia).

Kinnear, J.E., Onus, M.L. and Bromilow, R.N. (1988). Fox control and rock-wallaby population dynamics. *Aust. Wildl. Res.* **15**, 435-450.

Lindstrom, E. (1981). Reliability of placental scar counts in the red fox (*Vulpes vulpes* L.) with special reference to fading of the scars. *Mammal Rev.*, **11**(4): 137-49.